THURSDAY, OCTOBER 16, 1902.

THE END OF THE WORLD.

Der Untergang der Erde und die kosmischen Katastrophen. Von Dr. M. W. Meyer. Pp. viii + 380. (Berlin: Allgemeiner Verein für deutsche Litteratur, 1902.)

AT various times and by authorities of very varied reputation, but at tolerably frequent intervals, we are invited to consider the problems that are connected with the origin or the decay of the cosmos. It is doubtful in which category the present volume should be placed; the author, indeed, writes decay on his cover, but his pages have more to do with formation and development. The main thought running through the book is to declare the existence of a cycle of events, which may be accompanied with catastrophes of greater or less severity, but tending always to recovery and restoration. This is no new thought, and until some epoch-making discovery such as that of the spectroscope or the principle of the conservation of force widens and directs the issues of scientific investigation, it is difficult to understand how anything new can be written on the cosmogony as a whole. Dr. Meyer presumably thinks differently, and, with the pen of a ready writer, he is willing to rearrange, in a very pleasant manner, the few facts that have been collected, and to repeat the views of the original thinkers and workers on this fascinating subject. Occasionally, Dr. Meyer wanders slightly from recognised lines, and is then, as we think, neither so accurate nor so interesting as when he keeps on the well-trodden paths that his predecessors have followed. If, however, this rearrangement had been nicely managed, we could have forgiven the author much. If he had unfolded before us a panoramic view, in which the development of the cosmos could be traced continuously and uniformly, or had pictured for us the gradual cessation of the phenomena with which we are familiar, we could have welcomed his book as a contribution to popular scientific literature. But in this respect we do not think Dr. Meyer has done himself justice. The successive chapters of his book have too much resemblance to articles in a popular magazine, and may possibly have done duty in that capacity. Each chapter may read pleasantly enough, but the author has not nicely welded his material and dovetailed his story together. As evidence of the traces of magazine writing, we may quote the following passage (p. 201):—

". . . brennt nicht die Wohnstätten der Männer nieder, die für die Freiheit ihres Landes kämpfen, das sie mit schwieliger Hand der Wildnis abgetrotzt haben, drängt anderen nicht euer Christentum auf, bevor ihr es nicht übt an euren eigenen Brüdern. . . ."

Such interpolations have very little to do with the outburst of the new star in Perseus, in the description of which this occurs, but the passage is reminiscent of a style which we will hope has passed. It certainly would have been in better taste to have omitted it from a scientific treatise.

It is a little uncertain how far we may regard this book as the reflection of German thought and the expression of views currently held in astronomical circles in that country. Dr. Meyer has, however, filled positions of some scientific importance, and may to that extent be regarded as an authority. It should therefore have some interest to compare in detail the views he holds on the construction of the universe with those that obtain in this country, more especially on points which we are inclined to regard as having passed beyond controversy and to be generally accepted. Obviously, however, only a few such points can be selected, and the history of the moon is the most conspicuous instance, because it has been made the subject of an elaborate inquiry, in which it has been shown that the obliquity of the ecliptic, the eccentricity and inclination of the lunar orbit, the period of revolution of the moon and the rotation of the earth are coordinated together on the hypothesis that the moon originally existed near the present surface of the earth, and with small differential motion with respect to it. Further, that the discussion of the moment of momentum amongst the several planetary systems shows that the condition, obtaining on the terrestrial, differs widely from that of other planets, pointing to the necessity of unique treatment. But the references to Prof. G. H. Darwin's work are so scanty that we should doubt if Dr. Meyer has read it, or whether any popular account of the investigation exists in Germany.

To explain the origin of the planets and satellites, the author starts with a collision, and finds the materials for the construction of a new universe in the débris of previously existing, but now shattered, suns. This material will consist of gas, molten particles of every conceivable size, and solid fragments. These particles, in the form of dust, meteors, even gleaming suns, are originally gifted with rectilinear motion, but by a process the author does not fully explain, this motion is converted into spiral movement and finally becomes elliptic, characterised by considerable eccentricity, which diminishes with time until an approximately circular form is reached. At least, this process is followed by the more solid portions which are destined to become suns and planets; some portions have their velocities increased by collision, and are carried away to form wandering suns. The actual formation of a sun or planet by the process of conglomeration—a feature common to all cosmogonies—is very difficult of explanation, and the author can follow what train of reasoning he pleases without much fear of hostile criticism, though the necessity of passing through the stage of a double nebula is not very apparent.

With his centres of condensation and space charged with dust and meteors, Dr. Meyer apparently follows the suggestions of the late M. Faye, and assumes that many meteors moving in eccentric orbits strike against the nucleus and are absorbed by it, maintaining an elevated temperature in the central body by impact. Our moon and the satellites of other planets seem to have come into being simultaneously with the primaries, being formed from secondary rings, the separate existence and stability of which are not explained. But as condensation proceeds on the secondary rings, the bodies so formed necessarily cool more quickly than the larger planetary masses, and the precipitated meteoric matter, which is absorbed by the glowing and fluid planets without any difficulty, leaves holes in the thin crust of the satellite,

which is not yet sufficiently rigid to resist. The result is that phenomena resembling lunar craters are produced. These craters, therefore, are not the result of ejections resembling volcanic eruptions from within, but are the results of action from without. Further than this, the matter carried into the body of the moon will in its turn be melted in the heated interior; consequently the thin crust will no longer be able to support the internal pressure, and rents or fissures of the hardened exterior will take place, and this is the cause of the bright streaks or radiations which can readily be seen on the most superficial examination of the moon. It might be urged in opposition to this view that the molten matter ejected from the interior must soon cool, and not only destroy the traces of the meteoric bombardment, but would also thicken the crust and tend to prevent the penetration of fresh meteors. If one asks why the earth or Mars does not show similar signs of precipitated matter, Dr. Meyer is ready with his answer. By the time that the greater mass of a planet had sufficiently cooled, all the larger débris, the results of the original collision, had been absorbed, and the smaller masses either fell upon the stiffening crust without penetrating it, or were volatilised by friction with the atmosphere, which in those days, it is suggested, was more dense than at present. And if anyone, still unconvinced, asks how it is that Jupiter, for example, can drink up all the matter in a cosmical ring extending into indefinite space, and yet refuses to swallow the small mouthful which in the form of the fifth satellite tantalisingly tempts its capacious appetite, the answer is, wait. All the satellites will eventually be drawn in and form an integral portion of their respective primaries, just as these in their turn will be absorbed in the sun, to be followed again at immense intervals of time by the crashing together of defunct suns producing a larger set of planets with a larger and hotter sun, a solar system on a vaster scale than that in which we play our little part. And so growing in grandeur but diminishing in number, the final catastrophe will come, when there are no more suns to produce collisions, and one huge body cooled to the zero of space, void of available energy, will mark the final outcome of cosmical motion.

This, if we understand our author, is the final state of rest, but there are qualifications introduced which may modify this conclusion. We have endeavoured to draw the conclusion without entering into the limitations which depend, more or less, "in unsern unvollendeten Geist." The only objection one might urge is to the insistence on the lowering of the temperature of the mass to that of the absolute zero. It is only necessary for a uniform temperature, however great, to exist throughout the whole, when a practically useless state of kinetic energy would result, and no work would be possible.

On this world, however formed, it is necessary to introduce life, and, if possible, without a definite creative act implying a breach of continuity. Dr. Meyer follows, but without acknowledgment so far as we have seen, the hypothesis of Helmholtz or of Kelvin. We imagine that the author regards life as old as matter itself, and that its transition from a defunct world to a new one is effected by means of germs, borne through space on fragments; or so-called meteors, and whenever such germs meet with a favourable environment the processes of life are continued. In a collision, heat would be generated only in proportion as motion is destroyed, so that, as the author is careful to point out, fragments could escape without any great development of heat or necessary destruction of all forms of life. But we do not understand so clearly his theory of the method by which the meteoric fragment, carrying life to a new world, finds itself deposited there. But this is of little consequence, since meteors do come here, and if their surface is heated by friction, the interior can be of lower temperature. Or it can very well happen that germs lying on the surface would be blown away in the highest and most attenuated strata of the earth's atmosphere before the fragment reached the denser parts of the gaseous mass, where the compression becomes great enough to generate considerable heat. The author, however, seems to think it necessary to give to the meteor the same velocity as that of the earth, so that it is quietly and gently deposited on the surface without any arrest of motion and therefore without any increase of temperature. Indeed, he seems to think that meteors, bringing with them enormous masses of water, can accompany the earth for some days in its journey round the sun, giving rise to severe local storms, and marvels that meteorologists have not entertained such explanations as legitimate and worthy of consideration. It is true that the author does not say that these meteors are moving in a circular orbit, but he allows this to be inferred, since parabolic velocities do not seem to be considered. We gather from an account that the author gives of a controversy with Dr. Palisa that that astronomer has had some difficulty in following Dr. Meyer's views, and, so far as we can follow the account from the description of one of the disputants, we would respectfully associate ourselves with the opinion of Dr. Palisa.

We have dwelt, perhaps, at too great length on the points of difference that separate us from the author, and have no space to enter on other matters, which we would do the more willingly since no note of disapprobation need accompany our remarks. In many respects, the book is very interesting, and many chapters can be read with equal pleasure and profit, though the connection with terrestrial catastrophes is not very apparent. Dr. Meyer has selected a subject of great interest, but one on which diverse views can be maintained more or less legitimately. He can write pleasantly and clearly, and while his book may be instructive to the general reader, for he studiously avoids all technical expressions, it should not be offensive to the most orthodox theologian.

ARTIFICIAL MINERAL WATERS.

The Evolution of Artificial Mineral Waters. By William Kirkby, F.L.S. Pp. x + 155. (Manchester: Jewsbury and Brown, 1902.) Price 3*s.* 6*d.*

THIS little book has been written with the object of showing the origin and development of the mineral water industry, an industry the commercial importance of which may be to some extent gauged by the author's statement that our annual exports amount to more than

one million dozens and that, directly or indirectly, it gives employment to no less than 25,000 persons in London alone.

In his historical sketch of the evolution of artificial mineral waters as we know them to-day, the author shows that progress has been made along two main lines. The existence of these popular beverages undoubtedly had its origin in the desire of the earlier physicians to prepare by artificial means saline solutions which should have the same therapeutic and curative effects as the waters obtained from well-known natural springs such as those of Epsom, Seidlitz or Bath. This necessarily involved some knowledge of the chemical nature of their constituents, and it was not, therefore, until Boyle had given birth to analytical chemistry, and Bergman had brought his genius and industry to bear upon the chemical examination of the waters from many of the mineral springs, that such imitation became possible. At the same time, much speculation was being indulged in as to the exact nature of that wonderful "principle" which gave to many of the natural waters their sparkling character and piquant flavour; and the numerous researches which were being made in this direction culminated in the great discovery by Black of the chemical identity and true nature of carbonic acid gas. Along both these lines the author traces the gradual development of the mineral water industry, showing in true perspective and with due attention to their relative importance the various discoveries or steps by which its present position has been reached. In this connection, we think that the author has attached rather too much importance to Brownrigg's share in the discovery of the true nature of carbonic acid gas, and has perhaps given too little prominence to the masterly researches and brilliant deductions of Black. In the main, however, the chapters dealing with the work of the earlier discoverers are accurately and clearly written, and the book should certainly be read by all who are desirous of acquiring an intelligent knowledge of the beginnings and development of this now important industry.

There are, unfortunately, a few blemishes which ought scarcely to have escaped the author's notice. Thus we are told on p. 3 that the latter half of the eighteenth century witnessed the birth of chemistry, while on p. 13 that honour is assigned to the seventeenth. Whether we are to consider the former, the latter, or, indeed, either of these statements correct will naturally depend upon the precise meaning we are to give to the word "birth," but we presume that the author had in his mind the eighteenth century, which witnessed the labours of Black, Cavendish, Priestley, Scheele and Lavoisier, to mention only some of the giants who laid the foundation on which the wonderful superstructure of modern chemistry has been reared.

The statement on p. 34 that "it is possible to-day to obtain by mechanical and other means water of as great chemical and bacterial purity as any natural water from the deep springs" presumably refers to filtration, but is not by any means clear. On p. 67 we are told that Macquer purified carbonic acid by passing it through a vessel "containing lime and water," but are not told how much of the gas passed through. In connection with the use of sodium bicarbonate for the preparation of carbonic acid gas, the author makes, on p. 120, the truly astonishing statement that precautions have to be taken to prevent any *ammonia* present as an impurity *from passing over with the gas into the gas holders*. We should have thought, as a matter of fact, that the presence of the acid used for its decomposition would have constituted a sufficient "precaution." In one or two places, the language is a little involved, and there are several misprints and slips, such as Becheri for Becher on p. 42, Thiloria for Thilorier on p. 60, and *unabsorbed* would have been better than *unattached* on p. 120. The chapter on the syphon and its development is well written, and like the rest of the book is clearly illustrated by means of well-executed drawings. The author states in his prefatory remarks that he does not intend this to be a manufacturer's handbook, and that therefore he has given no formulæ for the preparation of the various waters. For the same reason, presumably, the description of manufacturing processes and machinery is contained within the limits necessary to render the book acceptable to the general reader. It contains a good index and a well-compiled bibliographical table, and we can, in conclusion, heartily commend it "to all whom it may concern." We cannot, however, help feeling that the author would have done well to have given his book a more independent character by dwelling with rather less emphasis on the excellence of the plant and manufactured products of a particular firm. A. C. C.

DEVELOPMENT OF THE HUMAN EMBRYO

Human Embryology and Morphology. By Dr. A. Keith. Pp. viii+324. (London: Edward Arnold, 1902.) Price 12*s.* 6*d.* net.

DR. KEITH is an accomplished anatomist, and in this morphological study of the development of the human embryo he has given us a valuable account, the result of wide and exact personal observation, of all the later phases of organogeny.

The descriptions of the changes that occur during the formation of the face and neck, the alimentary tract, the central nervous system, the heart and blood-vessels, the history of the development of the skeleton and musculature of the head and trunk, are evidently the work of one who is thoroughly familiar with the anatomy, not merely of the human subject, but of the apes and other mammals as well; and in what we may term the "anatomical embryology" here set before us there is much which will be of permanent scientific worth, apart from what is of practical importance for the ordinary surgeon.

From the other aspects, however, we regret that this treatise is less satisfactory. The earnest student who expects to find here a critical exposition of the thorny problems of modern embryology, or even a sufficiently accurate statement of the facts, will be sadly disappointed.

The account of the formation of the germinal layers and of the early changes in the mammalian blastocyst is not only inadequate, it is erroneous; we are told, for instance (p. 89), that "in lower vertebrates the mesoblast is entirely produced from the hypoblast," and (p. 243)

that it is "highly probable that the cœlom was originally a series of segmental diverticula derived from inflections of the hypoblast," while no attempt at all is made to discuss the difficult question of the significance of germinal layers. The chapter on the placenta might perhaps have passed muster ten or fifteen years ago.

The epiblastic origin of the pronephric duct is treated as an established fact, and the vertebrate kidney tubule compared to the nephridium of the annelids.

The writer appears to have quite misunderstood the results of recent work on the segmentation of the vertebrate head. On p. 221, for example, it is said that the motor nerve of the fourth cranial segment, comparable, therefore, to the nerves which supply the muscles of the eyeball, is the seventh, and the chorda tympani its sensory root; while the last-mentioned is spoken of here, and in the diagram on p. 35, as pre-spiracular in position, a statement which, however true it may be for some reptiles, is certainly at variance with Broman's careful account of its development in the human embryo.

Again, it would be gathered from the wording on p. 238 that the interventricular septum in Sauropsida is homologous with the similar structure in the mammals; and in chapter xiv. the author has been completely led away by a very dubious theory, to say the least, of the origin of the rods and cones of the retina.

Minor inaccuracies are the ascription of only one dentition to the marsupials (p. 67), the omission of any reference to the possible paired origin of the pineal eye, or to the paraphysis, the derivation of the Eustachian valve from the right valvula venosa alone, and the statement that in fishes the "mesial element" of the diaphragm is alone developed.

Such work as this can hardly be taken as a serious contribution towards the solution of those problems which beset the vertebrate embryologist, and it would have been wiser for Dr. Keith, who appears to intend his book preeminently as a *vade mecum* in the hospital wards, to have resisted the temptation to deal with questions which are beyond the scope and cannot be answered by the methods of mere surgical anatomy. Still, as a practical handbook we hope that this treatise may be a success, especially when, in a future edition, certain orthographical slips—"epiphyseal," "fasiculi," "anastomatic," "systematic" (for "systemic"), "embryoes," "Turicæ" (for "Turcica"), "hypopophysis"—are duly amended.

AN EDUCATIONAL COMPARISON.

The Making of Citizens. A Study of Comparative Education. By R. E. Hughes, M.A., B.Sc. Pp. viii + 405. (London and Newcastle: The Walter Scott Publishing Co., Ltd., 1902.) Price 6*s*.

THE educationist anxious to keep pace with all that has been written on the very wide subject with which he is concerned has had an almost impossible task during recent years. The annual reports of the Commissioner of Education, Washington, are so bulky—the last, that for 1899-1900, runs to 2348 pages—and the special reports of our own Board of Education are published so frequently, that one is tempted to give up in despair the effort to master their contents. In addition to these official publications there are the books written by private persons who have studied foreign methods of education on the spot. Mr. Hughes has, in the book before us, endeavoured to meet this difficulty, and to provide students with "a complete and accurate account of the present position of education in the four principa countries of the world," by which he means England, France, Germany and the United States of America. In the compilation of the volume, free use has been made of the official reports mentioned, and numerous quotations from many writers show that the author has a good knowledge of recent educational literature.

The plan of the book is very simple. After some preliminary pages, separate chapters are devoted to the primary school systems of each of the countries under comparison; after this a general view of the working of primary schools is followed by an account of higher elementary schools. The secondary schools of the four countries are allotted a chapter each, and the book is completed by a *résumé* of the provisions made for the education of girls and for the training of defective children.

With the wealth of material he had from which to select, it was not to be expected that Mr. Hughes would please everybody; naturally the same subjects do not appear of equal importance to all authorities. For instance, in our opinion too little attention is paid to the question of the science teaching in the schools described. The prominence given both in England and America to the need for rational methods in the teaching of science, and to the desirability of the inclusion of some instruction in the methods of science in schools of every grade, is scarcely mentioned by Mr. Hughes. We are told that the science side and master of the best English secondary schools are only tolerated (p. 307), and that chemistry is the favourite and first science taken up (p. 320), though it does not seem to be mentioned that this preference for chemistry as the initial science study is less marked year by year. It is pointed out that the German teacher relies upon the lecture rather than upon the laboratory method (p. 253), that the heuristic method is becoming the accepted way of teaching science in American high schools, and that in them it is usual to begin with the study of physics (p. 280); but these odd paragraphs exhaust all that is said on this important subject.

In view of the influence which science has exerted upon manufacture, commerce and thought generally, a careful comparison of the place which science teaching takes in schools of every grade in the four countries concerned would have been most valuable. The book is intended, however, for the ordinary person with a general interest in education, and this may explain why Mr. Hughes has given more prominence to administrative matters than to questions of curriculum. It only remains to be said that the author's personal acquaintance with English education and his wide experience of schools have enabled him to bring together in convenient compass very much of interest and importance about American, French and German systems of education.

OUR BOOK SHELF.

Animal Forms: a Second Book of Zoology. By David S. Jordan, M.S., M.D., Ph.D., LL.D., President of Leland Stanford Junior University, and Prof. Harold Heath, Ph.D. Pp. vi + 258; 140 figs. and frontispiece. (London: Hirschfeld Bros., Ltd., 1902.) Price 6*s.* net.

THIS attractive volume, distinguished by the freshness and excellence of its illustrations, is designed as "a second book of zoology," "to meet the needs of the beginning student of zoology." The opening chapters deal, somewhat lightly, with the characteristics of living things and of animals in particular, and with the cell and its protoplasm. They are clear and straightforward, but they lack both distinction and distinctiveness. If this sort of introduction is desirable it should be less easy-going.

The bulk of the book consists of a description of the classes of animals, with particular reference to representative types, considered mainly in their structural aspects, but with considerable attention to functions, habits and life-history—always in a simple, elementary fashion. Here and there throughout the chapters the student is judiciously pulled up for a moment before one or other of the deeper problems of biology, *e.g.* the plasticity of form in sponges, regeneration in worms, and the origin of species. Apart from the relative prominence given to "ecology," the absence of anything suggestive of a cramming synopsis and the really fine illustrations, the survey does not differ markedly from that to be found in a crowd of other books.

It is very important that a simple work of this kind should not give the student any impressions which he will afterwards have to discard; therefore we doubt the wisdom of speaking of the "skull" of cuttlefishes, the "external" skeleton of echinoderms, the "gills" of the lancelet, the air-bladder as "a modified or degenerate lung." With such a graphic illustration of the viscera of the starfish, it seems a pity that a "twentieth century" text-book should retain the absurd terms "cardiac" and "pyloric" for the two main regions of the gut. As we should expect from the authors, such blemishes are very rare. We have to lament, however, that the desirable prominence given to "ecology" seems to have practically excluded the good old-fashioned lessons on homology, which we believe to be very useful to "the beginning student," and might also expect in a book entitled "Animal Forms." Another defect seems to us to be the relative absence of the definite suggestion of problems for the student to think over.

The half-tone illustrations, many from photographs, deserve great praise. We may notice, in particular, the murres on the frontispiece, the piddocks in their holes, the long-eared sunfish, the rattlesnake, the raccoon and the baby orang-utan. J. A. T.

Das botanische Practicum. Von Dr. Eduard Strasburger. Vierte umgearbeitete Auflage. Pp. l + 771. (Jena: Gustav Fischer, 1902.) Price Mark 20.

THE third edition of this well-known book has been so favourably received that a fourth edition has now been published. The alterations and additions in this new issue are not so extensive as in the previous one, but they are nevertheless considerable, and the whole book has been subjected to careful revision. The scope of the book has certainly advanced beyond the author's original intention as conveyed by the title, "Introduction to the Personal Study of Microscopic Botany," for there are references to several important facts which are highly interesting, but the experiments connected with them one would not think of undertaking unless they formed part of an original investigation; parthenogenesis in Marsilia and the problem of intramortal or intravital staining are notable instances. As the facts are stated without critical opinions being offered, a simple reference to the publications would have been as valuable, and would have made a reduction even though slight in the size of the book. However, the greater number of the additional paragraphs are of considerable practical value, and not the least so are the directions or hints which emanate from Prof. Strasburger himself or from workers in his laboratory, as, for instance, the method of examining the root of *Vicia Faba*, the directions for embedding small algæ and the instructions for demonstrating protoplasmic threads (Plasmodesmen). Other notable additions include new tests for starch, fats, callus and cork, and the use of neutral violet as a reagent for pectic compounds. Darwin's device of using hornshavings as a hygrometer to determine the number of stomata and Buscalioni's collodion method for the same purpose are mentioned, and some account is given of Brown and Escombe's work on the diffusion of gases through small apertures. It will be found that this edition differs mainly by the insertion of new paragraphs, and practically the only chapter which is rewritten is the last, dealing principally with cell problems.

Principles of Sanitary Science and the Public Health. By Prof. William T. Sedgwick, Ph.D. Pp. xix + 368. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1902.) Price 12*s.* 6*d.* net.

A FEW sentences of the preface to this work serve admirably to indicate its scope and, it may be added, its attainment. "This volume deals with the principles, rather than the arts, of sanitation," the author writes. "It is intended to be no more than an elementary treatise on the subject; and while it is believed that it contains some new material, and some old material treated from new points of view, no special claim is made for originality either in substance or in method of presentation." The author has, therefore, chiefly sought to bring together and to present in a simple and logical form those fundamental scientific principles on which the great practical arts of modern sanitation securely rest.

If the chapter on disinfection is taken, that will serve well to illustrate the scope and limitations of the work. There the necessity for disinfection and the object of disinfection are dealt with, but no directions are given as to how principles are applied in actual practice.

It is a most readable work, in which every principle of sanitation that is enunciated is lucidly explained and convincingly advocated, and in which the history of the facts on which the principles of sanitation are based is brought right up to date. It is a good book for everyone to read, and there is certainly no better book for the student to master before he commences the study of the practical and administrative side to public health work.

The author is very sound in his opinions. It is necessary to aim at high ideals when one advocates preventive measures in the interest of the public health, for those measures which are generally thought to be extreme are frequently the only ones which attain their object; but the author's ideal of a city, the water-supply of which is derived from surface-water, owning the entire watershed and keeping it clean and uninhabited, is an impossible one. Even in America it must be rare indeed that a city can secure for its water-supply a totally uninhabited watershed; but everyone will agree that a systematic and frequent inspection should always be maintained to guard the purity of the water collected on such gathering grounds. It is one of the great reproaches upon the sanitary administration of this country that so little is done in this direction. Frequently one sees men employed to patrol river banks to guard the interests of those who have the sole right to the fishing, while no systematic inspection is carried out to guard against

dangerous pollution of the water in the higher interests of the public health.

The work is a welcome addition to public health literature, and it is sure to meet with general appreciation. It should appeal to a wide circle of readers, for it is written in a manner which presents a most important subject in a clear and intelligible light to everyone.

Nature Study: Realistic Geography. Model based on the 6-inch Ordnance Survey. Designed by G. Herbert Morrell, M.A. (London: Edward Stanford.) Price 3*s*.

THIS is a model of the country round Streatley-on-Thames, constructed by cutting out pieces of cardboard according to the contour lines and placing them one above another in the positions shown by the map. Spare pieces of cardboard, on which the contour lines are printed, ready for cutting out to make a second model, are enclosed in a portfolio along with the first. The construction of models of this kind has been carried out for some years in a number of schools, both in this country and abroad, but the general experience seems to be that, like the trigonometrical survey of the school and playground, and other similar devices, the time necessary to carry them out is too much for the value of the results obtained. The use of Mr. Morrell's model undoubtedly saves some time, inasmuch as the contour lines are already traced, but we suspect that the tracing of the contour lines is really the most important part of the exercise. But anything which assists in familiarising British school children with the ideas of contour lines and surfaces is to be welcomed; it is astonishing how many children who are familiarly acquainted with isobars, isothermals and "iso-" lines of all sorts have scarcely heard of contour lines, and it is not too much to state that the failure to present the conception of a contour or "iso-" line as the intersection of a surface with the surface of the earth is almost the fundamental defect in our teaching of advanced physical geography. Apart from its application to the purpose for which it is immediately intended, Mr. Morrell's model should be of value to teachers for demonstration.

A Junior Chemistry. By E. A. Tyler, B.A. Pp. viii + 228. (London: Methuen and Co., 1902.) Price 2*s*. 6*d*.

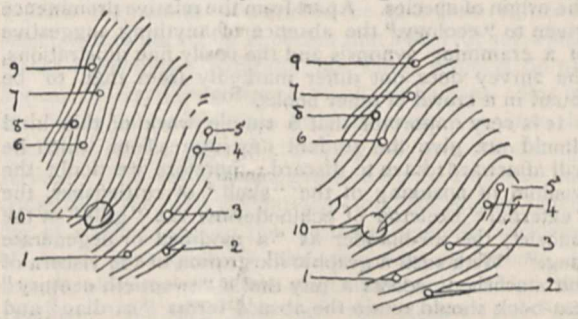
THE author's primary object seems to be to enable boys to present themselves successfully for the examinations in chemistry held in connection with the Oxford and Cambridge locals and similar examinations. He recognises the existence of a better way of teaching his subject than the one he adopts, and urges in extenuation of his procedure the inadequate provision made for practical science in most secondary schools and the small amount of time devoted to science in them. Mr. Tyler expresses the hope that the book he has written will enable boys in ordinary schools "to acquire, as far as possible, a scientific knowledge of chemistry," but he does not seem to understand that science is not properly included in the curriculum because of the information its study imparts, but rather as a means of developing a habit of mind. Unless chemistry is studied experimentally, and is made to train the pupil to observe and to reason from his observations, it has no right to a place on the school time-table. Before the pupil has been set to study the preparation and properties of a few simple substances, and from his own deductions taught to discover the laws of chemical combination, Mr. Tyler tries to explain to him the atomic theory, Avogadro's law, compound radicals, and other theoretical considerations. Though the author understands well enough all the chemistry a boy need learn at school, he does not quite appreciate why men of science desire such subjects as chemistry to be introduced into school work.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Finger Print Evidence.

BY the courtesy of authorities in Scotland Yard, I have just received duplicates of two enlarged photographs (on slightly different scales). These photographs were lately submitted in a court of law to prove the identity of *a*, the mark left on the window frame of a house after a burglary had been committed, with *b*, the impression of the left thumb of H. J., a criminal then released and at large, whose finger prints are preserved and classified in Scotland Yard. I wished to show the resemblance between *a* and *b* by the method described in my "Decipherment of Blurred Finger Prints," believing that to be the readiest way of explaining to a judge and jury the nature of the evidence about to be submitted to them. I send the results. The questions of the best mode of submitting evidence and of the amount of it that is reasonably required to carry conviction deserve early consideration, for we may have a great deal of it before long. It is as a contribution towards arriving at a conclusion that I send the enclosed. I should say that in the above-mentioned book, each pair of impressions was printed in triplicate and on a still larger scale than these. One of the three was untouched, the second had lines drawn like those in the figure, down the axes of the ridges, the third had the lines and numbers and nothing else, just as in the figure. The attention



a *b*

of the judge and jury could be easily directed by counsel to whatever pair of corresponding points he might desire, by reference to their common number on the chart. Without some such guidance it would be extremely difficult to do so, for persons unaccustomed to finger prints are bewildered by the maze of their lineations.

Certain more or less faint lines run across *a* that seem to have been made with the brush when painting the window frame. They seriously interfere with the lineations just above No. 5 and to the right of it. No. 5 is itself so far affected by them that I do not attach full weight to it as a point of reference. But accurate comparison is possible at nine other points, all of which are marked, and a close agreement will be found between every pair of them as well as in the number of intervening ridges. FRANCIS GALTON.

[The prints have been too much reduced from the tracings I sent, to be quite clear. Thus unless a lens be used, No. 2 in *b* will probably be misinterpreted.]

Remarkable Fossil Oysters from Syria.

IN examining a series of more than one hundred specimens of *Ostrea* (*Exogyra*) *flabellata*, Goldfuss, from the Middle Cretaceous of Lebanon, I was struck with the marked reproduction in the free upper valves of the figures of other shells to which the lower valves have been attached. These specimens were all collected in the same place, a hill near Bhamdûn, Mount Lebanon, Syria. They have been freed by weathering from a soft marly rock exceedingly rich in fossils. Specimens of Ostrea, Plicatula, Pecten and Anomia have the shell well preserved. Many others, including species of Cardium, Trigonia, Corbula, Isocardia, Cytherea, Leda, Nucula, Cerithium, Alaria, Melo, Pterocera, Turritella, Natica and others are preserved only as casts. Consequently the shell to

which the oyster was attached has usually disappeared, except in those cases in which it was attached to one of its own species. More than half of the specimens have the two valves united and free from adhesions, so that they are capable of exhibiting the phenomenon referred to. More than nine-tenths of these show more or less clearly in the upper valve the figure impressed upon the lower valve by the shell to which the latter adhered.

In most cases this is the figure of a part of the outer surface of a bivalve shell. In a few it is the inner surface of a bivalve shell. In one oyster the figure of part of a specimen of *Cerithium magnicostatum*, Conrad, is clearly shown above and below; in another, *Cerithium libanoticum*, Fraas, with a much better outer lip than is usually found in specimens of the original shell. In two cases the internal cast of a small Cerithium, together with some of the matrix, still adheres to the lower valve of the oyster, while its external form, lost below, is beautifully reproduced upon the upper valve.

In two very striking instances, the lower valve of the oyster shows the impression of a bivalve shell with spiny ribs, while a reproduction of these same spiny ribs appears in high relief upon the upper valve. These reproductions in the upper valve of figures impressed upon the lower valve might be supposed to result from the close contact of two valves when both valves were thin and small, and might be expected to be confined to the region of the umbo in well-grown specimens; but in all cases in which the oyster has been attached by a large portion or all of the lower valve, the impression is reproduced upon a correspondingly large portion of the upper valve. In view of the fact that in most specimens the shell is from 1·5 to 2 cm. thick, and, further, that internal surfaces when exposed show no traces of these external markings, it is noteworthy that the markings should extend over so much of the upper surface instead of being confined to the umbonal region.

ALFRED ELY DAY.

Syrian Protestant College, Beirût, Syria, September 22.

THE peculiar phenomenon referred to in the above letter is well known to occur among Secondary fossils, and has been fully explained by Prof. J. W. Judd in the *Geological Magazine* for 1871, p. 385, where several figures of Oolitic forms are given in illustration. The same peculiarity is also seen in certain oysters from the Lias. The thin growing edge of the shell adapts itself to the inequalities of the surface upon which it grows; the upper valve, being also thin, reproduces the form of the lower valve. The shell becomes thickened by additional layers on the inside, which thus gradually loses the markings that are retained upon the outer surfaces. E. T. N.

Refractivities of the Inert Gases.

A RELATION appears to exist between the refractivities (μ-1) of the inert gases of the atmosphere and that of hydrogen, which, so far as I am aware, has hitherto escaped attention. The following figures show that, taking the refractivity of hydrogen as 1, the refractivities of the other gases are very nearly in the proportion of ¼, ½, 2, 3 and 5.

By far the largest divergence is in the case of helium. This gas, as I am informed, is difficult to purify from the admixture of the heavier gases, so that a perfectly pure specimen would probably give a better result. Even if the relation to hydrogen is fortuitous, the ratios of the refractivities of the other five gases to one another are sufficiently interesting.

Refractivities[1] observed (Air=1).	Ratio to H.	Calculated from H=0·4733.	Error per cent.
Helium ..... 0·1238	¼	0·1183	−4·4
Neon ..... 0·2345	½	0·2366	+0·9
Hydrogen ..... 0·4733	1		
Argon ..... 0·968	2	0·9466	−2·2
Krypton ..... 1·450	3	1·420	−2·0
Xenon ..... 2·364	5	2·367	+0·1

CLIVE CUTHBERTSON.

9 York Terrace, Regent's Park, N.W., October 10.

[1] Ramsay and Travers, *Phil. Trans.*, vol. cxcvii. A, 1901, p. 47.

Trade Statistics.

IN his reply to my letter (October 2, p. 550), Dr. Mollwo Perkin brings forward fresh figures, apparently proving an enormous decline in British industry since 1870–74. This, however, is but to repeat Mr. Levinstein's mistake in an aggravated form. The Franco-Prussian war in 1870 checked manufacturing abroad for a twelvemonth, and in 1870–74 there was a heavy demand for British iron and coal at excessively high prices. That period, as is well known, is useless for comparisons of British and German export trade.

It is true, as Dr. Perkin points out, that the general rate of increase of exports (*i.e.* of their total values irrespective of the number of producers) has, in the last twenty years, been very slow in this country, rather rapid in Germany and very rapid in the United States.

But if we reckon per head of population, we get the following (from the Board of Trade "Memorandum," "Cd. 1199"):—

Annual Exports ("Special") per head of Population.

Average of period.	United Kingdom.	France.	Germany.	United States.
	£	£	£	£
1875–79	6·00	3·75	3·15	2·81
1880–84	6·66	3·67	3·43	3·30
1885–89	6·18	3·46	3·27	2·59
1890–94	6·15	3·57	3·14	2·95
1895–99	5·97	3·73	3·36	2·92

These figures are distinctly reassuring. They must not be used as an excuse for laxity in education or the application of science to manufacture, but they ought to allay unreasonable pessimism.

The slight decline per head in the British exports (as measured in money, not in commodities) would be a rather unsatisfactory feature if the export trade were our chief trade and chief source of income. Dr. Perkin perhaps thinks that it is, for he translates Mr. Levinstein's "foreign trade" into "trade." But the gross value of the export trade (280 or 300 millions per annum), large as it is, is small compared with the total national income, recently estimated by Sir Robert Giffen at 1500 millions sterling, while the income-tax assessments indicate that it is increasing faster than the population (*Times*, May 23, 1901). This enormous income is, of course, chiefly made up of the value of goods produced and consumed within the country, constituting the internal trade as distinguished from the foreign trade. From this point of view a close scrutiny of export statistics appears to be unnecessary, and may easily be misleading.

Unfortunately, we have no adequate statistics of total production. The figures for pig iron which Dr. Perkin gives are to the point, and the progress of our two great rivals is here very striking. But the pig-iron manufacture accounts for less than 3 per cent. of our national earnings. F. EVERSHED.

Kenley, Surrey, October 10.

Material for Natural Selection.

Verbesina exauriculata[1] is an evil-scented but handsome herbaceous plant with broad orange rays, very abundant in the town of Las Vegas, New Mexico. My class in biology has been making a study of the variations in the number of rays in the heads of this plant, and in so doing we took occasion to compare two sets, from the eastern and western parts of the town respectively. The result was as follows, calling these sets A and B respectively:—

Number of Rays.	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21
Number of heads, set A.	—	—	7	7	31	63	96	30	19	13	7	9	7	3	2.
Number of heads, set B.	1	6	10	19	32	73	84	25	12	5	2	1	—	1	—.

[1] *Verbesina encelioides exauriculata*, Robinson and Greenman, *Proc.* Amer. Acad., May, 1899, p. 544. Notwithstanding the name of this northern type, the petioles of the upper leaves are commonly strongly auriculate.

It will be seen that the mode is the same in each case, but the means are very different. To ordinary observation, the two sets of flowers looked exactly alike, and the demonstration of a difference in the average, while not at all extraordinary, is interesting. No doubt such differences exist in all organisms and all characters, and one can easily see how, under certain circumstances, they may have an important bearing upon the question of survival. The great variability no doubt indicates that the number of rays is *not* at present of much importance to the Verbesina; and no doubt those organs which have become variable for this reason, but suddenly become of importance through changed conditions, afford the best material for selection. In other words, evolution will proceed fastest when there are changes in the survival-value of organs. While examining the Verbesina, I found on the undersides of the leaves a new species of spinning mite (*Tetranychus verbesinae*); a little creature about half a millimetre long, pale yellowish, with two scarlet spots on the anterior part of the body, and irregular black spots (pertaining to the soft parts) arranged somewhat in the form of a crescent. The first pair of legs is somewhat more than half the length of the animal; mandibular plate with the sides as in *T. gioveri*, but the end rounded; hairs of body moderate, on very small tubercles. Further particulars will be given elsewhere.

T. D. A. COCKERELL.

East Las Vegas, New Mexico, U.S.A., September 17.

THE INTERNATIONAL METEOROLOGICAL COMMITTEE.

IF we come to consider the work of the International Meteorological Committee and its predecessor, the Permanent Committee of the Vienna Congress, it will be impossible to deal with the subject without taking notice of all the meetings, whether Congresses or Conferences, from which the committees above named took their rise.

It may here be explained that Congresses are convened through diplomatic channels; Conferences are brought together by private invitation to meteorologists of repute.

The first attempt to convene an international meeting was in 1845, when a Conference was held at Cambridge on the occasion of the meeting of the British Association in that year. This was attended by Dove, Kupffer, von Lamont, Adolph Erman and some other foreigners, and of course by the leading meteorologists of England. The difficulties in introducing uniformity in land observations were found to be too serious for definite arrangements to result.

This was followed, in 1853, by the Brussels Conference, which was instigated by Maury. It dealt with the Meteorology of the Sea, and its action met with general acceptance among maritime nations. It may be said that our own Meteorological Office was an outcome of this Conference.

In 1863 Dove endeavoured to convene a Conference on Land Meteorology. At the meeting of the Swiss Naturforscher Verein, he invited the meteorologists of Austria, France, Italy and Spain, but the invitation was not generally accepted.

Nothing definite, however, was done for Land Meteorology until Weather Telegraphy took its rise, about the year 1860, when the demand from each nation for regular intelligence from adjacent countries rendered it impossible for any Government to ignore the subject absolutely. Still, however, every country continued to deal with its Climatology as seemed right in its own eyes.

This was the state of affairs when, in 1872, Profs. Bruhns (Leipzig), Jelinek (Vienna) and Wild (St. Petersburg) issued a general invitation to a Conference, to be held at Leipzig coincidently with the meeting of the German Naturforscher Verein. This Conference was a signal success. It was attended by 52 members, and from it all subsequent meetings took their rise.

There have been in all seventeen of these meetings.

1872. Leipzig, Conference.	1882. Copenhagen, meeting of I.M.C.
1873. Vienna, Congress.	
Do. First meeting of Permanent Committee.	1885. Paris, meeting of I.M.C.
	1888. Zurich, meeting of I.M.C.
1874. London, Maritime Conference.	1891. Munich, Conference.
Utrecht, meeting of P.C.	1894. Upsala, meeting of I.M.C.
1876. London, meeting of P.C.	
1878. Utrecht, meeting of P.C.	1896. Paris, Conference.
1879. Rome, Congress.	1899. St. Petersburg, meeting of I.M.C.
1880. Berne, meeting of Int. Met. Committee.	1901. Paris, meeting of I.M.C.

An elaborate *résumé* of the resolutions at all the meetings, down to the Munich Conference, was printed by the late Prof. Wild in vol. xvi. of his "Repertorium für Meteorologie."

In dealing with the action taken at these several gatherings, it is found that many of the resolutions passed at early meetings were materially modified on subsequent consideration, and this is especially the case with reference to instruments and their observation. It is therefore proposed to mention only the final outcome.

The Barometer.—The use of aneroids as independent instruments was condemned, and it was decided that all standard barometers, at Central Offices, should be compared with the standard barometers of the Bureau International des Poids et Mesures at Paris.

As regards barometer corrections, the readings in climatological tables are to be given unreduced to sea level. It is desirable to apply the Gravity correction, and at all events it is to be stated in the tables if this correction has been applied or not, and what is its amount.

The Thermometer.—In this case too the standards at Central Offices are to be compared with the standard air thermometer of the Bureau International.

No recommendation has been made on the subject of thermometer exposure, owing to the impracticability of meeting the requirements of all climates. Meteorologists are referred to the published papers on the subject by Wild and others.

The desirability of devising a really good maximum thermometer was expressed. As regards minimum thermometers, the use of amyl alcohol instead of ordinary spirit was recommended.

Maximum and minimum thermometers are to be read at the latest observing hour of the day.

Humidity.—This subject was treated at considerable length, and the employment of ventilation with the wet bulb was urgently insisted on. At the meeting of St. Petersburg, Prof. Pernter proposed to abandon the use of the dry- and wet-bulb hygrometer, and to revert to the use of the hair hygrometer, but the proposal was not adopted.

Wind.—No general form of anemometer was recommended, nor was any action taken as to uniformity of installation or of altitude. As to wind direction, the English letters N. E. S. W. were adopted owing to the misunderstandings caused by the use of "O" for "Ost" in German and for "Ouest" in French.

Clouds.—At the Munich Conference, the international scheme of Cloud Observations, Direction and Velocity, for one year, was adopted, and the results of this work have appeared. At the same meeting, the Classification of Clouds proposed by Abercromby and Hildebrandsson was adopted, and from that has come the "International Cloud Atlas."

Rain.—It was decided to place rain gauges in such positions as should preclude their being buried in snow or exposed to splashing from the ground. It was recommended to mark especially the days of precipitation which did not reach the limit of 1 mm. and to ignore falls below 0·1 mm. Two columns are to be given

for Snow, one for amount, and the other for depth on the ground.

Unusual Occurrences.—The well-known international symbols were adopted at the Vienna Congress.

Glaciers.—A general recommendation was made to institute measurements of the motion of Glaciers.

Earth Movements.—The statements of Monsieur de Rossi, at Rome, as to what he terms "la météorologie endogène" were received with much interest.

As regards other matters, various combinations of hours for observing were suggested.

The simultaneous observations, proposed at Vienna, by the Chief Signal Office of the United States, were strongly supported.

As regards Weather Telegraphy, an international code for the messages was adopted and various details were settled.

The International Forms for the publication of climatological data (stations of the Second Order) were all arranged and have been very generally adopted.

Among the most lasting and valuable results of these gatherings has been the volume of International Tables, published by Gauthier Villars in 1890.

At several meetings endeavours were made to organise an International Office for directing international work, and this resulted in a proposal for an International Directing Bureau. This scheme, however, failed to secure approval. Various resolutions were framed as to international investigations.

The whole scheme of International Balloon Ascents, superintended by Prof. Hergesell, of Strassburg, took its origin at the Paris Conference of 1896.

The Circumpolar Observations of 1882-3, on the scheme of the late Lieutenant Weyprecht, also took a definite shape at the Roman Congress.

Terrestrial Magnetism.—This subject was first discussed at the Munich Conference in 1891, and at the Paris Conference of 1896 a special committee *ad hoc* was appointed, under the presidency of Sir A. Rücker, and in the report of that conference its action can be seen.

R. H. S.

JOHN HALL GLADSTONE.

THE scientific world has lost an indefatigable worker by the sudden death of Dr. Gladstone, which occurred on Monday, October 6. Few men had a larger circle of friends, for the beauty of his character and the kindliness of his nature endeared him to all those who had the good fortune to know him.

Dr. Gladstone was born in London in 1827, and was educated at University College, London, and Giessen University. He was twice married, first, in 1852, to May, daughter of the late Charles Tilt; and secondly, to Margaret, daughter of the late Rev. D. King and niece of Lord Kelvin. So early as 1850 he became lecturer on chemistry at St. Thomas's Hospital, and three years later (in 1853) he was elected a Fellow of the Royal Society. He served on its Council in the years 1863-1864 and again in 1866-1868, and a few years ago received the Davy medal. The Royal Society list of papers credits him with more than a hundred contributions to scientific literature, apart from those in collaboration with other writers. He held the Fullerian professorship of chemistry at the Royal Institution from 1874 to 1877, was first president of the Physical Society from 1874 to 1876, and was president of the Chemical Society from 1877 to 1879.

There can be no question, as an eminent English physicist has recently pointed out, that Dr. Gladstone was "one of the founders of physical chemistry, a fact which is fully recognised abroad, where his rightful position is accorded him." It is, however, only necessary to show how highly his work was appreciated in England to quote the reference to it which was made in 1898, on the occasion of a banquet to past presidents of the Chemical Society who had been Fellows of the Society for half a century, of whom Dr. Gladstone was one. Prof. Dewar then said, "Gladstone has worked out his long and brilliant scientific career as a labour of patient love. Furthermore, he has created an entirely new department—that which is in modern times regarded as physical chemistry. For half a century he has worked on this side of chemistry, for his early investigation of the spectrum of the atmosphere was one of marvellous suggestiveness. He found that the spectrum of Fraunhofer varied at sunset and at sunrise from that at midday, and showed that a large number of those absorption lines must originate in the earth's atmosphere. That discovery stimulated further inquiry as to the substance that could produce these lines so characteristic of the solar atmosphere; and later experimenters have found it in the vapour of water and in oxygen. Gladstone's greatest merit, however, lies undoubtedly in his optical researches on the atomic refractions and dispersions of the elements. He has determined the optical constants of hundreds of bodies, and has thus stimulated inquiry in that borderland between physics and chemistry which is so much cultivated in the present day, and the pursuit of which has added so much to our knowledge. He has also contributed largely to miscellaneous inquiries, especially those connected with various voltaic batteries, and other questions conducive to the study of both organic and inorganic chemistry."

His work was remarkable for its very varied nature. The title of his first paper was "Contributions to the Chemical History of Gun-cotton and Xyloidine," and, true to this early promise, he served as a member on the Gun-cotton Committee of the War Office from 1864 to 1868, having previously served as a member of the Royal Commission on Lights, Buoys and Beacons (1858-1861). Among his less known work, his investigations in connection with early metallurgical history well deserve mention. For instance, he showed that the use of bronze in Egypt went back as far as 3700 B.C., and that not only was bronze used, but that it was of a type common to much later periods, the ratio of copper to tin being as 9 to 1.

It is as an educational reformer that many of Dr. Gladstone's friends will best remember him, for he worked hard for twenty-one years, beginning in 1873, as a member of the London School Board, upon which body he represented the Chelsea division, and was for three years its vice-chairman. He was unwearied in his insistence upon the necessity for teaching science in elementary schools, keeping steadily in view its influence upon the nation as a whole. His attitude may best be gathered from the concluding sentence of his presidential address delivered before the members of the Chemical Section of the British Association in 1872. It ran as follows:—"While the rudiments of science are being infused into our primary education, now happily becoming national, while physical science is gradually gaining a footing in our secondary and our large public schools, and while it is winning for itself an honoured place at our universities, it is to be hoped that many new investigators will arise and that British chemists will not fall behind in the upward march of discovery, but will continue hand in hand with their continental brethren, thus to serve their own and future generations."

The prevailing ignorance of science and scientific methods is constantly rebuked by modern educational writers, but a sentence such as the following, which also occurs in Gladstone's presidential address in 1872, was unusually plain speaking for twenty years ago. He says "the so-called educated classes in England are not only supremely ignorant of science, they have scarcely

yet arrived at the first stage of improvement—the knowledge of their own ignorance."

Among the glowing tributes to Gladstone's memory which have been offered since his death, none are more significant than the following words from one who is singularly well qualified to form an opinion as to the value of his educational work. "It is twenty years," the writer says, "since I first made his acquaintance as a co-worker on my election to the London School Board, and the respect which I felt at first for his activity and devotion in the cause of London education soon ripened into a real personal affection and warm admiration for his unselfish and kindly nature and for his insight into the needs of children intended for industrial life. He was almost the first to see that elementary education must be widened to include the training of all the faculties if it is to be effective, and he did more than any to bring this knowledge to a practical result. It would be well for the country if more men existed of the same noble character."

He has left many witnesses to his power of influencing young scientific workers, to many of whom his memory will be very precious, for but few men have been so faithful throughout a long life to high ideals, and have at the same time so effectively promoted the welfare of humanity. W. C. R. A.

NOTES.

THE subject of the address of the retiring president (Dr. E. W. Hobson, F.R.S.) of the London Mathematical Society at the annual general meeting on Thursday, November 13, at 5.30, will be "The Infinite and the Infinitesimal in Mathematical Analysis." There are few people better qualified than Dr. Hobson, both on the mathematical and the philosophical side, to expound the change of view that has been gradually spreading over the field of advanced pure mathematical thought during the last half-century; and many persons interested in the subject will doubtless take advantage of his explanations who would not have time to make headway with the extensive literature, mainly foreign, to which these modern philosophical developments have given rise. At the same meeting, the triennial De Morgan medal will be presented to Prof. A. G. Greenhill, F.R.S., for his contributions to mathematical analysis and its application to mechanical problems.

WHILE attempting to navigate the air with a new steerable balloon, M. de Bradsky and his assistant, M. Morin, were killed at Stains, near Paris, on October 13. The balloon was so constructed that the weight of the gas and all its parts was about equal to the weight of air displaced, so that it remained at rest until the propelling screw was started. The screw was driven by a 16 horse-power motor and was behind a steel car, seventeen metres long, suspended by steel wires attached to a light wooden scaffolding. After the balloon had started, it was evident to the spectators that the motor power was insufficient to enable it to be steered. When at an altitude of about one hundred metres, the car broke away from the balloon and was dashed to the ground, causing the death of the two occupants—M. de Bradsky and M. Morin. The disaster appears to have been caused either by the fracture of the steel wires by which the car was suspended from the envelope, or by the whole framework slipping away from the balloon.

ON Friday, November 7, Lord Kelvin will reopen the ancient Cloth-hall at Newbury, which has been restored as a memorial to Queen Victoria and will in future be utilised as a local museum and art gallery.

THE committee of the Huxley Memorial at Ealing has had a memorial tablet placed in the Free Library, Walpole Park, and it will be unveiled by the Mayor of Ealing, on behalf of the Borough Council, on October 23 at 4 p.m.

THE annual "Fungus Foray" of the Essex Field Club will be held on Friday and Saturday, October 17 and 18—in the country near North Weald and Foot Hill on the Friday, and on the Saturday in Epping Forest. Botanists desirous of attending should communicate with the hon. secretary, Mr. W. Cole, Buckhurst Hill, Essex.

WE learn from the *Times* that an interesting antiquarian discovery has just been made in the neighbourhood of High Wycombe in connection with the construction of the new main line of the Great Western and Great Central Railway Companies. In the course of excavating a hill an ancient flint mine has been unearthed, together with an interesting specimen of a pick made of the antler of a stag with its points worn smooth. Many of the disintegrated blocks bear the marks made by the picks used by prehistoric workmen.

THE council of the Institution of Civil Engineers has, in addition to the medals and prizes given for communications discussed at the meetings of the Institution in the last session, made the following awards in respect of other papers dealt with in 1901–1902:—A Telford gold medal to Mr. J. Macfarlane Gray; a George Stephenson gold medal to Mr. R. Price-Williams; a Watt gold medal to Dr. W. Bell Dawson; Telford premiums to Mr. W. R. Cooper, Mr. E. M. De Burgh, Dr. George Wilson, Mr. Frank Oswell and Dr. A. W. Brightmore; a Crampton prize to Mr. C. D. H. Braine; the Manby premium to Mr. B. W. Ritso. For students' papers the awards are:—A Miller scholarship (tenable for three years) and the James Forrest medal to Mr. H. F. Lloyd; Miller prizes to Messrs. J. C. Collett, W. H. C. Clay, H. C. M. Austen, A. M. Arter, Robert Bruce, L. F. Wells and W. H. McLean.

PROF. ROBERT WALLACE is preparing for publication the "Reminiscences" of the late Miss E. A. Ormerod, to the preparation of which she devoted the leisure of her later days. The autobiography was not completed, and much additional material of an interesting character must be in existence. Prof. Wallace would be glad to receive such letters from Miss Ormerod as her correspondents may consider of sufficient importance, together with any other information which they think will be of interest to the general public. His add ress is the University Edinburgh.

THE remarkable successes achieved by the Marconi system in transmitting messages from Cornwall, across the continent, to the *Carlo Alberto*, moored off the coast of Italy, are well known; some further details of the experiments were published in the *Times* of October 14, from the official report upon them. It appears from this report that the magnetic detector, recently described by Mr. Marconi before the Royal Society, proved in every way superior to the coherer. It was much more accurate in its working and required no regulation. Moreover, it was less sensitive to atmospheric disturbances, giving fairly clear signals under conditions which put the coherer *hors de combat*. The experience on board the *Carlo Alberto* also served to confirm the observation that signalling was more difficult during the day than the night, but this only necessitates increasing the power at the transmitting station in order to carry on long-distance work continuously; there seems to be a practical limit to the sensitiveness of the receiver in that it must not be made too easily affected by atmospheric influences.

THE subject of this year's essay competition for the prizes of 10*l.* and 5*l.* annually offered by the Society for the Protection of Birds (3 Hanover Square, W.) is "Birds in the Field and Garden: their Economic Value to Man." The Society's object is to collect facts and opinions respecting the utility of birds as insect and weed destroyers, a matter which has in recent years compelled attention in various parts of the world, but is still

only very imperfectly understood and appreciated. Full particulars may be obtained from the hon. secretary.

THE Huxley memorial lecture was delivered on October 1 at the opening of the Charing Cross Hospital Medical School by Prof. Welch, of the Johns Hopkins University, whose discourse was entitled "Recent Studies of Immunity with Special Reference to their Bearing on Pathology." After a tribute to the memory of Huxley and of Virchow, Prof. Welch proceeded to discuss the specific properties of the cells and fluids of the body in health and disease in their relation to immunity, referring to the various antitoxic, bacteriolytic, hæmolytic and cytolytic functions exerted under certain conditions. He pointed out that whereas the tetanus and diphtheria bacilli elaborate toxins which can be separated from the organisms that produce them, such is not the case with other pathogenic bacteria, notably the typhoid bacillus, the toxin of which is believed to be intracellular and intimately associated with the bacterial cells. On this conception, the disease symptoms present in typhoid fever are assumed to be due, not to the living and vigorous organisms, but to typhoid bacilli which have died and in consequence have set free their protoplasmic poisons. Prof. Welch doubts whether this theory affords a complete explanation of the toxic phenomena in typhoid and other similar infections, and advances an ingenious alternative hypothesis. The injection of bacterial cells stimulates certain cells of the host to generate one component of the toxin, the intermediary body, which although itself not poisonous, becomes so by bringing about the union between a pre-existing toxophorous substance, the complement and the foreign cell which started the reaction. Similarly, Prof. Welch suggests that certain substances derived from the host may stimulate the invading organism and cause it to produce intermediary bodies which might have the power to link complements to cellular constituents of the host and thereby to poison the latter. That is to say, just as the cells of the organism react towards the invading bacterium, so Prof. Welch suggests does the bacterium react towards the cells of the host, a possible factor hitherto overlooked. Finally, it was pointed out that such researches as these can be carried out only by the experimental method, and that to impose unnecessary restrictions with regard to experiments upon animals is nothing short of a crusade against humanity.

WE have received a valuable series of meteorological results made at Truro for the Royal Institution of that town. The tables are divided into two sets, (1) the monthly values for the separate years 1882–1900, and (2) the average monthly values for fifty-one years, 1850–1900, compiled by Mr. G. Penrose, curator of the Truro Museum. The establishment of the observatory was mainly due to the late Dr. Barham, who prepared the summary for the years 1850–1881. The mean of the daily maximum temperature is 58°·5 and of the daily minimum 44°·7, the extremes being 92° in June, 1893, and 8° in January, 1867. The mean annual rainfall is high, 40·5 inches. It is noteworthy that the Cornwall Institution possesses several long series of observations, dating from those of Dr. Borlase, of Ludgvan, 1754–1772; Mr. James, at Redruth, 1787–1806; Mr. E. C. Giddy, at Penzance, 1807–1827. These are closely followed by Mr. Moyle's, at Helston, and others.

A REDETERMINATION of the density and coefficient of cubical expansion of ice at 0° C. is given by Mr. J. H. Vincent in the *Physical Review*. The author, after comparing previous results, obtains a value agreei ng closely with that found by Nichols for the density, but considers that the coefficient of cubical expansion is from 4 to 5 per cent. less than the mean of the previous determinations.

MR. S. J. BARNETT contributes to the *Physical Review* a note on Gauss's theorem, considered mainly with respect to electrostatics. It is pointed out that the ordinary demonstrations apply only to the case of a single homogeneous isotropic medium, and that the theorem is usually implicitly assumed to hold good in all cases. Mr. Barnett now attempts to deduce the generality of the theorem in a logical manner. But in order to extend the validity to a region containing any number of homogeneous dielectrics, or to a medium of varying permittivity, the author has to assume that in a condenser containing two dielectrics, one in contact with one face and the other in contact with the other, the charges on the two faces are equal and opposite. The theorem is thus seen to be based on experimental evidence and not to be capable of proof by deductive methods alone.

FROM the Report of the Survey of India for 1900–1, we notice that surveyors were engaged during the season in the determination of astronomical latitudes in Karachi, while another party was employed with satisfactory results on experimental work connected with the Jaderin base line apparatus. Tidal observations were continued as usual. Preparations for the commencement of a magnetic survey were continued during the year, and arrangements were made for the establishment of base stations at Bombay, Kodaikanal, Dehra Dun, Calcutta and Rangoon, at which magnetic observatories are to be built and self-recording instruments installed. The recent introduction of electric tramways in Calcutta and their impending construction in Bombay have rendered it necessary to arrange for the construction of the new observatories far enough away from the two cities to be beyond the effects of the electric current.

THE Bremer arc lamp, in which the arc is maintained between a pair of inclined carbons saturated with certain mineral salts (see NATURE, this volume, p. 272), has recently been subjected to careful photometric tests by two independent observers, M. Laporte in Paris and Prof. Wedding in Charlottenburg. A full discussion of the two sets of experiments is given in *L'Éclairage Électrique* for October 4. The results are not in very close agreement, though both bring out the superiority of the Bremer lamp over ordinary arc lamps. This is especially noticeable if one only considers the mean hemispherical candle power for the lower hemisphere, since the construction of the Bremer lamp is such that, when used without a globe, practically all the light is thrown downwards. The distribution of light in this direction is also particularly good, being nearly uniform throughout an angle of 50° on either side of the vertical. The consumption of power in a 400-watt lamp comes out at about 0·6 watt per spherical candle and 0·4 watt per hemispherical candle for the Bremer lamp with a globe, as against 1·1 and 0·65 for an ordinary lamp under similar conditions.

WE referred in these columns a short time ago to the fact that an American company had been formed to work a process for the fixation of atmospheric nitrogen. Some further particulars of the apparatus used by the inventors, Messrs. Bradley and Lovejoy, are given in the *Electrical World and Engineer* (N.Y.) for August 2 last. A cylindrical metal box is provided on its inner surface with six upright rows of fixed contacts, there being twenty-three contacts in each row. Each contact is connected through an inductance to the positive pole of a dynamo generating direct current at a pressure of 10,000 volts. A similar set of contacts is mounted on an inner rotating cylinder connected to the negative pole of the generator. As the inner cylinder rotates, the negative contacts come up to the positive and an arc strikes across; this is gradually drawn out and finally extinguished as the negative contact moves past, and away from, the positive. The action may be likened to the rotation of the cylinder in a musical box. Air circulates amongst the arcs, and is drawn off containing about 2½ per cent.

of oxides of nitrogen and led to absorbing towers. The air is circulated at the rate of about 5 cubic feet per contact per hour, and the inner cylinder rotates at the rate of 500 revolutions per minute, thus forming more than 400,000 arcs per minute. Sufficient data are not given to enable a calculation of the efficiency of the arrangement to be made. It will be remembered, however, that the result of Lord Rayleigh's experiment showed that, given cheap power, nitrates could be made by this process at less than the present cost.

THE geology of western Rajputana forms the subject of an essay by Mr. Tom D. La Touche (*Mem.* Geol. Survey India, vol. xxxv. pt. i. 1902). The country is for the most part a vast sandy plain diversified only by sand hills and by isolated knolls and groups of hills composed almost wholly of crystalline rocks. Except when rain is falling, no running water is to be seen, and the principal agents of erosion are the intense heat of the sun, or rather the great alternations of temperature that act on the superficial layers of rock, and the violent winds aided by the sand they bear with them. Deflation, or the action of sand-laden wind, is illustrated in many curious features, notably in certain scarped outliers of horizontal beds of sandstone which appear like pyramids in the plain. Some of these known as *zeugen* or "witnesses" are figured. The crystalline rocks exposed comprise schists and quartzite, granites, rhyolites and basic dykes. The sedimentary rocks include the Vindhyan, Talchir boulder-beds, Cretaceous (?) Sandstone, Nummulitic Limestone, and recent accumulations.

IN a recent issue of the *Journal* of the Asiatic Society of Bengal, Major J. Manners-Smith records the existence of hybrids between the common wolf and domesticated dogs in the Gilgit district.

IN the October number of the *Entomologist's Monthly Magazine*, Mr. Charles Rothschild describes two new British species of fleas, the one infesting the moorhen and the other various small mammals.

MR. W. L. DISTANT, in a recent issue of the *Annals* of the South African Museum (vol. ii. pt. ix. art. xii.), publishes a series of notes on the bugs of the country, with descriptions of new species.

IN a paper on the fishes of Mexico, published by the Field Columbian Museum (zool. series, vol. iii. No. 6), Mr. S. E. Meek figures a female of a viviparous species of Goodea in which the ovary is absolutely crammed with young.

A RECENT supplement to the *Tropical Agriculturist* (Colombo) contains the text of a preliminary report by Prof. Herdman, F.R.S., on the pearl fisheries of Ceylon. The report may, we understand, be seen by those interested at the Commercial Intelligence Branch of the Board of Trade, 50 Parliament Street, S.W.

IN the *Proceedings* of the U.S. Museum, Messrs. Jordan and Fowler continue their survey of the fishes of Japan, the latest fasciculus dealing with the trigger-fishes, file-fishes and trunk-fishes. Excellent figures are given of some of these strange fishes, one of which is made the type of a new species and genus.

THE effect of wind on the migration of birds, as exemplified by the case of hawks, forms the subject of an interesting article by Mr. C. C. Trowbridge in the September issue of the *American Naturalist*. It is inferred that the migratory movements of hawks are very largely affected by wind, an adverse wind retarding, if not completely arresting them. Several other conditions of the atmosphere which affect the migration are mentioned by the author.

IN the October number of the *Journal of Conchology*, Mr. R. Welch describes and figures a number of "sports" of the common black-lipped snail (*Helix nemoralis*), showing the spiral more or less elongated above the normal. It appears that enormous numbers of these snails are collected by the peasant women in a certain district of Donegal for the purpose of making necklaces of the shells. Among this number a small percentage of reversed specimens and others with abnormally tall spires are met with and picked out for special sale. In one of the figured specimens the spiral is so elongated as to recall a Scalaria.

IN the August issue of the *Biological Bulletin*, Mr. H. F. Perkins describes a remarkable degeneration-process observed in larval cœlenterates of the genus Gonionema. After mentioning the manner in which the larvæ disintegrate, the author observes that "the repeated fission of the individuals resulted in such diminution of the size of the pieces which came from the original individuals that after a time it was impossible to distinguish the bits of living matter from the other particles lying about on the bottom. But during the entire time in which it was possible to recognise the pieces of disintegrating larvæ, the sum total of this substance did not seem to be at all diminishing. It is impossible to assign any satisfactory explanation to the phenomena, but it is not unlikely that the condition of the water in this particular aquarium was peculiar."

THE affinities of that remarkable group of worm-like creatures known as Solenogastræ and their relationship to the Mollusca form the subject of a long article by Herr J. Thiele in the *Zeitschrift für wissenschaftliche Zoologie* (vol. lxxii. pts. ii. and iii). There are two families of these organisms, the one typified by Neomenia and the other by Chætoderma. Very generally the group is classed among the molluscs with the chitons; the author is, however, of opinion that the Solenogastræ are really worms allied to the thread-worms (as represented by the Gordiidæ) and annelids, but, in the relation of the heart to the uterus, as well as in the possession of a rudimentary tongue, or radula, approximating to the molluscs, and more especially to the chitons. If this view be correct, the Mollusca are descended from worms, the chitons representing the transitional type.

As the result of a considerable number of experiments, Dr. Margaret C. Ferguson finds that the most effectual plan for starting the germination of spores of *Agaricus campestris* is to include in the culture either some of the mycelium of this plant or else some spores which have already been induced to germinate. An account of the various methods devised to bring about the germination of spores of this and various basidiomycetous fungi is published as a *Bulletin* of the U.S.A. Department of Agriculture. An extremely useful historical summary of similar experiments is given at the end of the paper.

THE latest parts of Engler's "Botanisches Jahrbuch" contain a monograph of the Berberidaceæ and Podophyllaceæ, in which the writer, Dr. G. Tischler, proposes a separate order for Podophyllum and Diphylleia. Herr Baeyer finds that a comparative study of certain of the Anonaceæ bears out the latest division of that order by Engler and Diels into two suborders only, the Uvarioideæ and the Eupomatioideæ. An article, "Der Wind als pflanzengeographischer Factor," by Dr. Warming, is mainly a polemic against Prof. Hansen's book dealing with the East Friesian Islands. Another proposal to deal with the present confused terminology of phytogeography originates from America, and a system of nomenclature is suggested by Mr. F. E. Clements, of Nebraska.

MATTHEW ARNOLD'S well-known work on "Literature and Dogma," which, as its subtitle explains, is "An Essay towards a better Apprehension of the Bible," has been issued for the

Rationalist Press Association, Ltd., in paper covers at sixpence, by Messrs. Watts and Co.

A NEW medical and scientific circulating library has been opened by Mr. T. H. Prince, who was for many years with Mr. H. K. Lewis, and has just started as a medical and scientific bookseller at Praed Street, Paddington. It is promised that all standard works in the various branches of science will be available to subscribers.

WE have received the concluding part of the *Boletim Mensal* of the Observatory of Rio de Janeiro for the year 1901. In addition to the meteorological observations taken eight times daily at that observatory, the *Bulletin* contains monthly and yearly results for various parts of Brazil, and a valuable summary for twenty years (ending March, 1901) for Bahia, from observations made by Dr. Guimarães.

SEVERAL new forms of apparatus for the physical laboratory have lately been produced by Messrs. W. G. Pye and Co., Cambridge. Among the instruments are a table cathetometer and a reading microscope, constructed on the geometric slide principle, an improved pattern storage cell, five hundred of which have been in use at the Cavendish Laboratory for several months and have proved "very convenient and thoroughly satisfactory," and sets of patent resistance coils, in which the coils themselves take the place of the usual plugs and can be easily removed to show the wire and method of construction.

A NOTEWORTHY paper on the decomposition of urea is contributed by Mr. C. E. Fawsitt to the fifth number of the *Zeitschrift für physikalische Chemie*, vol. xli. When a pure aqueous solution of urea is heated at 100° C. for a considerable time, the urea is completely transformed into ammonium carbonate. This decomposition takes place also under the influence of acids and bases, the velocity under these circumstances being much greater. If strongly alkaline solutions are excepted, the decomposition takes place in all cases according to the simple equation for a unimolecular reaction, a result which does not accord with the ordinary method of representing the reaction. The author finds that the facts can only be satisfactorily explained by assuming that the urea is in the first place transformed into ammonium cyanate and that a state of equilibrium is set up between these two substances. The cyanate, however, is gradually decomposed with the formation of ammonium carbonate, the equilibrium being thus disturbed, and a further quantity of urea undergoes transformation into the cyanate. This decomposition of ammonium cyanate into ammonium carbonate takes place very quickly under the influence of acids. A large amount of experimental evidence is found to support the theory advanced, and the author concludes that urea is not directly attacked either by water, acids or moderately concentrated alkalis. Concentrated solutions of the alkalis have probably however a direct saponifying action upon the urea, in addition to the indirect action described.

AN investigation of the rate of bromination of carbon compounds by L. Bruner, which will be of considerable interest to organic chemists, is published in the current number of the *Zeitschrift für physikalische Chemie*. The catalytic action of iodine on the bromination of benzene has been carefully studied in a quantitative manner, and it is shown that this action is very probably due to the formation of iodine monobromide, which by its dissociation gives rise to free bromine atoms. These free bromine atoms are the active agents in the bromination process, and the catalytic influence of the iodine is due to the much greater dissociation of the iodine bromide as compared with that of bromine itself. The author shows that the substitution of bromine is a quadrimolecular reaction taking place according to the equation

$$C_6H_6 + 4Br = C_6H_5Br + HBr_3 \rightleftarrows Br_2.$$

The action of other carriers has also been investigated, the most active in the case of the bromination of benzene and bromobenzene being aluminium bromide. This compound has, however, no influence on the bromination of nitrobenzene. From the concentrated nitrobenzene solution, a compound of the formula $AlBr_3.2C_6H_5NO_2$ has been crystallised out, a fact of some interest in view of Gustavson's theory of the mode of action of $AlBr_3$ in the bromination of benzene, toluene and other compounds. The author has finally investigated the relative velocities of some so-called instantaneous reactions. It is found that the bromination of aniline takes place more rapidly than that of phenol, and that the velocity of the latter reaction is about one-fifth of that at which iodine is separated by bromine from potassium iodide solution.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mrs. Chas. Lisle Hacket; two Mozambique Monkeys (*Cercopithecus pygerythrus*) from East Africa, presented respectively by Mr. J. M. Creasey and Mrs. G. Ord; a Common Marmoset (*Hapale jacchus*) from South-east Brazil, presented by Mrs. Murray Simpson; a Gannet (*Sula bassana*) from Scotland, presented by Lord Ribblesdale; six Carolina Anolis (*Anolis carolinensis*) from Florida, two Tarantula Spiders, from Arizona, presented by Miss Ilda Orme; two Entellus Monkeys (*Semnopithecus entellus*), two Sambur Deer (*Cervus aristotelis*), two Nylghaies (*Boselaphus tragocamelus*), two Tigers (*Felis tigris*), two Gadwells (*Chaulelasmus streperus*), an Indian Adjutant (*Leptoptilus argala*) from India, two Nutmeg Fruit Pigeons (*Myristicivora bicolor*) from Moluccas, received in exchange; eight Saddle-backed Tortoises (*Testudo ephippium*), two Thin-shelled Tortoises (*Testudo microphys*), twenty-four South Albemarle Tortoises (*Testudo vicina*), one —— Tortoise (*Testudo* ——), seven —— Iguanas (*Conolophus subcristatus*) from the Galapagos, four Indian Porphyrios (*Porphyrio calvus*) from Eastern Asia, a Brindled Gnu (*Connochaetes taurina*) from South Africa, deposited.

OUR ASTRONOMICAL COLUMN.

A NEW TRANSITING DEVICE.—An article by Mr. M. B. Snyder, of the Philadelphia Observatory, in *Popular Astronomy*, No. 97, discusses a new device for transiting stars, in which the micrometer thread is moved, with a regular speed, across the field by means of an electric motor.

The fundamental idea of getting rid of the personal equation in transit observations by using mechanical transiters was first suggested by Braun in 1865 and since then has been persistently developed by Repsold. After discussing the various methods suggested by these and other inventors, Mr. Snyder gives some details of his own device, although full details are withheld for a future communication when circumstances have permitted of more time being spent on the subject.

In Mr. Snyder's instrument, the micrometer screw, and thereby the micrometer thread, is driven across the field of the instrument by an electric motor, at a speed depending on the declination of the object observed, whilst at the same time the observer, by using a secondary adjustment, keeps the star image accurately bisected, and the various positions of the thread are automatically recorded, by means of an ordinary chronograph, at the end of each revolution of the screw. Then at the moment of meridian passage an automatic electrical arrangement records the instant of transit. The micrometer in its fundamentals is of the ordinary type, and is at present attached to the 4-inch meridian circle of the Philadelphia Observatory; it is so arranged that, with the motor driving regularly, visual observations may be made, and recorded by any one of the usual methods, synchronously, thus forming a ready means of determining the personal equations existing between the various individuals of any group of observers.

THE SEARCH FOR A PLANET BEYOND NEPTUNE.—Herr T. Grigull, of Münster, Germany, describes in the October number of the *Bulletin de la Société Astronomique de France* his new contribution to the research which has for its object the discovery of another planet, beyond the orbit of Neptune.

In a previous paper (*Bulletin*, January, 1902, p. 31), Herr Grigull explained the hypothesis on which his calculations are based, and the elements of the hypothetical planet as deduced from the observations of the aphelia of three comets. In the present contribution, the elements given below have been calculated from the observed aphelia of twenty comets which appeared, and were observed and recorded, between the years 1490 and 1898. After giving due weight to the various cometary observations, the author has calculated these elements for the possibly existing planet :—

Epoch 1902.

$\lambda = 357^\circ 54 \pm 1^\circ 867$
Dist. from sun = 50·61 R.
Time of revolution = 360 years.
$\Omega = 90^\circ$ (???).
ω = ?.

A NEW MINOR PLANET.—In No. 3819 of the *Astronomische Nachrichten*, Prof. Max Wolf announces, along with other minor planetary observations, the discovery of another new minor planet, 1902 T.

COMET 1902 *b*.—A number of observations of this comet have been made.

A photograph taken on September 27 by Prof. Kononowitsch, Odessa, with three hours' exposure, shows a straight double tail extending in a southerly direction to a distance of 3°.

Prof. Nijland has published, in the *Astronomische Nachrichten* (No. 3817), a further ephemeris, from which the following extract is taken :—

1902.	app. α.	app. δ.	Brightness.
	h. m. s.	° ′	
Oct. 16 ...	18 16 24 ...	+16 30·5	
17 ...	9 55 ...	14 9·1	
18 ...	4 7 ...	11 58·9 ...	13·0
19 ...	17 58 52 ...	9 59·1	
20 ...	54 6 ...	8 8·9	
21 ...	49 43 ...	6 27·3	
22 ...	45 41 ...	4 53·6 ...	10·9
23 ...	17 41 56 ...	+3 26·9	

The brightness of the comet on September 16 is taken as unity, and it was then estimated at 7·5m.

THE BRITISH ASSOCIATION AT BELFAST.

SECTION A.

SUBSECTION OF ASTRONOMY AND COSMICAL PHYSICS.

OPENING ADDRESS BY ARTHUR SCHUSTER, F.R.S., F.R.A.S., CHAIRMAN OF SUBSECTION.

OUR proceedings to-day constitute an innovation and require a few words of explanation. When, a few years ago, some astronomers felt that our Association bestowed an insufficient share of attention on their subject, an easy remedy suggested itself in the formation of a special subsection devoted to that subject. Such a subsection was accordingly organised at Bradford and Glasgow, but for reasons, which are perhaps not altogether to be regretted, the experiment was only partially successful. In the meantime the work of Section A became heavier and heavier, and, as it seemed necessary to find some way of relieving its meetings, it was decided to hand over to the already established subsection of Astronomy other subjects, such as Meteorology, Terrestrial Magnetism, Seismology, and, in fact, anything that the majority of physicists is only too glad to ignore.

When the Council of the British Association asked me to act as President of such an enlarged subsection, I was very doubtful whether I ought to accept the honour. In the first place, I felt incompetent, owing to my almost complete ignorance of most branches of astronomy, and in the second place I do not approve of the formation of subsections dealing with important branches of Physics. If I eventually consented, it was partly because I lacked the strength of mind to refuse an honour of this kind, but partly because I was glad to have an opportunity of raising the whole question of the organisation of our meetings. The ground for such a discussion has, however, to a great extent disappeared, because, when the Organising Committee of Section A met in the spring, there appeared amongst those present a sudden revival of interest in the subjects assigned to the subsection and it was decided that the main section should not meet at all to-day so as to allow its members to help us in our discussions. The parent section has, therefore, voluntarily submitted itself to absorption by its neglected offspring, which now has to show that Cosmical Physics obeys the laws of Terrestrial Physics and that good absorbers are also good radiators.

Gratifying as this reunion must be to us, it fails to realise one of the original objects for which we have been called into existence, because instead of lightening your work it has added to it by imposing upon you the burden of having to listen to a second Presidential Address. I will try to make this additional burden as light as possible by concentrating my general remarks into a few sentences and then introducing the business of the section by means of a contribution to its scientific work, which I otherwise should have made in the ordinary course of the meeting.

To make our meeting as fruitful as possible, we should make the fullest use of the opportunities it gives us of personal contact and interchange of ideas. This is not accomplished by dividing into separate camps as soon as we have come together, but rather by finding some common ground for our debates. We should not try to minister to the separate needs of the specialist in electricity, or in meteorology or in astronomy, but should impress upon each of these specialists that they must bring before us the results of their investigations in so far as they bear on the more general questions in which we all are, or ought to be, interested. If it is necessary to lighten the work of the section this should be done by excluding all papers which are of interest only to specialists, or by establishing subsections for such papers. Let us divide—if divide we must—according to the character of the contribution, rather than according to the subject it happens to deal with. The difficult and, perhaps, unpopular censorship which such a course would involve would probably be temporary only, as the character of the papers which are desired for the main section would soon become known, and the increased attraction and usefulness of our discussions would, I am convinced, in a few years compensate for the initial trouble. We all require, occasionally, to be reminded that the detail work which is necessary, and on which most of us are engaged, is only of importance or interest if it helps us forward towards the solution of the great problems of Nature.

Addressing myself more particularly to Astronomers, I should like to say that we shall always welcome them as members of Section A, and that the benefit we shall derive from their contributions will be great in proportion as they will consider themselves to be citizens of the general empire of that section rather than inhabitants of an independently governed State.

There is one minor reform, or perhaps I ought to call it a protest against one of the traditions of the Association, which I feel called upon to urge on you. Discussion is our principal aim, and we are always trying to find suitable subjects for discussion ; yet we are prevented by the rules of the Association from discussing the Presidential address and the reports of Committees. Those who framed such a rule must have had some unfortunate idea that the dignity of the chair might be endangered if some criticism happened to be expressed in the discussion of the Chairman's address, or that the value of the report of a Committee might be endangered by some adverse comment coming from outside. But it seems to me that a scientific society or association, and especially one framed on a democratic constitution, ought not to take such a narrow and unscientific view. I can remember several Presidential addresses which might, and probably would, have given rise to most instructive debates had the rule not existed. Reports of Committees if not suitable for discussion should not be read at all ; but if read they should be open to discussion.

I hope that to-day you will not feel yourself bound by ancient custom, but in order that, at any rate, the more scientific portion of my contribution to our proceedings should not be stained by the suspicion of immaculate conception, I will now ask the duly-constituted President of our section to take his proper place.

The question I wish to bring to your notice to-day is an old one : if two events happen simultaneously or one follows the

other at a short interval of time, does this give us any reason to suppose that these two events are connected with each other, both being due to the same cause, or one being the cause of the other? Everyone admits that the simple concurrence of events proves nothing, but if the same combination recurs sufficiently often we may reasonably conclude that there is a real connection. The question to be decided in each case is what is "sufficient" and what is "reasonable." Here we must draw a distinction between experiment and observation. We often think it sufficient to repeat an experiment three or four times to establish a certain fact, but with meteorological observations the case is different, and it would, *e.g.*, prove very little if on four successive full moons the rainfall had been exceptionally high or exceptionally low. The cause of the difference lies in the fact that in an experiment we can control to a great extent all the circumstances on which the result depends, and we are generally right in assuming that an experiment which gives a certain result on three successive days will do so always. But even this sometimes depends on the fact that the apparatus is not disturbed, and that the housemaid has not come in to dust the room. Here lies the difference. What is possible in a laboratory, though perhaps difficult, is not possible in the upper regions of the atmosphere, where some unseen hand has not made a clean sweep of some important condition.

When we cannot control accessory circumstances we must eliminate them by properly combining the observations and increasing their number. The advantage does not lie altogether on the side of experiment, because the very identity of condition under which the experiment is performed gives rise to systematic errors, which Nature eliminates for us in the observational sciences. In the latter also the great variety in the combinations which offer themselves allow us to apply the calculus of probability, so that in any conclusion we draw we can form an idea of the chance that we are wrong. Astronomers are in the habit of giving the value the "probable error" in the publication of their observations. Meteorologists have not adopted this custom, and yet their science lends itself more readily than any other to the evaluation of the deviations from the mean result, on which the determination of the probable error depends. We look forward to the time when weather forecasts will be accompanied by a statement of the odds that the prediction will be fulfilled.

The calculation of the probability that any relationship we may trace in different phenomena indicates a real connection seems to me to be vital to the true progress of Meteorology, and although I have on previous occasions (Cambridge *Phil. Trans.*, vol. xviii. p. 107) already drawn attention to this matter I should like once more to lay stress on it.

The particular case I wish to discuss (though the methods are not restricted to this case) is that in which one of the two series of events between which relationship is to be established has a definite period, and it is desired to investigate the evidence of an equal period in the other series.

Connections between the moon and earthquakes, or between sunspots and rainfall if proved to exist, would form examples of such relationships. The question to be decided in these cases would be, is there a lunar period of earthquakes, or an eleven years' sunspot period of rainfall.

Everyone familiar with Fourier's analysis knows that there is a lunar or sunspot, or any other period in any set of events from volcanic eruptions down to the birth-rate of mice; what we want to find out is whether the periodicity indicates a real connection or not. Let us put the problem into its simplest form. Take n balls, and by some mechanism allow them to drop so that each falls into one of m compartments. If finally they are equally distributed each compartment would hold n/m balls. If this is not the case we may wish to find out whether the observed inequality is sufficient to indicate any preference for one compartment or how far it is compatible with equality of chance for each. If we were able to repeat the experiment as often as we like we should have no difficulty in deciding between the two cases, because in the long run the average number received by each compartment would indicate more and more closely the extent of bias which the dropping mechanism might possess. But we are supposed to be confined to a single trial, and draw our conclusions as far as we can from it.

It would be easy to calculate the probability that the number of balls in any one compartment should exceed a given number, but in order to make this investigation applicable to the general problem of periodicities we must proceed in a different manner. If the compartments are numbered, it does not matter in which order, and a curve be drawn in the usual manner representing the connection between the compartments and the number of balls in each, we may, by Fourier's analysis, express the result by means of periodic functions. The amplitude of each period can be shown *on the average* to be $\frac{1}{m}\sqrt{\pi n}$. It is often more convenient to take the square of the amplitude—call it the intensity—as a test, and we may then say that [the "expectancy" of the intensity is $4n/m^2$. The probability that the intensity of any period should be k times its average or expectancy is e^{-k}. We may apply this result to test the reality of a number of coincidences in periods which have been suspected. A lunar effect on earthquakes is in itself not improbable, as we may imagine the final catastrophe to be started by some tidal deformation of the earth's crust. The occurrence of more than 7000 earthquakes in Japan has been carefully tabulated by Mr. Knott according to lunar hours, who found the Fourier coefficient for the lunar day and its three first sub-multiples to be 10·3, 17·9, 10·9, 3·97; the expectancy on the hypothesis of chance distribution for these coefficients I find to be 19·3, 15·7, 10·6, 5·02. The comparison of their numbers disproves the supposed connection; on the other hand, the investigations of Mr. Davison on solar influence have led to a result much in favour of such influence, the amplitude found being in one series of observations equal to five times, and in the other to fifteen times the expectancy. The probability that so large an amplitude is due to accident in the first case is one in 300 millions, and in the second the probability of chance coincidence would be represented by a fraction, which would contain a number of over 70 figures in the denominator. We may, therefore, take it to be established that the frequency of earthquakes depends on the time of year, being greater in winter than in summer. With not quite the same amount of certainty, but still with considerable probability, it has also been shown that earthquake shocks show a preference for the hours between 9 a.m. and noon.

A great advantage of the scientific treatment of periodical occurrences lies in the fact that we may determine *a priori* how many events it is necessary to take into account in order to prove an effect of given magnitude. Let us agree, for instance, that we are satisfied with a probability of a million to one as giving us reasonable security against a chance coincidence. Let there be a periodic effect of such a nature that the ratio of the occurrence at the time of maximum to that at the time of minimum shall on the average be as $1+\lambda$ to $1-\lambda$, then the number of observations necessary to establish such an effect is given by the equation $n = 200/\lambda^2$. If there are 2 per cent. more occurrences at the time of maximum than at the time of minimum $\lambda = 01$, and n is equal to two million. If the effect is 5 per cent., the number of events required to establish it is 80,000.

To illustrate these results further, I take as a second example a suggested connection between the occurrence of thunderstorms and the relative position of sun and moon. Among the various statistical investigations which have been made on this point, that of Mr. MacDowall lends itself most easily to treatment by the theory of probability. One hundred and eighty-two thunderstorms observed at Greenwich during a period of fourteen years have been plotted by Mr. MacDowall as distributed through the different phases of the moon, and seem to show a striking connection. I have calculated the principal Fourier coefficient from the data supplied, and find that it indicates a lunar periodicity giving for the ratio of the number of thunderstorms near new moon to that near full moon the fraction 8·17 to 4·83.

This apparently indicates a very strong effect, but the inequality is only twice as great as that we should expect if thunderstorms were distributed quite at random over the month, and the probability of a true connection is only about 20 to 1. No decisive conclusions can be founded on this, the number of thunderstorms taken into account being far too small. We might dismiss as equally inconclusive most of the other researches published on the subject were it not for a remarkable agreement among them, that a larger number of storms occur near new moon than near full moon.

I have put together in the following table the results of all investigations that are known to me; following the example of Koeppen, I have placed in parallel columns the number of thunderstorms which have occurred during the fortnight including new moon, and the first quarter and the fortnight including the other two phases.

Place of observation and author.	Time of observations.	Percentage of thunderstorms during the fortnight including	
		New moon and first quarter.	Full moon and last quarter.
Karlsruhe (Eisenlohr) ...	1801–31	50·8	49·2
Gotha (Luedicke) ...	1867–75	72·5	27·5
Vigevano (Schiaparelli) ...	1827–64	46	54
Germany (Köppen) ...	1879–83	56	44
Glatz (Richter)	1877–84	62	38
United States (Hazen) ...	1884	56·5	43·5
Prag (Grüss)	1840–59	51	49
,, ,, ...	1860–79	52·5	47·5
Göttingen (Meyer) ...	1857–80	54	46
Kremsmunster (Wagner)..	1862–87	53·8	46·2
Aix la Chapelle (Polis) ...	1833–92	54·4	45·6
Sweden (Eckholm) ...	1880–95	53 8	46·2
Batavia (v.d. Stock) ...	1887–95	51·9	48·1
Greenwich (McDowall) ...	1888–91	54	46
Average	—	54·9	45·1

It will be seen that out of fourteen comparisons, thirteen show higher numbers in the first column, there being also, except in two cases, a general agreement as regards the magnitude of the effect. Two of the stations given in the table, Göttingen and Gotha, are perhaps geographically too near together to be treated as independent stations, and we may, therefore, say that there are thirteen cases of agreement, against which there is only one published investigation (Schiaparelli) in which the maximum effect is near full moon.

The probability that out of thirteen cases in which there are two alternatives, selected at random, twelve should agree and one disagree is one in twelve hundred. If the details of the investigations summarised in the above table are examined, considerable differences are found, the maximum taking place sometimes before new moon and sometimes a week later. There is, however, evidently sufficient *prima facie* evidence to render an exhaustive investigation desirable. The most remarkable of all coincidences between thunderstorms and the position of the moon remains to be quoted. A. Richter has arranged the thunderstorms observed at Glatz, in Silesia, according to lunar hours, and finds that in each of seven successive years the maximum takes place within the four hours beginning with upper culmination. If this coincidence is a freak of chance, the probability of its recurrence is only one in three hundred thousand. The seven years which were subjected to calculation ended in 1884. What has happened since? Eighteen years have now elapsed, and a further discussion with increased material would have definitely settled the question, but nothing has been done, or, at any rate, published. To me it seems quite unintelligible how a matter of this kind can be left in this unsatisfactory state. Meteorological observations have been allowed to accumulate for years, one might be tempted to say for centuries, yet when a question of extraordinary interest arises we are obliged to remain satisfied with partial discussion of insufficient data.

The cases I have so far discussed were confined to periodical recurrences of single detached and independent events, the condition, under which the mathematical results hold true, being that every event is entirely independent of every other one. But many phenomena, which it is desirable to examine for periodic regularities, are not of this nature. The barometric pressure, for instance, varies from day to day in such a manner that the deviations from the mean on successive days are not independent. If the barometer on any particular day stands half an inch above its average it is much more likely that on the following day it should deviate from the mean by the same amount in the same direction than that it should stand half an inch below its mean value. This renders it necessary to modify the method of reduction, but the theory of probability is still capable of supplying a safe and certain test of the reality of any supposed periodic influence. I can only briefly indicate the mathematical theorem on which the test is founded. The calculation of Fourier's coefficients depends on the calculation of a certain time integral. This time integral will for truly homogeneous periodicities oscillate about a mean value, which increases proportionately to the interval, while for variations showing no preference for any given period, the increase is only proportional to the square root of the time.

Investigations of periodicities are much facilitated by a certain preliminary treatment of the observations suggested by an optical analogy. The curve, which marks the changes of such variables as the barometric pressure, presents characteristics similar to those marking the curve of disturbance along a ray of white light. The exact outline of the luminous disturbance is unknown to us, but we obtain valuable information from its prismatic analysis, which enables us to draw curves connecting the period and intensity of vibration. For luminous solids we thus get a curve of zero intensity for infinitely short or infinitely long radiations, but having a maximum for a period depending on temperature. Gases, which show preference for more or less homogeneous vibrations, will give a serrated outline of the intensity curve.

I believe meteorologists would find it useful to draw similar curves connecting intensity and period for all variations which vary round a mean value such as barometric, thermometric or magnetic variations. These curves will, I believe, in all cases add much to our knowledge; but they are absolutely essential if systematic searches are to be made for homogeneous periods. The absence of any knowledge of the intensity of periodic variation renders it, *e.g.*, impossible to judge of the reality of the lunar effect which Eckholm and Arrhenius believe to have traced in the variations of electric potential on the surface of the earth. The problem of separating any homogeneous variation, such as might be due to lunar or sunspot effects, is identical with the problem of separating the bright lines of the chromosphere from the continuous overlapping spectrum of the sun. This separation is accomplished by applying spectroscopes of great resolving powers. In the Fourier analysis, resolving power corresponds to the interval of time which is taken into account, hence to discover periodicities of small amplitude we must extend the time interval of the observations.

I believe that the curve which connects the intensity with the period will play an important *rôle* in meteorology. It is a curve which ought to have a name, and for want of a better one I have suggested that of periodograph. To take once more barometric variations as an example, it is easy to see that just as in the case of white light the periodograph would be zero for very short, and probably also for very long, periods. There must be some period for which intensity of variation is a maximum. Where is that maximum? And does it vary according to locality? The answer to these questions might give us valuable information on the difference of climate. Once the periodograph has been obtained, the question of testing the reality of any special periodicity is an extremely simple one. If h be the height of the periodograph, the probability that, during the time interval chosen, the square of the Fourier coefficient should exceed kh is e^{-k}. If we wish this quantity to be less than a million, k must be about 11; so that in order to be reasonably certain that any periodicity indicates the existence of a truly homogeneous variation, the square of the Fourier coefficient found should not be less than 11 times the corresponding ordinate of a periodograph.

I have calculated in detail the periodograph of the changes of magnetic declination at Greenwich, taking as basis the observations published for the 25 years 1871–95. It was not, perhaps, a very good example to choose, on account of the complications introduced by the secular variation, but my object was to test the very persistent assertions that have been made as to the reality of periodic changes of 26 days or thereabouts. The first suggestion of such a period came from Hornstein, of Prague, who ascribed the cause of the period to the time of revolution of the sun round its axis. He only discussed the records for one year's observations, but the evidence he offered was sufficient to impress Clerk Maxwell with its genuineness. Since Hornstein's first attempts, a great many rough and some very elaborate efforts have been made by himself and others to prove a similar period in various meteorological variations. The period found by different computors differed, but there is a good deal of latitude allowed if the rotation of the sun really has an effect on terrestrial phenomena, because the angular velocity of the visible solar surface varies with the latitude. Hornstein himself and some of his followers deduced a period

not differing much from 26 days, while Prof. Frank Bigelow, using a large quantity of material, finds 26·68 days, and Eckholm and Arrhenius return to 26 days, or, as they put it more accurately, to 25·929 days. The two latter investigators do not, however, adopt the idea that this periodicity is due to the rotation of the sun. None of these periods can stand the test of accurate investigation.

As the result of my calculations, I can definitely state that the magnetic declination at Greenwich shows no period between 25·5 and 27·5 days having an amplitude as great as 6″ of arc. The influence of solar rotation on magnetic variation may therefore be considered to be definitely disproved.

The intensity of the periodograph increases rapidly with the period, and minute variations are, therefore, more easily detected in short than in longer periods. Six seconds of arc forms about the limit of amplitude, which can be detected in 25 years of observations, when the period is about 26 days; and from what has been said above, the amplitude which can be detected will be seen to vary inversely with the square root of the time interval. For periods of about 14 days, an amplitude of 3″ of arc is still distinguishable with the material I have used; and such an amplitude is actually found for a period which has half the synodic month as its time. The chance that this apparent variation is due to an accidental coincidence is one in two thousand; and I cannot, therefore, assert its definite existence beyond all possibility of cavil. But it is surely significant that of all the periods possible between 12·3 and 13·7 days, that gives the highest amplitude which coincides with half the synodic revolution of the moon. That it is at all possible to detect variations of 3″ of arc in the observations which are taken to 6″, with a probability of error of only one in two thousand, is, I think, a proof of the value of the method and the carefulness of the observations. The periodograph has another valuable use. It not only gives us the time necessary to establish true periodicities of given amplitude, but it also gives us an outside limit of the time beyond which an accumulation of material is of no further advantage. That limit is reached when the time is sufficient to discover the smallest amplitude which the instruments, owing to their imperfections, allow us to detect.

I am only concerned to-day with a purely statistical inquiry, and not with the explanation of any suggested relationship. To prevent misunderstandings, however, I may state that I consider the possibility of a direct magnetic or electric action of the moon excluded; as regards the latter, the diurnal variations of electric potential would be so much affected by a lunar electrification sufficiently strong to influence the outbreak of thunderstorms that it could not have escaped discovery. We must not, however, be dogmatic in asserting the impossibility of indirect action. The unexpected discovery of radio-activity has opened out an entirely new field, and we cannot dismiss without renewed careful inquiry the evidence of lunar action which I have given. Its reality can be decided by observation only. No—not by observation only—but by observation supplemented by intelligent discussion; and this brings me to my concluding appeal, which I wish to urge upon you with all the legitimate weight of strong conviction and all the illegitimate influence of presidential infallibility.

The subjects with which our subsection is concerned deal with facts which are revealed to us by observation more frequently than by experiment. There is in consequence a very real danger that the importance of observation misleads us into mistaking the means for the end, as if observation alone could add anything to our knowledge. Observation is like the food supplied to the brain, and knowledge only comes through the digestion of the food. An observation made for its own sake and not for some definite scientific object is a useless observation. Science is not a museum for the storage of disconnected facts and the amusement of the collecting enthusiast. I dislike the name "observatory" for the astronomical workshop, for the same reason that I should dislike my body to be called a food receptacle. Your observing dome would be useless without your computing room and your study. What you want is an Astronomical Laboratory, a Meteorological or Magnetic Laboratory, attaching to the word "laboratory" its true meaning, which is a workshop in which eyes and hands and brains unite in producing a combined result.

The problems which confront the astronomer being more definite than those of Meteorology, Astronomy has grown under the stimulus of a healthy tradition. Hence it is generally recognised, at any rate in the principal observatories, that the advance of knowledge is the chief function of the observer. Nevertheless, the President of the Astronomical Department of Section A last year (Prof. H. H. Turner) has found it necessary, in his admirable address, to warn against the danger there is that the astronomer should allow himself to be swallowed up in a routine work and mere drudgery. The descent is easy: You begin by being a scientific man, you become an observer, then a machine, and finally—if all goes well—you design a new eyepiece.

If such a danger exists in Astronomy, what shall we say about Meteorology? That science is bred on routine, and drudgery is often its highest ambition. The heavens may fall in, but the wet bulb must be read. Observations are essential, but though you may never be able to observe enough, I think you can observe too much. I do not forget the advances which Meteorology has made in recent years, but if you look at these advances, I think you will find that most of them do not depend on the accumulation of a vast quantity of material. The progress in some cases has come through theory, as in the applications of Thermodynamics or through special experiments as by kite and balloon observations, and when it has come through the ordinary channels of observation, only a comparatively short period of time has been ultilised. It would not be a great exaggeration to say that Meteorology has advanced in spite of the observations and not because of them.

What can we do to mend matters? If we wish to prepare the way for the gradual substitution of a better system, we should have some one responsible for the continuation of the present one. For this purpose it should be recognised that the head of the Meteorological Office is something more than a Secretary to a Board of Directors; also that he is appointed to conduct Meteorological research and not to sign weather forecasts. The endowment of Meteorology should mean a good deal more than the endowment of the Telegraph Office which transmits the observations. Terrestrial Magnetism and Atmospheric Electricity are looked after at present by institutions already overworked in other directions and should be handed over to an enlarged Department of Meteorology. Seismology in this country now depends on the private enterprise and enthusiasm of a single man, and as long as Prof. Milne is willing to continue his work, we cannot do better than leave it with him, but some permanent provision will ultimately have to be made.

An improved organisation such as I have sketched out would do good, but could only very slowly overcome the accumulated inertia of ages. I should prefer a more radical treatment. Organisation is good, but sometimes disorganisation is better.

Most earnestly do I believe that the subjects of meteorology and terrestrial magnetism, and possibly also of atmospheric electricity, could be most quickly advanced at the present moment if all observations were stopped for five years, and all the energy of all observers and computors concentrated on the discussion of the results obtained and the preparation of an improved scheme of observation for the future. When we have made up our minds what to do with the observations, when we have actually done it; when we know where our present instruments require refining or supplementing, and especially when we have found out whether we have not spent much time and trouble on unnecessary detail, then the time will have arrived for us to draw up an economical, sufficient and efficient scheme of observations. At present we are disinclined to discontinue observations, though recognised as useless, for fear of causing a break. We make ourselves slaves to so-called "continuity," which is important, but, may be, and I believe is being, too dearly purchased.

There are no doubt some, though probably not very many, observations which it is necessary to carry on continuously over long periods of time. But at present we are groping in the dark, and go on observing everything, and always in the hope that some time the observations might prove useful. Our whole point of view in this respect wants altering. We should fix on our problem first and then provide the observations which are necessary for the solution of the problem. Let us restrict, in the first instance, the secular observations to the smallest number, and concentrate our attention, for short periods of time, on some special question. Let us have, for instance, two or three years of thunderstorm observations, all countries joining in concentrating their energies to the elucidation of all the various features of their phenomena. When that is accomplished, it will probably be found that thunderstorms may be left to shift for themselves for a while, and attention might be

directed to some other matter. The whole question of lunar influence on meteorological phenomena might be settled in a comparatively short space of time if the civilised countries of the world could agree to record all observations during a few years according to lunar instead of solar coordinates. Other problems will readily suggest themselves to you, and several might possibly be dealt with simultaneously.

The great reform I have in view is this :—Before you observe, make sure that your observations will be useful and will help to answer a definite question.

I hope that, though my frankly outspoken criticisms may not command universal assent, you will agree that there is some foundation for them, and, if so, the time is obviously not well chosen when observational science can be separated from its mathematical and experimental sisters. We hope that cosmical physics may remain an integral portion of Section A, and, though we acknowledge our weaknesses, we claim to have also something to teach.

I hope that our proceedings this week may show that we can put aside observational detail and throw some light on the great and important problems with which our science is concerned.

MATHEMATICS AND PHYSICS AT THE BRITISH ASSOCIATION.

ALTHOUGH the number of communications made to the Section at Belfast was less than at Glasgow last year, there was no decrease in the interest of the meetings. The inclusion of cosmical physics in the subjects dealt with by the department for astronomy materially increased the attendance at the meetings of that department.

In the mathematical department, Miss Hardcastle described the ground covered by the second part of her report on the present state of the theory of point groups, and stated that a further communication would be necessary to bring the report up to the present time. In the absence of the author, Prof. Forsyth gave a short account of Mr. E. T. Whittaker's solutions of the partial differential equations of mathematical physics. Mr. Whittaker finds that an expression of the type

$$\int_0^{2\pi} f(z + ix\cos u + iy\sin u, u)\,du$$

is the most general solution of the potential equation of Laplace, where f is an arbitrary function of the arguments

$$z + ix\cos u + iy\sin u \text{ and } u, \text{ and } i = \sqrt{-1}.$$

It follows that Legendre's, Bessel's and other well-known solutions of the equation are special forms of Mr. Whittaker's. In the same way, the general solution of the equation of wave motion is of the type

$$\int_0^{2\pi}\int_0^{\pi} f(x\sin u\cos v + y\sin u\sin v + z\cos u + \frac{t}{k}, u, v)\,du\,dv,$$

where f is an arbitrary function. Mr. Whittaker points out that this solution may be analysed into plane waves, and therefore supports the conclusion arrived at by Dr. Johnstone Stoney in 1897, that all disturbances in the ether can be resolved into trains of plane waves.

In the department of physics, Lord Rayleigh brought forward the question of the accurate conservation of weight in chemical reactions. He considered the discrepancies found by experimenters too large to allow the law of conservation to be accepted as proved, and hoped that the experiments at present being carried out by Landolt and Heydweiller would soon lead to a definite conclusion. Prof. Morton described the experiments he and Mr. Hawthorne had carried out on the motion of a detached thread of liquid in a capillary tube. He concludes from them that there is some force of the nature of an attraction between the liquid and the material of the tube, which must be taken into account to explain completely the phenomena observed. He further detailed how he had, in conjunction with Mr. Vinycomb, repeated and extended the work of Raps on the mode of vibration of stretched strings, and investigated the effect of the rigidity of the support on the motion of the string.

Dr. Barnes, of Montreal, on continuing his experiments on the critical velocity of flow of water through tubes, has found that the velocity varies with temperature in the way anticipated from the viscosity term in the expression given by Prof. Osborne Reynolds in his classical paper on critical velocity. By applying in the case of mercury the method used in determining the specific heat of water, he has also found that the specific heat of mercury decreases at a rate which itself decreases slightly with increase of temperature. Lord Kelvin sent a short communication in which he suggested that the temperature of an animal surrounded by a saturated atmosphere hotter than itself was kept down by evaporation within the lungs.

Dr. J. Larmor, in a paper on the application of the method of entropy to radiant energy, showed that by defining the entropy of a given space containing radiant energy distributed in any arbitrary way, as the logarithm of the probability of the existence of that particular distribution, the law of distribution of the energy with wave-length, which was recently deduced by Planck by considering a space filled with electrical resonators, could equally well be established. According to it, the amount of energy between wave-lengths λ and $\lambda + d\lambda$ radiated by a perfectly black body at absolute temperature t is proportional to

$$\frac{1}{\lambda^5}\,\frac{1}{e^{\frac{a}{\lambda t}} - 1}$$

where a is a constant.

Mr. Petavel gave an account of the work he had done towards the production of a standard of light. He considered that the incandescent surface of a metal of the platinum group heated electrically furnished the best source, and proposed to fix the temperature of that source by the equality of the radiation transmitted by suitable thicknesses of two media, the absorption of one of which (water) increased, and of the other (black fluor-spar) decreased, with increase of temperature of the source. Dr. C. S. Myers called attention to a variation of pitch of Galton and other high-frequency whistles when the wind pressure was changed, which he had not been able to explain.

Lord Rayleigh prefaced a description of his own experiments to determine whether double refraction was produced in isotropic transparent bodies by their motion through the ether, by an account of those of Michelson and Morley. The latter led to the conclusion that light travelled with the same velocity, whether the direction of transmission was coincident with, across or opposed to that of the motion of the body. Lord Rayleigh's arrangement would have enabled a change of velocity of 10^{-10} of the velocity of light to be detected, but no change was observed when the light was transmitted through water or carbon bisulphide. The experiments on solids are not yet concluded.

Dr. Johnstone Stoney forwarded a note in which he showed that by substituting for Huyghen's wave surface, a wave film of finite thickness, within which the phases of the disturbances were given proper values, the disturbance propagated to a point outside the wave surface could be accurately calculated. In a second note, Dr. Stoney showed how his method of resolving the light traversing any isotropic medium into trains of plane waves might be applied to explain several optical phenomena which have not hitherto yielded to other methods.

Prof. E. Wilson described his experiments on the use of a magnetic detector in space telegraphy. His detector consists of an iron ring magnetised to instability by a current through a coil wound on the ring. The electric waves falling on the ring slightly disturb its magnetic state, and the disturbance is indicated by the sound produced in a telephone in series with a second coil wound on the ring. He finds such a detector very convenient and satisfactory in working.

Prof. Minchin has found that a coherer consisting of a carbon rod lightly supported in aluminium stirrups in an evacuated glass tube decoheres better than any other form he has tried, and is now engaged in applying the arrangement to long-distance transmission.

Dr. Marchant showed that the graphical method of determining the discharge of a condenser through a variable inductance gave results which agreed very closely with the calculated discharge in those cases in which the calculation could be carried out.

Mr. Butler-Burke gave a short account of his work on the phosphorescence produced in partially exhausted tubes by the passage of an alternating current round them. He concludes that it is due to the formation of groups consisting of a large number of molecules of gas within the tube.

In the department of astronomy and cosmical physics, Dr. W. E. Wilson exhibited a bolometer arranged to record solar radiation. It consists of two blackened coiled platinum wires, on one of which the light of the sun is allowed to fall through an opening in the metal box in which both are enclosed. The Rev. A. L. Cortie has examined in detail the Greenwich records of sun-spots and faculæ, and the diurnal ranges of the declination magnet, for the years 1899-1901, and finds that there is not sufficient accordance to support the statement sometimes made that sun-spots cause magnetic storms. He considers the two are correlated effects of some common cause still to be found.

The committee for investigating the upper atmosphere by means of kites gave a report of flights made from their station near Oban during July and August. The average height reached was about 3500 feet, and the average rate of decrease of temperature upwards about 3°·5 F. per 1000 feet.

Dr. Shaw, in his communication on radiation in meteorology, pointed out that radiation or absorption of heat by a cloud would result in motion of the cloud downwards or upwards. This motion would produce in its turn a heating or cooling of the cloud opposed to the initial change, and a much more careful and extended study of the radiation from clouds than had hitherto been attempted was necessary before several of the problems connected with cloud motion could be solved. He suggested several ways in which observers with simple instruments could help toward the solution of these problems.

Prof. Milne, in presenting the report of the Seismological Committee, stated that each of the recent West Indian eruptions had been preceded by sudden readjustments of the strata in the neighbourhood, which left their traces on the earthquake-recording instruments. This may, after further investigation, lead to a method of predicting eruptions.

Dr. Roberts exhibited photographs of nebulæ illustrating the nebular theory of the evolution of star systems, from cloudy nebulæ, through the spiral stage, to star clusters.

Mr. Hinks opened a discussion on the nebula surrounding Nova Persei by showing that some of the phenomena exhibited by the nebula might be due to its being ring-shaped. Photographs exhibited by Dr. Roberts did not, however, appear to support this view, and there seems little hope of coming to any definite conclusion as to the nature of the nebula until more information as to its appearance is available. C. H. LEES.

GEOLOGY AT THE BRITISH ASSOCIATION.

THE total number of communications brought before Section C at Belfast was thirty-five. None of them can be said to have been of really great importance, but they were for the most part records of good work. The Committee on Life-zones in the Carboniferous Rocks sent in an admirable report of careful and systematic fossil-collecting. The Committees on the Underground Waters of N.W. Yorkshire and on Erratic Blocks were also able to show excellent work, and Prof. W. W. Watts, as usual, brought a good series of photographs which had been collected by his committee during the past year. Proceedings opened on Thursday, September 11, with the president's address, which has already been printed in our columns. It was followed by a lecture on the geology of the country around Belfast by Prof. Grenville A. J. Cole. On the morning of Sept. 15 Prof. Cole gave a second lecture, on the geological structure of Ireland; both lectures were illustrated by lantern slides and were listened to with close attention by large audiences. A considerable number of the papers naturally dealt with the geology of Ireland, and it may be convenient to notice them first and then to mention some of the other communications in geographical order. A proof-sheet of the Drift edition of the geological map of Ireland was exhibited by Mr. Teall, the director of the Survey. He explained that it was printed in colour instead of being hand-coloured, and was consequently clearer and would cost much less than the hand-coloured maps now issued by the Survey.

The post-Glacial deposits of the Belfast district were described in a most interesting paper by Mr. R. Lloyd Praeger. A peat bed, representing an old land surface, is found 20 feet below low water at Belfast, but between tides at other places in the district. In it remains of the Irish elk have been found, and a little above it there is some 12 feet of blue clay, the upper part of which contains *Thracia convexa* and other shells, indicating a warmer climate than the fauna now living in the Irish Sea and a depth of five to ten fathoms, whilst in the lower part of the clay, *Scrobicularia piperata* and fossils of a shore type are found.

Mr. P. F. Kendall read a paper by Madame Christen giving an account of the recent work of the Belfast Field Club. The members have made a careful study of the drifts of the district. They have, for example, proved the transport of the Rhyolite of Tardree to the north as well as in other directions. Attention was also drawn to the wide dispersal through the district of blocks from Ailsa Craig, and it was stated that these blocks are practically always found associated with marine shells. The committee appointed to explore Irish caves was able to show excellent work in the caves of Keishcorran Mountain, a mass of Carboniferous Limestone fifteen miles south of Sligo. In the Coffey Cave, bones of the Arctic lemming had been found in considerable numbers. This, the report states, is the first record of its existence as a former inhabitant of Ireland. Excavations in an extensive series of caves at Edenvale, county Clare, were described. Remains of bear and of the Irish elk were recorded, as well as human implements, ornaments, &c., and Mr. R. J. Ussher, who read the report, said that he hoped for important evidence of the state of prehistoric Ireland from further exploration.

Mr. Joseph Wright announced his discovery of large numbers of marine Foraminifera in Boulder-clay from various places in Ireland and also from England, Wales, Scotland, the Isle of Man and Canada. He more especially dealt with the Boulder-clay of Knock Glen, near Belfast. From it he had obtained seventy-nine species, and he suggested a considerable depression of the area at the time of its deposition. This led to an animated discussion, Prof. Boyd Dawkins supporting the author's view and Messrs. Lamplugh and Kendall contending for a transport of the clay to its present position by land ice.

A paper by Mr. R. Clark dealt with the Silurians of north-east Ireland. The author described some new fossil localities and gave lists of the species found.

Mr. G. Barrow read a paper on the prolongation of the Highland Border rocks into county Tyrone. The author referred to the Jasper and green-rock series, which he had found between Blairgowrie and Stonehaven (*Q.J.G.S.* vol. lvii. p. 328), and explained that he believed it to correspond with a series found by Mr. Peach near Omagh. He thought these rocks were intermediate in age between the Highland rocks, which he looked upon as Archæan, and a newer series, the Pomroy rocks, of Silurian age.

An interesting discussion followed the reading of this paper.

Mr. McHenry agreed that in Ireland there are three series:—(1) An old series, which he thought was probably metamorphosed Llandeilo and Bala; (2) the green rocks; and (3) the Pomroy rocks, which are mapped Lower Silurian, but contain Devonian and Wenlock fossils with a few survivors of Bala type. The conglomerates of this third series contain pebbles of the green rocks. He agreed that the line between the green rocks and the older series was a great thrust which in his opinion affected the Old Red Sandstone. He had followed it south-west to Castlebar and Clew Bay into Clare Island.

Mr. Teall agreed that this line of disturbance in Ireland should be classed with that which the author had worked out in Forfarshire, but he thought further evidence was required as to the age of the rocks. Dr. Matley, Prof. Cole, Prof. J. F. Blake and Mr. Cunningham-Craig also spoke. In reply, the author said he was sure of the order of succession, but not of the precise age of the rocks.

A list of 113 minerals known to occur in Ireland was contributed by Mr. H. J. Seymour. He explained that it was but of a preliminary character and that he had only included species which he was satisfied really have been found in the country.

Passing to Scottish geology, a paper of very great interest was sent in by Mr. Kynaston and was read by Mr. Teall. The author described a series of volcanic rocks in the district extending from Glen Coe to the Black Mount. The lower part consists of some 1500 feet of basic andesites with sandstone, shale and conglomerate at the base. Above these andesites are agglomerates and breccias capped by some 700 feet of hornblende andesite. Messrs. Peach and Tait have discovered plant remains in a bed of black shale associated with these lavas which enable the author to fix their age as Lower Old Red Sandstone; that is, they are of the same date as the great volcanic series of Lorn.

The author then showed that the granite of Ben Cruachan

s newer than these volcanic series, thus solving a question of considerable interest. From this it follows that the boulders of granite found in the basement conglomerate of the volcanic series are not derived from the granite of the district, but must have come from some other area.

Two papers were sent in by Dr. W. Mackie. The first dealt with the conditions under which manganese dioxide has been precipitated in the Elgin sandstone. The second gave the results of a series of determinations of the soluble chlorides and sulphates in the same sandstone, made with a view to test the theory that from such an examination it is possible to determine the character of the waters of the basin of deposit of sedimentary rocks. The result was of a negative character, and the author believes it is not safe to infer that the soluble salts of a deposit represent the salts of the original waters of the basin of deposition.

English geology occupied a very small part of the time of the Section. Mr. Horace B. Woodward sent an interesting note relating to the Eocenes. A section on a new railway between Axminster and Lyme Regis shows a good example of Bagshot strata near Combe Pyne Hill which serves to connect the beds of that age at Bournemouth with the deposit at Bovey Tracey in Devon. This last is now admitted to be of Bagshot age. It used to be called Miocene, but Mr. Starkie Gardner has long contended that it is equivalent to the Bournemouth Series.

A paper on the fossil flora of the Cumberland Coalfield was read by Mr. E. A. Newell Arber, who described plants from both the Whitehaven sandstone and the Coal-measures.

Mr. P. F. Kendall dealt with the Vale of Eden. He believed that he could show from the relative position of the Permian breccias or Brockrams that a movement of the Pennine faults had taken place in Permian times.

There was one paper relating to Wales. It was by Mr. W. G. Fernsides, who described some new faunas which he had obtained at Pen Morfa, near Tremadoc. He described a zone with species of high Lingula Flag type 30 feet below the Lower Tremadoc. Some 30 feet above the horizon of Ramsay's Lower Tremadoc fossils, he had found a continuous zone of Dictyonema, and had mapped its outcrop for more than five miles. Finally, some 400 feet above the Dictyonema, he had found a Shineton fauna with a number of Swedish forms and some new species.

Passing now to papers dealing with localities outside the British Isles, we may mention a paper by Dr. R. H. Traquair on fishes of the Lower Devonian roofing slate of Gemünden in Germany. They belong to the class with mailed bodies and are there associated with a fauna thoroughly marine in character, a point of considerable interest. The author showed some beautiful photographs of the fishes and of starfishes, crinoids, trilobites, corals, &c., from the slates.

Indian geology was dealt with in an interesting note by Prof. H. G. Seeley. He said that hitherto there has been no evidence of Cretaceous strata in the Salt Range of the north of India, but he was now able to bring forward an account of a series of species found by Mr. E. G. Fraser on the shoulder of Sekasar. They are of the type or age of the Upper Greensand.

Two papers dealt with Victoria, Australia. Mr. James Stirling gave some notes on a new geological map of the colony, and Dr. Smith Woodward sent an account of some observations on a new Lower Carboniferous fish-fauna from the Broken River. Attention was first drawn to these Broken River fossils some twelve years ago, and the late Sir Frederick M'Coy described them as a mixture of Devonian and Carboniferous forms. This Dr. Woodward now shows to have been a mistake; he considers them typically and essentially Carboniferous. Dr. Traquair said that he had seen the collection and could corroborate all the statements in the paper. Palæontologists might now congratulate themselves that the myth which alleged the existence of fishes of Lower and Upper Devonian and Lower Carboniferous types in the same bed had been exploded.

With regard to America, the only contribution was a paper by Dr. H. Woodward on the Middle Cambrian Trilobites of Mount Stephen, British Columbia.

Most of the Palæontological papers have already been noticed, but an interesting note on the tusks and skull of *Mastodon angustidens*, by Dr. C. W. Andrews, deserves mention.

Prof. J. Joly brought forward a suggestive paper on the viscous fusion of rock-forming minerals, which gave rise to an interesting discussion in which Mr. Teall, Prof. Grenville Cole and Dr. Johnston-Lavis took part.

Prof. J. F. Blake read a paper on the original form of sedimentary deposits. He observed that during the continuance of constant physical conditions, the seaward boundary of river-brought deposits will be a marked line. Such a line has been called an escarpment and the edge of the continental plateau, but the author believed it to be the limit of terrigenous deposits in bulk. He also considered that limestones are most likely to form deposits of lenticular shape with the long axis parallel to the shore, and when they are found to give place to shales we should infer that we are approaching a river or other source of sediment.

In conclusion, we may mention that a series of excursions to places of geological interest was arranged by Messrs. G. W. Lamplugh, J. St. J. Phillips and H. J. Seymour, and were much appreciated by the geologists present at the meeting.

CARBON AND PLANTS.[1]

IN a paper recently laid before the Royal Society, dealing with the physical processes which regulate the entry of atmospheric carbon dioxide into the leaves of plants,[2] the authors incidentally described a series of experiments relating to the rate of absorption of dilute gaseous carbon dioxide by surfaces of solutions of caustic alkali, when air containing definite small amounts of this gas is drawn over the liquid. Contrary to what might be expected from the perfect absorbing nature of the solution, and the known laws of gaseous diffusion, the amount of CO_2 absorbed by unit area of the liquid surface in unit time ceases sensibly to increase when a comparatively low velocity of the moving air current has been reached. This, however, only holds good when the proportion of CO_2 in the air stream is maintained quite constant, any slight variation in the amount at once affecting the rate of absorption. On investigation, it was found that for dilutions of carbon dioxide lying between 0·6 part and 6 parts per 10,000 of air, the rate of absorption of the carbon dioxide *is strictly proportional to its partial pressure*.

In determining the rates of gaseous diffusion of atmospheric carbon dioxide through multiperforate diaphragms extended over chambers containing perfect absorbents, the same relations between partial pressure of the gas and its absorption were found to hold good; under these conditions the amount of carbon dioxide passing through the diaphragm in a given time is also directly proportional to the density of that gas in the moving stream of air which flows over the outer surface of the diaphragm.

But this latter case exactly defines the physical conditions under which atmospheric carbon dioxide enters the tissue of a living leaf, the multiperforate diaphragm being represented by the cuticle and epidermis, pierced with numerous stomata, and the inner absorbing chamber by the intercellular spaces of the parenchyma, bounded by the chlorophyll-containing cells in which the process of photosynthesis goes on (*loc. cit.*).

The authors have now found, by enclosing the living leaves in glass cases through which air containing known proportions of CO_2 is passed, that a living leaf is really able, within certain limits, to respond to increased amounts of carbon dioxide in the air surrounding it, in such a manner as to indicate an approximate proportionality between the photosynthetic work it can accomplish and the partial pressure the gas exercises in the air bathing the leaf surface.

The following experiment may be selected from several, in illustration:—

Experiment I.—In this case, comparative experiments were made on two successive days in August, 1898, with two similar leaves, A and B of *Helianthus annuus* whilst still attached to the plant. These were exposed to the strong diffused light of a clear northern sky under as nearly as possible identical conditions, with the exception of the composition of the air drawn through the cases.

Over leaf A was drawn normal air containing 2·8 parts per 10,000 of CO_2, whilst the air passing over leaf B contained 25·53 parts CO_2 per 10,000.

[1] Abridged from a paper on "The Influence of Varying Amounts of Carbon Dioxide in the Air on the Photosynthetic Process of Leaves and on the Mode of Growth of Plants," by Dr. Horace T. Brown, F.R.S., and Mr. F. Escombe. Read before the Royal Society on May 29.

[2] *Phil. Trans.*, B. 1900, vol. cxciii. p. 278.

Leaf A.	
Area of leaf	743·1 sq. cm.
Volume of air passed per hour, reduced to normal temperature and pressure...	159·03 litres.
CO_2 content of air entering case ...	2·80 parts per 10,000.
,, ,, leaving case ...	1·64 ,, ,,
Mean CO_2 content of air in contact with leaf during experiment ..	2·22 ,, ,,
CO_2 absorbed by leaf per hour ...	18·44 c.c.
,, per sq. metre per hour	248·2 c.c.
Leaf B.	
Area of leaf	863·75 sq. cm.
Volume of air passed per hour, reduced to normal temperature and pressure...	72·7 litres.
CO_2 content of air entering case ...	25·30 parts per 1000
,, ,, leaving case ...	4·12 ,, ,,
Mean CO_2 content of air in contact with leaf during experiment ...	14·82 ,, ,,
CO_2 absorbed by leaf per hour ...	155·7 c.c.
,, per sq. metre per hour	1802·8 c.c.

It is manifest that if we wish to determine the relation of the partial pressures of carbon dioxide to the rate of intake of that gas into the leaf, we must employ the values representing the mean carbon dioxide content of the air in contact with the leaf during the experiment, which may be taken as the arithmetical mean of the composition of the entering and emergent air. In the above experiment, we obtain the following relations:—

Ratio of partial pressures of CO_2 in A and B, 2·22 : 14·82 or **1 : 6·6.**

Ratio of CO_2 absorbed per sq. metre of leaf A and B in one hour, 248·2 : 1802 8 = **1 : 7·2.**

Thus by increasing the amount of CO_2 in the air passing over the leaf about sevenfold, we have, under similar conditions of illumination, increased the photosynthetic power of the leaf by a little more than the same amount.

Experiments of this nature are necessarily limited to comparatively short periods, and give no information as to how far the plant, as a whole, will respond to such changes in its atmospheric environment. When first drawing attention to these facts in 1899 (Presidential Address, British Association, Section B, Dover), it was pointed out that we were not justified, without direct experiment, in concluding that the plant would be able to avail itself indefinitely of the increased amount of plastic carbohydrate material formed in its leaves under these artificial conditions, and that translocation, metabolism and growth may have become so intimately correlated that the perfect working of the entire plant may only be possible in an atmosphere containing the normal amount of three parts of CO_2 per 10,000.

Experiments were started to test how far slightly increased amounts of CO_2 in the air would affect the dry weight of plants grown in such atmospheres, and they indicate that the plants were certainly not stimulated to increased growth by somewhat increasing the amount of CO_2 in the surrounding air. The evidence, in fact, points in the other direction, *i.e.* towards a slight diminution in the increment of dry weight, and to a less development of foliar area. There were also indications of certain morphological differences, which assumed some importance in the light of subsequent experiments. The plants grown in air slightly enriched with CO_2 had not only smaller leaves than the controls, but these leaves were of a distinctly darker green, and the internodes of the plants were decidedly shorter.

The results obtained with these preliminary experiments now induced the authors to extend their observations to a larger number of species, and arrangements were consequently made to carry out a series of experiments on a large scale. This was done in a greenhouse divided in two by a glazed partition. In one half, the plants, gourds, balsams, fuchsias, begonias, &c., were exposed to the CO_2-laden atmosphere; in the other, control plants were in ordinary air. The original paper must be consulted for experimental details and precautions.

A careful record was made of the differences in appearance of the two sets of plants on June 10, June 29 and July 13, that is to say, at 28, 47 and 61 days from the commencement of the experiment. The results are given in detail in the appendix to this paper, and may be summarised as follows:—

The effect of an increased amount of CO_2 in the air becomes in most cases apparent within a week or ten days from the commencement of the experiment, and rapidly increases as time goes on. There is a marked difference induced in the habit and general appearance of most of the plants owing to a stimulation of all axial growth, accompanied by a more or less pronounced shortening and thickening of the internodes. Usually, but not in all cases, there is an increased number of the internodes, so that the height of the two contrasted sets remains much about the same, but the chief difference of general habit is brought about by the development throughout the plant of secondary axes in the axils of the leaves, thus giving the plants grown under the influence of increased CO_2 a denser and more bushy appearance. This was particularly noticeable in the fuchsias, especially the dark-leaved variety, in which every axil bore a shoot and frequently extra axillary ones. Adventitious shoots were also developed rather freely at the base of the plants.

The leaf area of the plants under the influence of increased CO_2 was generally found to be much reduced, not so much by the formation of a smaller number of leaves as by the reduction in area of the individual leaves. This was found to be extreme in the case of the dark-leaved fuchsias, and it was also very marked in the second crop of the leaves of Impatiens. There was also produced in many of the plants a marked inward curling of the leaves, the extremes in this direction being found in the begonias and fuchsias. In the dark-leaved variety of fuchsia, the leaves were curled inwards like a watch-spring, which would doubtless tend to reduce excessive photosynthesis by preventing the normal amount of light from reaching the chloroplasts. This change of habit may, in fact, be regarded as an attempt on the part of the plant to adapt itself to its abnormal atmospheric surroundings.

The extra CO_2 in several cases induced a deeper green colour in the leaf, and in all other parts of the plant where chlorophyll was present. This was particularly noticeable in the second crop of leaves developed on the Impatiens, in the begonias and in the darker-leaved fuchsias.

On July 19, the Sachs test for starch was applied to the leaves of the two varieties of fuchsia, *Cucurbita Pepo* and *Impatiens platypetala*. In all cases, the leaves taken from the plants grown with increased CO_2 in the air showed a much larger accumulation of starch than did the leaves of the control plants. These differences were the most strongly marked in the leaves of Impatiens, which became quite black with the test.

It was, however, in the development of the *reproductive organs* of the two sets of plants that the most striking and important differences were found. Whilst the control plants in ordinary air flowered, and in some cases fruited luxuriantly, in the corresponding plants submitted to air containing 11·4 parts per 10,000 of CO_2, *inflorescence was almost totally inhibited.* With the exception of one or two sickly-looking flowers on the begonias, not a single flower-bud opened on any of the plants of this set. The plants of Impatiens, Kalanchoë and of the darker-leaved fuchsias did not even produce a flower-bud, whilst in the Nicotiana, Cucurbitas and lighter-leaved fuchsias, the small flower-buds which commenced to form were completely shed long before the time of opening.

In another series of experiments, carried out on similar lines, the air of compartment B was enriched with carbon dioxide to the extent of 6 per cent., that is to say, up to about 200 times the normal amount. The experiment extended from June 3 to August 26, and the general results both in the direction and amount of change of habit induced in the plants were so very similar to those induced in the plants with only three-and-a-half times the normal amount of CO_2 as to require no further special description. The results are, however, valuable as indicating that the observed differences cannot be due to any *direct* poisonous influence of the carbon dioxide, otherwise we should certainly expect a marked difference to be produced by increasing the amount of CO_2 from 11·4 parts per 10,000 to 600 parts per 10,000, *i.e.* more than fiftyfold, which was not the case to any appreciable extent.

The direction in which we must search for the true explanation of the effect is probably indicated by the experiments on leaves described in the early part of the paper, where it was shown that the amount of photosynthesis in the leaf lamina is, within certain ill-defined limits, a function of the partial pressure of the CO_2 in the surrounding air.

In the first series of experiments in the greenhouse, where this partial pressure was maintained at about three-and-a-half times the normal, the plants for a certain limited period must

have been manufacturing carbohydrate material within their chloroplasts at least three-and-a-half times faster than those in normal air, and, although this rate of photosynthesis would perhaps not be maintained for very long, yet there would always be a general tendency for the carbohydrate supply in the leaves to be kept up to a higher point than in the controls grown in ordinary air, a fact which was shown by the leaves of set B always being gorged with starch.

Since it is quite certain that this increased photosynthesis does not to any material extent contribute to the increase of dry weight of the plants, we can only conclude that the transformation, translocation and general metabolism of the leaf-reserves under these conditions cannot keep pace with the increased tendency to produce an extra amount of plastic material from the atmosphere. Moreover, it is clear that the whole mechanism of the plant on which normal nutrition depends has its parts so completely and accurately correlated that any slight increase in the composition of the surrounding air which favours increased photosynthesis destroys the adjustment of the various parts and results in a more or less abnormal development of the plant. That any such disturbance of the economy of the plant should profoundly modify the reproductive functions might perhaps have been expected.

It is somewhat remarkable to find that all the species of flowering plants, without exception, which have been the subject of experiment appear to be accurately "tuned" to an atmospheric environment of 3 parts of CO_2 per 10,000, and that the response which they make to slight increases in this amount are in a direction altogether unfavourable to their growth and reproduction. It is not too much to say that a comparatively sudden increase of carbon dioxide in the air to an extent of about two or three times the present amount would result in the speedy destruction of nearly all our flowering plants.

To a certain extent, we may regard the facts recorded in this paper as indicating that the composition of our atmosphere as regards its carbon dioxide has remained constant, or practically constant, for a long period of time, but the authors leave altogether untouched the question of any variations of a secular kind. All we are justified in concluding is that if such atmospheric variations have occurred since the advent of flowering plants, they must have taken place so slowly as never to outrun the possible adaptation of the plants to their changing conditions.

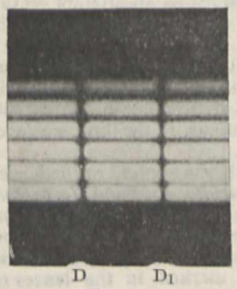


FIG. 1.

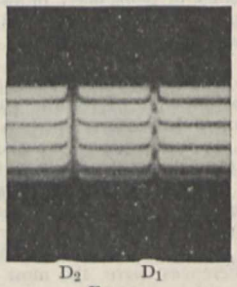


FIG. 2.

MAGNETO-OPTICAL ROTATION IN THE INTERIOR OF ABSORPTION BANDS.

AN interesting confirmation of Voigt's theory of absorption has been afforded by an experiment by Prof. Zeeman, described in the *Proceedings* of the Amsterdam Academy of Sciences of June 25. In Voigt's theory, the separation of a spectral line by the action of a magnetic field is found as the separation of an absorption line, and the theory requires a negative rotation of the plane of polarisation in the interior of the absorption band. Now in previous experiments, such as those of Corbino, the only observed result has been a very small positive rotation. The new experiment described by Prof. Zeeman is interesting, not only as showing the existence of a negative rotation in the interior of an absorption band, but also as being in perfect quantitative agreement with Voigt's theory.

By means of a system of quartz prisms such as have been used by Fresnel in his experiment on the division of a plane polarised ray into two circularly polarised rays, a number of interference fringes were formed at right angles to the bands of a spectrum, and when light from a bright source was allowed to pass through sodium vapour and analysed with a Nicol's prism, the effect produced by the sodium absorption lines and the interference lines combined was as shown in Fig. 1. If, however, the sodium vapour was subjected to the action of a powerful magnetic field, of from fifteen to twenty thousand units, the effects shown in Fig. 2 were observed. It will be noticed that the fringes moved upwards along the components of the doublets, whereas the parts of the fringes *between* the components became disconnected from the exterior parts and *moved downwards*. As the density of the sodium was increased, the interior portions slid downwards with increasing velocity, and at a certain stage those in the interior, more particularly of the D_1 line, resembled inverted arrows. At last with increasing proportions of sodium these arrows entirely disappeared, and it was observed that this disappearance was more rapid with the D_2 lines than with the D_1 lines. Among subsidiary features it was noticed that the slope of the interior interference fringes is greater towards the side of the greater wave-lengths than towards the violet. The interior fringes also show a slight asymmetry, so that, *e.g.*, the points of the arrows in Fig. 2 ought to be asymmetrical.

Using very much denser vapours, however, results were obtained agreeing more with the experiments of Macaluso and Corbino. Figs. 3 and 4 show the effects with field intensities of about 4500 and 10,700 units respectively, and the absorption bands appear to contain horizontal parts of an interference fringe which have undergone a very small displacement *upwards* by the action of the field. These horizontal parts are, however, broader and more ill defined than the markings in the circumstances previously described. It is possible that the conditions assumed in these later experiments are different from those required by the theory, and that some explanation of the difference in the two kinds of phenomena may be found.

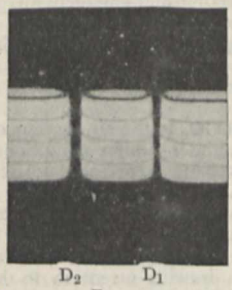


FIG. 3.

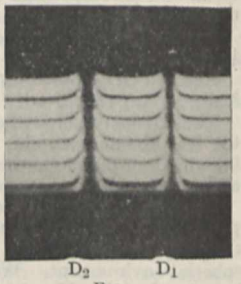


FIG. 4.

In a paper communicated to the Reale Accademia dei Lincei of Rome, also on May 31, Prof. W. Voigt discusses the same phenomenon on a theoretical basis, and quotes the formula

$$n\chi = KP\,\frac{(\Delta^2 - P^2 - 1)}{(\Delta^2 + P^2 + 1)^2 - 4\Delta^2 P^2},$$

where χ denotes the angular rotation of the plane of polarisation, n the geometrical mean of the indices of refraction of the two waves propagated in the vapour, P is proportional to the magnetic field, and Δ is proportional to the number of wave-lengths in the distance of the point considered from the primitive position of the absorption band. From this formula are obtained the curves shown in Fig. 5, which correspond to the values $P = 0{\cdot}5$, $P = 1{\cdot}5$, $P = 3{\cdot}0$, and the resemblance between these curves and Prof. Zeeman's photographs will be readily noticed.

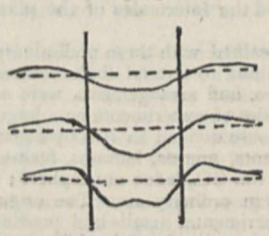


FIG. 5.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following is the letter of congratulation, written by the Public Orator, Dr. Sandys, on behalf of the University of Cambridge, and presented to the University of Christiania by Prof. A. R. Forsyth, F.R.S., the delegate appointed to represent the University of Cambridge on the occasion of the recent commemoration of the centenary of the birth of Niels Henrik Abel:—"Litterae vestrae, viri doctissimi, ad nos nuper perlatae sunt, in quibus certiores facti sumus, annum centesimum ex eo quo natus est alumnus vester insignis, Nicolaus Henricus Abel, Universitatem vestram Nonis Septembribus esse celebraturam. Alumnus ille vester, ut studiorum mathematicorum inter peritos ubique constat, inter scientiae illius ipsos principes merito iamdudum numeratus est, neque in sua tantum vita, intra annorum septem et viginti spatium angustum, nomen immortale est adeptus, sed etiam saeculo in eodem inter Europae gentes scientiae analyticae cultoribus plurimis novos stimulos indidit, et studiorum suorum ad regiones novas explorandas excitavit; e quibus unus, non secus atque alumnus ille vester, provinciae suae pulchritudine singulari commotus, existimavit 'functiones ellipticas non aliis adnumerari debere transcendentibus, sed speciem quandam iis inesse perfecti et absoluti.' Iuvat vitae illius annales ab uno e professoribus vestris summa cum scientia, summa cum humanitate, conscriptos evolvere; iuvat inter socios illius exteros, unum audire suis laudibus, suis laboribus omnibus illum maiorem esse dicentem; alterum, ab illo temporis exigui intra terminos 'monumentum aere perennius' esse exactum, quod indicaret quantum ex ingenio eius sperare licuisset, 'ni fata obstitissent'; iuvat nos quoque inter praeceptores nostros nonnullos numerare, qui alumni vestri vestigiis institerunt, alumni vestri famam indies latius extenderunt. Unum ex eis, etiam in Scandinavia horum studiorum cultoribus non ignotum, nuntium et legatum ad vos honoris causa mittimus, qui nostrum omnium vota optima ad vos perferat, et nostrum omnium nomine viri tanti memoriae celebrandae laetus intersit. Valete."

Mr. R. P. Gregory, St. John's, has been appointed a demonstrator in botany.

The following have been elected to fellowships at Trinity College:—A. E. A. Watt Smyth, P. V. Bevan, O. W. Richardson, F. J. Pollock.

Dr. D. MacAlister has been appointed assessor to the regius professor of physic; Prof. Thomson, F.R.S., an elector to the Isaac Newton studentship in physical astronomy; Mr. J. B. Peace, Emmanuel, demonstrator of mechanism and applied mechanics; and Mr. R. C. Punnett, Caius, demonstrator of comparative anatomy. Mr. Punnett has also been elected to a fellowship at his college.

IT is stated in the *British Medical Journal* that Prof. Johannes Orth, of Göttingen, has been invited to succeed Prof. Virchow in the chair of pathology at Berlin.

THE following appointments have been made at the Hartley University College, Southampton:—Assistant lecturer in physics, Mr. O. W. Griffith; assistant lecturer in electrical engineering, Mr. E. H. Dixon; assistant lecturer in civil engineering, Mr. R. Baldwin Wiseman.

AS already announced, the Manchester School of Technology is to be opened by Mr. Balfour as we go to press with this number. The school has occupied about seven years in building, and represents an endowment of nearly 300,000*l*., largely, but not entirely, of municipal origin. A sum of no less than 25,000*l*. has been expended upon the plant of the department of mechanical engineering alone, and the other departments have been equipped in the same liberal spirit. The city of Manchester thus possesses a technical school which should become an important factor of national progress.

WE have received the calendar of the Bristol Merchant Venturers' Technical College, which contains many illustrations of the workshops and laboratories in that institution. The College provides full courses of training in mechanical, electrical and sanitary engineering, and also prepares students for the B.Sc. examinations of the University of London in the faculties of science, engineering and economics. There are courses of training in the various branches of applied chemistry, including metallurgy, and special classes for persons intending to became architects, builders or surveyors. There is also a navigation department, a school for boys, and numerous evening classes.

THE Clothworkers' scholarship of 60*l*. a year for three years, awarded on the results of the matriculation or entrance examination of the Central Technical College of the City and Guilds of London Institute, has been awarded to W. H. Grinsted, from Horsham Grammar School, who obtained first place at the examination. Free studentships have been awarded by the Institute to W. M. Hooton, from King's Lynn Municipal Technical School, L. G. Morse, from Marlborough College, and H. K. B. Reed, from the South-Western Polytechnic, who came next in order of merit.

AN address on the reorganised University of London was given by Sir Arthur Rücker, F.R.S., at the opening of the winter session of St. Mary's Hospital Medical School on October 3. Referring to the educational equipment of London, he remarked that "it was and is in many respects inferior to what is provided, not only in Germany and America, but in our own provinces. There is not a single laboratory in the metropolis devoted to pure chemistry and physics which will compare in magnitude or in the perfection of its details with some of those which exist elsewhere." The hope was expressed that the teaching of the sciences connected with medicine would be combined with research; so that the University should contribute directly to the advancement of knowledge, and graduates of foreign and colonial universities might be attracted to London to study in research laboratories like those of the recently established physiological department of the University.

THE proceedings at Oxford on October 8 and 9 in connection with the Bodleian tercentenary were marked both by their enthusiasm and by their picturesqueness. Among the multitude of distinguished guests were representatives of the universities, libraries and learned societies in every part of the world. On the evening of October 8, a reception by the Provost of Oriel, in his capacity of Vice-Chancellor of the University, took place in the Ashmolean Museum, where Mr. A. J. Evans exhibited a number of drawings, photographs, plans and casts illustrating the excavations at Knossos, in Crete. On the following morning, a congregation, presided over by the Vice-Chancellor, was held for the purpose of conferring degrees upon certain of the eminent persons present as guests of the University, for receiving congratulatory addresses on the tercentenary of Sir Thomas Bodley's library, and for welcoming the visitors by the Public Orator, Dr. Merry. Among the honorary degrees, that of doctor of science conferred upon Prof. C. S. Minot, professor of histology and human embryology at Harvard University, may be mentioned as indicating that the claims of science were not forgotten. The congratulatory addresses, handed to the Vice-Chancellor by the delegates appointed for the purpose by the university or learned society they represented, were numerous, the list of universities and learned bodies presenting addresses included the following names:—Universities of Cambridge, Dublin, London, Birmingham, Durham, Wales, Edinburgh, Aberdeen, Glasgow, Toronto, Montreal (McGill), Sydney, Allahabad, Cape Town, Paris, Caen, Lille, Nancy, Breslau, Giessen, Göttingen, Leipzig, Kiel, Brussels, Ghent, Louvain, Cracow, Gratz, Copenhagen, Lund, Stockholm, Upsala, Geneva, Lausanne, Harvard, Cornell, Yale, Princeton, Columbia, Pennsylvania, Ireland (Royal), St. Andrews and Victoria, Royal Society, Royal College of Physicians, Royal College of Surgeons, Royal Geographical Society, Royal Irish Academy, Asiatic Society of Bengal, Royal Society of Sciences, Göttingen, Accademia dei Lincei, Rome, and Academy of Sciences, Vienna. After the congregation came the formal visit to the Bodleian Library. No preparations had been made, and the visitors found the Library wearing its every-day aspect. The celebrations were brought to a close by a dinner at Christ Church.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 29.—M. Bouquet de la Grye in the chair.—New experiments on the limit of intensity of current from a battery which corresponds to external electrolytic work apparent in a voltameter, by M. Berthelot. In a circuit consisting of one or more Daniell cells and a voltameter, the external resistance was increased until the gas resulting from the electrolysis was barely perceptible, and the limiting value determined. From these and earlier experiments on the same

subject, the conclusion is drawn that in electrolysis chemical energy is always necessary to commence the action, but not to maintain it. The preparation and properties of a new silicide of vanadium, by MM. H. Moissan and Holt. On heating silicon with an excess of vanadium trioxide in the electric furnace for some time, the silicide VSi_2, previously described, is obtained, which is stable in the presence of an excess of silicon. Another silicide, of the composition V_2Si, has been obtained in three ways—by the interaction of vanadium trioxide (120 grams) and silicon (14 grams), of silicon and vanadium carbide, or of the trioxide, silicon and copper, in all cases in the electric furnace. The new silicide is more infusible than the silicide VSi_2, from which it can also be distinguished by its colour, density, action with hydrochloric acid and easy decomposition on fusion with silicon.—On double fertilisation in the Cruciferæ, by M. L. Guignard. The phenomenon of double fertilisation can be followed completely in *Lepidium sativum* and *Capsella Bursa pastoris*, a detailed description of the stages being given.—Observations of the Perrine-Borrelly comet (1902 *b*), made with the Brünner equatorial at the Observatory of Lyons, by M. J. Guillaume.—The organisation of automatic spectrographs at the Observatory of Meudon, registering the radial movements and the thickness of the solar chromosphere, by M. H. Deslandres. The apparatus briefly described produces on the same plate ninety small spectra giving the radial velocity and thickness at 180 points on the sun's edge. These points are united on a circle of 95 mm. diameter. So far, it has not been possible to make continuous records on account of the expense; similar equipments at different parts of the world are also necessary for complete results.—On the continuous deformation of surfaces, by M. G. Tzitzéica.—On nitro-pyromucic acid and its ethyl ester, and on dinitrofurfurane, by M. R. Marquis. A mixture of nitric acid and acetic anhydride has been found especially serviceable in nitrating in the furfurane series. With ethyl pyromucate a mono-nitro derivative is readily obtained.—On the saponification of nitric esters, by MM. Leo Vignon and I. Bay. The results of experiments on the hydrolysis of various nitrates by sulphuric acid and by soda. The reaction is complex, nitrous acid and occasionally ammonia being produced.—On the utilisation of mineral substances by grafted plants, by MM. Lucien Daniel and V. Thomas. Transpiration is greater in the host than in the grafted plants, the total quantity of mineral material absorbed being considerably modified as a result of the grafting. It was also found that one effect of grafting was to profoundly modify the phenomenon of chlorosis.—On the caoutchouc-producing Landolphia of the French Congo, by M. Auguste Chevalier.—The earthquake at Salonica, by M. Christomanos. The earthquake of July 5, the epicentre of which was between Salonica and Gouvesno, was not of volcanic origin. Its effects were felt at great distances and for several days, hence it is probable that the seismic focus was at a great depth.

October 6.—M. Bouquet de la Grye in the chair.—Remarks by M. Appell on the third volume of his "Traité de Mécanique rationelle."—Observations on the sun made at the Observatory of Lyons with the 16 cm. equatorial during the first quarter of 1902, by M. J. Guillaume. The number of observations is smaller than usual owing to the unfavourable atmospheric conditions. Tables are given showing the number of spots, their distribution in latitude and the distribution of the faculæ in latitude.—Comparison of the tables of Vesta with the meridional observations made between 1890 and 1900, by M. Gustave Leveau.—Remarks on a problem of Clebsch on the movement of a solid body in an indefinite liquid, and on the problem of M. de Brun.—On a theorem of M. Frobenius, by M. de Séguier.—On a derivative of hydrogen peroxide, by M. R. Fosse. The reactions of dinaphthopyranol towards zinc dust, alcohol, pyrogallol and potassium iodide show that it behaves rather as a derivative of hydrogen peroxide than as an alcohol.—The synthesis of some tertiary alcohols; diphenylcarbinols, by M. H. Masson. The results of the action of magnesium phenyl-bromide upon a series of esters is given in summary, with a list of the alcohols and hydrocarbons obtained and their boiling points.—Anhydrous copper-ammonium sulphates, by M. Bouzat. A thermochemical paper.—On the examination and estimation of extract of chestnut wood mixed with oak extract, by M. Ferdinand Jean. The method is based on the fact that extract of chestnut sets free iodine from iodic acid, whilst extract of oak bark has not this property.—On the pectic fermentation, by M. Goyaud. Pectise forms pectic acid at the expense of the pectin. The phenomenon is not qualitatively influenced by the presence or absence of calcium salts.—The elaboration of venogen and of venom in the parotoid gland of *Vipera Aspis*, by by M. L. Launoy. The snake poison is formed in the cells of the parotoid gland of *Vipera Aspis* in two phases—the nuclear phase, with formation of grains of venogen, and the cytoplasmic phase, in which the venogen is transformed into the venom.—Palæontological researches in Patagonia, by M. André Tournouër.—On an enormous carnivorous mammal found in the plastic clay of Vaugirard, near Paris, by M. Marcellin Boule.

DIARY OF SOCIETIES.

FRIDAY, OCTOBER 17.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Oil Motor Cars of 1902: Captain C. C. Longridge.

TUESDAY, OCTOBER 21.

ANTHROPOLOGICAL INSTITUTE (Lecture Theatre, Burlington House), at 5.30.—Huxley Memorial Lecture. Right-handedness and Left-brainedness: Prof. D. J. Cunningham, F.R.S.

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