THURSDAY, AUGUST 25, 1904.

NATURAL HISTORY.

Catalogue of the Library of the British Museum (Natural History). Vol. ii. E—K. Pp. 501–1038. (London: Published by Order of the Trustees, 1904.) Price 20*s*.

Catalogus Mammalium, tam viventium quam fossilium, Quinquennale Supplementum. By E. L. Trouessart. Fasciculus i. Pp. iv+288. (Berlin: Friedländer and Son, 1904.) Price 12*s*.

Our Country's Animals and How to Know Them; a Guide to the Mammals, Reptiles, and Amphibians of Great Britain. By W. J. Gordon. Pp. viii+152. (London: Simpkin, Marshall, Hamilton, Kent and Co., Ltd., 1904.) Price 6*s*.

THOSE responsible for the preparation of the invaluable "Catalogue of the Library of the Natural History Museum" are to be congratulated on the comparatively short interval which has elapsed between the issue of the preceding volume and the appearance of the one before us. About half the works included in the library at the commencement of the undertaking are catalogued in the two volumes now before the public, so that two more volumes, with the addition of a supplement, ought to complete the work. Needless to say, the present volume is compiled on the lines of its predecessor. A feature to which we may direct attention is the printing of the entries in such a manner that they may, if required, be cut out so as to form a card catalogue, the names of authors being given in full with each entry. We venture to think, however, that it would have been better had a few copies been issued with the letterpress on one side only of the paper, so as to have been available for this purpose without the sacrifice of an extra copy. Another noticeable feature is the care with which the dates of publication of works issued in parts have been worked out—in many instances for the first time—whereby several amendments have been made in the commonly accepted dates of certain technical names. An instance of this is afforded in the case of the large series of French voyages entered on pages 606–608 under the heading of France, which contain in many cases original descriptions of species collected during the cruises in question. The bibliographical staff of the Natural History Museum deserves great credit for the accuracy and fulness of detail with which this work is compiled.

With Mr. Palmer's "Index Generum" (recently noticed in our columns) and Dr. Trouessart's work, when complete, the student ought to have little of which to complain in regard to facilities for reference to the literature of his subject. Not that such facilities were by any means uncalled for. During the last ten years or so the number of new generic, specific, and subspecific names proposed for mammals has been so great, and such sweeping changes (whether for better or worse we need not now pause to consider) in current nomenclature have been advocated, that, to use a colloquial expression, naturalists of a conservative type scarcely know where they are. It was, therefore, imperative that something should be done in the way of codifying, and that speedily. Dr. Trouessart, with characteristic energy, has stepped into the breach and supplied the want.

The second, and revised, edition of the author's well known "Catalogue" was published from 1897 to 1899, the last part containing an appendix. To include the additions and changes made since the latter date in an appendix would, however, have been almost a practical impossibility, and as an entirely new edition was considered out of the question, Dr. Trouessart has followed a kind of middle course by the compilation of the present "Supplement," of which the part before us contains the orders Primates, Chiroptera, Insectivora, and Carnivora. While every genus, species, and subspecies is entered, references to the original descriptions are given only in cases where the terms are new, or where they replace those previously in use; in other cases reference is merely made to the last edition of the "Catalogue." By this plan a vast amount of space is saved, without any inconvenience to the student—provided he has access to the original issue.

Dr. Trouessart professes to have brought his labours only down to January, 1903, but many names proposed later on in that year are entered. Nearly all recent proposed changes in nomenclature are adopted—even the transference from the squirrel-monkeys of the name Callithrix to the marmosets so long known as Hapale; but apparently the author will not accept pre-Linnean generic names, as he retains Trichechus for the walrus. Difference in spelling is considered insufficient to justify the use of the same term for two distinct species or groups.

Some idea of the magnitude of the task involved in the compilation of this supplement may be gleaned from the fact that, in the case of the Primates alone, the number of specific (exclusive of subspecific) names has been increased by thirty-five since the appearance of the last edition of the "Catalogue," while most of the genera have been the subjects of more or less important changes and revisions. As usual, Dr. Trouessart's work appears to be exceedingly accurate; as to its value to students, no words of ours are necessary. It is indispensable and unique.

We fear Mr. Gordon's little volume will give rise to a new "Irish grievance," for although Great Britain is alone mentioned on the title-page, the Irish stoat and the fossil vertebrates peculiar to the coal-fields of the sister island come within its scope. Neither is the title in another respect very happy, although we are fain to confess it would be difficult to find a single term to replace the word "animals" in the sense in which it is here employed. Like most other compilers of popular works of this nature, the author appears to be totally ignorant of the existence of that invaluable publication the "Zoological Record"; at all events, we are otherwise unable to account for his omission of any mention of the numerous subspecies of mammals now recognised by naturalists as peculiar to the British Islands, with the sole exception of *Mus sylvaticus wintoni*. One of the worst omissions of this nature is the absence of any reference to the marked distinctness of the British squirrel and its remarkable seasonal colour-changes. As regards nomenclature in general, we observe that while the author avoids such objectionable alliterations as *Vulpes vulpes* and *Lutra lutra*, he is in many respects—notably in the case of the bats—out of date.

In addition to existing types, the author also records extinct forms, but since the amount of descriptive matter allotted to these is very brief, the lists of genera and species are dismal and uninteresting. Nor are they free from error, Hyracotherium, for instance, being described as tapir-like, while Microchœrus is classed as an insectivore instead of as a lemur. Equally glaring are the errors in the list of fossil reptiles, where we find Ornithostoma among the crocodiles, the sauropod Bothriospondylus among the theropods, the theropod Palæosaurus in the sauropods, and many other errors of a similar type, in addition to numerous misprints.

The coloured illustrations, although not perhaps very artistic, are sufficient in most cases to enable the reader to identify the various species without difficulty, while the excellent glossary of technical terms should prove useful to the beginner. While welcoming this little volume as an honest attempt to popularise a knowledge of the British mammals and reptiles, we cannot but regret that the author did not seek specialist advice and assistance before going to press.

R. L.

PHILOSOPHY OF LIFE AND DEATH.

The Nature of Man: Studies in Optimistic Philosophy. By E. Metchnikoff. English Translation edited by P. Chalmers Mitchell, M.A., D.Sc. Pp. xviii+309. (London: W. Heinemann; New York: G. P. Putnam's Sons, 1903.) Price 12*s*. 6*d*.

PROF. METCHNIKOFF'S work is already known to many; it has been widely read in previous editions, and, now that it is offered in an English version, will become still more widely known. The great merits of the work have already been appreciated. The author is an acknowledged master of his subject, and no more fruitful source of valuable ideas could be imagined than a mind which combined with philosophical breadth and acumen an accurate and far-reaching knowledge of every grade of organism. One sees from the apt choice and effective use of examples how thoroughly the author has his materials at command.

If we might characterise with a word the central problem of the book, ethical would seem the term most appropriate. The key-words are harmony and disharmony; we ask sometimes, Why should we be moral? Prof. Metchnikoff's question is rather, Why do we need morality? The answer lies in the existence of disharmonies. The first part of the work deals with these disharmonies as a matter of scientific discovery; they are shown to exist in the structure of organisms throughout the vast scale of nature; not least do we find in man disharmonies of digestion, of reproduction, and of self-preservation; the whole discussion forms a chapter of extreme interest and importance. The second part reviews the attempts of religion and philosophy to account for or alleviate these disharmonies. The polemic is severe; religion especially is arraigned for failing in its own efforts and hindering those of science; belief in immortality is an illusion with which we soothe a mind conscious that it has been cheated of its due. Old age and death form the topic of greatest interest to the author. The principle underlying the third and closing section of the work is that no natural process should be productive of pain; death as the natural end of life should therefore be normally accompanied by a desire for the end; desire depends on physical conditions, and this harmony can only be produced if life is so far prolonged that the desire to live wanes with the physical strength. This, our author thinks, is a harmony which science can in time secure for us; the details must be left for the reader to discover; at any rate, he will find a topic of great interest excellently treated.

Prof. Metchnikoff's reputation in the scientific world is unique; he comes before us here as something more than a man of science, rather as a prophet, one might almost say, as a high priest. Faith, disillusioned, is to leave its old temples and take sanctuary in laboratories. If progress dictates this course, no prejudice should hinder it. Meanwhile the opposition of the second and third parts of this book affords an interesting view of the prospects. Take, for example, the contrast of the philosophic question and the scientific answer. The question propounded is, Can I hope for immortality? Science replies that the proper term of life is, say, 150 years. The spirit cries out to be saved from the prospect of annihilation; science replies that if you live properly you will some day want to die! Clearly one question is asked, but the answer is the answer of another and a different problem. The materialistic bias of a scientific position, accepted uncritically, seems to have left the refuted philosophy and the triumphant science in a kind of asymptotic relation. At the best it would seem that the theory cannot remove the mental disharmony which the realisation of finitude coexisting with the purpose to live must always produce. It is only in the more limited sphere that science succeeds in being optimistic, and the optimism of this book is conditioned upon our ability to regard the spiritual as a subordinate aspect of the material, a point that the disciple may delight to accept but the unbeliever desires to have demonstrated.

The translation of this book seems to have been carefully done, with only an occasional divergence from accuracy. Why have we three distinct spellings of Buddha (p. 120)? *cp*. Bhuddhism (p. 120), and Bouddha (p. 148). Meringitis (p. 132) requires correction, while the sentence "so there were only Tourgéneff . . . and me" (p. 121) might be improved in its grammar.

G. S. B.

OUR BOOKSHELF.

Warrington's Roman Remains. By Thos. May, F.E.I. Pp. 87. (Warrington: Mackie, 1904.) Price 5s. net.

ARCHÆOLOGISTS have long known that a Roman site existed near Wilderspool Brewery, close to the Mersey on the south side of Warrington. Discoveries have been made during the constructions of various canals, and remains have accumulated in Warrington Museum. Now a local antiquary, Mr. May, has attempted during the last eight or nine years to excavate a small portion of the site—some two or three acres out of an estimated total of thirty or thirty-five acres. In the volume before us he collects, revises, and illustrates various accounts of his work which he had previously published in scattered papers. The collection is a useful contribution to the local study of Roman remains. It has the merits and demerits of many books of the same kind. In his general attack on the problem of what Roman Warrington was, we think Mr. May has not succeeded. He calls it "a partly fortified industrial town" extending over a quarter of a mile on both sides of a Roman road; but his fortifications are puzzling, and his furnaces, smelting floors, &c., do not constitute an "industrial town" in any proper sense of that phrase. On the other hand, he records interesting minor discoveries in the way of pottery and small objects, and the traces noted by him of glass workers, iron workers, and potters are noteworthy, though it may be rash to call them "the earliest in Britain." The little volume is well illustrated, though printed on rather unpleasant paper.

The Experimental Bacterial Treatment of London Sewage. (London County Council.) By Prof. Frank Clowes, D.Sc., and A. C. Houston, M.B., D.Sc. Pp. xii+242. (London: P. S. King and Co.) Price 10s.

THIS report contains an account of the experiments carried out by the London County Council during the years 1902 and 1903. The main conclusions arrived at by Prof. Clowes in the first part (chemical and general) of the report are that coke is a suitable material for bacterial beds and does not disintegrate during use, that the bacterial effluent of settled sewage from such beds does not undergo offensive putrefaction and supports fish life, and that the use of chemicals is unnecessary when this mode of treatment is adopted. In the second part Dr. Houston deals with the bacteriological portion of the experimental work. His results seem to show that though the number of bacteria in the effluent from coke beds is less than in the corresponding crude sewage the reduction is not well marked, and while the bacterial effluent is chemically satisfactory, the bacteriological results are usually quite the reverse, because the microbes pass through the coke-beds. There seems to be small ground for belief that the typhoid bacillus would be destroyed in the beds; an important conclusion.

The report is copiously illustrated with diagrams and photomicrographs. R. T. HEWLETT.

Round the Coast. A Reading Book for Schools. By George F. Bosworth. Pp. viii+248. (London: George Routledge and Sons, Ltd., 1904.) Price 1s. 6d.

THESE short, miscellaneous reading lessons will serve to teach boys and girls many interesting facts about the geography and history of England. Numerous poetical pieces are included, and the maps and pictures much increase the book's attractiveness.

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.]*

Synthesis of Radio-active Substance.

IN connection with the suggestive letter of Sir William Ramsay and Mr. Cooke, the following observation appears to be of some interest. My friend Prof. H. H. Dixon, in conjunction with Dr. Wigham, in the course of some experiments on the β and γ radiations of radium on bacteria used a platinum rod to cast a shadow on the culture, in order the better to estimate by contrast whether the rays had effected the culture or not. The platinum rod so used to intercept the rays was of cylindrical form and about 3 mm. in diameter. Prof. Dixon's and Dr. Wigham's observations are published in the *Proc.* R.D.S., and also in NATURE.

Happening at the time to be repeating some of Dr. Russell's well known experiments on the influence of metals on photographic plates, I used this rod, among other specimens of metallic elements, to observe their photographic activity. This was about thirty days after Dr. Dixon had made his experiments. I was surprised to find that the rod, after resting twenty-four hours upon an instantaneous plate, had not only affected the plate, but had also produced all the appearance of intense solarisation, darkening the plate in its neighbourhood, but clearing it completely along the line of contact. The negative is still in my possession.

In this experiment the only action upon the plate was from the γ and β rays, the radium (5 mgrs.) being enclosed in a sealed glass tube.

In a subsequent experiment, a copper coin kept enclosed along with some radium contained in an aluminium button, when tested photographically, gave no specially marked result.

It would be desirable in experiments of the kind described by Sir William Ramsay and Mr. Cooke that α rays should in some cases be permitted to exert their influence. If Dr. Harold Wilson's suggestion as to the nature of these radiations is correct, it may well be that these positive ions may take part in synthetic effects.

I have already ventured to suggest the possibility of the synthetic origin of radium, partly in answer to a difficulty I have not seen discussed, *i.e.* what becomes of radiated ions when these are absorbed by atoms. J. JOLY.

Valencia, Co. Kerry, August 14.

Action of Metals on Photographic Plates.

IN the course of the experiments referred to above, as to the nature of the Russell effect, I found that metals (pure mercury and polished speculum metal) placed in contact with a rapid plate submerged under absolute alcohol, and the whole enclosed in an air-tight desiccator over calcium chloride, afforded the photographic marks on subsequent development just as vigorously as if obtained in ordinary moist air. Is not this experiment sufficient to show that Dr. Russell's explanation, which refers these marks to the formation of hydrogen peroxide, cannot be correct? Ought we not rather to seek the explanation in the ionising properties of metals indicated by other observations?

August 14. J. JOLY.

"The Primrose and Darwinism."

YOUR readers may remember a book published under the above title some few years ago, and my apology for bringing up the subject again is the delight with which many reviewers hailed it as totally destructive of Darwin's theory of the fertilisation of the primrose. Whilst viewing with distrust the entirely unscientific method displayed in the book, I considered a useful purpose might be served by repeating some of Darwin's primrose experiments under different conditions.

Plants of primroses were therefore potted up and forced in a hothouse in February, 1904, and crossed and selffertilised, and experiments of a similar nature carried out on wild plants *in situ* in June, 1903, and also June, 1904.

In no case could I get a flower to fertilise itself, though crossed flowers produced abundant seed under both conditions. A correspondent in Edinburgh, experimenting upon primroses for quite another purpose, confirms my experience in this matter.

The author of the above-mentioned work has in my opinion fallen into the common error of deducing a function from a structure without recourse to the experimental method, a mode of procedure which has, I believe, led him into grave error. E. A. BUNYARD.

The Bungalow, Allington, Maidstone, August 8.

An Optical Phenomenon.

MR. HILLIG's letter in NATURE of August 18 (p. 366) reminds me of a somewhat similar phenomenon which I observed last May when using a rotating cubical mirror and sensitive flame.

When the mirror was rotated by hand at moderate speed the upper and lower edges of the band of light seen in the mirror presented exactly the appearance of a faint spectrum, red being outside and pale green and blue inside. The central portion of the band was colourless.

The appearance was most distinct when the flame was influenced by a sound.

I repeated the experiment to-day with the same result.

GEORGE W. WALKER.

Physical Laboratory, The University, Glasgow, August 19.

Traction of Carriages.

IN further answer to your correspondent, p. 270, in passing along a road the wheels of a carriage encounter many small obstacles and inequalities over which they have to rise. In doing so the centre of gravity of the load (which is always higher than the axles) is raised to a greater vertical height when the axles are far apart than when they are close together. The work done in the former case is, therefore, greater than in the latter, by an amount the magnitude of which is proportional to the difference between the versed sines of the angles through which the carriage is tilted in each case respectively. The same argument applies in regard to lateral oscillations of the centre of gravity with the corollary that the narrower the gauge the more easily is the carriage propelled or drawn.

There may also be some question as to the influence of the different rates of retardation and acceleration of the centre of gravity in each case.

Cardiff, August 1. W. GALLOWAY.

Indian Rhynchota.

IN the issue of NATURE of August 11 (p. 341) there appeared a notice of my second volume on "Indian Rhynchota" (Blanford series), in which I read, "the two last families of the Gymnocerata (Hebridæ and Hydrometridæ) are left over to be included with the Cryptocerata" in the third volume.

This is an error. They have already appeared in their proper location, vol. ii. pp. 167 and 168–192.

W. L. DISTANT.

Steine House, Selhurst Road, South Norwood, S.E.

[The reviewer regrets the oversight which Mr. Distant has pointed out.—ED.]

The Earliest Mention of Hydrodictyon.

TWAN CHING-SHIH (*ob.* 863), in his "Yû-yang-tsah-tsu," Japanese edition, 1697, tom. xix., fol. 12, *a*, writes:—

"The *Shwui-mung-tsiau* (literally, Water-net-alga) grew in Kun-ming-chi [an artificial lake formed by the order] of the Emperor Wu-ti of the Han dynasty [reigned 140–87 B.C.]. Its branches, spreading sidewise, now come out of water slantly. It was eight to nine feet long and so closely resembling the meshes of a net that the ducks could not come out of it when got therein. Hence the name."

This is likely to be an exaggerated Chinese account of the now well known water-net (*Hydrodictyon utriculatum*, Roth.). In this part, when a paddy-field has its water drained off, we meet frequently this alga, "spreading sidewise, now coming out of the remaining water slantly," although such a gigantic dimension as "eight to nine feet" is totally out of the question. Perhaps this is the earliest record of the alga. KUMAGUSU MINAKATA.

Mount Nachi, Kii, Japan.

MARCONI WEATHER TELEGRAMS.

METEOROLOGISTS have for a long time felt that they have practically come to the limit of their resources in the matter of weather forecasting, so far as the weather changes in the British Isles are concerned, except, perhaps, if finance allowed that telegrams might be received at a later hour than 6 p.m. This later information might avoid the possibility of a storm system advancing towards our western coasts slipping in unobserved between the present hours of observation, 6 p.m. and 8 a.m., without proper intimation of its approach by the fall of the barometer and the backing of the wind being duly notified. Occasionally some of our worst storms spread over us in this way, and the forecaster, who has been unable to foresee the incoming disturbance by aid of the 6 p.m. weather telegrams, finds to his dismay when viewing the next morning's weather information that the full violence of the storm is upon us, for which no storm warnings have been issued. In this way, from time to time, the central area of an important storm is well over the United Kingdom before our Weather Office is aware of its existence.

Wireless telegraphy promises to supply the missing link in the connection of our shore weather system with that over the ocean to the westward of us, and the present praiseworthy effort on the part of the *Daily Telegraph* seems likely to prove, even now with the restricted powers of the Marconi system, that useful information can be obtained. The messages at present are transmitted only about 100 miles from land, but the scheme which has been most ably inaugurated has provided that, in addition to the latest weather report when approaching our shores, there should also be a report of the weather experienced some time previous, so that it is not merely an isolated observation with which we have to deal, but a fair knowledge of the weather from about mid-Atlantic is secured. This information is at times supplied by two or three vessels, so that synchronous observations are obtainable, and it will easily be understood that with further development of the system an approximate synoptic and synchronous map of the Atlantic may be produced. The storm areas very frequently follow a course almost due east when approaching our islands, but often when in fair proximity to our coasts they trend to the north-east, and any help in enabling a true estimate to be formed of the storm's path will be of the greatest possible advantage to the forecaster. Information with settled conditions will be of great value, since it is expected that forecasts should show with some certainty the advent or continuance of settled weather. When an area of high barometer readings is situated to the westward of our shores, and is willing to give way, it affords an indication of the early approach of storm systems, with disturbed weather, from the open ocean, while if the anticyclone maintains its ground the approaching disturbance will be fended off and made to follow a course more to the north-east, and may be taken altogether beyond the limits of the United Kingdom.

For some time past the Meteorological Office has had in hand the charting of the weather over the North

Atlantic, for which purpose it obtains observations of wind, weather, barometer, and temperature of air and sea from observers in the Mercantile Marine who are willing to assist in the advancement of our knowledge of the weather in this way, and a daily chart is prepared giving a picture of the weather over the Atlantic and for the adjacent continents of Europe and America for 8 o'clock each morning. A study of these is helpful to the furtherance of our better understanding of meteorology and its complicated problems, but necessarily these charts picture only what is past, although they afford an explanation of success or failure in forecasting, and often show why an unexpected and altogether unlooked for change of weather has occurred. These charts are prepared as closely as possible to date of occurrence. When the Meteorological Office has the advantage of receiving messages by the wireless telegraphy, both from outgoing and incoming Atlantic liners, they will unmistakably possess a power which has long been known to be wanting. The *Daily Telegraph* has taken the initiative, and it is to be hoped that the arrangements which the Meteorological Office has already been endeavouring to make with Lloyd's for fuller information will shortly meet with that success which it deserves, for the advancement of science and for the public benefit.

With the further development of Marconi's system there seems every reason to hope that we in England may be placed much on the same footing as Denmark, for example, is now, in full possession of the knowledge of what is going on for several hundred miles to the westward of the base of operations, to the immense gain of the forecaster for the country concerned. Knowing what is going on over the Atlantic to the westward of us would not only secure greater accuracy of forecast, but the time limit could probably be extended from twenty-four hours, as at present, to, say, forty-eight hours at least.

PROF. J. D. EVERETT, F.R.S.

THE death of Prof. Everett has removed a familiar figure from the ranks of English physicists. The news of his death came as a shock to his many friends and others acquainted with his great vitality and his intellectual activity, which seemed to remain quite unimpaired by advancing years. Some seven years ago he retired from teaching work in Queen's College, Belfast, where, for upwards of thirty years, he had occupied the chair of natural philosophy. Since that time he resided in London, where he took an active part in the proceedings of scientific societies, specially of the Physical Society, of which he was a vice-president.

Dr. Everett's name has been familiar to many generations of students of physics through his admirable translation of Deschanel's treatise, which has long served as a standard text-book. Many editions of this were called for; and as each fresh edition was carefully brought up to date by additions and alterations, the book became ultimately almost entirely a new work. Another very important service to physical science was rendered by the publication of Prof. Everett's book on the C.G.S. system of units. This very useful compendium made its first appearance at the time when the question of fixing the practical electrical units was being discussed, and proved of material service in that connection. It gives not only clear and precise definitions of fundamental quantities, but also numerical data carefully selected and compiled.

Dr. Everett's earliest original work consisted of an experimental determination of the elastic constants of certain solids. Subsequently he confined himself to work on his text-books and to theoretical investigations. His published papers, which appeared for the most part in the *Philosophical Magazine* or in the pages of this Journal, show by their subjects the wide range of his interests. Thus recent papers treat of the theory of combination tones, Hering's colour-theory, dynamical illustrations of optics, the theory of rent, the properties of certain linkages, and the mathematics of bees' cells. His last paper, elucidating a point in connection with Osborne Reynolds's theory of the universe, appeared only a month or so ago. He served for many years as recorder of the British Association Committee for Investigation of Underground Temperatures, and did much valuable work in drawing up the annual reports.

Dr. Everett's energy and ingenuity found outlets also in directions not purely scientific. He was the inventor of a system of shorthand which has found many adherents. He devised an extended form of slide-rule, ingeniously arranged on sheets of cardboard. An early and enthusiastic votary of cycling, he was much interested in cycle construction, and was an active member of the Cyclists' Touring Club. A man of great kindliness and geniality, he will be missed in many circles. His pupils will remember him always with gratitude and affection.

THE BRITISH ASSOCIATION AT CAMBRIDGE.

THE meeting of the British Association at Cambridge concluded yesterday. The meeting has been in every way a success. In all the sectional sessions large attendances were secured, and the general and social meetings were all successfully carried through and greatly appreciated. In regard to numbers of members, the Cambridge meeting was the largest since the Liverpool meeting of 1896. At this meeting there were 3181 members and associates, at the meeting just concluded at Cambridge the number of members and associates was 2783. It is interesting to compare the numbers of other large meetings with the one just held. The largest number of members and associates that have attended a meeting was at Manchester in 1887, when the number was 3838. At Newcastle in 1863 there were 3335, at Liverpool in 1870 there were 2878, and at Bath in 1864 the number was 2802. These meetings are the only ones which have had a larger attendance than that at Cambridge, and it is interesting to observe that in all these cases the meeting has been in a large city where the number of resident members and associates naturally would be very much larger than in a comparatively small town such as Cambridge. Compared with recent years the numbers show a large increase. Last year in Southport 1754 attended the Association, in Belfast the year before there were 1620, and in Glasgow in 1901 there were 1912. Comparing the meeting just concluded with the three former meetings held in Cambridge we find a great increase in numbers. In 1833 there were 900 members and associates, in 1845 there were 1079, and in 1862, 1161.

The cause of the great popularity of the Cambridge meeting this year is undoubtedly to be found in the great growth and expansion in scientific work at the University during the last twenty-five years. The work done at Cambridge in the last quarter of the nineteenth century in all branches of science has made Cambridge a great centre of attraction for scientific men the world over. At this year's meeting there were present 121 foreign members. Amongst these there was a large number of physicists attracted by the Cavendish Laboratory, and the interest attaching to it owing to the great succession of Profs. Maxwell, Rayleigh, and J. J. Thomson. The school of research built up by J. J. Thomson has done so much in investigating, especially the new field opened in physics in the last few years, that "the Cavendish" has attracted physicists from all parts of the world. In other branches of science also, in chemistry, in physiology, in zoology, in engineering, in anthropology, in fact, in almost all departments, the new spirit of research, which has permeated Cambridge, and the men who have done so much to put Cambridge in the forefront of progress in scientific discovery, has made this University a great attraction to all those who have the advance of science at heart.

The large number of serious students attending all the sectional meetings this year has been an encouraging sign, showing that the increase in numbers has not been due merely to the camp followers of science, but to those who are really interested, and who wish to make of the British Association more than an annual week of excursions and garden parties. There have been, of course, a large number of members and associates who have not joined the Association for any other purpose than a week of pleasant social meeting, and in some ways it seems a pity that there should be such a number who do not really add to the usefulness of the meeting.

This is not the place for any detailed account of sectional meetings, full accounts of these will appear in other columns of NATURE. Here all that is necessary is to give a short account of the general meetings and lectures. With regard to the entertainment of the Association there has been expressed by visitors to Cambridge nothing but satisfaction. The reception of the members of the Association by the President in Trinity College was a most successful meeting. Over 2000 members attended and were received by Mr. Balfour in the hall. The grounds and courts were illuminated. The President's address was delivered in the Corn Exchange, which was decorated for the occasion, and above 2000 members were present. At Peterhouse about 600 of the members were entertained by invitation of the Master and Fellows. The grounds of the college were illuminated, and a very pleasant evening was spent.

On Friday evening a reception was held at the invitation of the Cambridge Philosophical Society in the combination room and hall of St. John's College. Dr. Baker, the President of the Society, presided. This reception, which was limited in number, and for gentlemen, especially the foreign members of the Association, was perhaps the most successful meeting held. Smoking was freely indulged in, and more was done in the way of promoting acquaintance and friendship between members of the Association than at any other time. Garden parties were held at Emmanuel College, by invitation of the High Sheriff, at Newnham and Girton Colleges, and at the Botanic Gardens, by the invitation of the Lord Lieutenant of Cambridgeshire and the Mayor of Cambridge. The lectures by Mr. J. W. Clark, Prof. Darwin, and Prof. Osborn were crowded, and Mr. Clark and Prof. Darwin repeated theirs to afford the many members who could not obtain tickets the opportunity of hearing them. On Monday honorary degrees were conferred in the Senate House upon representative leaders in science, and the speeches delivered on that occasion are printed elsewhere in this issue (p. 418).

Acting upon the suggestion of the council of the Association, several of the sections arranged discussions upon subjects of wide scientific importance, and devoted afternoon meetings to lectures of a semi-popular character. The discussions have in each case elicited the expression of inspiring and authoritative opinion, and when the subjects of the afternoon lectures have been of a character which appealed to members of the Association in general, and not only to members of a section, the lectures have been attended by large and appreciative audiences. This year's experience shows unmistakably that when sufficient care is taken in the selection of suitable lecturers and subjects, the afternoon addresses are most successful. For the benefit of members of the Association who are not actively engaged in scientific work, but are interested in the progress of natural knowledge, it is to be hoped that these lectures will be given a place in the programme of each section in future meetings.

In the physics sub-section of Section A, great interest was shown in the discussion opened by Prof. J. J. Thomson on radio-activity. Amongst other papers perhaps the most interesting was that of Prof. Rubens, on the optical properties of metals, in which he showed that the theory of Maxwell led to results for reflection from metallic surfaces, which agreed within the limits of experimental error with the actually observed results for infra red rays of wave length about thirty times that of visible light. This result was particularly interesting in the university of Maxwell, as for many years the non-agreement of the theoretical and observed results was regarded as limiting the applicability of Maxwell's theory to the range of steady currents and slow oscillations. The discussion on n-rays left those who heard it with the conviction that the phenomena said to be observed correspond to no objective physical reality. In the section devoted to economics the morning given to discussion of fiscal problems was of general interest. The opinion of scientific economists, as far as it was represented in the discussion, is distinctly in favour of free trade. The articles dealing with the separate sections will describe the results of the sectional meetings; the two mentioned have been introduced because of their general interest; the new theory of the constitution of matter being one which has appealed to all men of science as well as physicists, and the economic question being also one of interest wider than Section F. With regard to the new views of the constitution of matter, it seems unnecessary to take quite so serious a view as was expressed by the President of the Association. The new view is in no way contrary to older theories of the atomic and molecular theories of matter, but is an extension and explanation of these, and in the hands of Prof. J. J. Thomson, has made, at any rate to physicists, a simplification and rational view of these without introducing the question of physical reality.

One of the most interesting features of the meeting has been the museums and laboratories, which have been open for inspection during the Association week. Special mention should be made of the zoological exhibits, and the exhibit of teaching apparatus and experiments by Mr. Searle, in the Cavendish Laboratory. Among the demonstrations we may mention, as of special interest, that of Prof. R. W. Wood, of Baltimore, of the anomalous dispersion of sodium vapour; that of Messrs. Heycock and Neville, on methods of investigating metallic alloys, and of Prof. Schäfer, on methods of artificial respiration.

The report of the council which was presented to the general committee on August 17 referred to the organisation of the deputation which waited upon the Prime Minister on July 15, to urge the importance of increased national provision being made for university education. The result of the action thus taken by the president at the request of the council has already been described in NATURE (July 21, p. 271). Several matters relating to the business of the officers of sections were mentioned in the report, and it was recommended that the following resolution sent to the council by the general committee for consideration, should be acted upon:—

That the sectional committees be continued in existence until the new sectional committees are appointed, and be authorised to bring to the notice of the council in the interval between the annual meetings of the Association any matter on which the action of the council may be desired in the interests of the several sections, and that a committee may be summoned at any time by the president of the section, or by the council.

Hitherto, the organisation of the work of the sections, and the arrangement of the programme, have been in the hands of the officers, but by this resolution the sectional committees are given a voice in the matter during the year between one meeting and the next, instead of ceasing to exist at the close of the meeting at which the members are appointed. The sectional committees, as at present constituted, are, however, so large as to be almost unmanageable as working committees, and probably the simplest practical way to secure continuity would be to select, say half a dozen members, from each committee to work with the officers during the year. The only other plan would be to limit the number of members to be appointed upon the committee of each section.

The members of sectional committees are not, in virtue of their membership, expected to take any essential part in the work of a section, though they may, and occasionally do, attend the meetings of the committees upon which they are appointed. In some cases vice-presidents understand their functions to be of the same negative significance, and neither attend the meeting for which they are appointed, nor send a timely notice of their inability to do so. To avoid this inconvenience the council has resolved that gentlemen nominated as vice-presidents of sections be informed that their attendance at the meeting for which they are nominated is expected.

Arrangements for the South African meeting in 1905 have received much attention during the year from a committee of council appointed for the purpose. The first half of the meeting will be held at Cape Town and the second half at Johannesburg, and official visits of the Association will be made to Natal and the Orange River Colony, in each of which colonies one or more discourses will be delivered by prominent members of the Association. The meeting will open at Cape Town on August 15, so that members starting for South Africa at the end of July will be able to spend at least three weeks in the colonies, and be back in England by the end of September. Prof. George Darwin will be the president of this meeting.

At the meeting of the general committee on August 19 the invitation to meet at York in 1906 was accepted unanimously.

Upon the proposal of Sir J. Dewar, seconded by Sir A. Rücker, Prof. J. Perry was elected to fill the office of general treasurer, in succession to Dr. G. Carey Foster, who has resigned that post.

A vote of thanks to Sir Norman Lockyer for the way in which he has discharged his presidential duties was proposed by Sir Henry Roscoe and seconded by Prof. Perry, and carried unanimously, as was also a similar vote of thanks to Dr. Carey Foster, moved by Sir A. Geikie and seconded by Major Macmahon.

SECTION A.

SUBSECTION, COSMICAL PHYSICS.

OPENING ADDRESS BY SIR JOHN ELIOT, K.C.I.E., M.A., F.R.S., CHAIRMAN OF THE SUBSECTION.

WHEN the suggestion was made to me that I should preside over this important Subsection my first thoughts prompted me to decline the honour. The position had been filled during the past two years by two distinguished physicists, both of whom had dealt chiefly with the problems and the position of meteorological science, and hence I thought that it should be offered to some representative of cosmical physics. I also doubted whether an official meteorologist whose time has been chiefly given up to duties of administration could have anything of interest to communicate to you. However, on fuller consideration it occurred to me that I might be able to place before you some features of Indian meteorology leading up to and assigning, as I hope, adequate reasons for the study of a portion of the field of tropical meteorology as a whole.

My address consists of three parts, viz.:

(1) A brief sketch of the broad features of the meteorology of India in their relations to the general meteorology of the Indo-oceanic region.

(2) Statement of abnormal features of the meteorology of that area for the unique period 1892–1902 illustrating the remarks in the preceding sketch.

(3) Suggestion of the co-ordination of the meteorological observations of the British Empire and the creation of a central office for the investigation of problems of general meteorology.

India is the most typical example of monsoon conditions, that is, of opposite air movements of six-monthly period which, in its case, depend on the annual temperature changes in the sea and land areas of the Indian Ocean and continent of Asia. The monsoon conditions in India are intensified by its unique position and topography. It projects southwards into the Indian seas over 15° of latitude, and is protected northwards by the vast barrier of the Himalaya Mountain range and Tibetan plateau. The axis of the Himalayan range is at least 2000 miles in length and has an average elevation of more than 20,000 feet. The extent of country more than 10,000 feet in elevation to the north of India is from 300 to 500 miles in width. These figures will give some idea of the magnitude of India's northern barrier.

During one period of the year there is an outflow in the lower atmosphere from land to sea. The direction of the lower air drift in India is determined in part by the lie of the mountains and river valleys, and is from north-east over the greater part of the Indian seas. January is the month most typical of this air movement and of the accompanying weather conditions.

During another portion of the year the lower horizontal air movement is from sea to land. This movement is much steadier and more powerful and influential in every respect than the former. July and August are the months most representative of the totality of the weather conditions of this period.

Conditions similar to those of January prevail in their entirety from about the middle of December to the end of February or middle of March—the period known in India as the cold weather or cool season. The lower horizontal air movement in India during the period has its origin in Upper India, where it is very feeble, and whence it increases seawards and is of moderate force in the Bay of Bengal (mean force 2 to 3, Beaufort scale) and the Arabian Sea (mean, 2 to 4). It is fed to a certain extent by drift down the river valleys, and passes in the North-West India frontier hill ranges. There is, on the other hand, no general drift down the Himalayan river valleys or across the main ranges from Central Asia. The normal air movement in the Western Himalayas (and perhaps the whole range) is an alternating up and down, or day-and-night movement, depending upon the diurnal heating and cooling of the plains of Northern India. Hence India (in its lower air movement) is at this time completely shut off from Central Asia.

The lower air movement is continued over the Indian seas southwards to a region of vertical movement over a narrow belt a little to the south of the equator. This belt is also the goal of the lower air movement of the south-east trades circulation at this time. The equatorial belt of calms is hence the termination of the lower air movement of the south-east trades and north-east monsoon. It is chiefly an area of uptake, and of outflow northwards and southwards, to replace the lower air inflow from the distant south and north. The influx to the Indian land area occurs chiefly or entirely in the upper and (perhaps) middle atmosphere. There is also, as indicated by the wind directions in the lower Assam and Burma hills, an influx from the adjacent seas in the upper portion of the lower atmosphere.[1] The diurnal land and sea breezes alternate with great regularity on the west coast south of Gujarat during this period, but probably do not contribute to the general upper influx compensating in part or whole the lower outflow.

The circulation over the Indo-oceanic region hence consists at this time of two semi-independent circulations, with a common sink or goal for the lower air movement, which shifts with the season and with the relative strengths of the two movements. It is hence probable that they react on each other to some extent, and possible that general abnormal actions may affect the two similarly.

The normal weather during the period is similar to that which obtains in anticyclonic periods during the summer in Central Europe—viz., the prevalence of light winds, with clear or lightly clouded skies, low humidity, moderate temperature, and large diurnal range of temperature, with a bracing, exhilarating atmosphere.

It is interesting to note that the air movement in India itself is from opposite directions in Northern India and the peninsula, with a belt of unsteady movement over the area of the Vindhya and Satpura hill ranges. The variations of weather conditions from the normal are as a rule inverse in these two regions—viz., Extra-tropical and Tropical India.

The season of the opposite air movement is present in its most complete form in July and August, and lasts from the beginning or middle of June to the middle or end of September. It commences as a lower air movement in an anticyclonic region over the South Indian Ocean, and is thence continued northwards to Abyssinia, South Arabia, India, and Burma. Persia, Afghanistan, and Baluchistan (where dry hot north-west winds chiefly prevail) are outside the field of this movement. The direction of the movement is from south, with more or less easting to the south of the equator, and with more or less westing to the north of the equator, dependent in part upon the earth's rotation and in part upon local conditions and the influence of neighbouring land areas, and hence more effective in the Bay of Bengal than in the Arabian Sea. This lower air current advances over an extensive tropical oceanic region before it reaches Southern Asia, and hence arrives charged with vast stores of aqueous vapour, which it discharges chiefly over the peninsulas of Southern Asia and the mountain region of Abyssinia.

The regions of rainfall indicate the areas of upward movement terminating the lower advance of the current. The circulation is undoubtedly maintained in large part by the release or addition of energy due to the condensation of its enormous stores of aqueous vapour. The lower air movement is of very considerable elevation, estimated at 15,000 to 20,000 feet in India. Above it is the outward upper return movement, in part only compensatory, and in part probably slowly filling up the Central and Southern Asian low-pressure region. The movement exhibits some interesting features in India, due to the fact that of the three areas to which it is mainly determined India alone is subject to a double influx from two sea areas in opposite directions. The current from the Arabian Sea passes eastwards across the Malabar, Konkan, and North Bombay coasts, the peninsula and Central India. The Bengal current is deflected in the north of the Bay and Bengal, and advances in a westerly direction up the Gangetic plain. Between the areas or fields of the two currents (roughly proportional to their relative strength and importance—viz., about 2 to 1) is a debatable area of variable winds and low pressure. This trough of low pressure varies in position with the relative strengths of the two currents. The cyclonic storms of the period, which are of comparatively frequent occurrence, advance along the trough. It is hence a factor of considerable importance in determining the distribution of the rainfall of the period. The trough is purely a resultant of the peculiar conditions of the air movement, and is not the cause of that movement; in other words, it is determined by it, and does not determine it.

[1] In India the lower atmosphere may be defined as from 0 to 5000 feet, the middle atmosphere from 5000 to 15,000 or 20,000 feet, and the upper atmosphere above 20,000 feet.

The transformation of the double circulation of the north-east monsoon period into the single circulation of the south-west monsoon over the Indo-oceanic region next requires consideration. It is evident that the chief stages in this change are (1) the discontinuance of the vertical movement over the equatorial belt; (2) the extension of the trade winds of the south-east trades across the equatorial belt, with an accompanying increase of pressure and of horizontal air movement; (3) the continuance of that northerly movement over the Indian seas into the peninsulas of Southern Asia.

The marine data of the Indian seas collected during the past fifteen years establish fully that this transformation is primarily due to actions in the Indian Ocean, producing a movement resembling in many respects that of a bore or storm wave. The actual transition may hence be described as catastrophic, due to impulsive action.

It is preceded in India by a period of preparation (as it may be termed), when pressure and other conditions are slowly established in Southern Asia, which directly contribute to the advance of the monsoon winds over the Indian seas, but which in no way assist the preliminary burst across the equator, the first stage towards the establishment of the south-west monsoon circulation.

This preliminary period is the hot-weather season, lasting from about the middle of March to the middle of June (on the average in Northern India). During this period temperature increases rapidly until the last week in May or first week of June, when maximum day temperatures ranging between 120° and 125° are usually recorded in the driest and hottest interior districts of Northern and Central India. Pressure decreases *pari passu* in the heated land areas of Southern Asia, which become areas of low pressure and indraught relative to the neighbouring seas. The indraught only extends to a comparatively short distance landwards and seawards from the coasts, more especially in the larger sea area, the Arabian Sea, over the centre of which light variable or northerly winds obtain even immediately before the advance of the monsoon currents. In the interior of Northern and in Central India exceedingly dry and hot westerly winds prevail with great steadiness.

The weather in India during this period depends almost entirely upon local thermal actions and contrasts of temperature and humidity conditions. Skies are generally free from cloud, but the air is more or less charged with dust and is excessively dry (humidities of 1 to 5 being of occasional occurrence in North-Western India).

The characteristic features of the dry season are hence most strikingly exhibited immediately before the advent of the wet monsoon. There is no gradual change over the greater part of India from one to the other such as would occur if the furnace, or Central Asia hot area, theory were correct. Over small isolated portions of India, including Tenasserim, Arakan, Lower Burma, Assam, Bengal, and Malabar, thunderstorms giving more or less heavy downpours occur in increasing frequency during the period. The rainfall is considerable to large in amount in these areas, and is of much agricultural value in some districts—*e.g.*, in Assam for the tea crop. In those areas the transition to the rainy season is much less abrupt and spasmodic, the chief differences being that the rainfall in the wet season is more general and frequent, larger in amount, *and rarely accompanies thunderstorms.*

The transformation from the hot weather to the rains is usually effected between June 1 and 15. It commences in the equatorial belt with a considerable increase of pressure and air movement accompanying a strong rush of southerly winds, the continuation of south-east trade winds, across the equator. If the burst be sufficiently strong the rush is continued northwards over the Indian seas as a wave of disturbance, squally weather, heavy rain, and much violent electric discharge or action, invading areas characterised previously by light and variable winds and fine weather. The disturbance usually increases with its northward advance, and frequently, when it reaches lat. 12° to 16° N., it concentrates into a cyclonic storm. Such a storm almost invariably marks the commencement of the monsoon in the Bay of Bengal, and in about two out of five years in the Arabian Sea. The advancing humid currents in the rear of these initial cyclonic storms or waves of disturbance march over the sea areas in a few days, and thence cross the coasts towards which they are determined by the low-pressure regions in the land areas of Southern Asia, where they produce an almost complete reversal or transformation of the weather conditions, the result of which is that moderately high temperature and small diurnal range of temperature, great humidity frequently approaching saturation, much cloud, and frequent rain obtain for the next three months over the greater part of India, until, in fact, the middle or end of September.

The reverse change—viz., the withdrawal of the humid south-west currents—then commences, and is a slow process, requiring usually from two to three months for its completion.

This is due to a gradual decrease of strength, and hence to a fairly continuous contraction of the field of the current, and also of its elevation or thickness. The current first withdraws from North-Western India, being replaced by light, variable, or north-westerly land winds. These land winds increase in extension and volume with the continued contraction of the south-west monsoon current. The more important phases of the contraction and withdrawal of that circulation from India are of especial interest. The first phase, the retreat of the current from North-Western India, accompanies a rise of pressure over the Persian area and North-Western India, with a shift of the trough of low pressure from W.N.W. to N. or N.E. and corresponding change of direction of the average tracks of the storms of the period. This is followed after a short period of rain in North-Eastern India and Burma by a rise of pressure in Assam, Upper Burma, and Bengal, and the withdrawal of the monsoon current from those areas. The current then recurves over the centre of the Bay, in the same manner as during the monsoon proper over the north of the Bay and Bengal, and is directed or determined to the west or Madras coast of the Bay, which hence receives frequent rain during a short period of about two months—the rainy season of the eastern and southern parts of the peninsula south of Orissa and Ganjam.

These rains were formerly described as accompanying the setting in of the north-east monsoon on the Madras coast. That, however, is a misnomer, as the true north-east monsoon winds are dry land winds, and the rain-giving winds of this period in Madras are those of the south-west monsoon in its retreat or contraction down the Bay. The period during which this rainfall occurs is hence now usually termed the retreating south-west monsoon.

The year in India may hence be divided into two monsoons of nearly equal length, viz.:

(*a*) The north-east or dry monsoon.

(*b*) The south-west or wet monsoon.

The first terms are based on the general direction of the air movement in the Indian seas during the periods, and the second on the most prominent feature of the weather in India itself. Of an average annual total rainfall of 41 inches (according to the most trustworthy calculation), at least 85 per cent. falls during the wet season, and only 15 per cent. during the dry season.

The dry monsoon in India is subdivided into—

(1) The cold-weather period.

(2) The hot-weather period or transitional period of preparation for the south-west monsoon.

The wet monsoon is divided into—

(1) The south-west monsoon proper, or the period of general rains.

(2) The period of the retreating south-west monsoon and gradual slow establishment of the dry monsoon.

Each of these periods practically covers three months.

One of the most noteworthy features of the meteorology of India not referred to in the previous statement is that the storms of each period—viz., the cold-weather period, the hot-weather period, and the wet monsoon—are characteristic and special to the period. They are all in the broadest sense of the word cyclonic in character; but they originate under different conditions and exhibit very different features in each of those periods.

The disturbances of the cold weather are large shallow depressions which originate in the upper humid return current of the north-east monsoon circulation, chiefly in the Persian plateau region, and which drift eastward with a slight southing across Extra-tropical India. Storms do not occur south of the Deccan or peninsula-dividing ranges during this period. These storms are chiefly remarkable for the frequent development of stationary secondary depressions in the Punjab, usually of much greater intensity than the primaries; a feature of which, I believe, there is no parallel elsewhere. They are of great importance, as they give the main snow supply to the Western Himalayas and the light but general occasional rain required for the wheat and other cold-weather crops of Northern India.

The storms of the hot weather are local disturbances of very limited extent, usually in large areas of slight depression, and are occasionally of remarkable intensity and great violence. In the areas to which the local sea winds of the period extend (more especially Bengal and Assam) they occur chiefly as local thunderstorms with violent winds and brief heavy downpours of rain, but sometimes as tornadoes rivalling those of certain districts of the United States in intensity and destructiveness. In the dry interior they occur as dust-storms, usually without rain, and are most violent in the driest districts, including Sind, the Punjab, and Rajputana. Occasionally, when the convective movement is especially vigorous, they develop into hail-storms of great intensity. The rainfall accompanying these hot-weather storms is of little general agricultural value except in the tea districts of Assam and Bengal.

Finally, the wet monsoon is characterised by the frequent occurrence of cyclonic storms of every degree of intensity and of very varying extent. The great majority of them originate in sea areas of nearly uniform temperature as disturbances in a massive current highly charged with aqueous vapour and subject to large variations of intensity and extension. The more prominent features of these storms, more especially of the most violent, including the hurricane winds, excessive rainfall, and the phenomena of the central calm and the accompanying storm wave, are too well known to require description. The chief importance of these storms, of which an average of about ten (of different degrees of intensity) occur every year during this period, arises from the manner in which they modify the distribution of the rainfall, discharging it abundantly over the districts traversed by the storms at the expense of the districts outside of their field.

The most important and variable feature of the weather in India from the practical standpoint is rainfall. Its value depends upon its amount and occurrence in relation to the needs of the staple crops. The measurement of rainfall is carried out, on a uniform system, at upwards of 2500 rain-gauge stations. The average distribution of rainfall, month by month and for each season, has been determined from the data of about 2000 stations. It should, however, be recognised that the probability that the rainfall will conform exactly to this distribution in any year is nil. Average rainfall charts represent a distribution about which the actual varies from district to district more or less considerably, the local variation for prolonged periods being practically compensatory. Such mean or normal data and charts are undoubtedly of value, more especially for the determination of rainfall anomalies and their relations to pressure, temperature, and other anomalies. There is apparently a tendency to assign a greater value to these charts of mean rainfall distribution than they deserve. Charts showing the amount and time distribution of the rainfall best suited for the requirements of the staple crops would—for India at least—be more interesting and valuable. This is a work that I regret has, for various reasons, not yet been carried out by the Indian Meteorological Department.

In most regions in India a moderate variation (positive or negative) in the amount of the rainfall is of comparatively small importance, more especially if the precipitation occurs in amount and at intervals suited to the requirements of the crops. During the thirty-year period 1874–1903 there were six years in which the distribution of rainfall affected to a serious extent the crop returns over large areas, and the rainfall was not compensatory. In four of these years the drought was so severe and widely spread as to occasion famine, with its attendant calamities, over large areas. Severe droughts and famines occur at very irregular intervals. A noteworthy feature is that they frequently follow in pairs separated by intervals of two to four years.

The previous statement of the meteorology of India has indicated the chief conditions which affect the crop returns seriously or disastrously over large areas in India. They may be summed up briefly as follows:—

(*a*) The dry monsoon. Absence or unusual feebleness of cold-weather storms.

(*b*) The wet monsoon. General feebleness of the monsoon current, due either to corresponding feebleness of the south-east trades, or to unusual diversion to East Africa; or local feebleness in a part of India, due to local conditions, or to abnormal diversion to other rainfall areas in South Asia. These conditions give rise in the areas affected to one or more of the following features:—

(1) Prolonged delay in the commencement of the rains.

(2) Scanty rainfall during the season, with prolonged periods of fine, clear, hot weather.

(3) Early termination of the rains.

These features are as a rule more marked in the drier districts of the interior than in the coast districts. The effect on crop production is greatest and most disastrous in the following areas:—

(1) Central Burma.

(2) The Deccan, including the Bombay and Madras Deccan districts, and Hyderabad.

(3) North-Western and Central India, more especially the South Punjab, East Rajputana, and the United Provinces.

The following important inferences are based upon the preceding presentation of facts and the experience of the past thirty years:—

(1) The lower air movement of the south-west monsoon is the northward extension of the lower movement of the south-east trades. The latter is a permanent feature of the Indo-oceanic region, and the former a periodic invasion of the Southern Asian seas and peninsulas initiated over equatorial regions and propagated northwards to the southern mountain barrier of the Central Asian plateau.

(2) The primary factors determining this impulse across the equator (the first stage of the establishment of the south-west monsoon) are to be sought in the permanent field of the south-east trades, and are not due to actions in the heated areas of Southern or Central Asia.

(3) The pressure conditions in the heated areas of Southern Asia and North-East Africa determine the direction, volume, and intensity of the advance over the Indian seas to what may be termed three competing areas for rainfall (viz., Abyssinia, India, and Burma). These conditions are hence important factors in the third stage of the advance of the south-west monsoon current.

(4) The movement when fully established by these actions over the Southern Asian seas and peninsulas is continued—first, by the momentum of the lower circulation; secondly, by the release of energy accompanying aqueous vapour condensation; and thirdly, by thermal actions in Southern Asia, due to direct solar activity. The termination of the lower horizontal current by vertical movement occurs irregularly over the areas of frequent heavy rain in Southern Asia and Abyssinia, and not over a heated area in Central Asia.

(5) The total volume of aqueous vapour brought up by this circulation not only varies in amount from month to month during the season, but also from year to year. The largest variations (seasonal and annual) depend chiefly, if not entirely, upon actions in the source of supply—viz., the Indian Ocean. If those actions determine an increased or diminished supply across the equator into the Indian seas, there is a corresponding variation in the total precipitation of the three competing areas. Amongst such causes and actions may be prolonged and untimely diversion of the south-east trades into East Africa, as in 1896, or general weakness of the air movement over the Indian Ocean, probably accompanying a displacement and decreased intensity of the southern anticyclone, as in 1899.

(6) The relative distribution of the total rainfall in the three areas of discharge of the aqueous vapour of the monsoon currents probably depends upon the relative intensities of the pressure conditions established during the hot weather, which are continued for a part or the whole of the monsoon by actions depending on the rainfall resulting from the initial pressure conditions—an example of the persistence of meteorological conditions and actions which is a prominent feature of Indian meteorology. The total rainfall of each of the three areas may differ considerably from the normal, but there may be partial or complete compensation on the whole. Thus it is the general (but not the invariable) rule that the rainfall variations in Burma and Assam are usually inverse to those of North-Western India and also of India as a whole.

(7) The distribution of the rainfall in any one of the three competing areas (but more especially in India as the largest) may vary widely from the normal—considerable deficiency in some areas accompanying considerable excess in others. This in India is undoubtedly due to local conditions—*e.g.*, local excess or deficiency of pressure at the commencement of the period and established during the previous hot weather. These pressure variations usually accompany abnormally prolonged and heavy snowfall or very scanty snowfall in the Western Himalayas.

(8) Local or general drought in India during the south-west monsoon may hence be due to—

(*a*) General weakness of the south-east trades circulation.

(*b*) Diversion of an unusually large proportion of the south-east trades to South-East or East Africa during the monsoon period.

(*c*) Larger diversion than usual of the monsoon currents to Burma or Abyssinia.

(*d*) Very unequal distribution in India itself, due to local conditions established during the antecedent hot weather.

These factors are given in the probable order of their importance.

(9) Scanty rainfall or drought during the dry season or north-east monsoon in Northern India results from absence or unusual feebleness of the cold weather storms which are the sources of rainfall at that time.

(10) The most prolonged and severe droughts in North-Western and Central India are due to the partial or complete failure of the rainfall of at least two seasons in succession.

(11) As the two circulations in the Indian oceanic region have a common goal in the dry season (more especially from December to March), it is probable that variations in the strength of one circulation (more especially the larger) will modify the field and strength of the other circulation. It appears that this relation would be shown most strongly between the southern circulation and the upper movement of the northern circulation. And, as cold-weather storms are disturbances in that upper movement, it is possible—if not probable—that the larger variations in the number and intensity of the cold-weather storms and the amount of the cold-weather precipitation may be related to conditions in the south-east trades regions.

(12) There appears to be little or no relation between the position and intensity of the Central Asian anticyclone and the number of the cold-weather storms and rainfall of Northern India in any season.

The meteorology of the period 1892–1902 is of especial interest for its confirmation of the above inferences, more especially the phenomena of the variations of rainfall in India and the causes or actions to which they are due. The year 1891 was noteworthy for a severe local famine in Rajputana and the adjacent districts to the north and east consequent on prolonged and excessive snowfall in the Western Himalayas during the winter of 1890–91. The following gives a brief summary of the more prominent features of the meteorology of this unique period:—

(1) The eleven-year period 1892–1902 corresponds in length to the sun-spot period, and it may be divided into two periods of unequal length—a short period of excessive rain and a long period of deficient precipitation. The maximum of the first period was in 1893. The second period had three strongly marked minima in 1896, 1899, and 1901, that of 1899 being the absolute minimum. The following table gives, for convenience of reference, data of the mean annual and seasonal variations of rainfall of the Indian land area for each year of the period:—

Variation of Mean Actual Rainfall of Period from Normal.

	Cold Weather: January and February	Hot Weather: March to May	South-west Monsoon. Complete Period: June to December	Whole year
1891	+0·34	+0·37	− 4·25	− 3·54
1892	−0·39	−0·21	+ 5·69	+ 5·09
1893	+1·63	+2·72	+ 4·72	+ 9·07
1894	+0·48	−0·76	+ 6·75	+ 6·47
1895	−0·01	−0·23	− 1·95	− 2·19
1896	−0·42	−0·82	− 3·59	− 4·83
1897	−0·01	−0·12	− 0·02	− 0·15
1898	+0·50	−1·00	+ 0·93	+ 0·43
1899	−0·38	+0·58	−11·34	−11·14
1900	−0·02	−0·25	− 0·26	− 0·57
1901	+1·47	−0·48	− 5·12	− 4·13
1902	−0·57	+0·16	− 1·64	− 2·05
Normal roughly...	1 inch	5 inches	35 inches	41 inches

(2) The following gives the chief features of the rainfall of the first period, 1892–4:—

(*a*) The excess was almost as marked in the dry as in the wet season. This is strongly shown in the year 1893 of maximum excess.

(*b*) The excess was on the whole more strongly exhibited in the field of the Bombay than of the Bengal current.

(*c*) The rainfall of the dry season was as markedly in excess in Persia, Baluchistan, Afghanistan, and the Himalayan area as in Northern India.

(*d*) The maximum height of the Nile floods (in September) was above the average. They were abnormally high in 1892 and 1894.

(*e*) The rains were favourable over Australia and South Africa during this period, according to the reports received in India.

(*f*) Hence, as a general inference, the rainfall was in general excess in each year of the period over the Indo-oceanic region, and not only in the south-west but also in the north-east monsoon in Southern Asia.

(3) The chief features of the rainfall of the second period, 1895–1902, in the Indo-oceanic region were as follows:—

(*a*) The rainfall was as deficient relatively to the normal in the cold weather as in the rains or wet season.

(*b*) The cold-weather or winter precipitation was almost continuously in marked defect in Asiatic Turkey, Persia, Afghanistan, Baluchistan, the Himalayan area, and South Tibet. The opposite variation obtained in Central Asia, as is shown by available data for Tashkend, Samarcand, Irkutsk, and other stations.

(*c*) The storms of the cold weather were fewer in number and feebler in character in each year of the period than on the average of the preceding sixteen years 1876–91.

(*d*) The south-west monsoon rainfall was most largely in defect in the interior districts served by the Bombay current.

(*e*) There was a marked tendency in each year for late commencement and early withdrawal of the monsoon currents, and for deficient rainfall throughout the whole season over the greater part of India. These features were very pronounced in the years 1896, 1899, and 1901.

(*f*) The most remarkable feature of the period was that the region to the south of the equator, including South and East Africa, Mauritius, and Australia, was similarly affected.

In India the years 1896 and 1899 were years of severe drought, followed by famine over very large areas. The area in which the crops failed more or less completely was about 250,000 square miles in extent in 1896 and 500,000 square miles in 1899. In the 1899–1900 famine upwards of 6,500,000 people were on famine relief for several months. The loss of cattle due to failure of water and fodder was very great, numbering many millions. In some districts from 90 to 95 per cent. of the cattle died off from slow starvation and want of water. In New South Wales and Queensland almost continuous drought prevailed from 1896 to 1902. It is estimated that more than fifty millions of sheep, value 12,500,000*l*., were lost in New South Wales during these seven years of drought.

Mr. Hutchins, Conservator of Forests, Cape Town, states that drought prevailed more or less persistently over the Karoo region in South Africa from 1896 to 1903, and that cattle and sheep perished by millions. He also states that the drought extended to British Central Africa from 1898 to 1903.

The previous statements evidence the continuity, extension, and intensity of the drought.

The Nile floods followed very closely the variations of the rainfall in Western India. The floods of the years 1899 and 1901 were both amongst the lowest on record. This shows that the rainfall in the Abyssinian region was more or less generally in defect during the period and most largely in the years 1899 and 1901, when the rainfall of the Bombay current was very deficient.

Hence, as a general inference, the period 1895–1902 was characterised by more or less persistent deficiency of rainfall over practically the whole Indo-oceanic area (including Abyssinia). The economic results in the dry interior districts of India, South Africa, and Australia were the same—large loss of cattle and great loss of capital. The drought in Southern Asia was as marked in the north-east as in the south-west monsoon, and hence the variation was not seasonal but general.

The variations of temperature, humidity, and cloud in India during the whole period were large and in direct accordance with the rainfall. In other words, during the period 1892–94 the air was damper with lower temperature than usual, and cloud above the normal. On the other hand, from 1895 to 1902 temperature was steadily in excess, cloud less than usual, and humidity below the normal.

The most remarkable variation was that of the solar radiation as indicated by observations of the solar radiation thermometer (black bulb *in vacuo*).

The most interesting feature of the meteorology of the period 1892–1902 is that the variations of the solar insolation are the inverse of those which might have been expected from the cloud and humidity data. In other words, solar radiation was in excess in the period of increased humidity and cloud, and in defect during the greater part of the period of drought, decreased humidity, and cloud. The series of eight curves exhibited, out of a larger number prepared from the data of a number of stations in India at which these observations are carefully recorded, show the most important facts, and indicate that there was a continuous decrease of insolation on the average of all stations from 1891 to 1902. The curves for Aden, Calcutta, and Leh, it will be seen, agree in their most important features. The observations are quite concordant and probably represent a most important feature of the period. They indicate either a continuous and considerable decrease of emission of solar energy during the period, or unusually large absorption in the upper atmosphere. In order to decide this question comparison is necessary with similar data for other large areas as, for example, Europe and North America. It is, however, clear that in India the insolation data of this unique period are of exceptional interest and value.

The preceding statements have shown that variations of rainfall for prolonged periods similar in character have occurred, and may hence occur again, over the very large area including the Southern Asian peninsulas, East and South Africa, Australia, and, perhaps, the Indian Ocean. The abnormal actions or conditions giving rise to these large and prolonged variations must hence be persistent for long periods, and be effective over the whole of that extensive area, and hence cannot be inferred with certainty from the examination of the data of one small portion of the area affected—*e.g.*, India. The variations undoubtedly accompany variations in the complete atmospheric circulation over the Indo-oceanic area, and the effective forces or actions must be such as to influence the whole movement in a similar manner in the two monsoons or seasons of inverse conditions in Southern Asia. This inference furnishes a very strong reason for the conclusion that the meteorology of the whole area similarly affected from 1892 to 1902 should be studied as a whole, and not in fragmentary detail by various weather bureaus, and as at present without any co-ordination of the results of these bureaus.

The discussion has also indicated that the south-west monsoon current is a periodic or intermittent extension of the permanent circulation of the south-east trades to the peninsulas of Southern Asia, and also that variations in the strength, volume, and direction of movement of the latter affect the extension, volume, aqueous vapour contents, and precipitation of the south-west monsoon currents in Burma, India, and Abyssinia. This fact further emphasises the necessity for the co-ordination and systematisation of the work of observation in the Indo-oceanic meteorological province and the continuous and systematic examination and discussion of observations for the whole of that area.

It is, of course, possible that it may be necessary to extend this work to a larger area than the Indo-oceanic region. For Sir Norman Lockyer and Dr. Lockyer have shown that similar pressure variations to those of Bombay occur over a large portion of the Eastern Hemisphere, and variations of opposite sign (similar to those of Cordova) over a considerable part of the Western Hemisphere.

The Indian Meteorological Department, with the sanction of the Government of India, is now arranging to collect and tabulate data for the whole area between the Central Asian winter anticyclone and the permanent South Indian Ocean anticyclone, and to utilise the information for the investigation of the causes of the large and general variations of rainfall in Burma and India from year to year. This extension of its labour is recognised as necessary for the improvement of the seasonal forecasts, an important feature of the work of the Department the value and importance of which are fully recognised by the Government of India.

Possibly the practice of the Indian Meteorological Department in the preparation and issue of long-period or seasonal forecasts is considered to be not only unscientific, but not justified by comparison with facts. Prof. Cleveland Abbe, in his paper on "The Physical Basis of Long-range Weather Forecasts," expresses his opinion that "we are warranted in saying that during the thirteen years (1888–1900) the only real failure has been that of the prediction of the monsoon season of 1899, the year of phenomenally great drought in that country." This opinion is probably more favourable than I should myself give, but it is the opinion of an independent meteorologist eminently qualified to give a judgment in the matter.

My own opinion with respect to weather forecasts is that there appears to be too strong a desire for absolute accuracy, possibly due to public and newspaper criticism. Certainty is not possible in weather forecasts based on imperfect information, and in which the introduction of a single unknown factor in regions beyond observation—*e.g.*, the upper or middle atmosphere—may completely alter the course of events. Percentages of success are an inadequate measure of the utility of forecasts. To be of real value as estimates of utility they should be calculated rather on the information required, and which might be reasonably expected, than on that actually given.

It appears to me that the striving after perfection in short-period forecasts to the exclusion of other claims is impeding the extension and progress of meteorology in other useful directions. It is absolutely essential that officials preparing or utilising forecasts should recognise that every forecast is based on imperfect information and experience, and hence that all important forecasts should be expressed as probabilities, and, whenever desirable, an estimate of the value of each probability be given.

The Government of India desires to have these seasonal forecasts, and has ordered its Meteorological Department to furnish them. The Government encourages the work, provides the additional means required by the Department for its proper performance, and issues the forecasts only to those who will use them as probabilities for practical guidance.

The importance of the work of seasonal forecasting in India may be judged from the following remarks:—

India is almost exclusively an agricultural country, with a population of nearly 300 millions. The material prosperity of practically the whole people is determined by the amount and distribution of the periodic rains. The variations in the amount and period of the rains are occasionally so great as to produce the most disastrous results in the staple crops over large areas. In 1899, for example, the crops failed more or less completely over an area several times the extent of England.

There is probably no country where the meteorological problems, of which these rainfall variations form one feature, are of greater interest or more practical importance. The daily weather and rainfall reports are studied during the greater part of the year with the closest attention by the officials, from the Viceroy downwards.

The Government is hence keenly interested in meteorological observation and investigation, and is most anxious to improve its meteorological service and utilise it for practical purposes, of which seasonal forecasting is one of the most important. To give two examples. A reassuring forecast at a critical period, followed by its realisation, might be of the greatest value to the agricultural population of a large province, as well as to the local and Imperial Governments. Again, a statement or forecast the probability of which was, say, at least 10 to 1 that the rains would fail more or less completely during a season over a large area might enable the Government to carry out early prudential measures for relief in the most economical and effective manner with the means at its disposal. The preparation and issue of seasonal forecasts will hence, I am confident, be in the future, as in the past, one of the most important duties of the Indian Meteorological Department.

There are several points in connection with weather forecasting in India which it is desirable should be borne in mind. The first is that weather in India is distinguished rather by the massiveness, intensity, and persistence of abnormal features than by the frequency and rapid succession of important weather changes. It is chiefly on this account that daily weather forecasts, even if they could be communicated with the necessary rapidity, are of no value to the Indian agricultural population. Also, the empirical knowledge of the significance of the important variations as factors determining or indicating future weather accumulates much more slowly than in Europe, and it is hence doubly important that in India the empirical knowledge derived from very limited experience should be, so far as possible, regulated and controlled by theory and scientific knowledge. It should also be remembered that there are large differences between the meteorology of tropical and temperate regions, and also between the relation of crops to weather in India and England. The instincts, habits, beliefs, education of the body of the people in England and India also differ very widely. Hence the possibilities of the practical applications of meteorological science in India cannot be judged from the European standard, and may from that standpoint be unique.

The possibilities of usefulness of the work of seasonal or long-period forecasting in India are almost unlimited. To be acceptable and useful to the agricultural population of areas liable to drought they should be fairly accurate with respect to the dates of commencement and termination of the periodic rains, their general character, and the probable occurrence of prolonged breaks likely to be injurious to the chief food crops. If the forecasts were found to be fairly trustworthy in these respects, it is quite certain that the agricultural population would value them and use them. Indications of a growing belief in the utility and value of this feature of the work of the Department by the people in different parts of India are not wanting.

The Government of India has sanctioned large changes in its Meteorological Department in order to enable it to carry out the extensions of work that recent experience has shown to be desirable. The Department is kept in touch with scientific opinion and judgment at home through the Observatories Committee of the Royal Society. The relations to other scientific departments in India are maintained by a special committee termed the Board of Scientific Advice. The scientific staff has been largely increased. The solar physics observatory at Kodaikanal and the magnetic observatory at Bombay have been placed under the Meteorological Department with a view to the complete co-ordination of the departments of scientific investigation for which they are maintained. Observational data for the whole Indo-oceanic area are now being collected and tabulated with a view to the early publication of daily and monthly weather reports and charts of that area.

The objects of this last extension have already been indicated. It will afford the Indian meteorologists the data necessary for the investigation of the extension and intensity of the more important variations in the meteorology of the whole region, to correlate the abnormal features in the atmospheric circulation over the area, and more especially to ascertain the causes of the occasional failure of the monsoon rains in India. Finally, it will, it is hoped, enable the Department to collect the information and acquire the additional experience necessary in order to render the seasonal forecasts more trustworthy and satisfactory than they have been during the past six or seven years.

The area to be dealt with (viz., the Indo-oceanic area) is partially covered by a number of independent meteorological systems, including those of Egypt, East, Central and South Africa, Ceylon, Mauritius, the Straits Settlements, and Australia. Large areas, as, for example, Arabia, Persia, Afghanistan, Tibet, and the greater number of the islands of the Indian Ocean, are now almost completely unrepresented.

The departments controlling these systems work independently of each other, chiefly for local objects, and are in no way officially correlated or affiliated. Their methods of observation and of discussion and publication of meteorological data differ largely. It is hence difficult, if not almost impossible, to make satisfactory comparisons of the data, and trace out for the work of current meteorology the extension or field of similar variations, their relations to each other, and their probable influence on the future weather.

The work which should be carried out in order that the investigation of the meteorology of the Indo-oceanic area might be effective and as complete as possible includes the following:—

(1) The extension of the field of observation by the establishment of observatories in unrepresented areas, and the systematic collection of marine meteorological data for the oceanic area.

(2) The collection and tabulation of the data necessary to give an adequate view of the larger abnormal features of the meteorology of the whole area.

(3) The direction by some authoritative body of the registration, collection, and tabulation of observations by similar methods in order to furnish strictly comparable data for discussion.

(4) The preparation of summaries of data required as preliminary to the work of discussion, and for the information of the officers controlling the work of observation in the contributory areas. The earliest publication of the data should be regarded as essential for the use of officers issuing seasonal forecasts.

(5) The scientific discussion of all the larger abnormal features in any considerable part of the area and their correlation to corresponding or compensatory variations in the remainder of the area by a central office furnished with an adequate staff.

(6) Possibly, sufficient authority on the part of the central office to initiate special observations required for the elucidation of special features for which there are no arrangements in the general work of the various systems.

The Indian Meteorological Department is making preparations to carry out a portion of this work; and will undoubtedly do the best it can single-handed with its limited means. It cannot do the work fully and as it ought to be done. It can do nothing which requires authoritative control over the remaining meteorological systems in the Indo-oceanic field. It is collecting information from those who are willing to supply it, and will utilise it for its special purposes.

It is evident the work can only be carried out fully by the co-operation of the various systems subject to limited control by a central office with acknowledged imperial or general authority behind it. The most important part of the work from the standpoint of the science of meteorology is the comparison and discussion of the whole body of observations. The constitution, position, and authority of the central office is hence of the greatest importance. It is quite certain that none of the meteorological systems directly concerned can provide such a central office. If the work is to be carried out fully and systematically it can only be arranged for in England, and by the English Government assuming the general direction and control. At the present time a section of the English Meteorological Office is devoted to the study of oceanic meteorology for the information of mariners. Another section should be created for the study of imperial meteorology for the benefit of its dependencies and colonies. I have reason to believe that the Government of India would contribute its share towards the cost of this extension of work.

In the preceding remarks are given the chief reasons for an important extension of work now in progress in the Indian Meteorological Department, an extension which can only be carried out imperfectly by that Department, but which could be performed with most valuable scientific results by the co-ordination of the labours of the weather bureaus concerned, with a central institution or investigating office in England under Government control.

Perhaps I may be permitted, from my Indian experience, to add some general remarks bearing on the methods and progress of meteorological inquiry.

In India the collection and publication of accurate current data relating to rainfall and temperature is required for the information of Government in its various Departments. The collection and examination of pressure and wind data by a central office with a view to the issue of storm and flood warnings is equally necessary. This work may, perhaps, be described as pertaining to descriptive or economic meteorology.

Economic meteorology, so long as it deals only with actual facts of observation, is not a science. Forecasts belong to the same department or branch of meteorology. They may be based on scientific theory and be obtained by scientific methods or the utilisation of empirical knowledge. The latter method is probably sufficient for by far the greater part of short-period forecast work, but the final development of that work and the preparation of long-period forecasts require the application of exact scientific methods and knowledge. And it is, perhaps, not too much to say that the extension of the range or period of forecasts is a measure of the progress of meteorology as a science. India, by the simplicity and massiveness of its meteorological changes (and perhaps Australia and Africa), appears to be best suited for the earliest experiments in this work.

India is, however, poor, not only in material wealth and capital as compared with England, but also in the appliances and means of scientific investigation, and hence looks to England for assistance and guidance in scientific matters. Unfortunately, England lags behind, not only the United States and Germany, but even behind India, in the important field of scientific meteorological inquiry. It will suffice to give a single illustration of the anomalous and inferior position which England takes in such matters.

All meteorologists and scientific men generally are agreed that the exploration of the middle and upper atmosphere by any available means—*e.g.*, kites, balloons, &c.—is of the utmost importance at the present stage of meteorological inquiry. The United States, France, and Germany have taken up the work vigorously. The English Meteorological Office is unable, for want of funds, to share or take any part in the work. The force of scientific and public opinion is apparently powerless to move the English Government to grant an extra five hundred pounds annually for this work. The English Government, on the other hand, some time ago suggested that the Indian Meteorological Department should assist. The Government of India, recognising the importance of the work, has provided the funds and sanctioned the arrangements necessary in order that its Meteorological Department may march with the most progressive nations in this investigation.

India has no body of voluntary observers or independent scientific workers and investigators. Whatever is required to be done to extend practical and theoretical meteorology can only be effected by the Government Department to which that work is assigned, with the sanction and at the cost of the Government—which naturally considers chiefly its practical wants in relation to its limited resources. It is, from one point of view, a painful if not quite an unexpected experience to me, on my retirement, to find that the Government of India is, in its attitude towards meteorological inquiry, more advanced, more liberal and far-sighted than the English Government, and that England has not yet taken up seriously the work of scientific meteorological investigation. There are undoubtedly too many observations and too little serious discussion of observations. The time has arrived when investigation should go hand in hand with accurate observation, and should direct and suggest the work of observation, and also that the sciences directly related to meteorology should be considered concurrently with it. There are undoubtedly definite relations between certain classes of solar phenomena and phenomena of terrestrial magnetism. The probability of definite relations between solar and terrestrial meteorological phenomena is also generally admitted.

Data for the determination of these relations are being rapidly accumulated, and numerous problems connected therewith are waiting and ripe for investigation. They are too large and complex to be undertaken by present English methods, and can only be attacked by a body of trained investigators under arrangements securing the continuity of method and thought requisite for the prolonged systematic inquiry gradually leading up to their complete solution.

It would hence be desirable to enlarge the scope of the central institution I have suggested, so as to include in its field of labour the investigation of the relation between solar and terrestrial meteorology and magnetism, so far as they can be solved by the comparison of the observations of the British Empire.

The central institution would thus have large and definite fields of work and most interesting problems for investigation. It would hence contribute towards the formation of a body of scientific meteorological investigators adequate to the importance and wants of the empire, and be of the highest educational as well as scientific value.

My predecessor in this position, Dr. Shaw, the head of the English Meteorological Office, made some remarks in his Address last year which deserve repetition in connection with this idea. He said: "The British Empire stands to gain more by scientific knowledge, and to lose more by unscientific knowledge, of the matter than any other country. It should from its position be the most important agency for promoting the advance of meteorological science, in the first place because it possesses such admirable varying fields of observation, and in the second place because with due encouragement British intellect may achieve as fruitful results in this as in other fields of investigation."

The establishment of the central institution as suggested above would provide a remedy for the defects pointed out by Dr. Shaw. The reorganisation of the English Meteorological Office is, I believe, under consideration. Is it too much to hope that a strong expression of opinion on the part of the British Association, and the influence of the learned University at which its present meeting is held, would induce the English Government to spend an additional 5000*l.* or 10,000*l.* annually for the promotion of meteorological investigation and the establishment of a central imperial institution in London in connection with its Meteorological Office?

SECTION D.

ZOOLOGY.

OPENING ADDRESS BY WILLIAM BATESON, M.A., F.R.S., PRESIDENT OF THE SECTION.

IN choosing a subject for this address I have availed myself of the kindly usage which permits a sectional president to divert the attention of his hearers into those lines of inquiry which he himself is accustomed to pursue. Nevertheless, in taking the facts of breeding for my theme, I am sensible that this privilege is subjected to a certain strain.

Heredity—and variation too—are matters of which no naturalist likes to admit himself entirely careless. Everyone knows that, somewhere hidden among the phenomena denoted by these terms, there must be principles which, in ways untraced, are ordering the destinies of living things. Experiments in heredity have thus, as I am told, a universal fascination. All are willing to offer an outward deference to these studies. The limits of that homage, however, are soon reached, and, though all profess interest, few are impelled to make even the moderate mental effort needed to apprehend what has been already done. It is understood that heredity is an important mystery, and variation another mystery. The naturalist, the breeder, the horticulturist, the sociologist, man of science and man of practice alike, has daily occasion to make and to act on assumptions as to heredity and variation, but many seem well content that such phenomena should remain for ever mysterious.

The position of these studies is unique. At once fashionable and neglected, nominally the central common ground of botany and zoology, of morphology and physiology, belonging specially to neither, this area is thinly tenanted. Now, since few have leisure for topics with which they cannot suppose themselves concerned, I am aware that, when I ask you in your familiar habitations to listen to tales of a no man's land, I must forego many of those supports by which a speaker may maintain his hold on the intellectual sympathy of an audience.

Those whose pursuits have led them far from their companions cannot be exempt from that differentiation which is the fate of isolated groups. The stock of common knowledge and common ideas grows smaller until the difficulty of inter-communication becomes extreme. Not only has our point of view changed, but our materials are unfamiliar, our methods of inquiry new, and even the results attained accord little with the common expectations of the day. In the progress of sciences we are used to be led from the known to the unknown, from the half-perceived to the proven, the expectation of one year becoming the certainty of the next. It will aid appreciation of the change coming over evolutionary science if it be realised that the new knowledge of heredity and variation rather replaces than extends current ideas on those subjects.

Convention requires that a president should declare all well in his science; but I cannot think it a symptom indicative of much health in our body that the task of assimilating the new knowledge has proved so difficult. An eminent foreign professor lately told me that he believed there were not half a dozen in his country conversant with what may be called Mendelism, though he added hopefully, "I find these things interest my students more than my colleagues." A professed biologist cannot afford to ignore a new life-history, the Okapi, or the other last new version of the old story; but phenomena which put new interpretations on the whole, facts witnessed continually by all who are working in these fields, he may conveniently disregard as matters of opinion. Had a discovery comparable in magnitude with that of Mendel been announced in physics or in chemistry, it would at once have been repeated and extended in every great scientific school throughout the world. We could come to a British Association audience to discuss the details of our subject—the polymorphism of extracted types, the physiological meaning of segregation, its applicability to the case of sex, the nature of non-segregable characters, and like problems with which we are now dealing—sure of finding sound and helpful criticism; nor would it be necessary on each occasion to begin with a popular presentation of the rudiments. This state of things in a progressive science has arisen, as I think, from a loss of touch with the main line of inquiry. The successes of descriptive zoology are so palpable and so attractive, that, not unnaturally, these which are the means of progress have been mistaken for the end. But now that the survey of terrestrial types by existing methods is happily approaching completion, we may hope that our science will return to its proper task, the detection of the fundamental nature of living things. I say *return*, because, in spite of that perfecting of the instruments of research characteristic of our time, and an extension of the area of scrutiny, the last generation was nearer the main quest. No one can study the history of biology without perceiving that in some essential respects the spirit of the naturalists of fifty years ago was truer in aim, and that their methods of inquiry were more direct and more fertile—so far, at least, as the problem of evolution is concerned—than those which have replaced them.

If we study the researches begun by Kölreuter and continued with great vigour until the middle of the sixties, we cannot fail to see that had the experiments he and his successors undertook been continued on the same lines, we should by now have advanced far into the unknown. More than this: if a knowledge of what those men actually accomplished had not passed away from the memory of our generation, we should now be able to appeal to an informed public mind, having some practical acquaintance with the phenomena, and possessing sufficient experience of these matters to recognise absurdity in statement and deduction, ready to provide that healthy atmosphere of instructed criticism most friendly to the growth of truth.

Elsewhere I have noted the paradox that the appearance of the work of Darwin, which crowns the great period in the study of the phenomena of species, was the signal for a general halt. The "Origin of Species," the treatise which for the first time brought the problem of species fairly within the range of human intelligence, so influenced the course of scientific thought that the study of this particular phenomenon—specific difference—almost entirely ceased. That this was largely due to the simultaneous opening up of lines of research in many other directions may be granted; but in greater measure, I believe, it is to be ascribed to the substitution of a conception of species which, with all the elements of truth it contains, is yet barren and unnatural. It is not wonderful that those who held that specific difference must be a phenomenon of slowest accumulation, proceeding by steps needing generations for their perception, should turn their attention to subjects deemed more amenable to human enterprise.

The indiscriminate confounding of all divergences from type into one heterogeneous heap under the name "Variation" effectually concealed those features of order which the phenomena severally present, creating an enduring obstacle to the progress of evolutionary science. Specific normality and distinctness being regarded as an accidental product of exigency, it was thought safe to treat departures from such normality as comparable differences: all were "variations" alike. Let us illustrate the consequences. Princess of Wales is a large modern violet, single, with stalks a foot long or more. Marie Louise is another, with large double flowers, pale colour, short stalks, peculiar scent, leaf, &c. We call these "varieties," and we speak of the various fixed differences between these two, and between them and wild *odorata*, as due to variation; and, again, the transient differences between the same *odorata* in poor, dry soil, or in a rich hedge-bank, we call variation, using but the one term for differences, quantitative or qualitative, permanent or transitory, in size, number of parts, chemistry, and the rest. We might as well use one term to denote the differences between a bar of silver, a stick of lunar caustic, a shilling, or a teaspoon. No wonder that the ignorant tell us they can find no order in variation.

This prodigious confusion, which has spread obscurity over every part of these inquiries, is traceable to the original misconception of the nature of specific difference, as a thing imposed and not inherent. From this, at least, the earlier experimenters were free; and the undertakings of Gärtner and his contemporaries were informed by the true conception that the properties and behaviour of species were themselves specific. Free from the later fancy that but for selection the forms of animals and plants would be continuous and indeterminate, they recognised the definiteness of species and variety, and boldly set themselves to work out case by case the manifestations and consequences of that definiteness.

Over this work of minute and largely experimental analysis, rapidly growing, the new doctrine that organisms are mere conglomerates of adaptative devices descended like a numbing spell. By an easy confusion of thought, faith in the physiological definiteness of species and variety passed under the common ban which had at last exorcised the demon Immutability. Henceforth no naturalist must hold communion with either, on pain of condemnation as an apostate, a danger to the dynasty of Selection. From this oppression we in England, at least, are scarcely beginning to emerge. Bentham's "Flora," teaching very positively that the primrose, the cowslip, and the oxlip are impermanent varieties of one species, is in the hand of every beginner, while the British Museum Reading Room finds it unnecessary to procure Gärtner's "*Bastarderzeugung*."

And so this mass of specific learning has passed out of account. The evidence of the collector, the horticulturist, the breeder, the fancier, has been treated with neglect, and sometimes, I fear, with contempt. That wide field whence Darwin drew his wonderful store of facts has been some forty years untouched. Speak to professional zoologists of any breeder's matter, and how many will not intimate to you politely that fanciers are unscientific persons, and their concerns beneath notice? For the concrete in evolution we are offered the abstract. Our philosophers debate with great fluency whether between imaginary races sterility could grow up by an imaginary Selection; whether Selection working upon hypothetical materials could produce sexual differentiation; how under a system of Natural Selection bodily symmetry may have been impressed on formless protoplasm—that monstrous figment of the mind, fit starting-point for such discussions. But by a physiological irony enthusiasm for these topics is sometimes fully correlated with indifference even to the classical illustrations; and for many whose minds are attracted by the abstract problem of inter-racial sterility there are few who can name for certain ten cases in which it has been already observed.

And yet in the natural world, in the collecting-box, the seed-bed, the poultry-yard, the places where variation, heredity, selection may be seen in operation and their properties tested, answers to these questions meet us at every turn—fragmentary answers, it is true, but each direct to the point. For if anyone will stoop to examine Nature in those humble places, will do a few days' weeding, prick out some rows of cabbages, feed up a few score of any variable larva, he will not wait long before he learns the truth about variation. If he go further and breed two or three generations of almost any controllable form, he will obtain immediately facts as to the course of heredity which obviate the need for much laborious imagining. If strictly trained, with faith in the omnipotence of selection, he will not proceed far before he encounters disquieting facts. Upon whatever character the attention be fixed, whether size, number, form of the whole or of the parts, proportion, distribution of differentiation, sexual characters, fertility, precocity or lateness, colour, susceptibility to cold or to disease—in short, all the kinds of characters which we think of as best exemplifying specific difference—we are certain to find illustrations of the occurrence of departures from normality, presenting exactly the same definiteness elsewhere characteristic of normality itself. Again and again the circumstances of their occurrence render it impossible to suppose that these striking differences are the product of continued selection, or, indeed, that they represent the results of a gradual transformation of any kind. Whenever by any collocation of favouring circumstances such definite novelties possess a superior viability, supplanting their "normal" relatives, it is obvious that new types will be created.

The earliest statement of this simple inference is, I believe, that of Marchant,[1] who in 1719, commenting on certain plants of Mercurialis with laciniated and hair-like leaves, which for a time established themselves in his garden, suggested that species may arise in like manner. Though the same conclusion has appeared inevitable to many, including authorities of very diverse experience, such as Huxley, Virchow, F. Galton, it has been strenuously resisted by the bulk of scientific opinion, especially in England. Lately, however, the belief in Mutation, as De Vries has taught us to call it, has made notable progress,[2] owing to the publication of his splendid collection of observations and experiments, which must surely carry conviction of the reality and abundance of Mutation to the minds of all whose judgments can be affected by evidence.

That the dread test of Natural Selection must be passed by every aspirant to existence, however brief, is a truism which needs no special proof. Those who find satisfaction in demonstrations of the obvious may amply indulge themselves by starting various sorts of some annual, say French poppy, in a garden, letting them run to seed, and noticing in a few years how many of the finer sorts are represented; or by sowing an equal number of seeds taken from several varieties of carnation, lettuce, or auricula, and seeing in what proportions the fine kinds survive in competition with the common.

Selection is a true phenomenon; but its function is to *select*, not to create. Many a white-edged poppy may have germinated and perished before Mr. Wilks saved the

[1] Marchant, *Mém. Ac. roy. des Sci.* for 1719; 1721, p 59, Pls. 6-7. I owe this reference to Coutagne, "L'hérédité chez les vers à soie" (*Bull. sci. Fr. Belg.* 1902).

[2] This progress threatens to be rapid indeed. Since these lines were written Prof. Hubrecht, in an admirable exposition (*Pop. Sci. Monthly*, July, 1904) of De Vries' "Mutations-theorie," has even blamed me for having ten years ago attached *any* importance to continuous variation. Nevertheless, when the unit of segregation is small, something mistakably like continuous evolution must surely exist. (Cp. Johannsen, "Ueb. Erblichkeit in Populationen und in reinen Linien," 1903.)

individual which in a few generations gave rise to the Shirleys. Many a black *Amphidasys betularia* may have emerged before, some sixty years ago, in the urban conditions of Manchester the black var. *doubledayaria* found its chance, soon practically superseding the type in its place of origin, extending itself over England, and reappearing even in Belgium and Germany.

Darwin gave us sound teaching when he compared man's selective operations with those of Nature. Yet how many who are ready to expound Nature's methods have been at the pains to see how man really proceeds? To the domesticated form our fashions are what environmental exigency is to the wild. For years the conventional Chinese primrose threw sporadic plants of the loose-growing *stellata* variety, promptly extirpated because repugnant to mid-Victorian primness. But when taste, as we say, revived, the graceful Star Primula was saved by Messrs. Sutton, and a stock raised which is now of the highest fashion. I dare assert that few botanists meeting *P. stellata* in Nature would hesitate to declare it a good species. This and the Shirleys precisely illustrate the procedure of the raiser of novelties. His operations start from a definite beginning. As in the case of *P. stellata,* he may notice a mutational form thrown off perfect from the start, or, as in the Shirleys, what catches his attention may be the first indication of that flaw which if allowed to extend will split the type into a host of new varieties each with its own peculiarities and physiological constitution.

Let anyone who doubts this try what he can do by selection without such a definite beginning. Let him try from a pure strain of black and white rats to raise a white one by breeding from the whitest, or a black one by choosing the blackest. Let him try to raise a dwarf (" Cupid ") sweet pea from a tall race by choosing the shortest, or a crested fowl by choosing the birds with most feather on their heads. To formulate such suggestions is to expose their foolishness.

The creature is beheld to be very good after, not before its creation. Our domesticated races are sometimes represented as so many incarnations of the breeder's prophetic fancy. But except in recombinations of pre-existing characters—now a comprehensible process—and in such intensifications and such finishing touches as involve variations which analogy makes probable, the part played by prophecy is small. Variation leads; the breeder follows. The breeder's method is to notice a desirable novelty, and to work up a stock of it, picking up other novelties in his course—for these genetic disturbances often spread—and we may rest assured the method of Nature is not very different.

The popular belief that evolution, whether natural or artificial, is effected by mass-selection of impalpable differences arises from many errors which are all phases of one—imperfect analysis—though the source of the error differs with the circumstances of its exponent. When the scientific advocate professes that he has statistical proofs of the continuity of variation, he is usually availing himself of that comprehensive use of the term Variation to which I have referred. Statistical indications of such continuity are commonly derived from the study, not of nascent varieties, but of the fluctuations to which all normal populations are subject. Truly varying material needs care in its collection, and if found is often sporadic or in some other way unsuitable for statistical treatment. Sometimes it happens that the two phenomena are studied together in inextricable entanglement, and the resulting impression is a blur.

But when a practical man, describing his own experience, declares that the creation of his new breed has been a very long affair, the man of science, feeling that he has found a favourable witness, puts forward this testimony as conclusive. But on cross-examination it appears that the immense period deposed to seldom goes back beyond the time of the witness's grandfather, covering, say, seventy years; more often ten, or eight, or even five years will be found to have accomplished most of the business. Next, in this period—which, if we take it at seventy years, is a mere point of time compared with the epochs of which the selectionist discourses—a momentous transformation has often been effected, not in one character but many. Good characters have been added, it may be, of form, fertility, precocity, colour, and other physiological attributes, undesirable qualities have been eliminated, and all sorts of defects " rogued " out. On analysis these operations can be proved to depend on a dozen discontinuities. Be it, moreover, remembered that within this period, besides *producing* his mutational character and combining it with other characters (or it may be groups of characters), the breeder has been working up a *stock,* reproducing in quantity that quality which first caught his attention, thus converting, if you will, a phenomenon of individuals into a phenomenon of a mass, to the future mystification of the careless.

Operating among such phenomena the gross statistical method is a misleading instrument; and, applied to these intricate discriminations, the imposing Correlation Table into which the biometrical Procrustes fits his arrays of unanalysed data is still no substitute for the common sieve of a trained judgment. For nothing but minute analysis of the facts by an observer thoroughly conversant with the particular plant or animal, its habits and properties, checked by the test of crucial experiment, can disentangle the truth.

To prove the reality of Selection as a factor in evolution is, as I have said, a work of supererogation. With more profit may experiments be employed in defining the *limits* of what Selection can accomplish. For whenever we can advance no further by Selection, we strike that hard outline fixed by the natural properties of organisms. We come upon these limits in various unexpected places, and to the naturalist ignorant of breeding nothing can be more surprising or instructive.

Whatever be the mode of origin of new types, no theoretical evolutionist doubts that Selection will enable him to fix his character when obtained. Let him put his faith into practice. Let him set about breeding canaries to win in the class for Clear Yellow Norwich at the Crystal Palace Show. Being a selectionist, his plan will be to pick up winning yellow cocks and hens at shows and breed them together. The results will be disappointing. Not getting what he wants, he may buy still better clear yellows and work them in, and so on until his funds are exhausted, but he will pretty certainly breed no winner, be he never so skilful. For no selection of winning yellows will make them into a breed. They must be formed afresh by various combinations of colours appropriately crossed and worked up. Though breeders differ as to the system of combinations to be followed, all would agree that selection of birds representing the winning type was a sure way to fail. The same is true for nearly all canary colours except in Lizards, and, I believe, for some pigeon and poultry colours also.

Let this scientific fancier now go to the Palace Poultry Show and buy the winning Brown Leghorn cock and hen, breed from them, and send up the result of such a mating year after year. His chance of a winner is not quite, but almost, *nil.* For in its wisdom the fancy has chosen one type for the cock and another for the hen. They belong to distinct strains. The hen corresponding to the winning cock is too bright, and the cock corresponding to the winning hen is too dull for the judge's taste. The same is the case in nearly every breed where the sex-colours differ markedly. Rarely winners of both sexes have come in one strain—a phenomenon I cannot now discuss—but the contrary is the rule. Does anyone suppose that this system of " double mating " would be followed, with all the cost and trouble it involves, if Selection could compress the two strains into one? Yet current theory makes demands on Selection to which this is nothing.

The tyro has confidence in the power of Selection to fix type, but he never stops to consider what fixation precisely means. Yet a simple experiment will tell him. He may go to a great show and claim the best pair of Andalusian fowls for any number of guineas. When he breeds from them he finds, to his disgust, that only about half their chickens, or slightly more, come blue at all, the rest being blacks or splashed whites. Indignantly, perhaps, he will complain to the vendor that he has been supplied with no selected breed, but worthless mongrels. In reply he may learn that beyond a doubt his birds come from blues only in the direct line for an indefinite number of generations, and that to throw blacks and splashed whites is the inalienable property of blue Andalusians. But now let him breed from his " wasters," and he will find that the extracted blacks are *pure* and give blacks only, that the splashed whites similarly give only whites or splashed whites—but if the two sorts of " wasters " are crossed together *blues only* will result.

Selection will never make the blues breed true; nor can this ever come to pass unless a blue be found the germ-cells of which are bearers of the blue character—which may or may not be possible. If the selectionist reflect on this experience he will be led straight to the centre of our problem. There will fall, as it were, scales from his eyes, and in a flash he will see the true meaning of fixation of type, variability, and mutation, vaporous mysteries no more.

Owing to the unhappy subdivisions of our studies, such phenomena as these—constant companions of the breeder—come seldom within the purview of modern science, which, forced for a moment to contemplate them, expresses astonishment and relapses into indolent scepticism. It is in the hope that a little may be done to draw research back into these forgotten paths that I avail myself of this great opportunity of speaking to my colleagues with somewhat wider range of topic than is possible within the limits of a scientific paper. For I am convinced that the investigation of heredity by experimental methods offers the sole chance of progress with the fundamental problems of evolution.

In saying this I mean no disrespect to that study of the physiology of reproduction by histological means, which, largely through the stimulus of Weismann's speculations, has of late made such extraordinary advances. It needs no penetration to see that, by an exact knowledge of the processes of maturation and fertilisation, a vigorous stock is being reared, upon which some day the experience of the breeder will be firmly grafted, to our mutual profit. We, who are engaged in experimental breeding, are watching with keenest interest the researches of Strasburger, Boveri, Wilson, Farmer, and their many fellow-workers and associates in this difficult field, sure that in the near future we shall be operating in common. We know already that the experience of the breeder is in no way opposed to the facts of the histologist; but the point at which we shall unite will be found when it is possible to trace in the maturing germ an indication of some character afterwards recognisable in the resulting organism. Until then, in order to pursue directly the course of heredity and variation, it is evident that we must fall back on those tangible manifestations which are to be studied only by field observation and experimental breeding.

The breeding-pen is to us what the test-tube is to the chemist—an instrument whereby we examine the nature of our organisms and determine empirically what for brevity I may call their genetic properties. As unorganised substances have their definite properties, so have the several species and varieties which form the materials of our experiments. Every attempt to determine these definite properties contributes immediately to the solution of that problem of problems, the physical constitution of a living organism. In those morphological studies which I suppose most of us have in our time pursued, we sought inspiration from the belief that in the examination of present normalities we were tracing the past, the phylogenetic order of our types, the history—as we conceived—of Evolution. In the work which I am now pressing upon your notice we may claim to be dealing not only with the present and the past, but with the future also.

On such an occasion as this it is impossible to present to you in detail the experiments—some exceedingly complex—already made in response to this newer inspiration. I must speak of results, not of methods. At a later meeting, moreover, there will be opportunities of exhibiting practically to those interested some of the more palpable illustrations. It is also impossible to-day to make use of the symbolic demonstrations by which the lines of analysis must be represented. The time cannot be far distant when ordinary Mendelian formulæ will be mere *as in praesenti* to a biological audience. Nearly five years have passed since this extraordinary re-discovery was made known to the scientific world by the practically simultaneous papers of De Vries, Correns, and Tschermak, not to speak of thirty-five years of neglect endured before. Yet a phenomenon comparable in significance with any that biological science has revealed remains the intellectual possession of specialists. We still speak sometimes of Mendel's hypothesis or theory, but in truth the terms have no strict application. It is no theory that water is made up of hydrogen and oxygen, though we cannot watch the atoms unite, and it is no theory that the blue Andalusian fowl I produce was made by the meeting of germ-cells bearing respectively black and a peculiar white. Both are incontrovertible facts deduced from observation. The two facts have this in common also, that their perception gives us a glimpse into that hidden order out of which the seeming disorder of our world is built. If I refer to Mendelian "theory," therefore, in the words with which Bacon introduced his Great Instauration, "I entreat men to believe that it is not an opinion to be held, but a work to be done; and to be well assured that I am labouring to lay the foundation, not of any sect or doctrine, but of human utility and power."

In the Mendelian method of experiment the one essential is that the posterity of each *individual* should be traced separately. If individuals from necessity are treated collectively, it must be proved that their composition is identical. In direct contradiction to the methods of current statistics, Mendel saw by sure penetration that masses must be avoided. Obvious as this necessity seems when one is told, no previous observer had thought of it, whereby the discovery was missed. As Mendel immediately proved in the case of peas, and as we have now seen in many other plants and animals, it is often impossible to distinguish by inspection individuals whose genetic properties are totally distinct. Breeding gives the only test.

Segregation.

Where the proper precautions have been taken, the following phenomena have been proved to occur in a great range of cases, affecting many characters in some thirty plants and animals. The qualities or characters the transmission of which in heredity is examined are found to be distributed among the germ-cells, or gametes, as they are called, according to a definite system. This system is such that these characters are treated by the cell-divisions (from which the gametes result) as existing in pairs, each member of a pair being alternative or *allelomorphic* to the other in the composition of the germ. Now, as every zygote—that is, any ordinary animal or plant—is formed by the union of two gametes, it may either be made by the union of two gametes bearing similar members of any pair, say two blacks or two whites, in which case we call it *homozygous* in respect of that pair, or the gametes from which it originates may be bearers of the dissimilar characters, say a black and a white, when we call the resulting zygote *heterozygous* in respect of that pair. If the zygote is homozygous, no matter what its parents or their pedigree may have been, it breeds true indefinitely unless some fresh variation occurs.

If, however, the zygote be heterozygous, or gametically cross-bred, its gametes in their formation separate the allelomorphs again, so that each gamete contains only one allelomorphic character of each pair. At least one cell-division in the process of gametogenesis is therefore a differentiating or *segregating* division, out of which each gamete comes sensibly pure in respect of the allelomorph it carries, exactly as if it had not been formed by a heterozygous body at all. That, translated into modern language, is the essential discovery that Mendel made. It has now been repeated and verified for numerous characters of numerous species, and, in face of heroic efforts to shake the evidence or to explain it away, the discovery of gametic segregation is, and will remain, one of the lasting triumphs of the human mind.

In extending our acquaintance of these phenomena of segregation we encounter several principal types of complication.

Segregation Absent or Incomplete.—From our general knowledge of breeding we feel fairly well satisfied that true absence of segregation is the rule in certain cases. It is difficult, for instance, to imagine any other account of the facts respecting the American Mulattos, though even here sporadic occurrence of segregation seems to be authenticated. Very few instances of genuine absence of segregation have been critically studied. The only one I can cite from my own experience is that of *Pararge egeria* and *egeriades*, "climatic" races of a butterfly. When crossed together, they give the common intermediate type of North-Western France, which, though artificially formed, breeds in great measure true. This crossed back with either type has given, as a rule, simple blends between intermediate and type. My evidence is not, however, complete enough to warrant a positive statement as to the total absence of segregation, for in the few families raised from pairs of artificial intermediates some dubious indications of segregation have been seen.

The rarity of true failure of segregation when pure strains are crossed may be judged by the fact that since the revival of interest in such work hardly any thoroughly satisfactory cases have been witnessed. The largest body of evidence on this subject is that provided by De Vries. These cases, however, present so many complexities that it is impossible to deal with them now. While so little is definitely known regarding non-segregating characters, it appears to me premature to attempt any generalisation as to what does or does not segregate.

Most of the cases of failure of segregation formerly alleged are evidently spurious, depending on the appearance of homozygotes in the second generation (F_2).

One very important group of cases exists, in which the appearance of a *partial* failure of segregation after the second generation (F_2) is really due to another phenomenon. The visible character of a zygote may, for instance, depend on the coexistence in it of two characters belonging to distinct allelomorphic pairs, each capable of being independently segregated from its fellow, and forming independent combinations. For the demonstration of this important fact we are especially indebted to Cuénot.[1] We have indications of the existence of such a phenomenon in a considerable range of instances (mice, rabbits (Hurst), probably stocks and sweet peas).

Nevertheless, there are other cases, not always easy to distinguish from these, where *some* of the gametes of F_1 certainly carry on heterozygous characters unsegregated. As an example, which seems to me indisputable, I may mention the so-called "walnut" comb, normal to Malay fowls. This can be made artificially by crossing rose-comb with pea-comb, and the cross-bred then forms gametes, of which one in four bears the compound unsegregated.[2] We may speak of this as a true *synthesis*.

In another type of cases segregation occurs, but is not sharp. The gametes may then represent a full series ranging from the one pure form to the other. Such cases occur in regard to some colours of *Primula sinensis*, and the leg-feathering of fowls (Hurst). In the second generation a nearly complete series of intermediate zygotes may result, though the two pure extremes (if the case be one of blending characters) may still be found to be pure.

Resolution and Disintegration.—Besides these cases, the features of which we now in great measure comprehend, we encounter frequently a more complex segregation, imperfectly understood, by which gametes of new types, sometimes very numerous, are produced by the crossbred. Each of these new types has its own peculiarities. We shall, I think, be compelled to regard these phenomena as produced either by a *resolution* of compound characters introduced by one or both parents, or by some process of *disintegration*, effected by a breaking-up of the integral characters followed by recombinations. It seems impossible to imagine simple recombinations of pre-existing characters as adequate to produce many of these phenomena. Such a view would involve the supposition that the number of characters pre-existing as units was practically infinite—a difficulty that as yet we are not obliged to face. However that may be, we have the fact that resolutions and disintegrations of this kind—or recombinations, if that conception be preferred—are among the common phenomena following crossing, and are the sources of most of the breeder's novelties. As bearing on the theoretical question to which I have alluded, we may notice that it is among examples of this complex breaking-up that a great proportion of the cases of partial sterility have been seen.

No quite satisfactory proof as to the actual moment of segregation yet exists, nor have we any evidence that all characters are segregated at the same cell-division. Correns has shown that in maize the segregation of the starch character from the sugar character must happen before the division forming the two generative nuclei, for both bear the same character. The reduction-division has naturally been suggested as the critical moment. The most serious difficulty in accepting this view, as it seems to me, is the fact that somatic divisions appear sometimes to segregate allelomorphs, as in the case of Datura fruits, and some colour-cases.

In concluding this brief notice of the complexities of segregation I may direct attention to the fact that we are here engaged in no idle speculation. For it is now possible by experimental means to distinguish almost always with which phenomenon we are dealing, and each kind of complication may be separately dealt with by a determination of the properties of the extracted forms. Illustrations of a practical kind will be placed before you at a subsequent meeting.

The consequence of segregation is that in cases where it occurs we are rid of the interminable difficulties which beset all previous attempts to unravel heredity. On the older view, the individuals of any group were supposed to belong to an indefinite number of classes, according to the various numerical proportions in which various types had entered into their pedigree. We now recognise that when segregation is allelomorphic, as it constantly is, the individuals are of three classes only in respect of each allelomorphic pair—two homozygous and one heterozygous. In all such cases, therefore, fixity of type, instead of increasing gradually generation by generation, comes suddenly, and is a phenomenon of individuals. Only by the separate analysis of individuals can this fact be proved. The supposition that progress towards fixity of type was gradual arose from the study of masses of individuals, and the gradual purification witnessed was due in the main to the gradual elimination of impure individuals, whose individual properties were wrongly regarded as distributed throughout the mass.

We have at last the means of demonstrating the presence of integral characters. In affirming the integrity of segregable characters we do not declare that the size of the integer is fixed eternally, as we suppose the size of a chemical unit to be. The integrity of our characters depends on the fact that they *can* be habitually treated as units by gametogenesis. But even where such unity is manifested in its most definite form, we may, by sufficient searching, generally find a case where the integrity of the character has evidently been impaired in gametogenesis, and where one such individual is found the disintegration can generally be propagated. That the size of the unit may be changed by unknown causes, though a fact of the highest significance in the attempt to determine the physical nature of heredity, does not in the least diminish the value of the recognition of such units, or lessen their part in governing the course of Evolution.

The existence of unit-characters had, indeed, long been scarcely doubtful to those practically familiar with the facts of variation (*cp.* De Vries, "Intracellulare Pangenesis," 1889), but it is to the genius of Mendel that we owe the proof. We knew that characters could behave as units, but we did not know that this unity was a phenomenon of gametogenesis. He has revealed to us the underworld of gametes. Henceforth, whenever we see a preparation of germ-cells we shall remember that, though all may look alike, they may in reality be of many and definite kinds, differentiated from each other according to regular systems.

Numerical Relations of Gametes and their Significance.

In addition to the fact of segregation, Mendel's experiments proved another fact nearly as significant; namely, that when characters are allelomorphic, the gametes bearing each member of a pair generally are formed in equal numbers by the heterozygote, if an average of cases be taken. This fact can only be regarded as a consequence of some numerical symmetry in the cell-divisions of gametogenesis We already know cases where individual families

[1] When $abc \ldots \times \alpha\beta\gamma \ldots$ gives in F_1 or F_2 a character (not seen in the original parents), which from F_2 or later may breed true: not because $a\alpha$, $b\beta$, $c\gamma$ do not severally segregate, but through simultaneous homozygosis of, say, aa and $\beta\beta$, giving a zygote $aa\beta\beta c\gamma \ldots$ which will breed true to the character $a\beta$.

[2] Owing to this behaviour, and to the simultaneous production of single-comb (? by resolution), there are, even in pure Malays, five types of individuals, all with "walnut" combs—as yet indistinguishable—formed by gametic unions $r \times p$, $rp \times rp$, $rp \times r$, $rp \times p$, $rp \times s$. Of these kinds three can at once be distinguished by crossing with single; but whether $r \times p$ can be distinguished from $rp \times s$ we do not yet know. [*r*, rose; *p*, pea; *s*, single; *rp* walnut.] In this example four allelomorphs are simultaneously segregated, one being compound. Neglecting sexual differentiation, there are therefore *ten* gametically distinct types theoretically possible; but of these only *four* are distinguishable by inspection.

show such departure from normal expectation that either the numbers produced must have been unequal, or subsequent disturbance must have occurred. But so far no case is known *for certain* where the average of families does not point to equality.

The fact that equality is so usual has a direct bearing on conceptions of the physical nature of heredity. I have compared our segregation with chemical separation, but the phenomenon of numerically symmetrical disjunction as a feature of so many and such different characters seems scarcely favourable to any close analogy with chemical processes. If each special character owed its appearance to the handing on of some complex molecule as a part of one chemical system, we should expect, among such a diversity of characters and forms of life, to encounter some phenomenon of valency, manifested as numerical inequality between members of allelomorphic pairs. So far, equivalence is certainly the rule, and where the characters are simply paired and no resolution has taken place, this rule appears to be universal as regards averages. On the other hand, there are features in the distribution of characters after resolution, when the second generation (F_2) is polymorphic in a high degree, which are not readily accounted for on any hypothesis of simple equivalence; but none of these cases are as yet satisfactorily investigated.

It is doubtful whether segregation is rightly represented as the separation of *two* characters, and whether we may not more simply imagine that the distinction between the allelomorphic gametes is one of presence or absence of some distinguishing element. De Vries has devoted much attention to this question in its bearings on his theory of Pangenesis, holding that cases of both kinds occur, and attempting to distinguish them. Indications may certainly be enumerated pointing in either direction, but for the present I incline to defer a definite opinion.

If we may profitably seek in the physical world for some parallel to our gametic segregations, we shall, I think, find it more close in mechanical separations, such as those which may be effected between fluids which do not freely mix, than in any strictly chemical phenomenon. In this way we might roughly imitate both the ordinary segregation, which is sensibly perfect, and the curious impurity occasionally perceptible even in the most pronounced discontinuities, such as those which divide male from female, petal from sepal, albino from coloured, horn from hair, and so on.

Gametic Unions and their Consequences.

Characters being then distributable among gametes according to regular systems, the next question concerns the properties and features presented by the zygotes formed by the union of gametes bearing different characters.

As to this no rule can as yet be formulated. Such a heterozygote may exhibit one of the allelomorphic characters in its full intensity (even exceeding it in special cases, perhaps in connection with increased vigour), or it may be intermediate between the two, or it may present some character not recognisable in either parent. In the latter case it is often, though not always, reversionary. When one character appears in such intensity as to conceal or exclude the other it is called *dominant*, the other being *recessive*. It may be remarked that frequently, but certainly not universally (as has been stated), the phylogenetically older character is dominant. A curious instance to the contrary is that of the peculiar arrangement of colours seen in a breed of game fowls called Brown-breasted, which in combination with the purple face, though certainly a modern variation, dominates (most markedly in females) over the Black-breasted type of *Gallus bankiva*.

In a few cases irregularity of dominance has been observed as an exception. The clearest illustration I can offer is that of the extra toe in fowls. Generally this is a dominant character, but sometimes, as an exceptional phenomenon, it may be recessive, making subsequent analysis very difficult. The nature of this irregularity is unknown. A remarkable instance is that of the blue colour in maize seeds (Correns; R. H. Lock). Here the dominance of blue is frequently imperfect, or absent, and the figures suggest that some regularity in the phenomenon may be discovered.

Mendel is often represented as having enunciated dominance as a general proposition. That this statement should still be repeated, even by those who realise the importance of his discoveries, is an extraordinary illustration of the oblivion that has overwhelmed the work of the experimental breeders. Mendel makes the specific statement in regard to certain characters in peas which do behave thus, but his proposition is not general. To convict him of such a delusion it would be necessary to prove that he was exceptionally ignorant of breeding, though on the face of the evidence he seems sufficiently expert.

A generalisation respecting the consequences of heterozygosis possessing greater value is this. When a pair of gametes unites in fertilisation the characters of the zygote depend directly on the constitution of these gametes, and not on that of the parents from which they came. To this generalisation we know as yet only two clear exceptions. These very curious cases are exactly alike in that, though segregation obviously occurs in a seed-character, the seeds borne by the hybrid (F_1) all exhibit the hybrid character, and the consequences of segregation in the particular seed-character are not evident until the seeds (F_3) of the second (F_2) generation are determinable. Of these the first is the case of indent peas investigated especially by Tschermak. Crossed with wrinkled peas I have found the phenomena normal, but when the cross is made with a round type the exceptional phenomenon occurs. The second case is that discovered by Biffen in the cross between the long-grained wheat called Polish and short-grained Rivett wheat, demonstrations of which will be laid before you. No satisfactory account of these peculiarities has been yet suggested, but it is evident that in some unexplained way the maternal plant-characters control the seed-characters for each generation. It is, of course, likely that other comparable cases will be found.

Appearances have been seen in at least four cases (rats, mice, stocks, sweet peas) suggesting at first sight that a heterozygosis between two gametes, *both* extracted, may give, *e.g.*, dominance; while if one, or both, were pure, they would give a reversionary heterozygote. If this occurrence is authenticated on a sufficient scale, we shall of course recognise that the fact proves the presence in these cases of some pervading and non-segregating quality, distributed among the extracted gametes formed by the parent heterozygote. As yet, however, I do not think the evidence enough to warrant the conclusion that such a pervading quality is really present, and I incline to attribute the appearances to redistribution of characters belonging to independent pairs in the manner elucidated by Cuénot. The point will be easily determined, and meanwhile we must note the two possibilities.

Following, therefore, our first proposition, that the gametes belong to definite classes, comes the second proposition, that the unions of members of the various classes have specific consequences. Nor is this proposition simply the truistical statement that different causes have different effects; for by its aid we are led at once to the place where the different cause is to be sought—Gametogenesis. While formerly we hoped to determine the offspring by examining the *ancestry* of the parents, we now proceed by investigating the *gametic composition* of the parents. Individuals may have identical ancestry (and sometimes, to all appearances, identical characters), but yet be quite different in gametic composition; and, conversely, individuals may be identical in gametic composition and have very different ancestry. Nevertheless, those that are identical in gametic composition are the same, whatever their ancestry. Therefore, where such cases are concerned, in any considerations of the physiology of heredity, ancestry is misleading and passes out of account. To take the crudest illustration, if a hybrid is made between two races, A, B, and another hybrid between two other races, C, D, it might be thought that when the two hybrids AB and CD are bred together, four races, A, B, C, and D, will be united in their offspring. This expectation may be entirely falsified, for the cell-divisions of gametogenesis may have split A from B and C from D, so that the final product may contain characters of only two races after all, being either AC, BC, AD, or BD. In practice, however, we are generally dealing with *groups* of characters, and the union of all the A group, for instance, with all the C group will be a rare coincidence.

It is the object of Mendelian analysis to state each case of heredity in terms of gametic composition, and thence to determine the laws governing the distribution of characters in the cell-divisions of gametogenesis.

There are, of course, many cases which still baffle our attempts at such analysis, but some of the most paradoxical exceptions have been reduced to order by the accumulation of facts. The consequences of heterozygosis are curiously specific, and each needs separate investigation. A remarkable case occurred in stocks, showing the need for caution in dealing with contradictory results. Hoary leaves and glabrous leaves are a pair of allelomorphic characters. When glabrous races were crossed with crossbreds, sometimes the results agreed with simple expectation, while in other cases the offspring were all hoary when, in accordance with similar expectation, this should be impossible. By further experiment, however, Miss Saunders has found that *certain* glabrous races crossed together give nothing but hoary heterozygotes, which completely elucidates such exceptions. There is every likelihood that wherever segregation occurs similar analysis will be successful.

Speaking generally, in every case the first point to be worked out is the magnitude of the character-units recognised by the critical cell-divisions of gametogenesis, and the second is the specific consequence of all the possible combinations between them. When this has been done for a comprehensive series of types and characters, it will be time to attempt further generalisation, and perhaps to look for light on that fundamental physiological property, the power of cell-division.

Segregation and Sex.—Acquaintance with Mendelian phenomena irresistibly suggests the question whether in *all* cases of families composed of distinct types the distinctness may not be primarily due to gametic segregation. Of all such distinctions none is so universal or so widespread as that of sex: may it not be possible that sex is due to a segregation occurring between gametes, either male, female, or both? It will be known to you that several naturalists have been led by various roads to incline to this view. We still await the proof of crucial experiments; but without taking you over more familiar ground, it may be useful to show how the matter looks from our standpoint. As regards actual experiment, all results thus far are complicated by the occurrence of some sterility in the hybrid generation. Correns, fertilising ♀ *Bryonia dioica* with pollen from ☿ *B. alba*, obtained offspring (F_1) *either* ♂ or ♀, with only one doubtful exception. Gärtner found a similar result in *Lychnis diurna* ♀ × ☿ *L. Flos-cuculi* as ♂, but only raised six plants (4 ♂, 2 ♀). From *L. diurna* ♀ × ☿ *Silene noctiflora* as ♂ he got only two plants, spoken of as females which developed occasional anthers. These results give a distinct suggestion that sex may be determined by differentiation among the male gametes, but satisfactory and direct proofs can only be obtained from some case where sterility does not ensue.

Apart, however, from such decisive evidence—which, indeed, would be more satisfactory if relating to *animals*—several circumstances suggest that sex is a segregation-phenomenon. Prof. Castle in a valuable essay has directed attention to distinct evidence of disturbance in the heredity of certain moths (*Aglia tau* and *lugens*, Standfuss's experiments; *Tephrosia*, experiments of Bacot and others, summarised by Tutt),[1] where the disturbance is pretty certainly connected with sexual differentiation. Mr. Punnett and I are finding suggestions of the same thing in certain poultry cases. Mr. Doncaster has pointed out that the evidence of Mr. Raynor clearly indicates that a certain variety of *Abraxas grossulariata*, usually peculiar to the female, is a Mendelian recessive. It is scarcely doubtful that this will be shown to hold also for some other female varieties, *e.g.*, *Colias edusa*, var. *helice*, &c. We can therefore feel no doubt that there is some entanglement between sex and gametically segregable characters. A curious instance of a comparable nature is that of the Cinnamon canary (Norduijn, &c.), and similar complications are alleged as regards the descent of colour-blindness and hæmophilia.

In one remarkable group of facts we come very near to the phenomenon of sex. Experiments made in conjunction with Mr. R. P. Gregory have shown that the familiar heterostylism of Primula is a phenomenon of Mendelian segregation. Short style, or "thrum," is a dominant—with a complication;[1] long style, or "pin," is recessive; while equal, or "homostyle," is recessive to both.

Even nearer we come in a certain sweet-pea example, where abortion of anthers behaves as an ordinary Mendelian recessive character.[2] By a slight exaggeration we might even speak of a hermaphrodite with barren anthers as a "female."

Consider also how like the two kinds of differentiation are. The occasional mosaicism in Lepidoptera, called "gynandromorphism," may be exactly paralleled by specimens where the two halves are two colour-varieties, instead of the two sexes. Patches of *Silene inflata* in this neighbourhood commonly consist of hairy and glabrous individuals,[3] a phenomenon proved in Lychnis to be dependent on Mendelian segregation. The same patch consists also of female plants and hermaphrodite plants. Is it not likely that both phenomena are similar in nature? How otherwise would the differentiation be maintained? The sweet-pea case I have spoken of is scarcely distinguishable from this. I therefore look forward with confidence to the elucidation of the real nature of sex—that redoubtable mystery.

We now move among the facts with an altogether different bearing. "Animals and Plants under Domestication," from being largely a narration of inscrutable prodigies, begins to take shape as a body of coherent evidence. Of the old difficulties many disappear finally. Others are inverted. Darwin says he would have expected "from the law of reversion" that nectarines being the newer form would more often produce peaches than peaches nectarines, which is the commoner occurrence. Now, on the contrary, the unique instance of the Carclew nectarine tree bearing peaches is more astonishing than all the other evidence together!

Though the progress which Mendelian facts make possible is so great, it must never be forgotten that as regards new characters involving the addition of some new factor to the pre-existing stock we are almost where we were. When they have been added by mutation, we can now study their transmission; but we know not whence or why they come. Nor have we any definite light on the problem of adaptation; though here there is at least no increase of difficulties.

Besides these outstanding problems, there remain many special points of difficulty which on this occasion I cannot treat—curiosities of segregation, obscure aberrations of fertilisation[4] (occasionally met with), coupling of characters, and the very serious possibility of disturbance through gametic selection. Let us employ the space that remains in returning to the problem of variation, already spoken of above, and considering how it looks in the light of the new facts as to heredity. The problem of heredity is the problem of the manner of distribution of characters among germ-cells. So soon as this problem is truly formulated, the nature of variation at once appears. For the first time in the history of evolutionary thought, Mendel's discovery enables us to form some picture of the process which results in genetic variation. It is simply the segregation of a new kind of gamete, bearing one or more characters distinct from those of the type. We can answer one of the oldest questions in philosophy. In terms of the ancient riddle, we may reply that the Owl's egg existed before the Owl; and if we hesitate about the Owl, we may be sure about the Bantam. The parent zygote, the offspring of which display variation, is giving off new gametes, and in its gametogenesis a segregation of their new character, more or less

1 *Trans. Ent. Soc. Lond.*, 1898.

1 It is doubtful if "thrum" ever breeds true, as both the other types can do. Perhaps "thrum" is a *Halbrasse* of De Vries.

2 Neglecting minor complications, the descent is as follows:—Lady Penzance ♀ × Emily Henderson (long pollen) ♂ gave purple F_1. In one F_2 family, with rare exceptions, *coloured* plants with *dark* axils were fertile, those with *light* axils having ♂ sterile, whites being either fertile or sterile. The ratios indicated are 9 coloured, dk. ax., fertile ♂ : 3 coloured, lt. ax., sterile ♂ : 3 white, fertile ♂ : 1 white, sterile ♂. The fertile whites, therefore, though light-axilled (as whites almost always are), presumably bear the dark-axil character, which generally cannot appear except in association with coloured flowers. This can be proved next year. Some at least of the plants with sterile ♂ are fertile on the ♀ side, and when crossed with a coloured light-axilled type will presumably give only light-axilled plants.

3 This excellent illustration was shown me by Mr. A. W. Hill and Mr. A. Wallis. A third form, glabrous, with hairy edges to the leaves, also occurs.

4 In view of Ostenfeld's discovery of parthenogenesis in *Hieracium*, the possibility that this phenomenon plays a part in some non-segregating cases needs careful examination.

pure, is taking place. The significance and origin of the discontinuity of variation is therefore in great measure evident. So far as pre-existing elements are concerned, it is an expression of the power of cell-division to distribute character-units among gametes. The initial purity of so many nascent mutations is thus no longer surprising, and, indeed, that such initial purity has not been more generally observed we may safely ascribe to imperfections of method.

It is evident that the resemblance between the parent originating a variety and a heterozygote is close, and the cases need the utmost care in discrimination. If, for instance, we knew nothing more of the Andalusian fowl than that it throws blacks, blues, and whites, how should we decide whether the case was one of heterozygosis or of nascent mutation? The second (F_2) generation from Brown Leghorn × White Leghorn contains an occasional Silver-Grey or Duckwing female. Is this a *mutation* induced by crossing, or is it simply due to a recombination of pre-existing characters? We cannot yet point to a criterion which will certainly separate the one from the other; but perhaps the statistical irregularity usually accompanying mutation, contrasted with the numerical symmetry of the gametes after normal heterozygosis, may give indications in simple cases—though scarcely trustworthy even there. These difficulties reach their maximum in the case of types which are *continually* giving off a second form with greater or less frequency as a concomitant of their ordinary existence. This extraordinarily interesting phenomenon, pointed out first by De Vries, and described by him under the head of "*Halb-*" and "*Mittel-Rassen,*" is too imperfectly understood for me to do more than refer to it, but in the attempt to discover what is actually taking place in variation it must play a considerable part.

Just as that normal truth to type, which we call heredity, is in its simplest elements only an expression of that qualitative symmetry characteristic of all non-differentiating cell-divisions, so is genetic variation the expression of a qualitative asymmetry beginning in gametogenesis. Variation is a novel cell-division.[1] So soon as this fact is grasped we shall hear no more of heredity and variation as opposing "factors" or "forces"—a metaphor which has too long plagued us.

We cease, then, to wonder at the suddenness with which striking variations arise. Those familiar with the older literature relating to domesticated animals and plants will recall abundant instances of the great varieties appearing early in the history of a race, while the finer shades had long to be waited for. In the sweet pea the old purple, the red bicolor, and the white have existed for generations, appearing soon after the cultivation of the species; but the finer splitting which gave us the blues, pinks, &c., is a much rarer event, and for the most part only came when crossing was systematically undertaken. If any of these had been seen before by horticulturists, we can feel no doubt whatever they would have been saved. An observer contemplating a full collection of modern sweet peas, and ignorant of their history, might suppose that the extreme types had resulted from selective and more or less continuous intensification of these intermediates, exactly inverting the truth.

We shall recognise among the character-groups lines of cleavage, along which they easily divide, and other finer subdivisions harder to effect. Rightly considered, the sudden appearance of a total albino or a bicolor should surprise us less than the fact that the finer shades can appear at all.

At this point comes the inevitable question, what *makes* the character-group split? Crossing, we know, may do this; but if there be no crossing, what is the *cause* of variation? With this question we come sharply on the edge of human knowledge. But certain it is that if causes of variation are to be found by penetration, they must be specific causes. A mad dog is not "caused" by July heat, nor a moss rose by progressive culture. We await our Pasteur; founding our hope of progress on the aphorism of Virchow, that every variation from type is due to a pathological accident, the true corollary of "*Omnis cellula e cellula.*"

[1] The parallel between the differentiating divisions by which the parts of the normal body are segregated from each other, and the segregating processes of gametogenesis, must be very close. Occasionally we even see the segregation of Mendelian characters among zygotic cells.

In imperfect fashion I have now sketched the lines by which the investigation of heredity is proceeding, and some of the definite results achieved. We are asked sometimes, Is this new knowledge of any use? That is a question with which we, here, have fortunately no direct concern. Our business in life is to find things out, and we do not look beyond. But as regards heredity, the answer to this question of use is so plain that we may give it without turning from the way.

We may truly say, for example, that even our present knowledge of heredity, limited as it is, will be found of extraordinary use. Though only a beginning has been made, the powers of the breeder of plants and animals are vastly increased. Breeding is the greatest industry to which science has never yet been applied. This strange anomaly is over; and, so far at least as fixation or purification of types is concerned, the breeder of plants and animals may henceforth guide his operations with a great measure of certainty.

There are others who look to the science of heredity with a loftier aspiration; who ask, Can any of this be used to help those who come after to be better than we are—healthier, wiser, or more worthy? The answer depends on the meaning of the question. On the one hand it is certain that a competent breeder, endowed with full powers, by the aid even of our present knowledge, could in a few generations breed out several of the morbid diatheses. As we have got rid of rabies and pleuro-pneumonia so we could exterminate the simpler vices. Voltaire's cry, "*Écraser l'infâme!*" might well replace Archbishop Parker's Table of Forbidden Degrees, which is all the instruction Parliament has so far provided. Similarly, a race may conceivably be bred true to some physical and intellectual characters considered good. The positive side of the problem is less hopeful, but the various species of mankind offer ample material. In this sense science already suggests the way. No one, however, proposes to take it; and so long as, in our actual laws of breeding, superstition remains the guide of nations, rising ever fresh and unhurt from the assaults of knowledge, there is nothing to hope or to fear from these sciences.

But if, as is usual, the philanthropist is seeking for some external application by which to ameliorate the course of descent, knowledge of heredity cannot help him. The answer to his question is *No*, almost without qualification. We have no experience of any means by which transmission may be made to deviate from its course; nor from the moment of fertilisation can teaching, or hygiene, or exhortation pick out the particles of evil in that zygote, or put in one particle of good. From seeds in the same pod may come sweet peas climbing five feet high, while their own brothers lie prone upon the ground. The stick will not make the dwarf peas climb, though without it the tall can never rise. Education, sanitation, and the rest, are but the giving or withholding of opportunity. Though in the matter of heredity every other conclusion has been questioned, I rejoice that in this we are all agreed.

NOTES.

THE sum of 120*l.* has been granted by the Paris Municipal Council to Prof. Grancher in furtherance of his researches as to the means of preventing tuberculosis in schools.

ON Monday and Tuesday, September 12 and 13, a visit is to be paid to London by a large party of Belgian engineers, members of the Association des ingénieurs sortis de l'Ecole de Liège—one of the most important technical societies on the Continent. The party will be the guests of the Iron and Steel Institute.

PROF. APPELL, dean of the faculty of sciences in the University of Paris, has had the civil title of commandeur de la Légion d'honneur conferred upon him by the French Minister of War. Prof. Appell has served for some time on the commission appointed to examine inventions likely to be of service to the French Army and Navy.

THE *Gazette* of August 23 gives notice that by the Wireless Telegraphy Act, 1904, it is provided that a person shall not establish any wireless telegraph station or instal or work any apparatus for wireless telegraphy in any place in the British Isles or on board any British ship in the territorial waters abutting on the coast of the British Isles except under and in accordance with a licence granted in that behalf by the Postmaster-General. Wireless telegraphy is defined by the Act to mean any system of communication by telegraph as defined in the Telegraph Acts, 1863 to 1904, without the aid of any wire connecting the points from and at which the messages or other communications are sent and received.

THE death is announced of Dr. George Pirie, professor of mathematics in the University of Aberdeen.

DR. HANS BATTERMANN, astronomer at the Berlin Observatory, has been appointed director of the observatory and professor of astronomy at Königsberg.

THE *Athenaeum* announces the death of the well known German geographer, Prof. F. Ratzel, at the age of sixty. Since 1886 he had been professor at the University of Leipzig.

THE twenty-third annual summer meeting of the English Arboricultural Society took place last week at Aberdeen, when Prof. Fisher, of the R.I.E. College, Coopers Hill, was elected president for the ensuing year.

AN international exhibition of hygiene, life-saving, first aid, and of industrial arts has been opened at the Grand Palais des Champs Elysées in Paris by the French Minister of Commerce, M. Georges Trouillot. The exhibition will be open until November.

THE first International Congress of Education and Home Protection of Infants will be held in September of next year in Liège in connection with the Universal Exposition at that place. There will be four sections in all, devoted to the following subjects:—(1) Study of childhood; (2) education of children (*a*, general questions; *b*, education by parents at home; *c*, collaboration of the family with the school; *d*, education in the family after the school period); (3) abnormal children; (4) various lines of work relative to childhood.

ACCORDING to the *Scotsman*, Mr. Eagle Clarke, of the Natural History Department of the Edinburgh Museum of Science and Art, will, by permission of the Commissioners of Northern Lights, spend some time during the coming autumn in the lighthouse on the Flannan Islands for the purpose of studying the migratory movements of birds. Since the lighthouse was erected on this outlying group a few years ago it has been ascertained that the islands lie in the course of a considerable stream of migratory birds *en route* between their northern spring and southern winter quarters, a fact which is of special interest owing to the far westerly situation of the isles, and one which renders it very desirable that the phenomena observed there should be investigated by an expert. Mr. Clarke will also investigate the limited terrestrial fauna and flora of the islands, which, owing to their remote situation and the difficulty of landing on them, have not hitherto received attention.

IN a recently published pamphlet entitled "An Introduction to the Study of Forestry in Britain," Sir Harold G. Hewett, Bart., makes an appeal in favour of the so-called new school of forestry, that is, scientific forestry as it is understood and taught on the Continent. In the author's opinion the different works on forestry in the English language recommend methods differing so widely as to bewilder the beginner. The object of this booklet is to criticise, compare, and reconcile where possible the advice given by the several writers. The author strongly advocates the adoption of more scientific methods in the treatment of British woodlands, the existing methods being too haphazard and antiquated.

IN celebrating its twenty-seventh annual excursion, the Royal Scottish Arboricultural Society visited France, where a fortnight was spent inspecting the various types of forests and studying the different methods of forest management as practised there. Three centres were chosen, where the society in turn established its headquarters. The party, numbering seventy members, proceeded first to Nancy, where the forest school and neighbouring forests belonging to the State were inspected. After spending several days in Nancy, the excursionists proceeded to Gerardmer, with the object of inspecting the coniferous forest of the Vosges Mountains. During the few days' sojourn in Gerardmer, the party had an opportunity of making a trip on the electric railway to the summit of the Schlucht, the highest point of the French Vosges, which reaches an altitude almost equal to that of Ben Nevis. During the ascent many interesting observations were made on the character of the trees and other vegetation according to altitude. On nearing the wind-swept summit, the forest trees became reduced to mere bushes and scrub. From Gerardmer the party then proceeded to Paris, where headquarters were established for the last week of the excursion, when the forests of Villiers Cotterêts, Compiègne, and Bellême were visited, which afforded many valuable object lessons in the treatment of beech and oak woods.

WE have received the report of the Meteorological Service of Canada for the year 1902, containing monthly and annual summaries for a large number of stations, including some in Newfoundland and one in Bermuda. Most of the telegraphic reports are forwarded to the weather bureau at Washington, which office in return supplies the Canadian Service with some sixty-eight reports from the United States, affording data for a very comprehensive daily weather chart, and for the issue of weather forecasts for all parts of the Dominion lying to the eastward of the Rocky Mountains. The percentage of success of these forecasts in each district is given for each month and for the year, and the general total reaches the high figure of 86·6. The predictions partly verified are divided by two before being added to the total percentage, which makes the figure quoted even more successful than appears at first sight. The storm warnings attain still higher success; 88 per cent. were fully, and 95 per cent. were fully and partially, verified. We congratulate the director, Mr. R. F. Stupart, on these very satisfactory results.

A NUMBER of papers dealing with experimental progress in the direction of aërial navigation have reached us during the last few months. As long ago as November last an illustrated account of the Barton airship was given in the *Automotor Journal*. Among other peculiarities we notice the use of aëroplanes for raising and lowering the balloon, the introduction of water tanks for maintaining a level keel, and the peculiar form of the propellers, each of which consists of three pairs of blades fixed one behind the other, thus embodying in the propeller the principle of superposed narrow vanes which has been so successfully applied to aëroplanes. In the *Revue scientifique* (5), i., 2, M. Jean Jaubert gives an account of the aëroplane machine constructed by Mr. Ernest Archdeacon at Berck-sur-Mer (France). A paper communicated to the American Association last year by Mr. Octave Chanute, contained a general account of recent progress in aërial navigation; this paper appeared in the *Popular Science Monthly* for March. Still more recently Captain Ferber, of the French Artillery, has brought out reprints of a paper from the *Revue d'Artillerie*, published by Berger-Levrault, of Paris, dealing mainly with gliding flight. Captain Ferber's own experiments were first conducted with pure gliding machines of the same type as those of the brothers Wright, but for his later experiments he has procured a mechanically propelled machine carrying a six horse-power motor, and weighing only 230 kilograms. Instead of experimenting in free air, Captain Ferber has adopted the principle of the captive machine, his machine being attached to a revolving arm 30 metres long supported on a pillar 18 metres high. This aërodrome is after the designs of MM. Goupil and Bazin.

IN the *Bulletin* of the Johns Hopkins Hospital (xv., No. 159, June) Dr. Percy Dawson gives an interesting biography of the Rev. Stephen Hales. The name of this great Englishman is familiar to every student of physiology as the first discoverer of the blood pressure, which he demonstrated by connecting a glass tube, now called the "Hales manometer," with an artery, and noting the rise of the blood within it. In addition, Hales contributed many papers on ventilation and natural history to the *Philosophical Transactions* of the Royal Society.

CAPTAIN GEO. LAMB, I.M.S., contributes a second communication on the specificity of anti-venomous sera to the *Scientific Memoirs of the Government of India* (No. 10, 1904; see NATURE, vol. lxviii. p. 395). He details experiments performed with two anti-venomous sera, one prepared with the venom of the *Hoplocephalus curtus* (tiger snake), the other with that of the cobra, these two sera being tested against the poisons of eight other snakes, including the king cobra, two kraits, common Indian sea snake, daboia, green pit viper, and Californian rattlesnake. Against the king cobra venom the cobra anti-serum had a slight neutralising effect, but not marked; as regards other venoms it had practically no neutralising power. The same holds good for the tiger snake anti-serum; while powerfully antitoxic for tiger snake venom, it is practically inactive against other venoms. These results confirm Captain Lamb's, and also Dr. Tidswell's, former observations that anti-venomous sera are strictly specific, and are active only against the venoms used to prepare them.

Two out of the three articles in the May number of the *American Naturalist* are devoted to botanical subjects, Prof. Penhallow continuing in the one his account of the anatomy of North American conifers, while in the second Dr. B. M. Davis commences a study of the structure of the vegetable cell. In the one zoological article, Dr. A. Hrdlička gives further examples of a division in the malar bone of the skull in man and monkeys.

IN the *Biologisches Centralblatt* for August Mr. G. Klebs continues his studies of the problem of development, as exemplified by the lowest plants, while Mr. C. Schaposchnikow offers a new explanation for the presence of a red coloration in the hind-wings of the butterflies of the genus Catocala. The red-winged Catocalas, as the author remarks, are restricted to the Holarctic region, and this distribution is of itself sufficient to indicate that their peculiar type of coloration is connected with their environment.

FIVE out of the six articles in the July issue of the *Quarterly Journal of Microscopical Science* are devoted to invertebrate morphology and anatomy. In the first of these Mr. E. S. Goodrich describes a remarkable arrangement in the branchial vascular system of the worm Sternapsis, by means of which the blood has an alternative path to the normal one, leading from the main dorsal to the main ventral vessel. In a second Dr. E. J. Allen describes the anatomy of the annelid Pœcilochætus, while in a third Dr. Herbert Fowler communicates notes on *Rhabdopleura normani*, an ally of Balanoglossus. A paper on the anatomy and affinities of the molluscs of the family Trochidæ, by Mr. W. B. Randles, and one on a sporozoan parasite found in the mouse, by Mr. H. M. Woodcock, complete the invertebrate list. Special interest attaches to an article by Mr. G. Smith on the middle ear and columella in birds. As the result of observations carried on at a very early stage of development, the author concludes that, while the stapes of birds and reptiles (Sauropsida) represents the same bone in mammals, the other parts of the auditory region have undergone a different development in the two groups. It may be noticed that Mr. Smith makes no mention of Dr. Broom's recent provisional identification of the inter-articular cartilage of Ornithorhynchus with the quadrate.

DR. J. P. THOMSON, secretary of the Queensland branch of the Royal Geographical Society of Australasia, contributes a paper on Queensland to the *Geographical Journal*. Dr. Thomson gives a very clear picture of the geography of north-eastern Australia, and we commend his paper to the notice of teachers.

WE have received a copy of a valuable paper issued by the Norwegian "Gradmaalings-Kommission" on the tides of the Norwegian coast. Analyses and discussion of extended observations at a number of stations are given, chiefly with the view of separating the two different systems of Atlantic and North Sea origin, and treating the complex interference phenomena observed off the southern extremity of Norway.

IN the *Bibliotheca mathematica*, v. 2, Prof. Gino Loria, of Genoa, gives an account of the life and works of the late Prof. Luigi Cremona, accompanied by a portrait and a chronological list of Prof. Cremona's writings.

THE theory of Maxwell and wireless telegraphy, by Prof. H. Poincaré, form the subject of the twenty-third volume of the physico-chemical series of *Scientia*, published by Messrs. Carré and Naud, of Paris. It appears to be an extension of the first volume of the series by the addition of chapters dealing with the principles and applications of wireless telegraphy.

WE have received a reprint of a lecture delivered by M. Maurice d'Ocagne at the Conservatoire des Arts et Métiers, having the title "Les instruments de précision en France." It contains a description of the more refined instruments in use at the Bureau international des Poids et Mesures, in the principal observatories in France, and in the French military survey.

UNDER the title of "Malerbriefe," Prof. Ostwald has published through the house of Hirzel, Leipzig, a series of seventeen short and suggestive essays on the theory and practice of painting. Though this slight brochure can scarcely add anything to the reputation of the distinguished author, it furnishes another example of the versatility of his genius.

AN instructive series of lantern slides illustrating waves and kindred forms of the atmosphere, hydrosphere, and lithosphere has been collected by Dr. Vaughan Cornish for Messrs. Newton and Co. The collection includes the most interesting pictures shown by Dr. Cornish at the Royal Geographical Society and elsewhere, and the descriptive notes which have been prepared for the slides direct attention to the chief points of interest.

WE have received from New York the first number of the *Mining Magazine,* an international monthly review of progress in mining and metallurgy. Though new in name, the magazine is really a development of the *Pacific Coast Miner,* a weekly journal of repute. It is edited by specialists, and the illustrations and typography reach the high standard that characterises American magazines. The contents are of varied interest. Mr. J. A. Church gives a sketch of mining, past and future. The geographical distribution of ores within the United States is discussed by Mr. F. L. Ransome. Mr. Carl Henrich gives an admirably illustrated account of the Guanajuato mining district of Mexico; and Mr. Henry S. Fleming discusses the commercial divisions of the competitive coal markets. Lastly, a useful index of current literature is provided.

OUR ASTRONOMICAL COLUMN.

VISIBILITY OF THE MARTIAN CANALS.—In *Bulletin* No. 12 of the Lowell Observatory Mr. Lowell extends and sums up the results recently outlined by him in a communication to the American Academy of Sciences under the title "The Cartouches of the Canals of Mars." During the last opposition he made 372 drawings of the planet's visible surface on 143 nights, and by carefully examining these and eliminating all known extrinsic variations he secured sufficient data to enable him to plot a visibility curve for each canal, between January 19 and July 26, which he believes exhibits only the actual, intrinsic variability of the marking in question. This curve he calls the "cartouche" of that canal.

Analysing the 109 curves thus obtained he finds, except in three cases, a well marked seasonal variation. These curves are not exactly similar, but on arranging them in a steadily progressive order it was seen that the order was one of latitude, the increase of visibility taking place in the north polar canals first and in the equatorial canals last. The reason assigned for the earlier quickening of the polar canals is that all these markings are due to vegetable growth, which requires both warm sunshine and water for its increase, and, as the general surface of Mars is devoid of water, this growth has to await the arrival of the liberated fluid from the polar caps before it can assume its vernal appearance. Naturally, the sun having already passed the summer solstice, those portions of the planet's surface nearer to the water supply will be the first to grow the new vegetation.

Further considerations, dealt with *in extenso* in the *Bulletin*, lead Mr. Lowell to the conclusion that both the anomalies and the generalities he has discovered argue for the artificial origin of the Martian canals.

TOTAL SOLAR ECLIPSE OF 1905.—An article in the August number of the *Bulletin de la Société astronomique de France* gives a number of details concerning the eclipse of 1905, and maps showing the entire path and the sections of it which traverse Spain and Tunis. A set of diagrams showing the appearance, at various places, of the greatest phase of the eclipse, indicates that for Paris the eclipse commences at 12h. 3·1m. (Paris Civil M.T.), has its greatest phase (0·818) at 13h. 19·1m., and finishes at 14h. 31·7m.

SOLAR PROMINENCES DURING 1903.—In No. 6, vol. xxxiii., of the *Memorie della Società degli Spettroscopisti Italiani,* Prof. Mascari summarises the results of the observations of prominences made at Catania during 1903.

Very few prominences were seen during the first months of the year, but they were notably augmented later. In January and February the phenomena presented themselves with equal intensity in each hemisphere, but in the second and third trimestres they prevailed in the northern hemisphere, whilst in the fourth they were more numerous in southern latitudes.

The number of days without prominences during 1903 was 38 per cent. of the total number of days of observation, instead of 67 per cent. as in 1902. The mean latitude of the prominences in 1903 was 42°·1, as compared with 48°·4 in the previous year. The undecennial minimum of prominence activity apparently occurred in October, 1902.

THE LOWELL SPECTROGRAPH.—In No. 1, vol. xx., of the *Astrophysical Journal,* Mr. V. M. Slipher gives a detailed description of the complete spectrographic equipment obtained for the Lowell Observatory from Mr. J. A. Brashear in 1901.

The chief instrument differs but little from the Mills spectrograph (Lick), and its linear and angular dispersion at Hγ, as compared with the other large instruments of its class, may be seen from the following table:—

Spectrograph	Focal length of camera		Dispersion: Linear, tenth-metres per mm.	Dispersion: Angular, for one-tenth metre
		mm.		″
Lowell	Short	386	14·5	36·8
,, ...	Long	471	11·4	36·8
Mills (Lick) ...		406	12·6	40·5
Potsdam III....	1	560	10·2	36·5
,, ...	2	410	13·8	36·5
Bruce (Yerkes)	A	449	10·7	42·8
,,	B	607	7·9	42·8

Mr. Slipher's communication gives all the details of the instrument's construction and mounting, and is illustrated by several photographs and colour-curves.

A NEW BAND SPECTRUM OF NITROGEN.—Whilst photographing the spectrum of the afterglow from metallic spark discharges in an atmosphere of nitrogen, Mr. Percival Lewis, of the University of California, has discovered what is presumably a new band spectrum of nitrogen. He found that the afterglow occurred only in chemically prepared, dried and purified nitrogen, and then only when a strong condenser discharge was employed.

The spectrum is discontinuous, consisting of lines and bands, some of the latter belonging to Deslandre's third group, whilst others were of unknown origin. No afterglow occurred in the metallic vapours unless there was an afterglow in the gas. New bands occur in most of the spectra obtained at λλ 2750, 2890, 3035, and 3200, whilst others, at approximate wave-lengths 3380, 3575, 3805, 4130, and 4540, only occur in some of the photographs. Of the latter bands several may be due to NO, but none of them are found in the spectrum of NO_2 (*Astrophysical Journal*, No. 1, vol. xx.).

THE PERSEID METEORIC SHOWER OF 1904.

THIS shower has not furnished a rich display this year; in fact, the number of meteors visible appears to have been decidedly below the average. Yet there was no moonlight to offer any impediment, and the nights were very clear just at the important time.

On August 9 there were a few Perseids, but the meteors recorded from all sources little exceeded the average number observable on an ordinary night in August, and I wrote down in my notebook that I had never seen so few meteors on August 9 in any previous year.

On August 10 there was an increase in the number visible, but I made no lengthy observations.

On August 11, between 10h. 30m. and 13h. 30m., Perseids were falling at the rate of about 25 per hour for one observer, and the radiant was at 46°+58° from 37 paths. This horary rate is for an observer who registered a few of the tracks, and whose attention, therefore, was not given continuously to the sky. Mr. McHarg at Lisburn, Ireland, says that from 10h. to 11h. local time the Perseids averaged 30 to the hour. Mr. J. Webb, of Bristol, counted 21 between 9h. 50m. and 10h. 50m.; Mr. W. E. Besley, of London, saw 66 meteors in 3 hours between 10h. 30m. and 13h. 30m., and others must have been missed while records were being made. He saw meteors as bright as Jupiter or Venus at 10h. 30m., 11h. 14m., 11h. 20m., and 13h. 7m. Mr. McHarg noted a brilliant green fireball > ♀ at 10h. 20m. G.M.T. falling in Libra a little west of α and directed from ε Boötis, so it was probably a Perseid.

On August 12 the Perseids were again in evidence, but not very abundantly. At Bristol between 10h. and 12h. 30m. there were about 17 or 20 per hour, but the watch was not quite continuous. The radiant was very sharply defined at $47^\circ+58^\circ$ from about 20 paths.

On August 13 the sky was less favourable; there was a good deal of haze, and the stars were blurred and faint; only a few Perseids were seen in these adverse circumstances.

Though the shower generally was not a plentiful one, it is likely to prove interesting in some of its results, for a number of its meteors appear to have been observed at more than one station, and their real paths can be computed.

Three features in reference to the shower of 1904 appear to the writer to deserve special mention:—

(1) The sharply defined point of radiation on August 11 and 12.

(2) The comparatively meagre character of the display.

(3) The fact that nearly all the Perseids appeared on the right (western side) of the radiant. This was very marked, and the writer has been struck with the same peculiarity in preceding years. There were many Perseids in Andromeda, Pegasus, Cassiopeia, Cepheus, and Cygnus, but few in Camelopardus, Auriga, the Lynx, and Ursa Major.

W. F. DENNING.

THE THIRD INTERNATIONAL CONGRESS OF MATHEMATICIANS.

THERE are few towns better suited for a scientific gathering than Heidelberg, and few scientific gatherings have passed off so successfully as the third International Mathematical Congress which met there from August 8 to 13. The number of mathematicians attending the congress was 330, giving with holders of ladies' tickets a total membership of nearly 400. The German Government, the Grand Duke of Baden, the municipal and university authorities of Heidelberg, the Deutsche Mathematiker Vereinigung, and an influential executive committee all joined in giving the congress a hearty welcome, and the local arrangements were perfect.

The formal proceedings opened on Tuesday, August 9, under the presidency of Prof. H. Weber, of Strasburg. The year 1904 being the centenary of the birth of Jacobi, the occasion was selected for the delivery of an address by Prof. Leo Königsberger on Jacobi's life and works. A large volume by Prof. Königsberger dealing with the same subject was published by Messrs. Teubner in connection with the present commemorations.

Another feature of the congress was the presentation, by Prof. Klein, of the first copy of vol. i. of the "Encyklopädie der matematischen Wissenschaften," which volume has just been completed. Considerable progress was also reported in the preparation of the French edition of the "Encyklopädie."

Prof. Gutzmer, of Jena, presented a history of the Deutsche Mathematiker Vereinigung, founded in 1890, as well as the July part of the *Jahresbericht* of the society, containing papers on the teaching of mathematics.

Passing on to a review of the work done in the sectional and general meetings, the most noticeable feature revealed by the general spirit in which many of the papers were written was the growing tendency in the mathematical world to devote greater attention to the practical and experimental aspects of mathematics, especially in connection with mathematical teaching. From such signs as this it appears not unlikely that we are on the eve of a renaissance period in the history of mathematics. A large collection of models, mathematical instruments, apparatus, and books was exhibited in the large hall of the museum. Prof. Runge, of Hanover, exhibited and described Leibnitz's calculating machine. A number of experiments on fluid motion past various boundaries were shown by Prof. Prandtl, of the same town. These differed from Prof. Hele-Shaw's experiments with thin films in that a vessel of some depth (say an inch or two) was used, and water or liquid of small viscosity employed; in this case a series of vortices were seen to be thrown off in succession from a cylindrical or other obstacle, and the various stages of formation of each vortex were clearly demonstrated by photographs as well as experimentally.

Prof. Greenhill's discourse on the theory of the top, considered historically, also contained an attempt to give graphical representations of the motion of the top, and was illustrated by experiments with bicycle wheels and other equally simple apparatus.

Coming to matters of more purely educational interest, Prof. Klein, in his address to the applied mathematics section, gave an amusing account of the methods in vogue in certain German middle schools for obviating the use of the calculus, a state of affairs reminding one of the old Cambridge "three days." Prof. Loria, of Genoa, stated that the attempt to abolish Euclid in Italy had failed owing to the badness of the text-books brought out to meet the new conditions, that a Government prize had been in consequence offered for a good manual on geometry, and that the books of Veronese, Enriques, Amaldi, Paolis and others were the result.

Prof. Gutzmer urged that elasticity and thermodynamics should form part of the training of every professor of applied mathematics. Resolutions were passed by the congress urging the Government to provide models and projection-lanterns for use in teaching mathematics in the German schools and technical colleges. A further resolution related to the teaching of geometrical drawing in schools.

In connection with the historical section, a resolution was passed relating to the publication of Euler's works by the Carnegie Institution. Prof. Schlesinger announced the appearance of the first volume of the works of L. Fuchs, and a bibliography of Wronski's works was presented by Prof. S. Dickstein.

Of papers in applied mathematics, the most remarkable was Prof. Sommerfeld's investigation on the motion of electrons; the remaining papers dealt *inter alia* with the problem of three bodies (Profs. Delaunay and Levi-Civita), equations of wave motion (Profs. Volterra and Hadamard), attractions (Prof. Genese), and geodesy (Prof. Börsch and others).

In pure mathematics the most striking papers were those by Prof. Hilbert on integral equations and on the foundations of arithmetic, and Prof. König's proof that the continuum cannot be equivalent to any well ordered group. Prof. Painlevé, of Paris, gave an admirable discourse on the integration of differential equations; Prof. Segre, of Turin, on the geometry of to-day; and Prof. Wirtinger, of Vienna, on Riemann's lectures on hypergeometric series. We also note papers by Prof. Schlesinger on Riemann's problem, by Prof. Borel on approximations of continuous functions, and many others too numerous to mention. Prof. E. Study showed that the paradoxical result $2=4$ could be obtained from considerations of intersections of quadric surfaces.

The congress was international in every sense, the membership including representatives of Germany, France, Great Britain, Italy, Switzerland, Austria, Sweden, Denmark, Spain, Russia, Japan, the United States, Greece, and other countries. Only seven of the members present were from Great Britain.

For the meeting place of the next congress in 1908, Rome has been selected, and the congress will take place at a somewhat earlier time of the year (probably about Easter). In this connection a prize is offered for the best thesis on the theory of algebraic gauche curves. It has been decided to hold the next following congress in England.

Not the least important feature of the congress was the large amount of local interest shown in the organisation of social entertainments. On Wednesday, August 10, a dinner was given to all the members in the new Town Hall of Heidelberg. On the Thursday we were received and entertained at Schwetzingen by the Hereditary Grand Duke of Baden. The next evening we sailed down the Neckar in illuminated barges, and on reaching Heidelberg the castle was illuminated by red fire, the proceedings ending with fireworks, including a set-piece of the Pythagorean Theorem (Euc. i., 47). The last evening we were entertained at a concert at the castle, followed by another illumination and a Kommers, for which a special song-book had been published that included a number of amusing mathematical songs written for the occasion. To make this insight into German student life more real, two delegates were elected by the students of German universities to officiate in the uniform of their corps, and with their swords.

The town concerts and many places of interest were specially thrown open to members. The arrangement of meeting places in one or more *cafés* was another feature which added considerably to the social success of the meeting. Excursions were organised to the Stift Neuberg, to Speyer, and up the Neckar Valley.

Mathematicians who had known of one another for years as mere names have now become personal friends, and we shall carry away life-long reminiscences of the many pleasant meetings which have done much to cement the bond of union between fellow workers in all branches of mathematics, and of all nationalities. G. H. BRYAN.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—On Monday, August 22, the University of Cambridge conferred seventeen honorary degrees on the occasion of the meeting of the British Association. The following are the speeches delivered by the Public Orator, Dr. Sandys, of St. John's College, in presenting those of the recipients who received the degree of Doctor in Science for distinction in natural sciences, mathematics, or anthropology :—

OSKAR BACKLUND, PROFESSOR OF ASTRONOMY, ST. PETERSBURG.

Ab exteris exorsi, primum omnium salutamus nuntium quendam sidereum, ab arce illa celeberrima prope Petropolin stellis observandis dedicata ad nos devectum, quae trium deinceps Struviorum nominibus iamdudum gloriatur. Ipse talium virorum haeres dignissimus, planetarum potissimum in moles motusque perturbatos diligenter inquisivit, et Enckii praesertim cometen, ter in quoque decennio inter sidera nostra lucentem, indagandum sibi sumpsit. Dum cometae illius reditum in mense proximo spe certa expectamus, sideris illius indagatorem indefessum hodierni diei inter lumina libenter numeramus.

HENRI BECQUEREL, PROFESSOR OF PHYSICS, PARIS.

Francogallorum e republica vicina cursu prospero ad nos pervenit scientiarum Academiae Parisiensis socius illustris, cuius etiam patrem avumque honore eodem ornatos fuisse constat. Ipse in vi magnetica praesertim exploranda diu praeclare versatus, nuper propterea imprimis famam est adeptus, quod metallum, sideris Urani inventoris in honorem, olim Uranium nominatum, primus omnium nuper probavit ipsum radios quosdam mirabiles emittere, quos etiam per metalla transire non dubitare. Laetamur virum tam illustrem scientiae lumen, a patre suo sibi olim traditum, splendore novo a sese exauctum, etiam aliis invicem iamdudum tradere. Etenim, scientiae quoque in lumine vitali per saecula hominum tradendo,

> "sic rerum summa novatur
> semper, et inter se mortales mutua vivunt, ...
> et quasi cursores vitai lampada tradunt."

J. W. BRUEHL, PROFESSOR OF CHEMISTRY, HEIDELBERG.

Salutamus deinceps virum urbis Palatinae inter professores illustres iamdudum numeratum, virum in scientia chemica insignem. Ut rem scientiae illius ad historiam pertinentem paulo altius repetamus, inter physicos antiquos olim, uti nostis, finem secandis corporibus esse negavit quidem Anaxagoras, Democritus autem affirmavit; Democriti vero atomos, per duo milia annorum inutiles et infructuosas existimatas, scientiae chemicae saltem inter professores rursus in honore esse constat. Viri huiusce autem inter merita id potissimum commemoratur, quod, experimentis exquisitis iam per quattuor et viginti annos adhibitis, praeclare ostendit, quae potissimum inter res in unum revera compositas atque atomorum, rerum earum in particula quaque consociatarum, distributionem ratio intercedat. Unde fit, ut etiam in rebus perquam multiplici modo compositis, atomorum illarum nexus accuratius explicentur, atque etiam in coloribus quibusdam novis vetera illa Lucretii verba denuo vera reddita sint, quo docente rerum primordia

> "variis sunt praedita formis,
> e quibus omne genus gignunt variantque colores
> propterea, magni refert quod semina quaeque
> cum quibus et quali positura contineantur."

ADOLF ENGLER, PROFESSOR OF BOTANY, BERLIN.

Universitatis Berolinensis e professoribus praeclaris adest vir, qui arborum et herbarum provinciam eximiam iam per annos quadraginta luculenter illustravit. Hoc iubente, quot arborum genera conifera, quot liliorum varietates, quot dicotyledonum species obscurae, e tenebris in lucem novam surrexerunt ! Idem (ne plura commemorem) etiam scientiae suae Acta a se condita iam per annos tres et viginti edidit, genera plantarum omnia in ordinem optimum reduxit, ne palaeontologiam quidem neglexit, neque Africam Orientalem neque Americam Australem inexploratam reliquit. Quod ad alios attinet, Victoris Hehnii librum celeberrimum de transitu plantarum ex Asia in Europam conscriptum accuratiorem reddidit, etiam plantarum per orbem terrarum distributionem Alexandri Humboldtii in memoriam prosecutus. In scientia botanica nemo fortasse hodie Plinii ipsius verba sibi verius potest arrogare :—" non unius terrae sed totius naturae interpretes sumus."

PAUL VON GROTH, PROFESSOR OF MINERALOGY, MUNICH.

Ex urbe pulcherrima, quod Bavariae totius caput est, ad nos pervenit vir studiorum in regione pulcherrima versatus, qui crystallorum scientiam physicam professus, Milleri nostri, viri insignis, crystallorum describendorum rationem et ipse praetulit et aliis omnibus per Europam totam commendavit. Quantum in scientia sua in ordinem redigenda atque etiam aliis tradenda profuerit, testantur Acta illa ab ipso condita et per annos plus quam quinque et viginti edita; testantur tot discipulorum et amicorum etiam inter exteros gratulationes recentissimae; testatur praeceptoris tanti in honorem imago ipsius arte eximia depicta et anni huius paulo ante Kalendas Maias donata ; testatur hodiernus denique dies, quo nomen viri " quem rumor alba gemmeus vehit pinna," tituli nostri signo honorifico consignamus. Etiam hodierni diei memor, poterit fortasse Martialis verba mutuari :—

> " Felix utraque lux, diesque nobis
> Signandi melioribus lapillis."

ALBRECHT KOSSEL, PROFESSOR OF PHYSIOLOGY, HEIDELBERG.

Urbem Palatinam denuo in memoriam vocat physiologiae illius chemicae professor insignis, quae quicquid vivit perscrutata, tot corpuscula textu tenuissima explorat et explicat, tot cellulas absconditas in lucem protrahit et enucleat. Abhinc annos sex eiusdem Universitatis, eiusdem scientiae, professorem in hoc ipso loco laudavimus, qui in unoquoque e tribus decenniis hanc scientiam magnopere adiuvit. In professore illo laudando sperabamus intra proximum decennium fore ut talium virorum laboribus physiologiae in provincia chemica laurus plurimae referrentur. Quod illo die sperabamus professoris illius successor feliciter ratum effecit.

HENRY F. OSBORN, PROFESSOR OF ZOOLOGY, NEW YORK.

E republica maxima trans aequor Atlanticum diu prospere constituta laetamur ad nos advectum esse virum palaeontologiae praesertim in scientia insignem, qui non modo in Universitate Columbiana, nobis et linguae et studiorum communium societate coniunctissima, zoologiam praeclare profitetur, sed etiam, Eboraci Novi in Museo maximo, animalium ingentium e rupibus ipsis effossorum multitudinem saxeam, sive Dinosauri sive Atlantosauri nominantur, sive alio aliquo nomine splendido glorientur, summa sollertia conquisivit, summa arte disposuit, summa cura custodit. Gaudemus rempublicam illam, tot rerum novarum varietate excellentem, etiam vitae pristinae vestigia tam antiqua tanta cum alacritate persequi. Iuvat virum hospitii iure cum plurimis coniunctum Ennii ipsius in verbis etiam propterea laudare, quod, in Museo illo " multa tenens antiqua," ipse " egregie cordatus homo " esse perhibetur.

VITO VOLTERRA, PROFESSOR OF APPLIED MATHEMATICS, ROME.

Quem genuit Ancona, quem arx antiqua Etruriae suo nomine ornavit, quem primum Pisarum, Galilei cum memoria consociatarum, deinde Augustae Taurinorum, denique Romae ipsius Universitas inter professores suos numeravit, multis profecto nominibus observantiae vestrae commendatur. Sed, ut relictis nominibus ad res ipsas progrediamur, inter peritos constat virum hunc lucis praesertim in legibus investigandis esse imprimis illustrem atque scientiae dynamicae (ut aiunt) in ratione universa exploranda plurimum pollere. Viri Italiae totius inter mathematicos conspicui meritis accuratius explicandis gravamur prorsus imparem esse veterem illam linguam Latinam, quam ipsa Italia Britannis olim donavit. His saltem in studiis Italia hodierna Italiam antiquam superavit.

SIR DAVID GILL, K.C.B., F.R.S., H.M. ASTRONOMER AT THE CAPE.

Ad patriam reversi, quam libenter salutamus virum in stellis observandis insignem, qui inter Aberdonienses suos astronomiae studia olim auspicatus, planetae Veneris transitum in oceano Indico accurate observandum curavit. Idem et Aegypti et Africae Australis coloniae extremae et Terrae Natalis spatia ampla dimensus est; stellarum omnium imaginum lucis ipsius auxilio reddendarum auctor fuit assiduus; Africae denique in promontorio remotissimo arcem caelestem sibi creditam quinque et viginti per annos fortiter et feliciter occupavit. In excubiis illis patria procul tolerandis quam fortem ipsum, in alios quam generosum sese praestitit; aliorum labores quantis stimulis incitavit, ad exitum felicem perductos quanta benevolentia excepit! Viri talis sub auspiciis et unius e professoribus nostris sub praesidio pro scientiarum societate Britannica in annum proximum Bonae Spei in Promontorio bene nominato licet omnia fausta augurari.

A. W. HOWITT, F.G.S., HONORARY FELLOW OF THE ANTHROPOLOGICAL INSTITUTE, &c.

Australiae praesertim aborigines, in annos singulos ad minorem numerum redactos, nonnullis vero in locis prope funditus extinctos, simplicitatis pristinae mores antiquos diutissime conservasse constat. Hic autem, a collega optimo, Collegii vicini alumno adiutus, indigenarum illorum primum consuetudines nuptiales, deinde adulescentium initiationes, denique religionis rudimenta prima, diligenter investigavit, et prioris aevi memoriam evanescentem litterarum monumentis fideliter mandavit. Talium virorum laboribus historia, si non "magistra vitae," at certe "lux veritatis," "nuntia vetustatis," "vita memoriae" esse gloriatur.

SIR NORMAN LOCKYER, K.C.B., F.R.S., DIRECTOR OF THE SOLAR PHYSICS OBSERVATORY, SOUTH KENSINGTON.

Inter astronomiae et scientiae physicae fines patet provincia, ubi, instrumentis subtilissimis adhibitis, etiam solis ipsius radii retexuntur, et, linearum varietate quadam minutissima observata, corpora prima, e quibus sol ipse est compositus, inter sese distinguuntur. Adest vir in regione tam pulchra exploranda inter principes numeratus, qui, ne his quidem finibus contentus, non solis tantum defectus identidem observavit, sed etiam astronomiae provinciam amplissimam sibi vindicavit. Idem, per annos prope quinque et triginta Actis quibusdam praeclaris luculenter editis, anni cuiusque septimo quoque die rerum naturae totius varietatem orbi terrarum patefecit.

MAJOR P. A. MACMAHON, F.R.S., FORMERLY PROFESSOR OF PHYSICS AT THE ORDNANCE COLLEGE, WOOLWICH.

Adest deinceps militis insignis filius, miles mathematicis praesertim in studiis spectandus, qui praeter alios laudis titulos etiam scientiarum societatis Britannicae inter ministros praecipuos numeratur. Studiorum suorum in caelo puro, in regione illa sublimi a Cayleio nostro feliciter peragrata, diu versatus, studiis illis caelestibus sermonis Latini Musam pedestrem, longe infra in terris relictam, nihil aliud quam numerorum theoriam quandam e longinquo contemplari patitur. Cetera omnia scientiae tam sublimis mysteria, peritis patefacta, a nobis certe palam divulgari non concessum. Illud autem unum dixerim. Si, Syracusis captis, Archimedem, intentum formis, quas in pulvere illo erudito descripserat, Marcelli in exercitu miles talis aspexisset, caeli spectatorem illum unicum, tormentorum bellicorum machinatorem illum mirabilem, sine dubio nunquam interfecisset, sed velut socium et fratrem statim esset amplexus.

SIR WILLIAM RAMSAY, K.C.B., F.R.S., PROFESSOR OF CHEMISTRY AT UNIVERSITY COLLEGE, LONDON.

Virum inter Caledones suos atque inter Germanos educatum, titulo nostro Academico fortasse eo digniorem putabitis, quod iam in orbe terrarum toto Academiis fere viginti honoris causa est adscriptus. Per annos septemdecim inter Londinienses scientiam chemicam praeclare professus, aëris praesertim elementa exploravit, et (cum alumno nostro insigni, Rayleio, consociatus) elementum illud *Argon* nuncupatum repperisse confitetur. Etiam propterea laudandus est quod in metallis *Helium* invenit; quod in aëre ipso *Neon*, quod *Krypton*, quod *Xenon*, tot elementa ex ipsa rerum naturae origine latentia detexit, detecta nominibus pulchris, nominibus Graecis, ornavit. Nonnullis certe e nobis non ingratum, etiam in elementis novis nominandis linguae Graecae antiquae utilitatem comprobatam contemplari; iuvat etiam ipsius nomen gentile et olim et nuper propter linguarum peritiam inter Caledones celebratum, in rerum et nominum inventore tanto, etiam rerum naturae scientia illustratum admirari.

ARTHUR SCHUSTER, F.R.S., PROFESSOR OF PHYSICS IN THE VICTORIA UNIVERSITY OF MANCHESTER.

Virum libenter rursus agnoscimus, qui primum Moeni sui in ripa, deinde inter Mancunienses, denique in urbe Palatina educatus, inter nosmet ipsos et Maxwellii et Rayleii nostri inter adiutores praecipuos olim numerabatur. Postea solis defectioni in India trans Gangen observandae quondam praepositus, a societate regia ob lucis arcana feliciter explorata numismate aureo est donatus. Laetamur virum, qui fluminis paterni in ripa ad rem argentariam non sine lucro magno sese dedere potuisset, scientiae lucem lucro praetulisse et lucem ipsam explorandam elegisse. Virum talem dum coronat, Academia Virtutem ipsam aemulatur,

"diadema tutum
deferens uni propriamque laurum
quisquis ingentes oculo irretorto
spectat acervos."

SIR WILLIAM THISELTON-DYER, K.C.M.G., F.R.S., DIRECTOR OF THE ROYAL BOTANICAL GARDENS, KEW.

Laurea nostra iuvat hodie decorare virum Florae in studiis insignem, cuius socerum in eisdem studiis illustrem abhinc annos duodequadraginta Academia libenter ornavit. Isidis propter undas educatus, scientiam suam eximiam et in Anglia et in Hibernia professus, Tamesis in ripa, Florae in hortis pulcherrimis, iam per annos prope triginta vitae suae tabernaculum collocavit. Nomen autem eius non modo regionis Tamesinae sed etiam Africae Australis, Africae denique interioris, cum floribus consociatur. Satis amplus igitur laudandi campus patet, campus floribus consitus, omnique pulchritudinis varietate distinctus; sed Flora vocat, sed horti nostri vos invitant, sed oratorem vestrum, Maronis non immemorem, hortos canere volentem, temporis spatium excludit.

"Extremo ni iam sub fine laborum
vela traham et terris festinem advertere proram,
forsitan et pingues hortos quae cura colendi
ornaret canerem, biferique rosaria Paesti,...
verum haec ipse equidem, spatiis exclusus iniquis,
praetereo, atque aliis post me memoranda relinquo."

DR. J. LORRAIN SMITH, Musgrave professor of pathology at Queen's College, Belfast, has been appointed professor of pathology and pathological anatomy in the University of Manchester.

DR. JULES TANNERY, subdirector of the Paris École normale supérieure, has been appointed professor of differential and integral calculus, and Dr. Houssay professor of zoology in the faculty of science. These two appointments are consequent upon the inauguration of the new régime at the normal school, which has now been attached to the Sorbonne.

IN September, 1902, the Board of Education referred to the consultative committee the question of drafting regulations for the establishment of supplemental registers for teachers of special subjects. Acting upon the report of a subcommittee appointed to consider the subject, the Board of Education has announced that the establishment of supplemental registers will be postponed until the teaching of the subjects proposed for the supplemental registers has been further organised in connection with general education.

THE Duke of Devonshire, on August 20, handed over from the trustees of the Keighley Mechanics' Institute to the Corporation of the town the title deeds of premises valued at more than 50,000*l.*, which the municipality is taking over. During the course of his speech on that occasion, the Duke of Devonshire referred to the work with which he has been associated as president of the National Association for the Promotion of Technical and Secondary Education. The association has pointed out that the industrial and commercial supremacy of our country, upon which its power and greatness mainly, if not entirely, depend—a supremacy which once was unquestioned and undisputed—is not unassailable and is not unassailed. Our former supremacy rested mainly, if not entirely, upon the possession of great natural resources, and upon the energy and industry of our people. These are not now the only, if they are the chief, elements in industrial success. The discoveries of science and the application of science to industries have revolutionised the conditions of industry. Other nations, among whom Germany and the United States have been foremost, but all other Continental nations—France, Italy, Switzerland, and others—have appeared to realise this fact sooner than we have done, and to make greater efforts, and more organised efforts, than we have done to give to all classes engaged in these industries the scientific instruction which is in the present day the necessary condition of success. There are signs that these efforts on their part, and on the part of other countries, and this comparative negligence on our part are already having effect, and it is incontrovertible that it must sooner or later have a vast effect prejudicial to our own commercial and industrial supremacy. It is now recognised that scientific instruction for the whole of our people is a necessary element to our industrial success. Cultivated brains are as essential to industrial efficiency as even the strongest arms or the most willing hearts. The duty of imparting this instruction to those who need it is one that can no longer be safely left to the efforts of the benevolent or the philanthropic, but is the duty of the State as much as that of national defence, the defence of our Imperial possessions, or the defence of our own shores.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 16.—"The Lethal Concentration of Acids and Bases in respect of *Paramoecium aurelia.*" By J. O. Wakelin **Barratt.**

The author finds that the strong mineral acids, hydrochloric, nitric, and sulphuric, in 0·0001 N concentration kill Paramœcia in ten to fifty minutes. Organic acids, in the same concentration, kill sometimes with greater rapidity (formic, lactic, and oxalic acids), sometimes with less rapidity (citric and acetic acids). Exceedingly weak acids (carbonic, carbolic, boric, hydrocyanic) require a much greater concentration in order to kill Paramœcia in the above period of time.

The hydrates of potassium, sodium, lithium, calcium, strontium, and barium in 0·002 N concentration are fatal in five to sixty minutes. Ammonium hydrate is more lethal, and far more so is the extremely weak base anilin. The lethal character of the alkalis exhibits an order corresponding to their periodic grouping.

The experiments made indicate that the action of acids and alkalis upon the living protoplasm of Paramœcia is of the nature of a chemical reaction, and is not purely hydrolytic in character.

PARIS.

Academy of Sciences, August 16.—M. Mascart in the chair.—The second approximation to the equation for the flow of sheets of underground water under slight pressures: J. **Boussinesq.**—New researches on the liquefaction of helium: Sir James **Dewar.** A side tube containing charcoal is added to a vacuum tube, and the tube filled with helium. When the charcoal is cooled down by means of liquid hydrogen to 15° C. absolute temperature, the vacuum produced is so good that a coil giving a 16-inch spark in air is required to produce a slight phosphorescent discharge in the middle of the tube. It follows that at this low temperature the charcoal is a good absorbent of helium. These experiments are regarded as confirming the conclusion that the boiling point of helium will not be found to be below 5° C. absolute.—On a crystalline combination of the acetate and thiosulphate of lead, $2PbS_2O_3,(CH_3—CO_2)_2Pb$: P. **Lemoult.** This compound is precipitated from a solution of lead acetate to which some sodium thiosulphate has been added, and the precipitate of lead thiosulphate re-dissolved by the addition of acetic acid. The above formula was established by analysis.—The alloys of zinc and magnesium: O. **Boudouard.** A series of alloys was prepared containing from 5 per cent. to 90 per cent. of magnesium, the melting points of which were determined. The melting point curve showed a maximum and two minima. The maximum corresponded to a definite combination, Zn_2Mg, and the microscopic study of a polished section proved the existence of a second definite compound, $ZnMg_4$. Both these alloys were isolated.—The properties and constitution of chrome steels: Léon **Guillet.** Two series of chrome steels were studied, both by micrography and by mechanical tests. One series contained very little carbon, the other 0·85 per cent. The steels studied were found to fall into four classes, and the limitations to their practical use are given.—On the evolution of structure in metals: G. **Cartaud.** A micrographic study of the crystallisation of lead.—The first stages in the development of *Sacculina carcini*: Paul **Abric.**—On the comparative values of the tissues of the tail from the point of view of regeneration in the larvæ of Alytes, and on the possible absence of this regeneration: P. **Wintrebert.**—The geology of Chabrières (Hautes-Alpes): E. A. **Martel.**

CONTENTS.