THURSDAY, OCTOBER 31, 1907.

THE THEORY OF FUNCTIONS OF A REAL VARIABLE.

The Theory of Functions of a Real Variable and the Theory of Fourier's Series. By Dr. E. W. Hobson, F.R.S. Pp. xvi+772. (Cambridge: University Press, 1907.) Price 21*s.* net.

IT is impossible to read Dr. Hobson's book without reflecting on the marvellous change that has come over Cambridge mathematics in the last twenty years. Twenty years ago Cambridge mathematics was a thing standing by itself, and with its own virtues and defects. Pure mathematics in Cambridge meant Cayley and a few disciples; and Cayley (widely as he read) owed little or nothing to anyone but himself. Certainly he never appreciated the most fundamental ideas of modern Continental analysis. It is probable that he could not have defined a function or a limit in a way which would have satisfied Weierstrass or Dr. Hobson: it is certain that he would have been as incapable as any Senior Wrangler of proving any of the less obvious theorems of convergence. The first signs of the absorption of these ideas are to be found, not in Cayley, but in Stokes.

Now Cambridge has fallen into line. There are no Cayleys, perhaps, but there is quite a flourishing school of pure mathematics, working by what may be called German methods and on German lines, and making up in numbers and soundness for anything that it has lost in distinction. The school of Cayley is dead, and so (what is perhaps even more to be regretted) is the old Cambridge school of applied mathematics: pure mathematics and experiment have combined to kill it, and the Stokes Lecturer in Applied Mathematics writes books like this. We wonder what Clerk Maxwell or even Stokes himself would have thought of it.

However, all this is not Dr. Hobson's fault, and we must not blame him if the reflections which it inspires are not altogether pleasant. And we hasten to congratulate him on the completion of what is, without a doubt, a magnificent piece of work. It would be a fine piece of work even if were a mere compilation; for the subject is one of which there was no systematic account in English, and which no previous English writer had ever really mastered. But the book is far from being a compilation, for Dr. Hobson has made the subject his own, and writes with the air of mastery that only original work can give: and even in French, German, or Italian, there is no book which covers anything like the same ground. Dini (whom Dr. Hobson has obviously taken as his model) has held the field for a long time, and Dr. Hobson can fairly claim to have superseded him.

In taking Dini as his model, Dr. Hobson has made the "theoretically general," rather than what Borel has called the "practically general," his goal. No doubt he had to make his choice, but we must confess that he seems to us to have gone too far. Let us consider his treatment of "double limit problems," for example, problems such as those of the differentiation or integration of an infinite series or an infinite integral (why will he persist in making the uninitiated scoff by his fondness for the word "improper"?). Such problems may be approached from two different points of view. We may ask, "What is absolutely the most general form in which we can state our theorems, when we utilise all the most modern theories of sets of points, Lebesgue integrals, and the like?" This is the point of view of Dini and Dr. Hobson. On the other hand, we may ask, "In what special forms do these problems naturally occur in analysis? What are *the really important cases*? Can we state our theorems in such a way that writers on applied mathematics, or other branches of pure mathematics, when they are confronted, as they continually are, with particular problems of this kind in all conscience difficult enough, will be able to turn to us for a solution of their difficulties?" These questions must be continually before us, if we are aiming at Borel's "practically general" completeness, and even an author who has decided to aim at the other ideal will do well to keep them clearly in sight; and we wish that Dr. Hobson had more often adopted this point of view. He might then have made his book a good deal more useful and attractive for the ordinary worker in the fields of analysis. The latter, as it is, is likely to find himself faced by many theoretical difficulties to which he will not easily find an answer in Dr. Hobson's pages. However, it is perhaps as well that Dr. Hobson should leave something for someone else to do.

But it is time that we said a little of the details of the book. It is needless to say that it is beautifully and almost faultlessly printed. It is a pity, though, that the chapters are so long. Long chapters do not make a difficult book easier to read, nor do they make it easier for the author to arrive at the proper logical arrangement of the subject-matter—as appears very clearly in chapters v. and vi., which had much better have been broken up into half a dozen shorter chapters. We should like to have seen a great many more examples. Summaries of the chapters, too, would have been useful; and the author is too sober in his use of different kinds of type. In a word, he shows too great a contempt for the arts of popularity.

There are seven chapters in all. For the first three, which are of a particularly abstract character, we have practically nothing but praise. The matter is admirably selected and admirably arranged, and Dr. Hobson writes with a lucidity and distinction rare indeed among mathematicians. Nothing could be better in its way, for example, than his terse criticism of the "formal" view of mathematics (pp. 9–10). We cannot entirely agree with the conclusions at which he arrives in the course of the critical discussions of chapter iii, but we can appreciate the clear and temperate manner of his criticisms, advanced, as he says, "with some diffidence, on account of the great logical difficulties of the subject," and in the hope that "they may be of utility as a contribution towards the discussion of questions of great interest which, at the present time, cannot be regarded as having been decisively settled."

In chapter iv. we begin for the first time to be

bored in places. The four derivatives of a function *are* dull, and no one will ever make them seem anything else; and a good deal of Brodén's work is much more solid than inspiring. Occasionally we do not quite like Dr. Hobson's choice of words—in particular we may instance his use of "indefinitely great," in such phrases as "has indefinitely great values," "the functional value is regarded as indefinitely great," "the lower limit is indefinitely great." Why not, in the last case, simply "there is no lower limit"? Dr. Hobson could reply that he has expressly warned the reader against any such confusion of thought as is sometimes implied in modes of expression such as these; and there is certainly none in his own mind. None the less we wish that he had expressed himself in a different manner.

In this chapter, let us single out for special praise the sections on double and repeated limits (pp. 303 *et seq.*). We particularly like the author's generalisation of the definition of a repeated limit, which enables him to simplify the statements of a number of theorems. We have already said that we do not altogether like the arrangement of the next two chapters. Surely it would have been better to introduce the notion of a series at an earlier stage. As it is, some of the theorems concerning integrals are separated from one another in a rather irritating way. But most of the discussions of particular theorems are admirable. We may mention especially the treatment of the "absolutely convergent improper integral" (pp. 364 *et seq.*), the sections on the transformation of double integrals (pp. 445 *et seq.*), and the account of Baire's theory of the representation of functions (pp. 522 *et seq.*). A few criticisms of details suggest themselves. Is it worth while to define "principal values" if nothing more is to be said about them? There is a curious slip on p. 454, l. 14; obviously the condition stated is not *necessary:* and it is very odd that Dr. Hobson should define *divergence* and *oscillation* in such a way that $1-2+3-4+\ldots$ is a divergent rather than an oscillating series. The last word has not yet been said about Weierstrass's non-differentiable function (pp. 620 *et seq.*). What about $\Sigma a^n \cos b^n x$, where ab is only a little greater than 1? One would expect the function to have no differential coefficient whenever $ab \geqq 1$; but no one seems to have found out whether this is the case or not.

Finally, chapter vii. (Fourier's Series) shows Dr. Hobson quite at his best. The last part, in which he supplies a final touch of rigour to some of Riemann's work, is extremely difficult, but that was inevitable. The remark at the foot of p. 647 is open to dispute. Was not something very much like the theorem, ascribed to Lerch on p. 727, also proved by Stokes? On p. 732, l. 24, for "diminished" read "increased."

A short appendix contains some further critical remarks, in addition to chapter iii. We wish that there had been space for a summary of König's rather watery theories, and the author's neat and convincing reply in the London Mathematical Society's Proceedings. We must confess to a strong temptation to argue with Dr. Hobson concerning the remarks at the top of p. 765, but the temptation must be resisted.

Dr. Hobson has attempted an appalling task. There is no region of pure mathematics (unless it be the theory of numbers) which is quite so difficult as this; certainly none of which the literature is so scattered and so difficult to collate, or in which the writing of a big book requires a greater combination of drudgery and critical insight. All things considered, he has succeeded wonderfully. We can think of no one else who would have done half as well. G. H. H.

LIEBIG AND GÜSSEFELD.

Justus von Liebig und Emil Louis Ferdinand Güssefeld. Briefwechsel: 1862–1866. Herausgegeben von Dr. O. E. Güssefeld. Pp. viii+72. (Leipzig: Johann Ambrosius Barth, 1907.) Price 3 marks.

THIS little book has a twofold interest. To the scientific agriculturist it is interesting as elucidating the history of the introduction of the modern methods of agriculture into Germany, and especially of the introduction of the so-called chemical fertilisers, due largely to the teaching and influence of Liebig; it serves also to throw some sidelights upon the character and habits of Liebig himself, and is therefore of interest to the historian of chemistry. It consists simply of a collection of thirty-eight letters which passed between Liebig and Emil Güssefeld from 1862 to 1866, twenty-two of which are contributed by Liebig, and the whole has been arranged for publication, with explanatory notes and annotations, by the pious care of the son of one of the correspondents.

Emil Güssefeld was a Hamburg merchant, of the conventional type, dealing mainly in coffee and other colonial products. In a fortunate hour he accepted an agency from an American company for the sale in Germany of guano from Baker Island, in the Pacific Ocean, and thereby laid the foundations of a prosperous business in phosphatic manures. Emil Güssefeld indeed stands to Germany in much the same relation that the late Sir John Bennett Lawes stands to this country, and both reaped fame and fortune by the far-sighted enterprise which induced them to give practical effect to the theoretical views of Liebig. As a prudent man, Güssefeld, before undertaking the agency, seems to have consulted Liebig as to the probability that the Baker guano, of the merits of which he was well assured, would find a ready sale among a body of agriculturists who are even more conservative than our own, and Liebig's reply constitutes the first letter in the series. It is in every respect worthy of him—sound, thoughtful, and considerate, and with that note of cautious optimism which the eminently practical mind of the Hamburg merchant could not fail to appreciate. Liebig, as this correspondence abundantly testifies, never spared himself when his interest was aroused, and he was ever ready to give of his best, without fee or thought of reward, when the object commended itself to him. In this large-hearted liberality Liebig resembled Davy, who nearly half a century previously had striven in the same self-sacrificing way to infuse something of the scientific spirit into the oldest of the arts. Liebig's letters are rich in practical advice, business hints, analytical information

—all given with no other thought than of doing what in him lay to further the true interests of agriculture. How greatly Güssefeld benefited by his wise counsel, and what material advantages he gained from Liebig's altruistic interest in the development of the industry of which he was a pioneer in Germany, Güssefeld's letters clearly indicate. His letters, too, indicate his sense of gratitude. He repeatedly pressed upon his distinguished correspondent his earnest desire to make some substantial recompense, but Liebig declined to entertain any thought of pecuniary reward. All Güssefeld could do was to appeal to one of the most characteristic of Liebig's frailties. He was, to quote Dr. O. E. Güssefeld, a "leidenschaftlicher Raucher und wollte schwere und nur gute Zigarren haben." These, we are told, are particularly easy to obtain in Hamburg; and we are assured by Liebig that Güssefeld sent him of the best the city could furnish, and kept him well supplied. There is much virtue in a good cigar; how much German agriculture owes to it may be plainly discerned in this interesting correspondence.

T. E. T.

BOTANICAL WORKS.

(1) *Botanisches Jahrbuch.* Edited by Dr. A. Engler. Vols. xxxvi to xxxix. (Leipzig: W. Engelmann, 1905–7.)

(2) *Das Pflanzenreich.* Edited by Dr. A. Engler. Vols. xxii to xxvi, xxvii and xxix. (Leipzig: W. Engelmann, 1905–7.)

(3) *Recueil de l'Institut botanique.* Edited by Dr. L. Errera and Dr. J. Massart. Vols. i, ii, and vi. (Bruxelles: H. Lamertin, 1906.)

(1) ENGLER'S "Botanisches Jahrbuch" serves mainly as a repository for information on systematic botany and plant geography. The issue is peculiar, as usually three or four volumes are in progress simultaneously, but the irregular appearance of the parts serves to ensure rapid publication of papers containing new identifications. Vol. xxxvi was begun and completed in 1905, but the three succeeding volumes form a simultaneous triad that date from September, 1905, to March, 1907. Throughout the four volumes there are only four instalments of the "Beiträge zur Flora von Afrika," in which special interest attaches to the Orchidaceæ and Asclepiadaceæ mostly collected and described by Mr. R. Schlechter, two new genera of the Podostemonaceæ founded by Dr. A. Engler, the collation of the Combretaceæ by Dr. L. Diels, and the list compiled by Dr. F. Pax of plants collected by Mr. F. Rosen in Abyssinia. Another monograph of a similar nature is concerned with the plants collected by Dr. A. Weberbauer on a tour of exploration over the highlands of Peru, of which a brief outline was given in vol. xxxii, and a map with the two first instalments of determinations prepared by various workers under the editorship of Prof. I. Urban appears in vol. xxxvii. Dr. Weberbauer also contributes two short articles that may be regarded as preparatory to a volume for the series "Die Vegetation der Erde."

The subject of insular floras is enriched by several papers. To a phytogeographical account of New Caledonia, Mr. R. Schlechter has added a systematic account of the flora, and Dr. E. Lemmermann has compiled a list of algæ collected in the Chatham Islands.

Among the summaries representing recent work on individual orders and genera, a general comparative account of the Cornaceæ is presented by Mr. W. Wanguerin. The review of the order Valerianaceæ by Dr. P. Graebner affords an indication of a more elaborate commentary to appear in a future volume of the "Pflanzenreich." The genus Anemone forms the subject of a monograph by Dr. E. Ulbrich.

Two papers of more universal interest are provided in the accounts of myrmecophilous plants by Mr. E. Ule and Mr. H. v. Ihering. The symbiotic hypothesis, as well as the view that the hollow spaces in the stems are the result of natural selection, are refuted. The biology of tropical flowers and fruits is discussed by Prof. H. Winkler, and an ecological study of the vegetation on some newly-formed islands in a Swedish lake is described by Mr. S. Birger.

(2) "Das Pflanzenreich" has attained to twenty-nine volumes, of which eight have been published since November, 1905. The volume on the Primulaceæ has been prepared by Prof. F. Pax and Dr. R. Knuth. The genus Primula is remarkable, both for the beauty of the flowers and its wide distribution. From the map provided it will be seen that centres of distribution occur in Switzerland and in the Himalayas, but the richest source lies in western China. Dr. A. K. Schindler has contributed the monograph on the Halorrhagaceæ, from which he excludes the genus Hippuris. Dr. Fr. Buchenau has summarised the fruits of his researches in the volume on the Juncaceæ. The anatomy of the leaves, the germination of the seedlings, and the numerous hybrids are important features of the order. Prof. L. Diels is responsible for the Droseraceæ, that show many interesting characters in anatomy, regeneration, and growth forms. In dealing with the Polemoniaceæ, Dr. A. Brand pays special attention to the work of American botanists. The latest volume by Mr. O. E. Schulz is concerned with the Erythroxylaceæ.

(3) The papers collected in these volumes of the "Recueil de l'Institut botanique" of Brussels constitute a scientific memorial to the late Prof. Errera, as they represent research carried out by him or inspired by his influence. The first volume contains several papers by Prof. Errera on glycogen in plants, and contributions on the same subject by Dr. E. Laurent and Mr. G. Clautriau. In the second volume is published a series of papers dealing with the cycle of nitrogen compounds, including those by Dr. E. Laurent on the reduction of nitrates, and Mr. E. Marchal's account of ammonia formation in the soil by bacteria. Another important collection of papers relates to alkaloids and proteid substances. This series begins with the paper on the localisation and significance of alkaloids in plants, written by Prof. Errera in conjunction with Dr. Maistriau and Mr. G. Clautriau. The next three volumes are reserved for papers published before the year 1903. The sixth

volume, edited by Dr. J. Massart, opens with a contribution by him on the subject of irritability in the higher plants. It also contains the instructive essay by Prof. Errera on the primrose, an account by Miss J. Wéry on the attraction of bees by flowers, and an investigation carried out by Dr. A. Jacquemin on the localisation of alkaloids in the Leguminosæ.

OUR BOOK SHELF.

Les Observatoires astronomiques et les Astronomes. By P. Stroobant, J. Delvosal, H. Philippot, E. Delporte, and E. Merlin. Pp. vi+317; with one chart. (Brussels: M. Hayez, 112 Rue de Louvain, 1907.)

In collecting and publishing the information contained in this volume, Prof. Stroobant and his collaborators have rendered a service of inestimable value to all interested in astronomy. The purpose of the publication is to permit astronomers of every class to learn readily what is being done in their own line of work, and by whom and where it is being done, and the arrangement of the matter makes this a very simple task.

In the main list all the known observatories are arranged in alphabetical order, and for each one is given the country wherein it is situated, its latitude, longitude, and altitude, the nature and titles of any publication it issues, the names of the director and staff, and, finally, a brief *résumé* of the observatory's history, instruments, and work.

This is followed by a list of astronomical societies arranged in the order of their foundation, a brief statement of particulars concerning each society, such as its meeting place, subscription, number of members, titles of its publications, &c., being given. The chief astronomical reviews are then similarly treated.

An alphabetical list of some 1500 names of individual astronomers gives page references to the list of observatories, which enables one to refer immediately to any person named, and find at once his specialities and resources. Then follow a geographical list of all the places referred to, and a list of the astronomical societies and publications of each country.

The work concludes with a chart of the world, on which the distribution of observatories is shown, and which should be consulted by those who are desirous of founding new observatories. Whilst western Europe and the eastern States of the U.S.A. are thickly dotted with observatories, only seven are shown in the whole of Africa. The southern hemisphere and the torrid zone are remarkably deficient in this respect.

The whole of the work of compilation and publication has been done by the Comité de bibliographie et d'études astronomiques of the Royal Observatory of Belgium. Their names appear on the title page, and they are to be heartily congratulated upon the efficiency and expedition with which they have performed their self-imposed task.

Lese- und Lehrbuch für ländlich-gewerbliche Fortbildungsschulen. By H. Gehrig, Dr. A. Helmkampf, Dr. Th. Krausbauer, and Fr. Stillcke. Pp. vii+343. (Berlin: B. G. Teubner.) Price 2 marks.

In Germany, as in England and other industrial countries, there is a growing difficulty in keeping country lads in the country, and attempts are being made to stimulate interest in rural matters by giving definite agricultural instruction in certain of the schools.

The present volume is intended for the Fortbildungsschulen, continuation schools at which attendance is compulsory for two or three years after leaving the elementary school. Like other readers in use at these schools, it contains literary and patriotic sections in addition to the purely technical matter. The book opens with a few poems and short prose pieces in praise of a country life, and exalting the husbandman's calling; towards the end comes the section headed "Deutschland über alles," describing some of the glories of the Fatherland.

The technical part covers a very wide range. Some of the readings deal with economic questions, cooperative societies and banks, liquidation of mortgages, the legal position of the workman with regard to holidays, taxes, &c. Others are hygienic, and give rules for bathing, advice about fresh air and tuberculosis, and first aid to the injured. The purely agricultural part occupies about a quarter of the volume, and is distinctly practical. Useful hints on the management of farm stock are given, together with general accounts of soils, crops and manures. There is also a collection of proverbs dealing with husbandry that will help the pupil fix in his mind the instruction he has received. So far the book is very good, both in conception and in execution. But we are not quite clear why the authors should have attempted accounts of apparently extraneous matters like the metallurgy of copper and steel, the theory of the microscope and of the dynamo. The treatment is necessarily vague and general, and the space might well have been utilised for a fuller development of things falling clearly within the scope of the book.

However, a good deal will depend on the teacher. If he is an enthusiastic countryman he will find the book very useful; if not, it may prove rather dull. Whether a reader of this sort will really attract boys to agriculture remains to be seen; the result of the experiment will be watched with great interest by those in this country who are trying to solve the same problem. E. J. R.

La Houille verte. By Henri Bresson. Pp. xxii+278. (Paris: H. Dunod et E. Pinat, 1906.)

The title of this work, if literally translated, signifies "green coal," and a word of explanation is necessary as to what this combination of words implies. The word "houille" in this sense is intended to convey the idea of energy, more particularly that due to waterfalls and rivers, and the qualifying adjective "verte," as opposed to "blanche," indicates that the sources of the energy are the rivers and watercourses to the exclusion of snow- and glacial-fed torrents.

A book with such a title might be an engineering work or a statistical record; in the present case the latter is the more correct description. Throughout the volume the scientific information is scanty and very elementary. A large part is taken up with a chronicle of the utilisation of water power in the various departments of France; this part comprises 127 pages out of a total of 278. The first half is devoted to "Généralités et Theories," but it must be confessed that the theories are not very serious, and that the generalities are the more prominent.

A large quantity of statistical information is contained in the last fifteen or twenty pages, in which several tables are given showing the volumes of the various rivers and the numbers of hydro-electric installations. These tables will probably be of more interest to the serious student of the subject than all the rest of the book.

The illustrations are fairly numerous, and consist chiefly of landscape scenes; they help to make the book appear lighter, but hardly serve any other purpose.

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.]*

Transit of Mercury across the Sun's Disc, November 13-14, 1907.

PREMISING that the times given on p. 451 of the Nautical Almanac for 1907 are the Greenwich mean astronomical times of the several contacts in the above transit as seen from the centre of the earth, it may be useful to the readers of NATURE to record the corresponding Greenwich mean astronomical times of the contacts as seen from Greenwich. These times are deduced by the formulæ printed on the above-mentioned page of the Nautical Almanac :—

		d.	h.	m.	s.
External contact at ingress ...	November	13	22	23	24
Internal contact at ingress ...	,,	13	22	26	1
Internal contact at egress ...	,,	14	1	48	10
External contact at egress ...	,,	14	1	50	50

Angle from north point of sun of contact at ingress, 62°; angle from north point of sun of contact at egress, 345°; measured towards the east in both cases.

A. M. W. DOWNING.

H.M. Nautical Almanac Office, October 26.

Origin of Radium.

IN a letter to NATURE (June 6) I gave the experimental evidence which led me to conclude that in ordinary actinium preparations a new substance was present which was slowly transformed into radium. By a chemical method this substance was separated from actinium, and a solution of the latter was obtained which showed no appreciable growth of radium over a period of eighty days. Observations on this solution have been continued over a total period of 240 days, and there is still no detectable increase in the quantity of radium. The growth of radium, if it occurs at all, is certainly less than 1/500 of that observed in other experiments.

In two recent letters to NATURE (September 26 and October 10) Dr. Boltwood has given the results of his later experiments in this direction. He has confirmed my conclusions, and has, in addition, been successful in devising a satisfactory method of separating this new substance from actinium, and has examined its radio-active and chemical properties. He suggests that the name "ionium" be given to this new body, which is probably the immediate parent of radium. Dr. Boltwood is to be congratulated for his admirable work on this very difficult problem, for, apart from the chemical operations, the radio-active analysis required for correct deduction is unusually complicated and difficult.

Dr. Boltwood has not been able to separate the parent of radium from actinium by the reagent employed by me, viz. ammonium sulphide, but has found the use of sodium thiosulphate effective. In explanation of this discrepancy, he suggests that I employed old ammonium sulphide. As a matter of fact, I did not use the ordinary laboratory solution of ammonium sulphide, but added ammonia to the actinium solution, and then saturated it with sulphuretted hydrogen. The complete separation effected in my experiment was, I think, probably due to an accidental production of finely divided sulphur in the solution.

In a letter to NATURE of last week, Mr. N. R. Campbell raised objections to the name "ionium" given by Dr. Boltwood to the new body, from the point of view that every radio-active substance should be given a name to indicate its position in the scheme of radio-active changes. This system is very excellent in theory, but I have found it extremely difficult to carry out in practice. The continual discovery of new products in very awkward positions in the radio-active series has made any simple permanent system of nomenclature impossible. Besides uranium and thorium, twenty-four distinct radio-active substances are now known to exist in radio-active minerals. The number of products still to be discovered is, I think, nearly exhausted. When there is a general consensus of opinion that this is the case, I feel it will be very desirable for physicists and chemists to meet together in order to revise the whole system of nomenclature. There is not much to be gained in doing so immediately, as the discovery of a new product in the midst of a series would entail the alteration of the names of a possible half-dozen others which follow it. At the same time, I think it will be desirable to retain a distinctive name for those radio-active substances which, like radium, have a long enough life to be separated in sufficient quantity for an examination of properties by the ordinary chemical and physical methods. It is probable that the parent of radium fulfils these conditions, and should thus have a distinctive name like radium.

Personally, I do not much like the name "ionium," but for similar reasons neither do I care for the name "actinium." It is not easy to suggest a name that is at once simple and explanatory. I have for some time thought that possibly "paradium" or "picradium" might be suitable for the new substance. The former name suggests that it is the parent of radium, but I recognise that a possible play on words may make it unsuitable. The name uranium A, suggested by Mr. Campbell, in itself innocuous, is open to the objection that in the case of radium, thorium, and actinium the suffix A is applied to the first product of the disintegration of the respective emanations, while no such emanation has been observed in the initial series of changes of uranium.

E. RUTHERFORD.

University of Manchester, October 27.

The Nature of X-rays.

IN a paper published in the October number of the *Philosophical Magazine* (pp. 429–449), Prof. Bragg, after discussing the properties of various electric radiations, arrives at the conclusion that although a beam of X-rays contains some ether pulses, these may not after all constitute the bulk of Röntgen radiation. In place of the usually accepted theory, he proposes the hypothesis that these rays consist mainly of "neutral pairs" (consisting of a positive and a negative particle) each revolving in a plane containing its direction of translatory motion. This, he considers, affords an easier explanation of the properties of the rays, and is not improbable *a priori*.

I do not intend to discuss more than one point here, for it seems to me that the record of a simple experiment is of more value in deciding between the two hypotheses than a series of comparisons or discussion of probabilities possibly could be.

To explain the phenomena of secondary radiation from light atoms, he supposes that a "pair" striking a light and yielding atom does not suffer disarrangement, but may be returned unchanged and constitute a scattered ray. He also supposes that it is liable to be taken up only by an atom revolving in the same plane as itself, and that if ejected again the subsequent rotation and translation will continue to take place in the one plane. The secondary radiation in a direction perpendicular to that of propagation of the primary will then consist of pairs rotating in the plane of the primary and secondary propagations, and the tertiary will therefore be strongest when in the same plane, thus explaining the polarisation effect.

It is important to notice that this theory can only account for the amount of polarisation which I found to exist in a secondary beam from carbon (Proc. Royal Soc., A, vol. lxxvii., 1906), if the assumed relation between the plane of rotation and direction of propagation is an accurate one.

Now it can easily be shown that, according to the ether pulse theory, when an unpolarised X-ray beam is incident on a substance of low atomic weight, such as carbon, the intensity of secondary radiation is at a minimum in a direction perpendicular to that of propagation of the

primary beam, and a maximum in, or opposite to, that direction.

On the neutral pair hypothesis, if we only assume that the chance of ejection from an atom is equal in all directions in the plane of rotation, it may as simply be shown that the directions of minimum and maximum intensity are the same as on the previous hypothesis; but whereas on the ether pulse theory the intensity of the secondary rays in the direction of propagation of the primary is double that in a direction at right angles, on the "neutral pair" hypothesis it varies as the cosecant of the angle which the direction of propagation of the secondary makes with that of the primary, becoming infinite along the direction of propagation of the primary. In other words, the intensity of secondary radiation varies as the density of the lines of longitude (or as the secant of the latitude) on a sphere with the secondary radiating mass at its centre, the direction of primary propagation being along the axis.

I have made experiments to test the two hypotheses, using an electroscope to compare the intensities of secondary radiation as nearly as possible in these two directions. Taking into account the finite section of the beams and consequent obliquity of the rays, the ratios on the two hypotheses would be roughly 1·9 : 1 and 8 : 1, assuming perfect scattering and neglecting the effect of tertiary rays in the first case and assuming the plane of rotation to contain accurately the direction of propagation in the second. If the assumption is only approximately correct in either case, the ratio will be somewhat reduced. It is evident that great accuracy in the experiments was not essential. They, however, leave no doubt as to the conclusion, for the ratio of intensities was roughly 1·6 : 1—one that might be expected on the ether pulse theory, and appears impossible on the other. It is possible that with suitable primary rays and thickness of secondary radiator, results showing more perfect scattering will be obtained.

These preliminary experiments, however, to my mind furnish quite conclusive evidence in favour of the ether pulse theory.

CHARLES G. BARKLA.

University of Liverpool, October 26.

On Correlation and the Methods of Modern Statistics.

I DO not know that much profit is likely to arise from continuing this discussion further; it appears to me to be merely unwrapping considerable convolutions in Mr. Hinks's mental attitude towards Miss Gibson and myself. The chief charge made at the British Association was that we had overlooked a curved regression line between magnitude and parallax—that now appears to have disappeared into limbo. In his first letter to NATURE Mr. Hinks apparently objected to our finding "a quite significant and important" relation between parallax and proper motion, but one not more than half-way up the correlation scale. He has now discovered that "the point of most general interest" is that of colour. He charged us with stating a far-reaching suggestion on the basis of the Cape stars. It turns out now that the element in our far-reaching suggestion is not the *suggestion* at all, but what I am prepared to assert as a fact, namely, that the magnitude of the stars "is not mainly determined by parallax or distance, but is more closely associated with colour, and thus probably with chemical or physical condition." The colour and magnitude correlation is essentially that determined by Miss Gibson, 0·3; the values for the spectral class and magnitude correlations run up according to the classification used to double this value, and even to 0·7. The colour and spectral class correlations reach, as we might expect, a still higher value. Meanwhile, the magnitude and parallax relation in its best determination is 0·28. I agree with Mr. Hinks that this is a point of "general interest," and I am glad that his last letter enables me to assert it, not as "the vaguest of suggestions," which words had reference to the discontinuity of frequency in star counts, but as a fact which may be slightly modified when more data are reduced, but is substantially correct as I have given it.

KARL PEARSON.

The Interpretation of Mendelian Phenomena.

I AM sorry Mr. Lock should mistake what I devoutly hope is a sense of proportion for a desire to belittle Mendelian work. In science clear ideas are of importance, and I wished to elicit something more definite than the vague notion that Mendelism will someday and somehow furnish a master key to the problems of heredity. I made no complaint that Mendelism "does not immediately lead to the solution of all the most difficult problems which biology affords," as Mr. Lock rather extravagantly asserts, but merely asked what conceivable bearing it can have on any problem save that of sex. By the problem of sex I mean the problem of the function of sex—or of conjugation if Mr. Lock prefers. I confess I cannot imagine what light Mendelism has shed on the question of the alleged transmission of acquirements, and as for the "problems of the actual transmission of characters," these, as dealt with by Mendelians, *are* nothing other than problems of sex. That is, Mendelian experiments demonstrate nothing more than the degree in which certain characters (mutations) are transmitted or distributed under, or affected by, conditions of conjugation. Doubtless it is true that the majority of Mendelian cases have been observed in self-fertilised types, but I am not aware that they have ever been observed unless cross-fertilisation had previously occurred. In parthenogenesis the individual arises from an unfertilised ovum; how, then, is segregation possible? What segregates?

The evidence on which I base my assertion that there is no segregation in the mulatto is that of my own eyes. Mulattoes vary amongst themselves, but the blend is usually very obvious, and is reproduced in subsequent generations when breeding is *inter se*. With every infusion of European blood the negro type—skin colour, hair texture, shape of features, and the like—grows fainter, until at length the "touch of the tar-brush" is hardly if at all perceptible; and this blending, so far as I am aware, occurs, not only in all crossed human varieties, but in other natural varieties as well. There may be exceptions; in fact, I believe there are; but blending appears to be the rule in the vast majority of instances.

How can the fact that human races have crossed more often than any other animal complicate the problem? My statement implied, not that every human race is a chaotic mixture of types, nor even that there are no pure types, but only that we have here a very large and varied mass of material on which to found our judgments. Nor did I imply that mutations are especially frequent under conditions of cultivation. I believe they are quite as common in nature. Our hospitals and asylums are full of them—hare-lips, cleft-palates, club-feet, hæmophilia, colour-blindness, deaf-mutism, feeble-mindedness, and so forth. Their inheritance is usually Mendelian, but I never heard of a human mutation that was useful. I implied merely that artificial selection is founded on mutations, and that the striking difference between artificial and natural varieties indicates that natural selection is not founded on them. We know the past and present of man better than that of any other type, certainly of any natural type. Men are fond of noting wonders, and we have a written history of thousands of years; but never yet has the differentiation of a human variety by mutation been recorded. On the other hand, so surely as a human race separates into sections, between which there is little or no intercourse, gradual differentiation sets in, which, under conditions of savage warfare and very restricted intercourse, may be seen in the inhabitants of quite small tracts of country, as in New Guinea. Amongst plants and lower animals parthenogenetic types are particularly rich in varieties. "Thousands of forms may be cultivated side by side in the Botanical gardens and exhibit slight but undoubted differentiating features, and reproduce themselves truly by seed" (de Vries, "Species and Varieties," pp. 50–60). When reproduction is bi-parental, varieties are few if individuals from distant parts of a wide area are able to mate, and proportionately more numerous if intercourse is more restricted. Thus in every valley of Samoa is found a distinct variety of snails; but species of birds, mammals, and fishes which possess considerable powers of locomotion have few varieties. Is Mr. Lock able to conceive any

interpretation of all these facts except that under natural conditions fluctuations are selected and inheritance is blended?

He lays stress on the circumstance that man is not amenable to experiment; but man is not the only species that has natural varieties. May I, in turn, lay stress on the fact that it seldom pays the cultivator to select small differences (fluctuations)? Of necessity he selects mutations. The Mendelian experimenter has practically limited himself to the materials so created. He himself chooses for his experiments, and can choose, only glaring differences. In other words, he has, *qua* experimenter, absolutely no acquaintance with the small differences (fluctuations) which normally distinguish mating individuals in natural breeding. He judges the normal from the abnormal, the rule from the exception, and then appeals to earth to note the precision of his methods and thanks heaven he is not as other men, even as mere observers who seek to take the whole of the facts into consideration. Notwithstanding his parade of exactness, his belief that he reproduces natural conditions "is an assumption which still lacks the support of facts." Once more, therefore, let me challenge Mr. Lock and his comrades. If Mendelism deals with any other problem but that of sex, what is that problem? If no other problem can be named, what is the evidence that Mendelism deals with anything more than those abnormalities of sexual reproduction which occur under conditions of artificial selection? As I say, I do not ask for the solution of any problem. I ask only for an indication that Mendelism has any conceivable bearing on it. If the latter question also cannot be answered, then by all means let Mendelians pursue their very interesting studies; but let it be understood that "the new science of genetics" implies, not the study of heredity in general, but only the study of certain curiosities of artificial breeding. G. ARCHDALL REID.

Southsea, October 20.

Pagan Survivals and Christian Adaptations.

IT may interest some of the readers of NATURE to find that the institution of the "kern-baby" (corn-baby) still exists in our island; and a writer in the *Christian World* for October 3 was present at the bringing home, on the last load, of this Pagan institution, and was present at the harvest supper this year, when the effigy was honoured by being placed on the table. It was, presumably, only a survival of olden time, when our ancestors "ate and drank" with their gods—especially the gods of agriculture (Judges, 9, v. 27).

Again, I received a letter the other day from the rector of Fobbing, Essex (formerly rector in the Scilly Islands), informing me, in reply to an inquiry, that the Beltane fires are, up to the present day, lit there on the highest point of the islands on May eve, just as our ancestors lit them in honour of the rise of Baal (or the sun). My informant, who has only left the islands two years, often witnessed the jumping of the youths "through the fire." I should be very pleased to learn of any ancient customs of this kind still carried out on the eves of "May Day," "Easter," "All Hallows," "Christmas," or other solstitial and equinoctial periods, and not heretofore recorded in standard books on the subject. In trying to ascertain the uses of certain stone circles and monster cromlechs this evidence is of great importance, as the early missionaries purposely "adapted" so many of the Pagan festivals to Christian worship. Wales is the most promising field. J. W. HAYES.

West Thurrock Vicarage, Grays, Essex, October 16.

The "Quaternary."

IN reply to Dr. Wright's comment on my letter (p. 639), I would point out that the restricted use of the word "Quaternary" appears to be confined to anthropologists. Geologists (Sir Archibald Geikie, Prof. Kayser, and Prof. Lapworth, for instance) who employ the term include in it everything from the commencement of the Glacial period to the present time. JOHN W. EVANS.

Imperial Institute, October 25.

THE "MAURETANIA."

THE first impression of the *Mauretania* is one of colossal size, the last is wondering amazement at the forethought and design which appear in details, trivial in themselves, but of supreme importance to individual comfort, of the fittings. Only those who saw the ship in the narrow waters of the Tyne can realise her huge dimensions. Eight hundred feet long herself, she floated abreast the builders' yard in a river less than 900 feet wide, which runs in a narrow cleft between low hills. In that narrow valley the great bulk of the ship made a prodigious spectacle, and over the valley before the start on the maiden voyage the smoke from her four great funnels moved like a pall.

In the brief voyage from the Tyne to the Mersey which took place last week, some of the peculiar features of the great ship were revealed. The Tyne is winding and narrow, and on the Tuesday afternoon its course was obstructed by crowds of steamers laden with sightseers. In this difficult passage the handiness of the vessel was at once apparent. Proceeding under her own steam, steered by propellers and the rudder, she was easily manœuvred at the sharp bends. To the writer, who was on the bridge at the time, it was obvious that the great turbines, which in the aggregate can develop 70,000 h.p., can be stopped or started with ease and certainty.

At sea, though the recurrent shocks characteristic of vessels fitted with reciprocating engines are absent, vibration is noticeable, though relatively slight. Generally speaking, it is maximal in the after part and diminishes thence to the bows. The distribution, however, is erratic, regions of maximal vibration often being close to regions of minimal vibration. In the great dining saloon at 22 knots the tremors were barely noticeable, being something like the passage of a vehicle in a street outside. On the other hand, a region of marked vibration was forward of this, about the level of the second funnel.

The cause of the vibration in turbine-propelled ships is not at all obvious, and experts at present seem to be unprovided with a satisfactory hypothesis. The turbines themselves are singularly free from it. Leaning against their great steel shells one is not conscious of a movement. In the shaft tunnels, however, it is very marked. The vibration has been referred to the impact of the water thrown by the blades of the wing propellers against the sides of the ship, to the unequal thrusts which each blade exerts in the course of each revolution, and to the formation of twisting couples between the propellers when they synchronise in certain ways. Inequalities in the thrust arise from the fact that owing to skin friction the water near the side of the ship is dragged bodily along with it. Each blade, therefore, as it revolves, passes through water moving in the direction of the ship to water which, relatively speaking, is still.

The vibrations themselves are markedly periodic, mounting by a long crescendo to a climax, followed usually by complete quiet. This periodic nature unquestionably suggests a dependence upon synchronism between propellers on opposite sides of the ship, and it was found in the case of, I believe, the *Deutschland* that vibration was much lessened when her twin screws were set to rotate respectively at 70 and 80 times a minute instead of both being at approximately the same rate. The whole subject is being investigated on the *Mauretania* by means of the pallograph, which registers at the same time the shaft movements and the vibrations.

As it is not possible to get an indicator diagram of a turbine, the work done is measured on the

Mauretania by torsion meters directly applied to each shaft. Two wheels are fitted on the shaft at some distance apart, each of which in its rotation makes an electrical contact. The contacts are exactly in line, and therefore are coincident in point of time when the shaft is at rest. When the shaft is rotated it suffers torsion, and the aft contact lags behind the forward one. The angle of the lag measures the torsion. The instrument is calibrated by determinations made in the shops of the twist which the shaft suffers from couples of known magnitude. In the navigating house of the *Mauretania* are four dials, on each of which a hand revolves in the direction and at the speed of the particular propeller shaft to which it is attached. It is obvious that the torsion meter might be so adjusted as to give direct records on the bridge of the work of each turbine from moment to moment.

The two most impressive parts of the machinery are the controlling platform, already mentioned, of the engine-room, where a few small levers control the gigantic forces pent up in the long polished barrels of the turbines, and the small, easily manipulated wheel in the wheel-house, which, by means of a small hydraulic motor, controls the enormous steering engine sunk below water level some 650 feet distant!

The plates of the *Mauretania* were delivered rolled to a guaranteed thickness. This is, I believe, a new departure in the building of English merchant ships, and it enabled the builders to save 500 tons of dead weight. The use of silicon steel in the boilers effected a further saving of 500 tons, making a total of 1000 tons, which, reckoned as cargo, represent a gain to the Cunard Company of about 22,000*l.* a year in the earning power of the vessel. An interesting saving in dead weight was also effected in connection with the decoration. The lifts in the well of the main staircase are enclosed by a beautiful piece of metal work adapted from existing sixteenth-century wrought-iron work. It is carried out in aluminium instead of iron, and thereby 20 tons weight is saved. One wonders whether the high affinity of the metal for chlorine and the presence of chlorides in sea air have been adequately taken into account.

The engine-room of the *Mauretania*, despite the absence of the main reciprocating engines, is very closely packed, and the greatest ingenuity is manifested in the arrangements. The four main turbines, each of 15,000 h.p., are controlled from a tiny platform by six small levers. Over the great engine-room steam pipes arch large enough for a boy to walk through, and the exhaust from each low-pressure turbine passes through a "pipe" 14 feet by 16 feet! The distinctive noise of the engine-room is the continuous roar of the steam passing through the main steam pipes. The engine-room, counting main turbines, turbo-generators, and auxiliary engines, holds machinery capable of developing something over 80,000 h.p., and the rotating mass of the main turbines amounts to about 600 tons, and rotates about 200 times a minute.

The gigantic low-pressure turbines receive the steam at nearly atmospheric pressure, which falls to a condenser pressure of about minus 27 inches of mercury. Ingenious gauges are fitted on each turbine, which record the pressure at different steps in the expansion, so that, should some of the blades become stripped, the injury can be at once located.

The stokeholds are so efficiently ventilated by powerful fans as to be cool save when the furnace doors are actually opened, in spite of the presence of 192 furnaces.

The magnitude of the strains which a ship nearly the length of the Houses of Parliament must experience in a heavy head sea is brought to mind by the provision which has been made for bending. The boat deck, together with the deck houses on it, which contain the long suite of public rooms, are cut completely through in three places, so as to allow the ship to give longitudinally.

No description can give the effect of the stately progress of so great a ship down the narrow Tyne. The grey autumn day, the cheering crowds piled on the hill-sides to their summits, and the anxious pilot striving to make his orders heard amid the clamour of steam whistles and fog signals, are vivid recollections. So, too, are the raucous blasts of welcome flung to us from the great headlands as we passed them by. The sombre cliffs of the Pentlands in the grey dawn, Cape Wrath under the autumn sun, lonely light vessels, tiny fishing craft, and liners, each after its own fashion wished us the freedom of the seas.

W. B. HARDY.

THE GEOLOGICAL SUCCESSION IN SOUTH AFRICA.[1]

EVERY year our knowledge of the geological succession in South Africa becomes more extended as a result of the labours of the Geological Commission of the Cape, the Geological Survey of the Transvaal, and the host of private workers who contribute to the Transactions of the Geological Society of South Africa. The newly published Report of the Cape Commission for the year 1906, and the Transactions of the Geological Society for the period January to June of this year, are full of interesting matter. The Cape surveyors have been working in Bechuanaland and Griqualand West, and have thus come into close contact with the work of the Transvaal geologists; for although the operations of the official Survey of the Transvaal have as yet been confined to the Pretoria and Middelburg districts, the Marico district and the neighbourhood of Mafeking have been explored by unofficial geologists in the employ of big land companies. Pioneer work of this nature, although unsanctified by official publication, is not to be contemned, since in many cases it is done, under conditions of considerable difficulty, by enthusiastic geologists and keen observers whose labours have often laid the foundation for the detailed work of the Government surveyors.

The earliest work in Griqualand West was by Mr. G. W. Stow, who communicated some of his results to the Geological Society of London (Q.J.G.S., vol. xxx., pp. 581–680, 1874). Unfortunately, a considerable proportion of his observations was embodied in reports to the Griqualand West Government, which since they were handed in have never emerged from their pigeon-holes. However, his classification of the Griqualand West rocks has, with the exception of the Keis series, been adopted by the Cape Survey. It is as follows:—

Matsap Series...	Quartzites and conglomerates
(unconformity)	
Griquatown Series ...	Magnetite-jasper rocks
Campbell Rand Series ...	Limestone and quartzite
Keis Series	Quartzites and mica schists

[1] Eleventh Annual Report of the Geological Commission of the Colony of the Cape of Good Hope, 1906. (Capetown, 1907.)
Geological Map of the Colony of the Cape of Good Hope. Sheet xlvi. (Published by the Geological Commission, 1907.)
Transactions of the Geological Society of South Africa. Vol. x., January to June, 1907. Pp. 1–68. (Johannesburg, 1907.)

The next step was the tracing by Mr. E. G. Holmes in 1904 from the Transvaal into Bechuanaland of the Black Reef, Dolomite, and Pretoria Series (Trans. Geol. Soc. S.A., vol. vii., p. 130). He followed these well-known Transvaal formations near enough to the original localities of the Keis, Campbell Rand, and Griquatown Series described by Stow to suggest the correlation which was proposed in the following year by Hatch and Corstorphine in their "Geology of South Africa" (p. 311), namely, in the following manner:—

Griqualand West	Transvaal
Matsap Series	= Waterberg Series
(unconformity)	(unconformity)
Griquatown Series	= Pretoria Series
Campbell Rand Series	= Dolomite Series
Keis Series	= Black Reef Series

Mr. Rogers appears to doubt whether Stow, by his Keis Series, referred to the quartzites which succeed the Campbell Rand Series in downward succession. He therefore substitutes the Transvaal name—Black Reef Series—and with this modification accepts the correlation; but he points out that the Matsap and Waterberg Series present marked points of difference, especially in regard to their volcanic rocks, which are of a more acid character in the latter than in the former.

The Matsap Series is subdivided by Mr. Rogers as follows: an *upper* group of quartzites and sandstones, developed in the Langebergen proper; a *middle* group of quartzites, lavas, and fragmental rocks of volcanic origin; and a *lower* group of quartzites, slates, and conglomerates forming the foothills east of the Langebergen, north of Pad Kloof. The basal bed contains many boulders and pebbles of quartzite, quartz, and red jasper in a quartzite matrix which is sometimes highly ferruginous.

In the Transvaal, Mr. Mellor has recently shown (Trans. Geol. Soc. S.A., vol. x., p. 44) that while the base of the Waterberg System is often marked by the presence of coarse conglomerates, in the Middelburg district a series of acid and intermediate lavas, interbedded with tuffs, agglomerates, shales and sandstones, underlies the usual sandy types of sedimentation. The whole volcanic series attains a thickness of approximately 8000 feet.

The Griquatown Series is divided by Mr. Rogers into an *upper* group, consisting largely of slaty rocks, together with some brown and red jasperoid rocks and thin beds of chert and limestone; a *middle* group, consisting for the main part of the Ongeluk volcanic beds, together with some banded jasper beds; and a *lower* group, comprising banded jaspers, quartzites and mudstones. The conglomeratic rocks that occur at or near the top of the lower group in the Hay district contain "striated and flattened pebbles and boulders," which, according to Mr. Rogers, "certainly owe their characteristic shape and scratches to glacial action" (Rep. for 1905, p. 162). Seeing that these beds belong to a geological period considerably older than the Dwyka Glacial Series (they occur at least 15,000 feet lower down in the succession—even more if the Matsap Beds are considered to be older than the Table Mountain Sandstone), this is an interesting contribution to the fast-growing history of glacial action in the remotest periods of geological time.

The Campbell Rand Series occupies practically the whole of the Kaap plateau. As in the Transvaal, this formation consists mainly of dolomitic limestone with which cherts are often associated. The shales which occur near the bottom of the series were searched by Mr. Rogers without success for fossils. Conformably underlying it is the Black Reef Series, consisting of quartzites, grits, felspathic quartzites, conglomerates, shales, &c. An exact divisional line between the two formations cannot be drawn owing to the alternation of beds of quartzite and limestone near the junction.

The three series—Black Reef, Campbell Rand, and Griquatown—are grouped together by Mr. Rogers as the Transvaal System, a term introduced by Molengraaff for the corresponding series in the Transvaal. The name is scarcely a happy one; but since it has also been adopted by the Transvaal Geological Survey, it will probably remain. Below the Black Reef Series is a basic series of amygdaloidal lavas—the Pniel series of Stow—and this is succeeded by an acid volcanic series to which the Cape geologists have given the name Zoetlief Beds. There is an unconformity between the two series; but Mr. Rogers has decided to include them in one group under the name of the Ventersdorp System, which name is used for the equivalent formation in the Transvaal.

The Ventersdorp, Transvaal, and Matsap Systems lie on a floor of granite and schists, and have been folded during pre-Dwyka times into arches and troughs, the axes of the folds embracing a wide area of low mountains, the principal range of which is the Langebergen. The underlying schists are grouped as the Kraaipan Series; they are equivalent to the Swaziland Series of the Transvaal, and consist largely of magnetitic schists and thin quartzites. The Cape geologists have found no evidence of the granite being intrusive into the schistose formation, although this has been clearly proved in the Transvaal (Abelskop, Monte Maré, &c.). In this connection it is interesting to note that the Geological Survey of the Transvaal has recently recognised that the granite mass which lies north of Johannesburg is younger than the schists of the Swaziland Series (Moodies Series), while it also admits the correctness of the view that it constituted an older floor on which the basement beds of the Witwatersrand Series were deposited (Trans. Geol. Soc. S.A., vol. x., pp. 55 and 57; *cp.* also "Geology of South Africa," p. 93).

Summarising, there is in South Africa, lying on an old floor of schists and granite (which is almost certainly of Archæan age), a succession of sedimentary rocks, older than the Devonian, and including the Waterberg or Matsap, the Transvaal, the Ventersdorp and the Witwatersrand Systems, all separated by strong unconformities. In this accumulation of sediments, which is estimated to have a thickness of between 50,000 and 60,000 feet, not a single fossil has as yet been found.

With regard to the Karroo rocks of the Transvaal, a further step in their elucidation is marked by the conclusion arrived at by the Survey, that the Bushveld Sandstone Series (a succession of red marls, shales, and fine-grained sandstones), together with the overlying amygdaloids, are the equivalent of the Red Beds, Cave Sandstone, and Volcanic Group of the Stormberg Series of the Cape, the Orange River Colony, and Natal (Kynaston, Trans. Geol. Soc. S.A., vol. x., p. 34). The recent discovery by Mr. J. Mitford Bowker, in the Zoutpansberg district near the Limpopo River, of fossil bones, which Dr. Broom has determined to be of Stormberg age, shows that the Bushveld Sandstone Series extended far to the north; for it is found to cross the Limpopo River into the Victoria district of Mashonaland, where coal-seams have been reported to occur in it (Proceedings of the meeting of the Geol. Soc. of S.A. held on June 24, 1907).

F. H. HATCH.

THE ROMANCE OF PHOTOGRAPHY.[1]

ALL phenomena are wonderful in the measure that we are unaccustomed to them, and if quite strange to us they are incredible. The romantic character of the details of any subject is therefore an individual matter, but the author in this particular case assumes no exact, and very little general, knowledge on the part of his readers, and so he is justified in his repeated asseverations of the marvellous character of the various details of the discovery and achievements of photography. We take it that the duty of the writer of such a volume is very largely to rob his subject of its atmosphere of romance by showing its gradual development and the reasonableness of its results. In this the author is successful. He gives no "instructions," but merely tells his story in a readable form and illustrates it well, for every one of the sixty or more illustrations has a definite and sufficient reason for its presence. He treats it in an easy and sometimes, perhaps, rather too discursive manner, giving many apt analogies of the development of photography and of its applications in instantaneous work and kinematography, the making of book illustrations, the photography of the invisible as by means of Röntgen rays or the ultra-violet of the spectrum, and the reproduction of colour.

Telegraphed Photographs. These photographs are just as they were received by the electric telegraph. The left-hand portrait is that of the Crown Prince of Germany, and the other is a portrait of Prof. Korn. From "The Romance of Modern Photography."

One of the most interesting chapters deals with the detection of crime and the identification of criminals, for it is seldom that those who are not engaged in the work itself have the opportunity of seeing examples of photographs taken for these purposes. There is also a chapter on telegraphic photography, described in NATURE of August 19 (p. 445). The accompanying illustration from this chapter is reproduced by the courtesy of the publishers. In another chapter we learn how "the largest photograph in the world," 40 feet long by 5 feet wide, was developed by mounting it face outwards on the periphery of a large broad wheel made for the purpose, and rotating it in a comparatively shallow tank that contained the developer, and find details of many other cases in which great difficulties were successfully overcome. The number of examples given of extraordinary methods of work is considerable, and they cover so wide a field that probably no one who reads the book will fail to find something new to him.

When an author sets out with the avowed purpose of dealing with the romantic side of such a subject, the critic naturally looks for a little exaggeration here and there, and when so many branches of the subject are dealt with he expects to discover a few inaccuracies. It may be true to a certain extent to say that kinematography will enable our descendants to see the incidents in our great battles, but it is a mistake to state, concerning a picture of a group of men in the act of diving, that "the whole detail of this living scene was recorded by the great artist, Light, in one five-hundredth part of a second" by means of a focal-plane shutter, as the narrow slit in the shutter probably took thirty or forty times as long as this to pass over and so expose the surface of the plate. It is also incorrect to state that a Lippmann photograph "must have its mercury background" to view it properly. But the slips of this kind are not very serious, and they are very few.

C. J.

[1] "The Romance of Modern Photography." By Charles R. Gibson. Pp. 345. (London: Seeley and Co., Ltd., 1908.) Price 5s.

M. MAURICE LOEWY.

"RIEN ne saurait exprimer la consternation et l'affliction que la mort foudroyante de Tisserand a répandues autour de lui, car l'amitié, l'estime et l'admiration entouraient comme d'une auréole l'illustre astronome qui s'est éteint dans la nuit de mardi." These words, which M. Loewy spoke at the graveside of his friend and predecessor, Tisserand, may very well be remembered when expressing our sense of the loss which France and science suffer in the sudden removal of the director of the National Observatory of Paris. Even the painful suddenness, which added an increased bitterness to the grief we experienced in the loss of Tisserand, is repeated again with depressing emphasis, for we understand that M. Loewy was struck down while attending a meeting of the Conseil des Observatoires astronomiques.

The director of a great National Observatory does not usually enjoy unfettered discretion in the selection of the lines of investigation to be pursued. In such institutions large pieces of work are not unfrequently undertaken, for the conduct of which both ample time and funds are needed. Too often he who plans does not see the full fruition of his work, and loyalty to the reputation of predecessors and the influences of tradition alike restrict the direction along which activity is possible. The long connection of M. Loewy with the Paris Observatory, previous to his occupancy of the director's chair, would make him particularly anxious to complete, if possible, certainly to forward, two very heavy legacies of work be-

queathed to him by former astronomers. One of these was the great Paris catalogue of stars, depending upon meridian observations made within the period 1837–1881, including the re-observation of all Lalande's stars. The complete work, published in four sections, furnishes the places of nearly 35,000 stars, based upon 387,000 single measures. This heavy piece of work was brought to a very satisfactory conclusion under the supervision of M. Loewy, and by its completion the observatory staff is relieved of an oppressive incubus. The other is the International Star Chart, which had its origin under Admiral Mouchez. Not only has this work been prosecuted with ardour at the observatory, but encouragement and assistance were given to all who participated in the scheme, by means of conferences that have been held from time to time in the observatory at the suggestion of the regretted director. To both these projects M. Loewy gave as generous and consistent support as though he were responsible for their introduction.

M. Loewy's more immediate influence on the conduct of the observatory is shown in the steady prosecution of another piece of work, the chart of the moon derived from photographs taken with the equatorial coudé, a form of telescopic mounting with which M. Loewy's name is closely connected. The long focal length, which is one of the advantages secured in this class of telescope, giving an image of the moon more than seven inches in diameter, made this instrument peculiarly suitable for the investigation. The admirable reproductions made from the negatives justify the time and attention that have been bestowed on the enlargements. Concurrently with the issue of the maps there have been published acute dissertations on the physical constitution of the moon, founded on a minute critical study of the lunar surface. This close and detailed examination led the director to conclude that there were evidences of a permanent elongation of the moon's figure towards the earth, and of a surface action tending to diminish the angular velocity of rotation.

But besides the study of the moon's surface, the equatorial coudé has served another purpose. The principle of construction is so well known that it is not necessary to describe it here. But in designing this instrument M. Loewy had in view the possibility of obtaining greater stability than is attainable with ordinary equatorials, and by taking advantage of this stability to measure large angular distances on the celestial sphere. Having determined, by a thorough examination of the theory, the sources of error inherent in the instrument, M. Loewy proceeded to use it for obtaining a new value of the constant of aberration by an entirely novel method. For this purpose he placed a double mirror, formed by silvering two faces of a large prism of glass, in front of the object glass. The double mirror was capable of rotation about the axes of the telescope, so that by reflection from the two silver surfaces the images of two stars in different parts of the sky could be brought into the field side by side, and the distance between them measured in the common plane of reflection. By choosing suitable stars and making the necessary measures six months apart, the quantity measured could be made four times that of the constant of aberration. For greater accuracy the stars selected had the same altitude so as to reduce the effects of refraction to a minimum. But by changing the plan of observation it was possible to investigate the effects of refraction separately. The instrument lent itself to methods of great beauty and ingenuity, displaying both the mechanical ability of the inventor and the varied resources of the mathematician and astronomer. The Royal Astronomical Society fittingly acknowledged its appreciation of the important services M. Loewy had rendered to astronomy by awarding him the gold medal. Needless to say, he was an honorary member of that society as of many others, both in his own country and abroad.

It would not be possible, even if it were desirable, to record all the varied occupations in which M. Loewy was engaged in the course of his scientific career. His position made him frequently the adviser of his Government in many important matters. His services to the Bureau des Longitudes, in his capacity of director of the Connaissance des Temps, will be readily acknowledged. The part he played in various conferences, such as those which arranged the scheme for observing the planet Eros and for securing uniformity in the employment of astronomical constants, has been already mentioned. We can only deplore, in company with the whole guild of science throughout the world, the loss of one who ornamented a dignified position and worthily supported the traditions of the National Observatory. Within the last few years the continuity of its direction has been too frequently interrupted by the loss of its distinguished chiefs. Among these brilliant memories the name of Maurice Loewy will hold an honoured place. Round his grave in respectful sympathy were grouped the representatives of many learned societies. In addition to those of France, there were present members of the Academy of Sciences of Vienna, of the R. Accademia dei Lincei, while the Royal Society of London, as well as the Royal Astronomical Society and the British Association, were represented by Sir David Gill and Major MacMahon.

NOTES.

IT is reported that at Monday's meeting of the Paris Academy of Sciences Prof. Lapparent described some experiments by Prof. Bordas upon the conversion of corundum into precious stones by the influence of radium. It is stated that when fragments of corundum were placed in contact with a tube containing radium for a month they changed colour entirely, and were transformed into crystalline varieties of the mineral, some pieces becoming yellow, like topaz; others purple, like amethyst; blue, as sapphire; and red, as rubies. The gems thus produced were submitted to a jeweller, who was unable to distinguish them from precious stones. We shall await with interest the appearance of the *Comptes rendus* of Monday's meeting for particulars of these experiments and results.

THE death is announced of Prof. Gustav Adolf Zeuner, the distinguished authority on applied mechanics. Born at Chemnitz in 1828, he was the founder, and editor from 1853 to 1857, of the German journal the *Zivilingenieur*. In 1855 he was appointed professor at the Zurich Polytechnic, of which institution he was director from 1865 to 1868. From 1871 to 1875 he was director of the Freiberg School of Mines, and from 1873 to 1890 he was also director of the Dresden Polytechnic. He retired in 1895. His works included treatises on valve gearing and on the mechanical theory of heat.

DR. ELIS STRÖMGREN, private tutor at the Kiel University, has been appointed professor and director of the Copenhagen Observatory in succession to Prof. T. N. Thiele, retired.

SIR HERBERT MAXWELL has been appointed chairman of the council of the National Association for the Prevention of Consumption in succession to the late Sir William Broadbent, and Dr. C. Theodore Williams has been elected vice-chairman.

THE cup for the winner of the International Balloon Race, to be awarded to the aëronaut landing furthest from St. Louis in a measured straight line, has been won by Herr Erbsloh (Germany), who descended at Annapolis Junction, Maryland, having covered a distance of 874·4 miles.

THE death is announced of Mr. T. F. Brown, a recognised authority on the geology of the South Wales coalfield. Mr. Forster Brown was a member of the Institute of Civil Engineers, a Fellow of the Geological Society and of the Surveyors' Institute, and past-president of the South Wales Institute of Engineers.

WE are asked to announce that the annual "fungus foray" of the Essex Field Club will take place on Saturday, November 2, at Loughton and Theydon Bois, Epping Forest. The director will be Mr. George Massee, of the Kew Museum. Botanists wishing to be present should communicate with the secretary, Mr. W. Cole, Buckhurst Hill, Essex.

REFERRING to his letter in NATURE (October 3, p. 568), the Rev. Dr. Irving writes to state that his assignment to the Upper Eocene or Oligocene of the fossiliferous limestone discovered in a well-sinking at Thorley, near Bishop's Stortford, was erroneous. The bed in question is probably Lower Eocene, of the age of the Oldhaven beds.

COUNT G. N. PLUNKETT, who has just taken office as director of the Dublin Museum of Science and Art, initiated the system of museum "demonstrations" about ten years ago, and has lectured on the arts and artistic crafts, and also on Irish archæology. In the Cork Exhibition of 1903 he organised a nature-study section, the work of more than a hundred schools. He is known outside Ireland through his book on Sandro Botticelli.

THE list of lectures to be delivered at the London Institution during the present winter session is varied and comprehensive. Prof. G. S. Boulger takes for his subject the Andes of Peru; Prof. W. M. Flinders Petrie, F.R.S., will describe ancient Egyptian houses; Mr. E. S. Bruce is to explain the coming of the aëroplane, with the aid of experiments and illustrations; Mr. A. R. Hinks will discuss the evidence for life on Mars; Mr. I. S. Scarf takes up the subject of flames; Mr. L. E. Hill, F.R.S., researches on deep-sea diving; Prof. W. B. Bottomley, soil inoculations; and Mr. P. Chalmers Mitchell, F.R.S., ruminating animals. The lectures for juveniles will be delivered during the Christmas vacation by Prof. Grenville A. J. Cole, his subject being three days of open-air geology.

CALABRIA was subjected to a severe earthquake shock during the evening of October 23. The disturbance, which occurred at 8.30 p.m., seems to have followed the same line and to have been felt throughout the same districts as that of 1905. The centre of the disturbance was located in Monteleone, and its effects seem to have been noticed from Catanzaro to Reggio di Calabria. Reports of varying amounts of damage have been received from Gerace, Sinopoli, Pizzo, Tropea, and other places, which also suffered two years ago. Secondary shocks were felt on October 24, but from observations which have been recorded it is believed that the earthquake of last week was less severe than that of 1905. The shocks on both days were recorded by Prof. Milne's instruments at Shide, in the Isle of Wight, and by Prof. Belar at Laibach, in Austria. The number of victims is variously estimated, Reuter putting the number at 600. The damage is extensive and widespread. Shortly before 6 p.m. on October 28 a violent shock was experienced at Monteleone, Santa Eufemia, Bagnara, and Sinopoli.

MR. BALFOUR on October 25 opened the new administrative buildings and two new wards at the Royal Victoria Hospital for Consumptives at Craigleith, Edinburgh. During the course of an address, Mr. Balfour said it is impossible to withhold wonder at the enormous strides which scientific medicine has made in the treatment of consumption in less than thirty years. Referring to future work in this direction, he remarked:—"If we cannot destroy and expel the tubercle bacillus from among us, we can reduce its power to do evil to a degree which may seem to us at the moment to be almost incalculable. We have an example before us of what has been done with regard to typhus. I doubt whether there is a single case of typhus in Edinburgh at this moment; and it may be that our children will live to see the time when consumption will be as little known in their midst as typhus is at this time. We have made the conditions of infection with regard to typhus so small that the power of resistance of the community at large is amply adequate to prevent its making any lodgment of a serious kind in our midst. That is the ideal to which we look forward with regard to tuberculosis." Continuing, Mr. Balfour pointed out that it is a great responsibility resting upon every person to see that the doctrines of modern scientific medicine penetrate, not merely among the well-to-do, but to every class in the community.

ACCORDING to *Museum News* for October, a figure of a native Australian, carefully modelled by an eminent Washington sculptor, has been placed in the Brooklyn Museum alongside stuffed specimens of the man-like apes, in order to illustrate the wide differences between the latter and the lower races of mankind. Silk-worm-culture and silk-manufacture are now illustrated in the museum by cases of living silk-worms, as well as by exhibits of the more important descriptions of raw silk.

TOTAL prohibition of the use of the plumage of wild birds as articles of dress is regarded by Prof. T. H. Montgomery (Bull. Univ. Texas, No. 79) as the only effectual remedy against what he regards as a mischievous fashion. "It will not do," he writes, "to prevent the killing of our American birds and to allow the importation of foreign ones, for this would be injuring another country, and in the long run, for the sake of greater cheapness, would result in the killing of our native species."

THE additions to the Zoological Society's menagerie during September were 149 in number, of which sixty-eight were acquired by presentation and two by purchase, while sixty-five were received on deposit, four by exchange, and ten were born in the gardens. Amongst these, special attention is directed by the secretary to the following, viz. a female giraffe, born on September 20; a male gayal, born on September 6; three harnessed antelopes (*Tragelaphus scriptus*); a nagor antelope (*Cervicapra redunca*); and two side-striped jackals (*Canis lateralis*), from Gambia, presented by Sir George Denton; and a Cayenne kite-falcon (*Leptodon cayennensis*), deposited.

VOL. lxxxviii., part i., of *Zeitschrift für wissenschaftliche Zoologie* contains an exhaustive article on the morphology and life-history of the vine Phylloxera (*Phylloxera vastatrix*), by Mr. H. Stauffacher, of Frauenfeld, Switzerland, illustrated by a coloured plate showing the chief developmental stages and the dimorphic phases

of the winged adults. At the conclusion of the article special attention is directed to the origin of these dimorphic phases, which include a larger and a smaller form; diagrammatic illustrations being given of the various theories proposed. According to the author's view, trimorphic nymphs are developed, from which are produced what he terms the α form, β form, and γ form, which in turn respectively give rise to the parthenogenetic generation, to males, and to females.

To the July issue of the Proceedings of the Philadelphia Academy, Mr. E. G. Conklin contributes a paper on the embryology of the gastropod Fulgur, from the point of view of the influence of the yolk on development. The eggs of this genus are remarkable for their large size, the bulk being almost wholly due to the quantity of yolk; and one of the problems to which special attention was devoted is the effect of large or small yolks on the development of the organs of the embryo. For the author's conclusions our readers must be referred to the original paper; but it may be mentioned that after a certain stage the elements of the Fulgur yoke cleave irregularly, a feature which may foreshadow the "meroblastic" eggs of birds and reptiles, in which only a portion of the yolk undergoes cleavage.

We have received copies of a circular issued by the Vigilance Committee of the Fur and Skin Trade Section of the London Chamber of Commerce directed against the alleged practice of certain retailers in wrongly marking, naming, and advertising furs for sale, in violation of the Act of Parliament against "false trade descriptions." The action taken by the committee has already led to satisfactory results, but there appears reason to believe that the illegal practice still continues. Among the scheduled items are musquash and nutria (coypu) fur, sold, "when pulled and dyed," as seal; and nutria, when "pulled natural," sold as beaver. Dyed rabbit fur sold as sable, white rabbit as ermine, and dyed white rabbit as chinchilla, also appear in the list. It is added that purchasers who may have any doubt as to whether furs sold to them are correctly described can obtain expert opinion, free of charge, by forwarding the articles to the offices of the London Chamber of Commerce, Oxford Court, Fleet Street, E.C.

In the introduction to his report on the diatoms collected in the Pacific Ocean on the voyages during the years 1898 to 1904 of the steamer *Albatross*, belonging to the United States Bureau of Fisheries, Dr. A. Mann claims that, as owing to their minuteness diatoms can be transported by slow currents or surface drifts, a tabulation of the species found at different stations would provide useful data for determining the direction and extent of ocean currents. He also quotes several instances to show how different species are confined to, and therefore typical of, distinct localities. The systematic enumeration contains a careful digest and sifting of previous nomenclature. The genera Navicula, Biddulphia, and Coscinodiscus are richest in species, and also provide the larger number of new species. The report is published as vol. x., part v., of the Contributions from the United States National Herbarium.

We have received the annual report of the medical officer of health (Dr. Seaton) of the administrative county of Surrey for 1906. The prevalence of enteric or typhoid fever in the administrative county is the subject of a special report. The incidence of 2093 cases occurring during the last twelve years has been reviewed, and the opinion is expressed that it is doubtful whether even 10 per cent. of the cases can be attributed to the drinking of a polluted or infected water supply, and there seems to be no evident relation between the rainfall, and consequent floods, to typhoid prevalence. Dr. Seaton believes that polluted and infected foods are a much more frequent source of typhoid illness than is even now generally supposed. He also refers to the occurrence of cases which it is impossible to connect with any other case, and suggests the possibility of new origin (*i.e.* apart from human infections) through bacilli other than those which are regarded as the invariable specific causes of typhoid. With regard to this, it may be mentioned that recent German researches have shown that patients may harbour the typhoid bacillus for months after they have recovered from an attack, and that even well persons may occasionally be the hosts of the organism; it seems hardly necessary, therefore, to suggest a *de novo* origin.

Under the title of "The Tuna as a Food for Man," Mr. R. F. Hare and Mr. D. Griffith have provided in Bulletin No. 64 of the Agricultural College, New Mexico, an illustrated account of the varieties of fruit—commonly called prickly pear—grown to a considerable extent in Mexico. The fruits described are species of Opuntia; they have a thin skin more or less covered with spicules, under which is a rind enclosing the pulp and embedded seeds. The pulp alone is generally eaten, but sometimes part of the rind is included. The fruit is relished by the peons and poorer classes, and is harvested for shipment. There is also a local manufacture of products of the nature of honey, sugar-paste, and toffee.

The Quarterly Journal of the Liverpool Institute of Commercial Research in the Tropics, vol. ii., No. 5, contains excellent illustrations of some African fibrous plants from photographs by Mr. J. A. Alexander, formerly of Portuguese East Africa. Dr. E. Drabble furnishes notes on the synonymy, morphology, and fibres of leaves of *Sansevieria guineensis* and *Agave rigida*, also on the seeds of *Myristica angolensis* and fruits of *Lophira alata*. From the latter the natives of West Africa obtain a cooking oil, and the fat of Myristica is suitable for soap-making. Dr. D. Spence contributes articles on the analyses of latex and rubbers, the most important being a discussion of the methods of analysing raw rubbers.

A second hundred of the leaflets published by the Board of Agriculture for free distribution has been completed. They deal with farm and garden crops, insects and fungal pests, and the breeding and management of farm animals. Among recent issues are two containing information on the winter rot of potatoes caused by the fungus *Nectria solani*, and the black rot of cabbage attributed to the bacterium *Pseudomonas campestris*. The Nectria appears on stored potatoes, forming white, and later pink, patches, from which arise crops of spores that spread the disease and reduce the tubers to a fœtid mass. The ascospores developed in the following season can infect growing crops. The cabbage rot is readily distinguished by the black appearance of the vascular bundles along which the bacteria travel. The Sycamore leaf-blotch, caused by species of Rhytisma, so familiar by reason of the black patches produced, is described in another leaflet. An account of the coltsfoot, *Tussilago farfara*, and a note on the Fertilisers and Feeding Stuffs Act, 1906, have also been published.

The King has instituted a new medal for bravery in mines. The Royal Warrant states that the King is desirous of distinguishing by some mark of Royal favour the many heroic acts performed by miners and quarrymen who endanger their own lives in endeavouring to save the

lives of others. The new medal will be of two classes, which are to be designated the Edward medal of the first class and the Edward medal of the second class. The ribbon will be dark blue with a narrow yellow stripe on either side.

THE *Engineering Magazine* for October is a special number of great interest, devoted exclusively to mining. There are articles on the copper situation in the United States, the production of gold, the mechanical engineering of the mine, the manufacture of steel and wrought iron, asbestos, excavations for the foundations of a modern tall building, electrometallurgical progress, steam production from the cheaper grades of anthracite, underground workings in New York City, and the unwatering of mines in the anthracite region. All these articles are written by leading authorities and are admirably illustrated, and the whole forms a trustworthy review of current practice.

AT the first meeting of the new session of the Institution of Mechanical Engineers, Prof. Bertram Hopkinson read an important paper on the indicated power and mechanical efficiency of the gas engine, describing an investigation made with the object of finding whether the indicator power of the gas engine does, in fact, vary so much and is so difficult of determination as the report of the committee of the Institution of Civil Engineers on the efficiency of internal-combustion engines suggests. The conclusions reached were as follows:—(1) If precautions are taken to keep the pressure of the gas supply constant, the diagrams given by the engine are remarkably regular, and whether the engine be missing ignitions or not, it is possible, by the use of a sufficiently accurate indicator, to obtain the indicated power from diagrams within 1 per cent. or 2 per cent. It seems probable that the difficulty experienced by the committee was due either to the essential defects, for this purpose, of the ordinary form of indicator, or to casual variations in the gas supply per suction due perhaps to variation in the gas pressure at the engine. (2) The difference between indicated horse-power and brake horse-power is rather less than the horse-power at no load under the same conditions of lubrication, mainly because of the difference in the power absorbed in pumping. In the particular engine tested by Prof. Hopkinson the error from this cause in obtaining the indicated power would amount to about 5 per cent. The friction is substantially constant from no load to full load, provided that the temperature of the cylinder walls is kept the same, but the influence of temperature is very great.

THE current number of the *Quarterly Review* includes an important article, by Mr. Urquhart A. Forbes, on the water supply of the United Kingdom. The importance of treating water supply on broad lines was pointed out by the 1869 Commission on Water Supply, when the adoption of the watershed area as the administrative unit for water supply was recommended. Since the water supply for purposes of navigation is derived from the various watersheds traversed by canals and river navigations, it is desirable that the authority in each watershed should be empowered to exercise some control over canal companies and river trustees with respect to the amount of water to be abstracted from it. Such watershed boards with the powers indicated would be able to carry out the scientific regulation of all water from its first arrival as rain to its disappearance in the ocean. It has been suggested that the staff of the central authority, which would be a department under the Local Government Board, would, in addition to the administrative head, comprise (1) an engineer and assistants, with a special knowledge of geology and water supply, charged with the duty of collecting and digesting for use all the facts requisite for the scientific treatment of our water system; (2) a bacteriologist and a chemist, with a special knowledge of the bacteriology and chemistry of sewage, trade effluents, and water supply, who should be provided with a laboratory for experiments; (3) a staff of inspectors for carrying out its supervisory work with respect to both pollution and waste of water. In addition to the facilities it would provide for the treatment of our water system on scientific principles, the establishment of a central water department offers the best means of restoring order in the present chaotic condition of things.

THE great changes wrought by the eruption of April, 1906, necessitated a re-survey of Mount Vesuvius, which has been effected by the Italian Military Geographical Institute. The extreme height of the mountain was determined as 1223 metres above sea-level, as compared with 1335 metres before the eruption; the height of the crater rim has become more irregular, dropping to only 1103 metres on the E.N.E., with a diameter of 725 metres from N.N.E. to S.S.W., and 645 metres from N.W. to S.E. At lower levels the contours have everywhere been enlarged from those of the survey in 1900, and in the Atrio del Cavallo and Valle dell'Inferno the depression has been filled up to the extent of from 5 metres to 50 metres.

IN travelling by rail, or still better by steamer, from Lyons to Avignon, a marked narrowing of the Rhone Valley is noticed after Valence, between the pre-Alps of Dauphiné on the left and the singular dark ridge of Coirons on the right. This easterly spur of the central *massif* of France is capped by a thick sheet of basalt, which affords a striking instance of inversion of topography. There is no doubt that, at the close of the Miocene, when the molten rock issued from a vent located near Mount Gerbier des Joncs, it followed one of the channels of the river system of that period. Since that time the eastern border of the central *massif* (Cévennes) has been subjected to strong erosion, increased by the subsidence of the lower part of the Rhone Valley, and the consequent lowering of the base-level. The surrounding Cretaceous and Upper Jurassic limestones have been easily worn down and reduced to gentle slopes. The basaltic flow, about thirteen miles in length and three miles wide, resisted much more successfully the subaërial disintegration. In consequence of this very unequal weathering, what was once a valley is now a long ridge standing 2200 feet above the level of the Rhone. The history of the Coirons may be compared to that of the Scuir of Eigg in western Scotland. Unfortunately, a portion of the sheet of lava of Coirons rests upon the Oxfordian, easily undermined by the head-waters of the lateral torrents; the edges of the volcanic table are liable to break away and to creep down the slopes upon the clayey substratum. The landslip which occurred on October 11 above Moulin-Artige is only an episode in this process of slow undermining, which has reduced the formerly continuous basaltic plateau to the shape of a fish-bone. As a consequence of the torrential rains which occurred in southern France during the first part of October, nearly one million cubic metres of rocks has moved a distance of 900 metres, threatening to block a valley and to form a lake. Such incidents are bound to occur again on both sides of the Coirons, and the suggested re-afforesting of the district will tend to diminish, but not to prevent, all future danger. Perhaps it would be wise to restrict the construction of villages to safer ground.

MR. W. ERNEST COOKE, Government astronomer at the Perth Observatory, West Australia, directs our attention to an exhibition of globe lightning, or a fireball of some sort, which was noticed by two observers on September 7. Mr. Cooke did not himself see the display, but he can certify that about the time mentioned by the observers there was a blinding flash of lightning in the vicinity, followed almost immediately by a heavy crash of thunder. The observers who reported the matter to Mr. Cooke are stated by the *Daily News* of West Australia (September 9) to have described their experience as follows:—In the middle of the reverberation of the thunder a tremendous explosion about 6 feet from the ground was heard, and a momentary flash of blinding intensity was seen. Both saw a lurid red ball, estimated by them as about 4 inches in diameter with a circle of bright yellow flame, with a diameter which seemed to be 18 inches, which graduated in colour until it faded at the edges. As there are only a few authenticated instances of similar displays, it is desirable to place each new instance on record.

MESSRS. GEORGE PHILIP AND SON, LTD., have sent us a specimen of their "New Standard Time Dial" designed by Prof. R. A. Gregory for the determination of the local mean time at any place on the earth's surface, corresponding to the time at the place where the dial is being used. This simple and useful device consists of a stout wooden board on each side of which is printed a clock face showing the hours from noon to midnight and midnight to noon. Within each dial is a rotating disc on which is printed, on the one side, a map of the northern, and on the reverse side a map of the southern, hemisphere. Meridians of longitude are drawn at intervals of 15° on each map, and where a meridian marks a commonly used standard time, such as Greenwich, mid-Europe, or inter-Colonial, it is so designated; the meridian where the date changes from the American to the Asiatic date is also marked. By simply rotating the inner disc until the meridian of a place is opposite to the actual time, as shown on the dial, the corresponding local time at any other place may be read off directly. The device will be found serviceable, and its low price (3*s*. 6*d*. net) should ensure its appearance in all places, especially schools, where the longitude-time problem has to be solved frequently.

Le Radium for September contains an important article by M. Jean Becquerel on the influence of temperature on the absorption of solids. It appears from M. Becquerel's researches that increase of temperature of a solid displaces the absorption bands towards the red end of the spectrum by two or three units of the fifth figure of the wave-length per 100° C., while the bands at the same time increase in width and change in intensity, the width being proportional to the square root of the absolute temperature.

THE communication to the Physical Society of Berlin in which Dr. E. Goldstein announced his discovery of the existence of two independent spectra of each of the elements cæsium, rubidium, and potassium has been reproduced in full in the *Physikalische Zeitschrift* for October 15. The new spectra are produced by powerful condenser discharges, and have not a single line in common with the old, or as Dr. Goldstein names them, the arc spectra. The new lines do not appear to fall into series, and the author suggests that they constitute the "fundamental spectra" of these elements, the arc spectra being due to polymerisation in the metal vapour, which is impossible in the powerful sparks necessary to produce the former.

IN the June number of *Terrestrial Magnetism and Atmospheric Electricity*, Mr. Y. Homma calculates the rates of change of the electrical potential at different distances above the earth's surface on various assumptions as to the distribution of positive charges in the atmosphere, the earth being taken as a sphere. None of the calculated rates of change agrees with the somewhat meagre observations which have been made, and the author points out the importance of further work in this direction.

IN the report of the third Prehistoric Congress of France in NATURE of October 24 reference was made to some photographs of Japanese megaliths, which were said to have been taken by M. Goodhan (p. 649, col. 2, line 3), Prof. W. Gowland writes to say that the photographs were taken by him, and were lent to Mr. F. V. Dickins for exhibition at the conference. The name was printed exactly as it was given by the secretary of the conference, who furnished the report of which a translation appeared in NATURE.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN NOVEMBER:—

Nov. 4. 15h. 33m. to 19h. 14m. Transit of Jupiter's Sat. III. (Ganymede).
10. Saturn's major axis outer ring = 43″·00, minor axis = 0″·64.
12. 4h. 11m. Moon in conjunction with Mars. (Mars 0° 58′ S.)
13. 22h. 23m. to 14. 1h. 47m. Transit of Mercury across the Sun.
,, 10h. 24m. Moon in conjunction with Saturn. (Saturn 2° 26′ N.)
14–16. Epoch of the Leonid meteors. (Radiant 150° + 22°.)
17. 10h. 1m. Minimum of Algol (β Persei).
20. 6h. 50m. Minimum of Algol (β Persei).
,, 4h. 25m. to 5h. 4m. Occultation of δ^1 Tauri (mag. 3·9).
,, 4h. 44m. to 5h. 35m. Occultation of δ^2 Tauri (mag. 4·7).
21. 17h. 6m. to 17h. 54m. Occultation of ζ Tauri (mag. 3·0).
23. 15h. 41m. to 17h. 1m. Occultation of δ Geminorum (mag. 3·6).
25. 20h. 34m. Moon in conjunction with Jupiter. (Jupiter 1° 57′ S.)
29–30. Mercury rises 2h. 2m. before the Sun.
30. 18h. 49m. to 23h. 39m. Transit of Jupiter's Sat. IV. (Callisto).

COMET MELLISH, 1907*e*.—Three observations of Mellish's new comet are reported in No. 4207 of the *Astronomische Nachrichten* (p. 111, October 17). Prof. Hartwig's observation on October 15 showed that the comet was round, with a diameter of 3′ and a central condensation. The magnitude at 15h. 52m. on October 15, as estimated by Prof. Becker at Strassburg, was 9·3.

THE TRANSIT OF MERCURY.—In view of the approaching transit of Mercury (November 14), Mr. W. T. Lynn publishes a letter in No. 388 of the *Observatory* (p. 382, October) in which he directs attention to earlier observations of this phenomenon and to its periodicity. He states that the first authentic observation of the transit was made in 1631 by Gassendi, and was followed by an observation by Jeremiah Shakerly, an Englishman who went to Surat, India, in 1651, for the purpose of observing the transit. Halley observed the 1677 transit at St. Helena, and this led him to suggest that transits of Venus would afford a peculiarly advantageous means of determining the solar parallax, a suggestion that was first carried out officially in 1761.

Mr. Lynn also directs attention to the peculiar commensurability existing between the orbital periods of the earth and Mercury, the former completing forty-six in

nearly the same time that the latter completes 191 revolutions; the periods are 16,801 and 16,802 days respectively, and thus transits of Mercury must occur every forty-six years at the same node.

THE PERSEID METEORS.—In No. 4206 of the *Astronomische Nachrichten* (p. 81, October 16) Herr W. Milowanov, of the Kasan University Observatory, Russia, gives an account of the Perseid observations made at Kasan in August, 1906. Two hundred and seventy-two meteor-paths were recorded, by three sets of observers, on August 11, 12, and 13, forty-nine of which were not Perseids. The horary rate on August 11 was 21·5, and on August 12 25·4. The time of observation, the path and the magnitude of each meteor are given, together with a list of the variously estimated radiants; the centre of the radiant for 1906 is given as $\alpha=43°{\cdot}5$, $\delta=+55°{\cdot}0$. The heights of twenty-four meteors are also given, the mean heights of appearance and disappearance being 111 km. (sixty-nine miles) and 73 km. (forty-five miles) respectively.

A RICH NEBULA REGION.—On a plate exposed in the Bruce telescope for three hours on July 16, 1906, Prof. Max Wolf found an extensive nebulous cloud having its centre some $1\frac{1}{2}$ degrees north-east of ϵ_2 Sagittarii. Later observations show that the region is very rich in small nebulæ, a plate exposed on July 16 showing a large number of such objects over a region of forty-eight square degrees. Most of these nebulæ are of Prof. Wolf's class I_1, being round objects with central condensations (*Astronomische Nachrichten*, No. 4207, p. 109).

RAIN-GAUGE EXPOSURE AND PROTECTION.

WHEN during the nineteenth century rainfall observations by means of gauges began to be carried out upon an extensive and scientific system, it was soon discovered that gauges which stood in situations much exposed to the wind invariably indicated a smaller amount of rain than such as were protected from the wind.

The greater part of our knowledge regarding the effects of wind exposure upon the indications of rain-gauges was derived from a careful study of the diminution of recorded rainfall with the elevation of gauges, either upon buildings or poles, above the ground, and an abundance of experimental work carried out during the nineteenth century in many European countries, notably, perhaps, in England, as well as in the United States of America, left no doubt but that this indicated decrease of rainfall with height above the ground was only apparent, and due to the more imperfect catch of rain by the gauges consequent upon their increased exposure to wind.

The well-founded conclusion is that wind interferes with the proper catch of rain by eddying around the mouth of the rain-gauge, and that consequently a rain-gauge should on theoretical principles be protected from wind disturbance if we would know the true quantity of rain that falls upon the ground in its vicinity. Nothing is known as to the mode of formation or of the complexity of these wind eddies, and information respecting these questions could only be suggested through laboratory experiments. When a gauge is elevated above the ground upon a thin pole there is merely the augmented wind velocity to be considered in explanation of the decreased amount of rain it will receive as compared with a similar one upon the ground, but when a gauge is placed upon an edifice or close to the edge of a steep cliff or bank the case is far more complicated through new disturbances introduced by such obstructions themselves to the wind, which has the effect of causing a deficit of rain upon the windward side of buildings and a relative surplus upon the leeward side.

The whole subject, however, of decrease of recorded rainfall with height above the ground has been thoroughly investigated, as mentioned above, in its several relations, so that there offer themselves for discussion, more particularly the methods that have been adopted for protecting rain-gauges from, or of correcting their readings for, wind error.

It was about the year 1889 that Prof. Cleveland Abbe,[1] of the United States, made an exhaustive study of the data at that time available from different parts of the world with reference to the apparent decrease of rainfall with elevation above ground, and relating his data to a law known to meteorologists as Archibald's, connecting increase of wind velocity with square root of altitude for small altitudes above the surface of the earth, showed that the deficit of rain indicated by an elevated gauge was proportional to the square root of its altitude above the ground. From these results Abbe deduced for a rain-gauge in a free, open situation a numerical wind correction which may be explained as follows:—

If a second gauge, in all essential respects similar to the one for the readings of which the correction is to be applied, be placed twice as high above the ground as the latter, the quantity $E\times 2{\cdot}414+R=C$, where E is the excess of the reading of the lower gauge above that of the upper, R is the reading of the lower gauge, and C is the corrected reading of the lower gauge; to state this in words, add to the reading of the lower gauge 2·414 times its excess above that of the upper, and the result is the amount of rain which the lower gauge would have caught in the absence of wind disturbances. The validity of this correction, which depends, of course, upon the extent to which for any particular occurrence of wind and rain the necessary assumption of Archibald's law is trustworthy, is doubtless such as to enable at least a close approximation to the true rainfall to be reached. But two conditions must be complied with before the records of two gauges placed at different heights above the ground can thus bear a simple relation to differences of wind velocity corresponding to different amounts of error through eddy action at the mouths of the gauges:—(*a*) the two gauges must be of the same form and dimensions; (*b*) if the lower gauge rests upon the ground, the upper one must be supported on a somewhat thin pole as may not induce, by offering an obstruction to the wind, other disturbances operating at the mouth of the rain-gauge in addition to those due to the gauge itself.

Of the various types of wind-shield for rain-gauges that have been suggested or tried, by far the most serviceable is the protecting funnel jacket[1] originally devised about the year 1879 by Prof. F. E. Nipher, of the United States. This is screwed on to the cylinder of the rain-gauge at such a height that the rim of its broad upper portion lies level with that of the mouth of the gauge, and consists usually of copper gauze for the purpose of preventing or minimising the splashing of water into the gauge from the inner surface. The efficiency of such a protector has been tested, not only by Nipher himself, but by Prof. R. Börnstein in Germany and Dr. H. Wild in Russia, with the result that the contrivance may, on the whole, be regarded as an appropriate means of eliminating, or at all events reducing, injurious wind eddies around the mouth of a rain-gauge, as will be shortly seen. Since the protecting jacket was invented by Nipher it has been improved in various ways, a comparatively recent modification, as used at some of the Russian rainfall stations under the direction of the Central Physical Observatory at St. Petersburg, being capable of being taken to pieces so as to facilitate packing for transport.

Another type of protection contrivance, more accurate than the Nipher jacket, was established about 1880 in St. Petersburg by Dr. H. Wild. This took the form of a rectangular fence enclosure composed of wooden slabs, 2·5 metres in height, at certain equal distances on each side from the rain-gauge, the mouth of which was 1 metre above the ground, and provided with a door for the entry or exit of the observer. A comparison of anemometer observations within and without such an enclosure shows that even during the prevalence of high wind the conditions within approximate nearly to those of a calm, so that a fence enclosure of the dimensions adopted by Wild may be taken as the standard of accuracy for wind-protection contrivances.

[1] *Monthly Weather Review*, vol. xxii., 1894, p. 25. "The Reliability of the Rain-gauge"; *American Meteorological Journal*, vol. vi. p. 241, "The Determination of the Amount of Rainfall."

[1] *Zeitschrift der Osterreischischen Gesellschaft für Meteorologie*, Band xiv., 1879, s. 250, "Ueber die Bestimmung der wahren Regensmenge mittelst hochaufgestelltes Regensmesser, von F. F. Nipher; *Meteorologische Zeitschrift*, Band i., 1884, s. 381, "Ueber den von Nipher vorgeschlagenen Schutztrichter für Regenmesser," von R. Börnstein; *Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg*, v^e série, vol. iii., 1895, p. 103, "Kritische Untersuchung der Angaben freier und geschützter Regenmesser," von Emil Berg.

Respecting the relative efficiency as protecting agents of the Nipher jacket and the Wild fence, experimental observations have been, and are apparently still being, conducted in Russia, a country, be it noted, where, owing to the large quantities of snow that fall during the colder months of the year, the sources of error in rain-gauge records through wind assume greater magnitude than they do, for instance, in England, where the winter precipitation consists largely of rain. It may be said that, while the Nipher protector is generally well adapted to its purpose for ordinary situations of rain-gauges, it may be with advantage replaced by the fence enclosure in the case of gauges which are unduly exposed to the full force of the wind in unsheltered locations. If the accuracy of the Wild fence be taken as 100, that of the Nipher jacket may approximate to 100 in more sheltered positions, but may be as low as 80 or even lower in such as are quite open to the violence of the wind. It should be added that a Nipher gauge ought to be fitted with some form of heating apparatus adequate to prevent accumulations of snow in winter upon the protecting jacket, from which into the rain-gauge portions of such accumulated snow are liable to be blown.

This brief abstract of the chief methods of diminishing or eliminating the wind error due to rain-gauges would be incomplete were it omitted to mention a process of calculation [1] by which the rainfall figures for a sufficiently long period, as indicated by a gauge at a place which suffers undue exposure to the wind in comparison with another gauge in the neighbourhood, say a few miles distant, at a more sheltered spot that may be regarded normal, may be corrected. The method depends upon the relation subsisting between the amounts of discrepancy in the records of two such gauges during periods of rain and of snow. If the rainfall for a specified time at the sheltered station be represented as 100, and that at the exposed station as 100−A for periods of rain and 100−A−B for periods of snow, the equation $K=\frac{x+A}{B}$, when solved for x, affords the correction required. The value of K, which for a few localities in Germany has been found to range from 0·13 to 0·22, must be empirically determined for a particular district by establishing two similar rain-gauges close together, or, if possible, side by side, one of which is fitted with an efficient wind-protection contrivance, the other being left free; for a pair of gauges in such close proximity x may be considered to vanish, so that K becomes $=A/B$. The value of K for the locality being thus found, x is solved $=KB-A$, which will, of course, be a *plus* or *minus* quantity according as the true rainfall is slightly greater or less at the exposed than at the sheltered station. This method of calculation, which is applicable in many instances, has been tested by another more direct one involving anemometer readings, whereby the measured quantities of precipitation could be reduced to equal mean wind velocities, and as the two have given most concordant results, it may be concluded that the one briefly delineated above is correct.

Thus at Karzig, in Neumark, the rainfall at an open, wind-swept spot on the outskirts of a forest, though indicated by a rain-gauge as considerably less than that of a glade more than 2 kilometres distant, was found by both processes of calculation to be actually 2 per cent. greater.

To summarise the contents of this article:—

(1) Experimental observations extensively carried out during the nineteenth century in many countries have established the fact that in the measurement of rainfall errors of considerable magnitude accrue from the presence of the rain-gauge during the prevalence of wind, and point to the conclusion that such errors arise from the eddying or rebounding of wind about or from the mouth of the rain-gauge.

(2) The readings of a rain-gauge in a free, open situation may be corrected by means of a method involving their comparison with those of another similar gauge placed at twice the height above the ground.

(3) The most efficient wind-protection contrivances for rain-gauges are the Nipher jacket and the Wild fence enclosure; the latter, though more accurate and advantageous in special circumstances, is generally less used than the former.

(4) The corrected rainfall for a sufficient length of time of a wind-swept spot may in many instances, if the rainfall for the corresponding period of a sheltered spot in the same neighbourhood, say a few miles distant, be known, be determined by means of an equation involving as known data (*a*) the relative amounts of discrepancy in the records of the gauges at the two places during periods of rain and of snow; (*b*) an empirically determined constant K.

L. C. W. BONACINA.

[1] *Meteorologische Zeitschrift*, Band xxiii., 1906, s. 444, "Wald und Niederschlag in Westpreussen und Posen und die Beeinflussung der Regen und Schnee-messung durch der Wind," von J. Schubert.

RECENT DEVELOPMENTS IN THE THEORY OF MIMICRY.[1]

THE remarkable resemblances that exist between certain insects belonging to widely different orders have long been known to naturalists. Wasps and hornets are imitated by the "clear-wing" moths, the resemblance being so close that it has sometimes deceived for the moment a skilled entomologist. Certain two-winged flies that inhabit the nests of humble-bees are scarcely to be distinguished from their hosts, and the handsome Xylocopas, or carpenter-bees, familiar objects in the tropics, are deceptively copied by two-winged flies found in the same regions.

But it is not only the bees and wasps that are so imitated, nor are the imitating insects to be found only in the ranks of moths and flies. An ichneumon fly in Borneo, belonging to the same order as the bees and wasps, though not in the same sense a stinging insect, is closely copied by a Reduviid bug.

Other instances are numerous. So long ago as the year 1836, the French entomologist Boisduval directed attention to the extraordinary resemblance that exists between certain butterflies which are not at all closely related to each other, belonging, indeed, to groups which are widely distinct. One of these butterflies is a member of the Danainæ, a group of which we have no resident representative in this country; a second is nearly related to our familiar "swallow-tail" of the Cambridgeshire fens; while the third is a Nymphaline, not far removed from our British "White Admiral." The structural differences between these butterflies show the want of real affinity between them in spite of their superficial resemblance. The "cell," for example, of the hindwing is open in the Nymphaline, while in the other two it is closed by a transverse vein. This illustrates the point that these resemblances affect only obvious characters; they are independent of affinity or blood relationship, and leave untouched such morphological features as do not readily meet the eye.

An insect thus resembled by another is spoken of as its "model," the imitating insect is called a "mimic," and the combination of model and mimic or mimics is known as a "mimetic pair" or "mimetic assemblage," as the case may be.

What is the meaning of these resemblances? Many of them were well known to the older naturalists, who, however, had nothing to offer by way of explanation but vague talk about "repetition" and "analogy" in nature. The well-known entomologists Kirby and Spence got so far as to suggest that in some cases the resemblance might be of advantage to the mimic, but in their day it was not likely that the subject should be treated from the evolutionary point of view, and the first really scientific explanation of the matter was given by Bates on his return from his famous visit to the Amazon, now nearly fifty years ago.

Bates had observed that in these cases of deceptive resemblance between butterflies, one member of the pair or of the group was often characterised by abundance of individuals, while the whole group was marked by slowness of flight, conspicuousness of appearance, and immunity from the attacks of insect-eating birds. On these grounds he put forward the suggestion that the mimicking species enjoyed protection from attack by their

[1] An evening discourse delivered at the Leicester meeting of the British Association on August 5 by Dr. F. A. Dixey.

resemblance to their more abundant models, the immunity of which, he thought, was due to the possession of some distasteful quality—probably a scent or flavour disliked by the birds.

Accepting Darwin's view of evolutionary process, he attributed the formation of these resemblances to the accumulation by natural selection of variations in the mimicking species that happened to point in the appropriate direction; so that these mimics had gradually put off the general aspect of the group to which they properly belonged, and had become more or less completely assimilated in outward appearance to the members of an entirely different assemblage; thus sailing, as it were, under false colours, as if a peaceable merchantman were to disguise itself under the rig and ensign of a man-of-war. This is the well-known Batesian theory of mimicry. It was at once, and cordially, accepted by Darwin; while the array of facts from South America on which it was based was soon afterwards shown to be paralleled by corresponding phenomena in the Malayan Archipelago and in South Africa. This was the work of two great naturalists happily still with us, Alfred Russel Wallace and Roland Trimen.

An objection was raised in early times to Bates's view on the ground that it was difficult to account for the first advances towards the formation of a mimetic pattern. This objection was felt in some degree both by Darwin and by Fritz Müller, of whom we shall hear more presently. Darwin and Müller thought that the objection might be met by supposing a considerable original likeness between mimic and model; it can, however, quite easily be shown from forms actually at present existing that a complete series of gradations may occur between the ordinary type of a mimetic genus and its very distinct-looking model or models. The transitional forms, even those exhibiting the earliest stages of mimetic assimilation, are evidently able to maintain themselves (how they do it we shall see later), and they in many cases form a perfect succession of links between extreme forms of the utmost divergence in aspect. Hence it is unnecessary to suppose that a considerable initial resemblance must exist between mimic and model, while the initial stages of the mimetic pattern, however we are to account for them, are not only theoretically possible, but are found to be in actual existence.

The beauty and simplicity of Bates's theory commended it strongly to public acceptance, and it is probable that to this day, when the subject of mimicry is mentioned, it is the Batesian theory that presents itself to most people's minds.

But notwithstanding the immense value of Bates's contribution to knowledge, it is now evident, as we shall see, that he only touched the fringe of a great subject, and that a much wider view is necessary before the facts observed by him, and subsequently by others, can be fully explained.

Those who read Bates's classical paper cannot avoid remarking that he himself was not thoroughly happy about all the facts there recorded. He directs attention to the circumstance that not only do the mimics resemble their models, but that the models themselves often show an extraordinary resemblance to each other. He speaks of "a minute and palpably intentional likeness which is perfectly staggering."

To take an instance: two species of the Ithomiine genus Dircenna, *D. epidero* and *D. rhaeo*, structurally distinct, but almost indistinguishable on the wing, were noted by Bates as being always found together where they occur in the Amazonian region. A moth, *Hyelosia tiresias*, was regarded by Bates as a mimic of *Dircenna epidero*, but it did not escape him that his theory failed to account for the resemblance of the two Dircennas to one another, the subfamily Ithomiinæ, to which they belong, being on good grounds supposed to be generally distasteful. The difficulty becomes still greater when it is realised that not only members of the same presumably distasteful genus, but also members of different genera, all with the same habits and denizens of the same region, wear the same extraordinary likeness to each other. There are, for example, some twenty species of Ithomiines, belonging to no less than seven different genera, all with the same, or very nearly the same, external appearance. But this is not all, for the same mimetic assemblage will be found to include, not only these Ithomiines, but also butterflies belonging to the group of Danaines (genus Ituna) and Pierines (genus Dismorphia), as well as moths of the two widely separated groups of Hypsidæ and Castniadæ, all with a common facies.

If it were merely a case of resemblance between two or more species of the same genus, such as the Dircennas that have just been mentioned, we might be tempted to say that the resemblance was merely due to affinity, and to explain, as Bates did, the circumstance of the constant companionship of the two species by appealing to the "social and gregarious instincts of the group." When, however, we see that not only Dircennas, but Ithomiines generally, Danaines, Pierines, and moths all come into the same mimetic assemblage, the explanation from affinity breaks down. Affinity, no doubt, may help mimicry, but there is no necessary connection between the two. Some members of the company are closely related; others are widely distinct. Bates himself saw clearly enough that his theory of one distasteful and immune form sheltering others which would be attacked if detected would not apply to cases of this kind. If all the species but one of a "homœochromatic" group are to be considered as edible mimics, we should have to account for the fact that they vastly outnumber the model, in which case the mimicry would be more harmful to the model than beneficial to themselves; we should also have to face the improbability of one species of a genus being distasteful and immune, while other species of the same and allied genera were edible and liable to attack. It was plain that the distasteful models did really imitate each other, but why?

All that Bates could do in the face of this difficulty was to fall back, somewhat doubtfully, on the hypothesis of some local or climatic cause acting equally upon the forms of different groups, and in some unexplained way bringing about this strange resemblance between them. In this supposition he was for a time followed by Wallace.

It is not to be denied that there is a certain plausibility at first sight in this view concerning the direct action of external conditions. It is, for example, a striking fact that the members of a mimetic group of very diverse affinities will, as Bates says, every few hundred miles all change their hue and pattern together, "as if by the touch of an enchanter's wand."

There is a well-marked assemblage of this kind, generally characterised by a pattern composed of the three colours red, yellow, and black. It contains, besides moths, butterflies of many diverse groups, Ithomiines, Heliconiines, Danaines, Nymphalines, and Pierines—in some of the latter the female only taking part in the mimetic cluster, a point to which we shall return later on. The members of this assemblage as it occurs in the northern part of Central America—Guatemala to Nicaragua—present in common a remarkable streakiness of pattern, a feature that makes them easily recognisable among the corresponding forms from other regions of the same continent. Passing on to Venezuela, we find among the geographical races, or, if we like to call them so, the representative species, that there replace the Central American forms, a tendency to the breaking-up of the streaks, and a slight encroachment of the red ground-colour upon the yellow of the apex. In Trinidad there occurs a general paling of the ground-colour, due to an increase of yellow pigmentation, and running, as before, through the entire group. Next, taking the corresponding Guiana forms, we find a further breaking-up of the streaks into spots, and also a general darkening, especially of the hindwings, which gives a most characteristic aspect to the whole assemblage. In East Brazil we have a modification which somewhat recalls the Trinidad facies, though here the yellow streak on the hindwing is better defined, and the black of the apex is less broken up. At Ega, on the Upper Amazon, a curious dark chestnut tinge pervades the group, while in Peru a characteristic spottiness takes the place of the streaky pattern we saw elsewhere, and the apex becomes more uniformly dark. Finally, in Ecuador the streaks have all but disappeared, and even the spots have become almost blocked out by a

dark infusion which now occupies, not only the apex, but also a large part of the base of the forewing, and the whole, or nearly so, of the hindwing. After a little study of some of the typical members of each of these geographical groups, it becomes easy to pronounce, with a considerable degree of confidence, upon the local habitation of a species that we may never have met with before.

If facts of this kind were the only ones with which we had to deal, there might be some justification for adopting the theory of the direct effect of geographical conditions, but it is now incumbent on us to consider whether this hypothesis of common surroundings producing a common aspect will bear further examination. We will take the instance of a group of ant-like insects caught by Mr. Guy Marshall in Mashonaland on one day on a single plant. All were to outward appearance ants; but while the first four were veritable ants, the next two were bugs, and the last was a locustid, belonging, that is to say, to the order of crickets and grasshoppers. If a common environment has of itself produced the ant-like appearance of the bugs and the locust, why has it not done something towards assimilating the points of structure that do not meet the eye? As a matter of fact there is no such approach. In internal organisation each member of the group preserves the exact characters of its own order.

There is a certain ant-like locustid, possibly of the same species as that last mentioned, in which the body of an ant is, as it were, painted on that of the locust. The constriction between thorax and abdomen, real in the ant, is in the locustid only apparent. Can the external conditions which are supposed to have caused the characteristic shape of the ant actually paint a copy of the ant on the otherwise unaltered body of the locust?

Again, there are cases where the supposed external influence must have acted, if at all, as sculptor instead of painter. In a certain ant-like Membracid (an insect allied to our common "cuckoo-spit") the body of the insect is concealed beneath a shield, which grows backward from the fore part of the thorax. This shield or screen, which is quite separated from the body except along one line of attachment in front, is hewn or moulded, so to speak, into the form of an ant, reproducing even the small swelling in the peduncle which is characteristic of some ants of the region that this insect inhabits.

Another instance, probably familiar, but so much in point that I cannot refrain from mentioning it, is that of the immature form of a Membracid found by Mr. W. L. Sclater in Guiana among a number of leaf-cutting ants. The flat green body and brown head and legs of the Membracid make a very fair copy of the ant engaged in its occupation of carrying home the cut leaf, the picture including, not only the ant, but the leaf as well. Ants are avoided by some enemies, though not by all, and in a procession of ants of this kind it is not likely that an enemy, however sharp-sighted, would readily pick out the Membracid from among its leaf-carrying companions. The idea that external conditions can produce in another insect a copy, not only of the ant, but of the leaf which it carries, needs, I think, only to be mentioned to be dismissed.

Looking at the matter from a slightly different point of view, we may take the instance of the wonderful African butterfly *Papilio dardanus*, no very distant relative of our English "swallowtail." The male of this insect is non-mimetic, while the female occurs in three or four different forms, each of which is a palpable mimic of a separate model. On the theory of direct external causes we have to explain why these external conditions have brought about a resemblance between each form of the female and a separate model of different affinities, while these causes have not been able to prevent individuals of the same species from going off in four or five different directions.

The facts here have been questioned, but as all the diverse forms have been found among the offspring of one individual, there is no longer any room for doubt that they are all really conspecific.

We can get more light on the subject if we return for a moment to our assemblage with transparent wings, the assemblage, that is, which contains the two Dircennas, *rhaeo* and *epidero*.

Now if the effect of transparence, which is common to the entire group, had been the direct result of an external cause, we should expect it to have been brought about in all cases by the same means; but whereas in the Ithomiines the transparence is due to an alteration in shape and diminution in size of the minute scales which normally clothe the wing, in the Pierines the same effect is produced by a mere diminution in size, the shape remaining unaltered. The Danaines of the group owe their transparence to a reduction in the *number* of the scales, not to any alteration in shape or in size; while in the associated moths the effect results, not from any change in size, shape, or number of the scales, but from the fact that the individual scales themselves become transparent, and are sometimes set up vertically, so as to let the light pass between them.

In view of these facts, the investigation of which we owe to Prof. Poulton, it is difficult, if not impossible, to imagine any direct agency which will produce the same visual effect by all these different means. The likeness is superficial; the real difference is profound. The common features, if we may so express it, are only meant to be looked at. They must stand in relation to vision of some sort; and to whose vision, we may well ask, if not to the vision of would-be enemies? Natural selection will attain the desired end by any means that come to hand, and these observations of Poulton seem to put every other explanation in this case out of court. If we may be allowed to use, without prejudice, teleological language, we may say that these resemblances have been brought about by natural selection for a mimetic purpose. Any variation, whether in size, shape, number, transparence, or position of scales, which leads in the required direction, will be preserved; and the final result, though to ordinary vision identical in all cases, will bear evidence, on close examination, of the manner, different in each individual case, in which it has been effected.

But, it may be said, many of your instances are simply cases of Batesian mimicry, and for them we can allow the sufficiency of natural selection; it is the other cases which want explaining. This is quite true, but a great point is gained if we have shown that, in many of these cases, neither affinity nor the direct agency of external conditions will account for the facts, while natural selection will do so if only we can find out why it should be an advantage for these distasteful types to form themselves into groups. If we *can* bring both kinds of mimicry under one cause, we are bound to do so. The old logical canon, the "razor of Occam," applies here. "Entia non sunt multiplicanda praeter necessitatem"; in other words, having found an adequate cause for one case of a given phenomenon, we are not at liberty to go out of our way to seek another cause for a second case of the same phenomenon. We must first try if the cause already established will not meet the requirements of the situation.

What we have to do, then, is to prove, if we can, why it should benefit these *distasteful* forms of various affinities to fall into homœochromatic groups, groups, that is, essentially similar in outward aspect. For a long time the key to the puzzle eluded discovery; it was at last found by Fritz Müller.

This admirable naturalist, working, like Bates, in South America, put forward in the year 1879 a suggestion which, when developed into its full consequences, has revolutionised our conception of the whole subject.

His suggestion rested on the assumption (since shown, mainly by Lloyd Morgan, to be correct) that birds have no instinctive knowledge of what forms would be suitable for food and what should be avoided, so that each bird has to gain its knowledge by experience. Hence a certain number of distasteful forms must be sacrificed by each generation of birds until these enemies have learned to leave such forms alone. In other words, each distasteful form has to *pay a tax* for its immunity.

Now if two distasteful species resemble each other so closely that birds or other enemies do not distinguish between them, the disagreeable experience gained by tasting an individual of one species will be applied to the benefit of the other, and so each of the two species will only need to contribute a portion of the tax, instead of

each paying the whole—a consideration which, I think, will go home to most of us. And what is true of a combination of two species will be equally true of a larger assemblage; the greater number of forms that can be got to share the tax, the better for all. Hence the formation of these large "inedible associations," or, as they might be called, Müllerian groups. I do not wish to be understood as saying that the Batesian and Müllerian theories are mutually incompatible. They are *supplementary* to each other, and there is ample room for true mimicry beside or within the ranks of the Müllerian associations.

Though the theory of which I have just given an account is really quite simple, it has never been so generally understood and appreciated as that of Bates. May I, at the risk of being tedious, try to illustrate the relation between the two?

Imagine a large box of sugar-plums, and a schoolboy given *carte blanche* to help himself from it as he likes. Imagine, further, that the sugar-plums are of different colours and flavours, and that some of them are flavoured with an essence which the boy does not like—we will say aniseed. Further, let all the aniseed sugar-plums be coloured pink. The boy will soon find out that the pink sugar-plums are unpleasant to his taste, and *after a trial or two* they will be left until all the others have been disposed of, or, if sufficiently disagreeable, they will be refused altogether. The pink colour is here an *aposeme*, to use Prof. Poulton's term, or the visible mark of a distasteful character.

Suppose a few pleasantly flavoured sugar-plums to be coloured pink like the aniseed sugar-plums. These, if there are not so many of them as to destroy the impression of nastiness associated with pink, will also be left. This represents Batesian mimicry. The few pleasantly flavoured sugar-plums share in the protection afforded by the pink aposeme.

Now for Müllerian mimicry. Let us suppose that there are *two* flavours disliked by the boy, say aniseed and peppermint, and that the sugar-plums with these flavours are coloured pink and green respectively. The boy would have to try both pink and green before he learned to avoid them. Perhaps two of each, two of the pink and two of the green, *i.e.* four in all, would be sufficient to complete his education in this respect; but if *both* kinds of disagreeable sugar-plums were coloured pink, a trial of two only, instead of four, would be sufficient to protect all the rest, of both flavours, aniseed and peppermint, from the boy's depredations. In other words, the tax paid by each would be halved, and so with larger numbers. Hence the advantage of a common aposeme for *distasteful* objects, whether sugar-plums or butterflies.

This illustration refers only to the relation between the two theories. It says nothing, of course, as to the means by which the sugar-plums originally became coloured and flavoured; but what we *have* done is to show the advantage to be gained by Müllerian association, and therefore to supply the required motive power for natural selection.

Müller's suggestion was brought to the notice of British naturalists by Prof. Meldola in the year of its first publication, and in its further developments at the hands of Meldola himself and of Poulton it was accepted both by Wallace and by Trimen, the two naturalists who had done most by their own observations to confirm the validity of the supplementary (though earlier-devised) theory of Bates.

Fritz Müller had spoken chiefly of the resemblance between two butterflies, Ituna and Thyridia, belonging to distinct subfamilies, but it was soon pointed out by Prof. Meldola that the general likeness between members of the same distasteful family groups came easily under the same principle.

In order to appreciate this point fully, let us consider the common European Vanessas, the Peacock, Red Admiral, large and small Tortoiseshells, Camberwell Beauty, &c., several of them familiar objects in our own country. We see at once that though there is certainly a family likeness between them, they are distinguishable from one another at a glance; no one would think of taking one of them for another. Contrast this with a similar group of closely allied species, known to be distasteful, from a part of the world where competition is keen, for instance, the Acræas of Africa. Of these, four or five species may be taken on the same day, looking all alike while on the wing, and practically indistinguishable from one another without close examination. Or take a group of Euplœas, another distasteful genus, from the Oriental region. Here again we may have some five separate species, all quite distinct, but so much like one another that it needs much more than a casual glance to distinguish between them.

These and similar cases were shown by Meldola to be easily explicable on the basis of the Müllerian theory of mutual protection by the adoption of a common scheme of warning colours on the part of inedible forms, and the possibilities of the theory were still further expanded by Poulton, who pointed out that in any given region the fewer independent schemes of warning coloration there were to learn, the better chance there was of the protection they afforded being effective; so that the same simple warning badge, such, for instance, as the alternate black and yellow rings on the body of a wasp, might be employed by insects, like the caterpillars of the Cinnabar moth, which are widely separated from the wasp in point of affinity. The aposeme, or signal to an enemy to keep his distance, may be recognised and obeyed even when hoisted by insects which have little else in common between them. A great part of the significance of the facts that we have noticed depends, of course, on the circumstance that the members of each of these closely assimilated groups inhabit the same geographical areas. We do not find an Eastern Euplœa resembling an American Heliconius, or an Ithomiine from Brazil recalling an African Acræa. As a further illustration of what Poulton has aptly named "synaposematism," or the adoption of a common warning badge on the part of distasteful forms, we may take the wonderfully diverse assemblage that centres round the conspicuous and distasteful beetles belonging to the genus Lycus. This assemblage, in South Africa, contains wasps, Braconids, moths, a bug, and a two-winged fly, besides beetles belonging to three or four different families. I have myself seen several members of this group, heterogeneous in affinity though wonderfully similar in hue and pattern, on or about one tree at East London, in South Africa. Be it remarked that they were all conspicuous insects, and exposed themselves freely, so that there could be no question of a common cryptic coloration. The assemblage, beyond doubt, is mainly if not entirely synaposematic.

We have now reached what may at any rate rank as a preliminary generalisation, that is to say, that the resemblance between distasteful forms is to their advantage, and is an adaptation brought about by natural selection. Following the approved logical method of Mill and Jevons, we ought next to see what consequences are involved in the hypothesis we have formed, and then to make a fresh appeal to the facts for verification or the reverse.

(1) It is obvious that in Batesian, or true mimicry, the advantage is all on the side of the mimic. Experience gained by tasting the mimic would be used to the injury of the model. While, therefore, there is every inducement for the mimic to seek safety by approaching nearer and nearer to the aspect of the model, there is no reason for the model to assimilate itself to the mimic, but rather the contrary.

In a Müllerian association, on the other hand, the benefit is mutual. Each fresh accession to the group is a source of strength, not of weakness. Everything is in favour of the formation of such groups as rapidly and on as large a scale as possible; hence there is nothing to impede, and everything to promote, the free interchange of characters all round, each member being able to act, so to speak, *as both mimic and model*. This, we saw, could not happen in the case of Batesian mimicry.

Now does this interchange of characters, as a matter of fact, ever take place? If it does, it will be, of course, a confirmation of our theory.

One of the most characteristic features in the subfamily of Pierines, or "white butterflies," is the possession of red or yellow spots, streaks, or patches on the underside

of the hindwing, near the base. These marks reach a high state of development in some members of the Eastern genus Delias, and relics of them are to be seen in the common white butterflies of our own country.

Now no one who accepts mimicry at all will be inclined to doubt the existence of a mimetic relation between *Heliconius guaricus* and the Pierine *Pereute leucodrosime*. How has it been brought about? The dark colour and red band are not at all characteristic of Pierines, and have no doubt been copied from the Heliconius; but the Pierine red spots have passed the other way, being taken up by the Heliconius from the Pierine. This, I believe, was the first case of mimetic interchange noticed.

Another instance. White is not an ancestral colour in Heliconius; it *is* ancestral in the Pierines. The Pierine *P. locusta* falls by its undersurface into mimetic association with the group of Heliconius represented by *H. alithea* and *H. galanthus*. The white colour has passed from Pieris to Heliconius; the dark, in great measure, from Heliconius to Pieris.

Much the same has happened in the case of *Heliconius leuce* and the female of *Pieris noctipennis*. These two have undergone reciprocal change. The white comes from the Pieris, the black from the Heliconius.

There is another case where two species belonging to widely separated sections of the same subfamily are in question. The hindwings of the island form of the Pierine *Huphina nerissa* have been drawn away into imitation of the hindwing of *Ixias baliensis*, also a Pierine; while the forewing of the Ixias, leaving the usual aspect of its genus, has been assimilated to the forewing of Huphina.

Another good example of interchange is afforded by the "swallowtail" *Papilio rex* from Uganda, which is in undoubted mimetic relation with the Danaine *Melinda formosa*. The brown at the base of the forewings is a Danaine character adopted by the Papilio; the pale areas at the base of the hindwings are a Papilionine character adopted by the Danaine. Each has in one of these respects acted as a model to the other. The two African genera Mylothris and Phrissura, the species of which form a parallel series of mimetic pairs analogous to the Ithomiines and Heliconiines of tropical America, furnish what is probably another instance of the same phenomenon. For this mutual approach by a process of give and take on both sides, Prof. Poulton has proposed the apt term "diaposematism," the idea of reciprocity being conveyed by the Greek particle "dia."

Let us now look at the working of this reciprocal principle in another direction.

It is well known that where the sexes differ in the extent to which they are protected, whether by power of concealment or by other means, it is almost invariably the female that has the advantage. This was pointed out long ago by Dr. Wallace, and was, no doubt rightly, attributed by him to the fact that the continuance of the life of the female, as the guardian of the early stages of the future brood, was of greater importance than that of the male to the welfare of the species. So we find many cases in which the female alone is mimetic, not the male. Shall we say that "Nature abhors the unprotected female"?

We have already noticed the case of *Papilio dardanus*, with its non-mimetic male, and three or four different forms of female, each form in mimetic relation with a Danaine model.

The case of the Pierine *Leuceronia argia* is in many respects parallel to that of the Papilio. Again we have a non-mimetic male, and several different forms of female, each being in mimetic relation with another butterfly of quite different affinities.

Once more: the female of the Nymphaline butterfly *Hypolimnas bolina* falls into mimetic association with Danaines and with a Papilio, leaving its own male outside the group. It will be remembered, also, that much the same thing occurs with certain of the South American Pierines which we considered in an earlier part of the present lecture.

These instances are sufficient to show the readiness of the female, as distinct from the male, to enter a mimetic combination.

Bearing these facts in mind, when we look at such a combination as that of *Papilio iphidamas* with *Euterpe approximata*, we shall have little or no difficulty in recognising that here we have an analogous case. The sexes of the Euterpe (a Pierine) and the female of the Papilio all resemble each other, while the male of the Papilio stands apart. We have just seen how readily the female of a given species may be drawn away into a mimetic relation apart from its own male, and we have every reason to suppose that the same has occurred here, only that in the case of *P. dardanus*, *L. argia*, and *H. bolina* the pull has been mainly or entirely away from the *dardanus*, *argia*, and *bolina* standard, while here there is no doubt that the female Papilio has pulled the Pierine away from the usual Pierine standard, though it has in turn been pulled away from its own male. The male, it is true, belongs to a synaposematic group of its own, but the female has joined the stronger combination. The pull has been mutual between female Papilio and Pierine, and the association must therefore be Müllerian.

(2) Here is one more piece of evidence. We have seen that from the nature of the case the attraction (so to call it) in a Müllerian assemblage acts, or may act, in all directions, for each member of a Müllerian group is potentially both mimic and model.

It ought then sometimes to happen, if the Müllerian theory is correct, that although one dominant species, distinguished perhaps for its hardiness and distasteful qualities, may act as the centre of a group, influencing all the other members, yet that these other (subordinate) members of the group should show signs of having influenced each other, apart from the dominant species.

Does this ever happen? Certainly it does.

Limnas chrysippus, a Danaine, is one of these dominant forms, numerous in individuals, hardy, conspicuous, proved to be distasteful, and accompanied by mimics wherever it goes. Among its mimics in Africa are an Acræa, and a Lycænid (allied to our common blues). Now it is quite evident that there is a mimetic relation between the Acræa and the Lycænid apart from that which exists between them both and the Limnas. In short, they resemble each other in some respects more than either of them resembles the common model. Hence one or other of these two, or perhaps both, must be distasteful, and therefore there must be a Müllerian element in the whole group, if, indeed, it be not entirely Müllerian.

It has been pointed out by Prof. Poulton that many beetles, belonging to different families, are all in a sense mimics of the hymenopterous group of the Mutillidæ, and yet they have become assimilated to each other in non-Mutilloid points.

Facts of this kind prepare us for a further consideration of great importance, with which I shall conclude.

(3) We find that it is impossible to regard the mimetic assemblages of a given region as so many isolated groups. As a matter of fact, though there are certain dominant forms which act, so to speak, as centres of attraction, we often find that the mimetic forms constitute a nexus, models of the most dissimilar aspect being held together, as it were, by a kind of connection which runs from group to group, gradations from one group to another being formed in the most unexpected ways. From the nature of things this point is difficult to illustrate within the limits of a lecture like the present; a few examples may suffice.

Starting from a white Pieris of ordinary aspect like *P. phaloe*, we can pass by easy stages through *P. calydonia* ♀ and *P. demophile* ♀ into a well-marked distasteful group of which the Ithomiine *Aeria agna* is a good example. From *P. demophile* ♀ we can also pass through *P. viardi* ♀ to the pattern of *Heliconius charitonia*, or in yet another direction by way of *P. tithoreides* ♀ to *Heliconius atthis* and *Tithorea pavonii*. *P. calydonia* ♀, again, gives us a fresh starting point from which to proceed by way of *P. kiçaha*, *P. pandosia*, and *P. leptalina* up to a well-marked Ithomiine group typified by *Napeogenes inachia*. We have already seen how *P. locusta* ♂, which presents the Pierine characters of *P. phaloe* in an intensified form, comes into association with another group of Heliconii, while the same butterfly forms an early link in the chain

which leads up by easy gradations through both sexes of various species of Perrhybris (another Pierine genus) to the red, black, and yellow Müllerian assemblage we have already considered. From an intermediate stage in this latter series, exemplified on the undersurface of *Perrhybris lorena* ♀, we get a passage to yet another Heliconiine scheme of coloration, that shown by *H. aranea*. Here, then, we have groups centring round protected Heliconiines and Ithomiines of the most varied aspects, all held together and linked up with white butterflies of the ordinary Pierine facies by a network of almost imperceptible gradations.

As a final illustration, let me direct your attention to the series formed by *Papilio iphidamas* ♀, *Euterpe approximata*, *E. bellona*, *E. nigrina* (underside), and *Heliconius venusta*.

We have only to examine a gradated series like this to see how difficult it is to account for it on Batesian lines. There is the common aposeme, the yellow patch on the dark forewing, running right through; but if the Papilio is the model for all the rest, why should these Euterpes, which are Pierines, mimic a mimic (the Heliconius) instead of going to the model itself (the Papilio)? If, on the other hand, we regard the Heliconius as the model, we are met by exactly the same difficulty, only that it is reversed. Now we know that some at least of these intermediate forms are numerous in individuals, and as soon as the Müllerian principle is admitted we can see how easily forms protected by distastefulness can arrange themselves into a gradational series of this kind. For every distasteful form tends to protect other forms on each side of itself; hence the existence of these transitional stages is just what we should expect. This group represents in miniature what is everywhere to be found when we examine a tropical butterfly fauna from the point of view of mimicry, and I think we have here discovered the answer to an objection that met us at the outset, namely, the difficulty of accounting, on the principle of natural selection, for the existence of these intermediate forms, including the initial mimetic stages. Whether or no the difficulty is a real one in the way of the Batesian theory, in view of the Müllerian principle it is non-existent.

The comparison may perhaps be allowed between these mimetic groups, each with its own type of coloration, and the solar and stellar systems. Sometimes, as in the solar system, there is one central member of the group dominating the whole and influencing its attendant planets to an extent in comparison with which the force they themselves can exercise is insignificant. At other times, as in the systems of double and multiple stars, there are bodies more nearly equal in mass and importance bound together by mutual attraction into a single combination, where each one effectively controls and is controlled by the rest. Could we imagine irregular wanderers through cosmic space which from time to time get drawn within the limits of some established system, we might in them find an analogy to certain species which seem to hover on the outskirts of mimetic groups, undecided, as it were, whether to throw in their lot with one association or another.

What result have we been able to reach to-night? Starting from the fact, long recognised by naturalists, of the wonderful likeness borne to each other by certain insects of widely different affinities, we have found that the first rational explanation of the phenomenon was given by Bates, who nevertheless did not conceal from himself that his interpretation left many of the observed facts unaccounted for. The fertile suggestion of Fritz Müller went far to supply what was still wanting. Expanded by Meldola and by Poulton, accepted by travelled naturalists like Wallace and Trimen, the Müllerian generalisation has proved a powerful means of interpretation of many complicated relationships. We have seen reason for concluding that such rival attempts at explanation as those which allege affinity, or geographical and climatic conditions, as adequate causes for the phenomena before us, break down on serious examination; and we have applied the final test of arguing deductively from the premises, and finding, on a fresh appeal to the facts, that our results are in accordance with expectation.

This verification, we saw, is concerned with the three chief topics of (1) the interchange of characters, or diaposematism; (2) the influencing of subordinate members of mimetic groups by one another; and (3) the nexus of protected conspicuous forms which may overspread a whole zoological continent.

I think no one who has paid attention to the facts that have been before us can fail to recognise that here, as everywhere in organised nature, the principle of adaptation is paramount. No scientific explanation of adaptation that really meets the case has yet been offered except natural selection. Whatever bearing the principle of adaptation by selection may have on the question of the origin of species—I for one venture to think that it has a very important bearing—it is a principle which cannot in fairness be ignored.

In what has been said I have tried to be explanatory rather than controversial, though it has not been possible to avoid altogether points that have given occasion for dispute. Those who are conversant with the subject will know that many questions of interest have been left unnoticed; but I trust that in this survey, necessarily brief, I have said enough to show how much of biological importance and interest is involved in the really great subject of mimicry.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. R. C. Punnett has been re-elected to the Balfour studentship for one year from Michaelmas, 1907.

A grant of 50*l.* from the Balfour fund has been made to Mr. W. E. Agar in furtherance of his expedition to the Paraguayan Chaco.

A proposed change in the Previous Examination, which may be of far-reaching importance, will be voted on by the Senate next week. At the suggestion of the Board of Examinations, a paper on elementary heat and chemistry will be set in part ii. of the Previous Examination as an alternative to the papers on Paley's "Evidences" and elementary logic. The Board also proposes the substitution of a single combined paper on arithmetic and algebra for the present separate papers on these subjects in the same examination.

The Special Board for Mathematics has issued an important report with reference to the constitution of the board. Owing to the new regulations, the examiners and moderators will in future be nominated by the board. The representatives of the college on the board given them in past years by the nomination of the moderators will thus disappear. The board considers it advisable that there should be direct representation of the mathematical lecturers of the University and of the colleges; it is therefore suggested that two members be nominated each year at a meeting held of the lecturers in subjects for the mathematical tripos.

The reforms which the board of mathematics have introduced into the University in the last four years are numerous and far-reaching. They include a complete revision of the mathematical tripos, the recognition that the teaching of mathematics should be correlated with that of physics and engineering, the establishment of a qualifying examination in mechanical sciences, re-casting of the mechanical sciences tripos, and reforms in the mathematical special examination for the ordinary degree.

Dr. Hobson has been re-elected president of the Cambridge Philosophical Society. The new vice-presidents are Prof. J. J. Thomson and Mr. S. Ruhemann. The new members of the council are Prof. T. B. Wood, Prof. B. Hopkinson, Dr. Searle, and Mr. W. E. Dickson. Mr. H. F. Newall has been re-elected treasurer, and Mr. A. E. Shipley, Dr. E. W. Barnes, and Mr. P. V. Bevan secretaries.

OXFORD.—The Romanes lecture will be delivered by the Chancellor of the University, Lord Curzon, All Souls' College, on Saturday, November 2, at 2.30. in the Sheldonian Theatre. The subject of the lecture will be "Frontiers."

Mr. J. S. C. Douglas, Christ Church, Radcliffe travelling fellow, has been elected to the Philip Walker studentship in pathology.

THE London Day Training College, Southampton Row, W.C., will be opened by the Earl of Rosebery on Saturday, November 2, at 3 p.m. The ceremony will be conducted by Mr. H. Percy Harris, chairman of the London County Council.

DR. W. GOODWIN has been appointed head of the chemical department of the South-Eastern Agricultural College (University of London), and Mr. B. N. Wall head of the agricultural department. A new department of soil bacteriology is being established under the charge of Mr. C. T. Gimingham. A conference of hop-growers will be held on November 27 under the chairmanship of Mr. E. C. Lister-Kay, when papers on fertilisation of hops, eel-worms, and hop-drying will be communicated.

AT the annual general meeting of the Old Students' Association at University College (University of London), Dr. Tempest Anderson was elected president of the association for the year 1907–8. The annual dinner of the association will be held on Thursday, December 5. The new wing that has recently been added to the college will be completed by that time, and will be open to inspection. Former students of the college who desire to be present should communicate with Mr. George A. Aitken at 42 Edwardes Square, Kensington, W.

PROF. L. F. VERNON HARCOURT, who died on September 14, bequeathed 1000*l.* to the Institution of Civil Engineers in memory of the many advantages he had derived from its library and lectures, to found a yearly or biennial (in the discretion of the institution) lecture, medal, premium, or prize, in connection with river, canal, or maritime engineering. The residue of his property he left to his wife for life, and after her death to the University of Oxford, if there shall have been founded there in the lifetime of himself and his wife a school of engineering or mechanical science, 1000*l.* for the promotion of the teaching of engineering science there. He also bequeathed 200*l.* to University College, London, for a yearly prize in civil engineering.

THE new laboratories of the scientific departments of the College of Liberal Arts of Boston University have now been opened in the building formerly occupied by the Harvard Medical School. We learn from *Science* that the top floor is occupied by the departments of astronomy, physics, and mathematics, and comprises large and small lecture-rooms, laboratories, and offices; a large part of the basement is also given over to physics. The chemical and biological departments occupy the second floor, and consist of large, well-lighted class laboratories, private laboratories and store-rooms, professors' rooms, and an amphitheatre for the larger classes. The two domes for the telescopes of the astronomical department are situated on the roof, and are not quite completed. The equipment of all the laboratories is new, and was purchased in part by special funds given to the University for that purpose. The scientific departments are under the same directors as last year.

THE report for the year 1907 on secondary education in Scotland, prepared by Dr. J. Struthers, the permanent secretary of the Scotch Education Department, has just been published. It appears that instruction in experimental science continues to make headway steadily. The schemes of study submitted to the department for approval often show a tendency to attempt a larger volume of work than can be accomplished satisfactorily in the time allotted to the subject, and teachers find difficulty in treating inductively the more advanced subjects included in the school course of physics and chemistry. The chief examiner reports a large increase in the number of candidates presented at the examination for leaving certificates. It is exceedingly satisfactory, the report continues, to know that in more than 50 per cent. of the schools the examiners were able to accept the teacher's list without change or modification of any kind. This is a sure sign of the growth of that mutual confidence between teachers and examiners which is essential to any really healthy system of examination.

THE scientific training of the pharmacist was the subject chosen by Prof. Meldola, F.R.S., for the inaugural address upon the occasion of the opening of the present winter session of the School of Pharmacy. From the lecture we gather that for the two examinations of the school the passing of which qualify the student as a pharmacist, a period of fifteen months' training is all that is required. The standard of the examinations themselves is unquestionably high, and too high, in the opinion of Prof. Meldola, for so short a period of training, creating the danger of the instruction of the school degenerating into a "cram." It appears, however, that at present no knowledge of the action of drugs is demanded of the pharmacy student, although a most intimate acquaintance with the methods of physical and chemical analysis is demanded of him. There can be no doubt that legally great responsibility rests upon the pharmacist, in that if he cannot make his own preparations he is expected to know how they are made and how to assure himself that the products he dispenses are of the nature and substance demanded. In Germany a more thorough and a more prolonged scientific training is necessary before a legal qualification in pharmacy can be obtained, and in this country certain universities have, after a prolonged and thorough curriculum, granted degrees in pharmacy. In conclusion, Prof. Meldola suggested that the Pharmaceutical Society should demand of those students entering the school a higher standard of general education and some specific scientific training either in addition to or in the place of the present three years' apprenticeship, or, in other words, that more attention should be given to the scientific status of pharmacy, even if this has to be done at the expense of its commercial aspects.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 21.—M. H. Becquerel in the chair.—The transits of Mercury across the sun, and in particular on that of November 14: G. **Bigourdan.** A discussion of the various phenomena which have been observed in connection with the transits of Mercury, together with suggestions regarding instruments, &c., for use in the coming transit.—Some formulæ relating to the minima of classes of quadratic forms, binary and positive: G. **Humbert.**—The spawning of the cod in the south of the North Sea: Alfred **Giard** and C. **Cépède.** The authors criticise the views put forward by T. Wemyss Fulton in a recent paper on the same subject. The spawning of the cod in the Pas-de-Calais, the south of the North Sea, and the Baltic takes place in winter, the maximum being produced towards the middle of February, or a month earlier than indicated by Fulton. There is no indication of there being two spawning seasons in certain localities.—The installation of a large astronomical instrument at the summit of the Pic du Midi: B. **Baillaud.** This was carried out in 1906 and 1907 with the assistance of officers and men of the French artillery. Observations will be commenced in August, 1908.—Observation of the Mellish comet (1907*e*) made with the bent equatorial of the Observatory of Lyons: J. **Guillaume.** The comet appeared on October 17 as a diffuse nebulosity of about 35″ diameter, with a faint central nucleus. Its lustre is about that of a star of the tenth magnitude. The apparent positions of the comet and comparison stars are given.—Observations of the new comet (1907*e*) made at the Observatory of Marseilles with the Eichens 26 cm. equatorial: M. **Borrelly.** Similar observations made on October 17 and 18.—Integral equations: E. **Goursat.**—The integrals of the differential equation $y' + A_2y^2 + A_3y^3 = 0$: Pierre **Boutroux.**—The variation of the mass of the electrons in the interior of the atom: H. **Pellat.**—The formation and preparation of aluminium carbide: Camille **Matignon.** Four methods of preparing this carbide without the use of the electric furnace are described: heating a mixture of aluminium powder and lampblack in a Perrot gas furnace for twenty minutes, inducing the reaction to start at a point in the same mixture by the addition of iodine or sulphur, the use of the oxy-acetylene blow-pipe, and by the interaction of aluminium and hexachlorobenzene. In the first two cases the purity of the product was tested

by treating with water and analysing the methane produced.—A delicate method for the detection of nickel in the presence of cobalt: Z. **Tchougaeff.** A direct comparison of the dimethylglyoxim reagent suggested by the author some years ago with the reagent recently proposed by M. Pozzi-Escot (ammonium molybdate) shows that the latter is much inferior in delicacy, and under certain conditions may also give rise to a precipitate with cobalt.—Syntheses in the camphor group. The complete synthesis of campholene: G. **Blanc.** The starting point of this synthesis is ethyl malonate, and the sodium derivative of this, treated with γ-bromodimethylbutyric ester, $CH_2Br.CH_2.C(CH_3)_2.CO_2C_2H_5$, gives the ester of 1 : 1-dimethylbutane-1 : 4 : 4-tricarboxylic acid. This is saponified and the acid heated, giving ααδ-trimethyladipic acid, the anhydride of which, slowly distilled at the ordinary pressure, is converted into 1 : 1 : 4-trimethyl-*cyclo*pentanone-5. This with magnesium methyl iodide gives the corresponding tertiary alcohol, and the latter spontaneously loses water on distillation, giving a hydrocarbon identical in boiling point, density, and refractive index with campholene from β-campholenic acid.—Sodium anilarsenite in syphilis: Paul **Salmon.** This substance is sold commercially under the name of atoxyl, and by its use comparatively large quantities of arsenic can be administered with comparative impunity. A physiological comparison of three commercial specimens, two amorphous, one well crystallised, showed that no appreciable differences could be detected. It was noteworthy that whereas in animals poisonous symptoms in the medulla were not infrequent, no such untoward effects were observed in man. Of 181 syphilitic subjects, only about 15 per cent. showed intolerance of the drug.—The causes of trypanolytic crises and relapses which follow: A. **Massaglia.** From experiments *in vitro* it is concluded that the crises are due to the formation of an anti-body in the blood of the animals infected by trypanosomes; a small number of the parasites escape destruction and grow accustomed to the action of the anti-body, and it is to these parasites which escape that the relapses are due.—The true accelerating action of sodium fluoride on the coagulation of milk by vegetable ferments: C. **Gerber.**—A preliminary sketch of the geology of Dahomey: Henry **Hubert.**—The displacements of the maxima of the positive and negative anomaly of gravity relatively to the configuration of the earth: Giulio **Costanzi.**

DIARY OF SOCIETIES.

FRIDAY, NOVEMBER 1.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Resumed discussion by Capt. H. R. Sankey on Prof. Bertram Hopkinson's paper on The Indicated Power and Mechanical Efficiency of the Gas-engine.

GEOLOGISTS' ASSOCIATION, at 8.—Conversazione.

MONDAY, NOVEMBER 4.

ARISTOTELIAN SOCIETY, at 8.—The Presidential Address on The Methods of Modern Logic and the Conception of Infinity: Rt. Hon. R. B. Haldane.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—The Determination of Indigotin in Indigo-yielding Plants: Cyril Beretheil and R. V. Briggs.—Analysis of Indigo (Part iii) and of the Dried Leaves of *Indigofera arrecta* and *Indigofera Sumatrana*: R. Gaunt, F. Thomas and W. P. Bloxam.

TUESDAY, NOVEMBER 5.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Address by the President, Sir William Matthews, K.C.M.G., and Presentation of Medals and Prizes awarded by the Council.

SOCIOLOGICAL SOCIETY, at 8.—The Evils of Cities; a Study of the Degeneration of Communities, and of the Deterioration of their Individuals: Prof. Geddes.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Presentation of the Huxley Memorial Medal to Dr. E. B. Tylor.—On Methods of Determining the Stature and taking other Measurements of the Living Person: Prof. D. J. Cunningham, F.R.S.

WEDNESDAY, NOVEMBER 6.

ENTOMOLOGICAL SOCIETY, at 8.—On some of the Butterflies of Tobago: Dr. G. B. Longstaff.—On a Large Series of Nycteribiidæ (Parasitic Diptera) from Ceylon: Hugh Scott.

SOCIETY OF PUBLIC ANALYSTS, at 8.—Discussion on the Sealing of Samples.

THURSDAY, NOVEMBER 7.

ROYAL SOCIETY, at 4.30—*Probable Papers*: The Effect of Pressure upon the Arc Spectra of Metals: W. Geoffrey Duffield.—The Diurnal Variation of Terrestrial Magnetism: Prof. A. Schuster, F.R.S.—The Electric Discharge in Monatomic Gases: F. Soddy and T. D. Mackenzie.—On the Measurement of Temperature in the Cylinder of a Gas Engine: Prof. H. L. Callendar, F.R.S., and Prof. W. E. Dalby.—Note on the Association of Helium and Thorium in Minerals: Hon. R. J. Strutt, F.R.S.

RÖNTGEN SOCIETY, at 8.15.—The Presidential Address, The Production of High Frequency Oscillations, with Demonstrations: W. Duddell, F.R.S.

LINNEAN SOCIETY, at 8.—The Origin of the Di-trimerous Whorls among Flowers of Dicotyledons: Rev. George Henslow.—Unrecorded Acari from New Zealand: Albert D. Michael.—On *Ænigmatistes africanus*, a new Genus and Species of Diptera: R. Shelford.—*Exhibits*:—A copy of Hudson's "Flora Anglica," 1778, with numerous annotations by the Rev. William Kirby: Alexander Stevenson.—Abnormal Stem of *Eucalyptus salmonophloia*, F. Muell., from West Australia: Dr. A. B. Rendle.

CHEMICAL SOCIETY, at 8.30.—Gaseous Nitrogen Trioxide: H. B. Baker and Mrs. M. Baker.—The Atomic Weight of Tellurium: H. B. Baker and A. H. Bennett.—The Isomerism of the Double Sulphites of Sodium and Potassium: M. H. Godby.—Studies in the Camphane Series, Part xxiv, Camphoryldithiocarbamic Acid and Camphorylthiocarbimide: M. O. Forster and T. Jackson.—The Vapour Pressures of Triethylamine, of *sym*-Trimethylpyridine, and their Mixtures with Water: R. T. Lattey.—Liquid Triethylamine: R. T. Lattey.—The Action of Sulphuretted Hydrogen on Solutions of Sodium Hydrosulphite: F. S. Sinnatt.—The Alkyl Compounds of Gold. Diethylauric Bromide. Preliminary Note: W. J. Pope and C. S. Gibson.—Note on the Constitution of Homoeriodictyol: F. B. Power and F. Tutin.—The Interaction of Methylene Chloride and the Sodium Derivative of Ethyl Malonate: F. Tutin.—Preparation of Aliphatic Nitro-compounds by the Interaction of the Alkyl Iodides and Mercurous Nitrite: P. C. Rây and P. Neogi.—Some Mercury Derivatives of Camphor: J. E. Marsh and R. de J. F. Struthers.—Contribution to the Chemistry of the Terpenes. II. The Oxidation of Limonene with Chromylchloride: G. G. Henderson.—The Synthesis of Acridines and Phenonaphthacridines: Tetra- and Hexa-methylacridines: Dimethylphenonaphthacridines: Dixylylmethylenediamines: A. Senier and A. Compton.

FRIDAY, NOVEMBER 8.

ROYAL ASTRONOMICAL SOCIETY, at 5.

MALACOLOGICAL SOCIETY, at 8.—Description of a New Species of Clathurella, probably from Ceylon: H. B. Preston.—On the Mollusca of Birket-el-Qurun, Egypt: C. A. Smith.—*Turbo granoliratus* (New Guinea); *Sistrum chrysalis*, *Purpura bougei*, *Natica bougei* (New Caledonia); *Urosalpinx walkeri*, *Listra walkeri* (N. W. Australia); *Amalthea coxi* (Port Stephens); *Pitaria elata* (Sierra Leone); all new species: G. B. Sowerby.—Note on the Originals of the Illustrations for E. M. da Costa's "Historia Naturalis Testaceorum Britanniæ," London, 1778: Alex. Reynell.

PHYSICAL SOCIETY, at 8.—Discussion on Mr. Campbell's Paper on the use of Variable Mutual Inductances.—A Graphic Method for Stream-lines and Equipotential Surfaces: L. F. Richardson.—On the Lateral Vibrations of Bars Supported at two Points with one end Overhanging: Dr. J. Morrow.

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