THURSDAY, JULY 13, 1899.

SAUNDERS'S BRITISH BIRDS.

An Illustrated Manual of British Birds. By Howard Saunders. Second Edition; revised. Pp. xl + 776. Figs. and Maps. (London: Gurney and Jackson, 1897–99.)

THE demand for works on British birds shows no signs of diminution, the popularity of the present instructive volume being vouched for by the fact of the exhaustion of the first edition of 3000 copies in less than eight years from the date of completion. The first edition being out of print early in 1897, the publishers lost no time in preparing a second, which commenced in November of that year and was completed on the first of June last. That this new issue is in no sense a mere *replica* of the preceding one is at once shown by a glance at the preface, where it is stated that, while the number of species admitted as British was then 367, it has now been raised to 384. Of course, these additional species are merely stragglers; and it seems to us that, in cases like those of the frigate-petrel and the black-browed albatross, it would have been decidedly better to include such stragglers in a separate list, as they have nothing whatever to do with the true British fauna. It must, however, be admitted that in making such a list of foreign stragglers it would be exceedingly difficult to know where to draw the line, so that we are not going to blame the author for the course he has thought fit to pursue.

The accounts of the various species, although necessarily somewhat brief, are all that can be desired from a popular point of view; and as these accounts are in nearly all cases supplemented by an excellent illustration, it may be safely said that there is no other work of its size in which so much information on the subject of British birds can be obtained. The great majority of the illustrations are the same as those in the fourth edition of "Yarrell"; and although the impressions of many of these do not compare favourably when contrasted with the latter, yet their attractive character and zoological accuracy may well justify their use. New figures, by Mr. G. E. Lodge, are, however, given of many of the species recently added to the British list, while a considerable number of the old-established birds have been redrawn by the same talented artist. A special feature of the work is the carefully compiled synopsis of genera in the introduction, where all the essential diagnostic characters of each are given in simple and yet precise terms. Another notable feature is afforded by the three admirably coloured maps at the end of the volume. The first of these shows the comparative elevation of the land and the depth of the surrounding seas in the United Kingdom, while the second does the same for Europe generally. The former, as the author states, serves to remind the reader that, owing to the indentations of the coast, comparatively few spots in the British Islands are situated at a distance of more than fifty miles from the coast; and how important a bearing this has on climate —and consequently on bird-life—scarcely needs mention. The third map is a North Polar chart, embodying Nansen's discoveries; and although this is primarily intended to assist in estimating the range of Arctic-breeding species, it will be found highly useful to many others besides ornithologists.

Fortunately, Mr. Eagle Clarke's valuable digest on bird-migration appeared in time for its results to be incorporated in this volume. And how important are these results in regard to the non-continuation of the Heligoland migrations to Britain, and also in respect to the effects of wind on migration, needs no telling on this occasion.

With regard to the difficult subject of classification, we are glad to find that the author follows the lines of the last edition of "Yarrell," so that the number of families and genera is considerably less than in certain other recent manuals of British birds. We are likewise pleased to see the retention of the old ordinal names, such as Passeres and Gallinæ, instead of their fashionable substitutes Passeriformes and Galliformes. So, too, is it refreshing to notice the absence of alliterative names; the familiar goldcrest, for instance, appearing as *Regulus cristatus* instead of *Regulus regulus*.

At the same time, it is greatly to be deplored that ornithologists should not, by a system of give-and-take, come to some general agreement over what is really, in one sense, an extremely unimportant matter—*i.e.* the names and limits of the orders, families, genera, and species of British birds. In the introduction, the author observes that the limits of a genus are mainly—and often purely—a matter of convenience. With this statement we thoroughly agree; but it is surely a matter of the most extreme *inconvenience* when each and every writer on British birds adopts his own views on such limits, without any regard to those of his fellow workers.

Contrast, for instance, Mr. Saunders's classification of the *Turdidae* (Thrush family) with the grouping of the genera contained therein by Mr. Sharpe in his "Handbook of British Birds," as exemplified in the following table:—

SAUNDERS.	SHARPE.
Fam. Turdidæ.	Fam. Regulidæ.
Sub-fam. Turdinæ.	1. *Regulus*.
1. *Turdus*.	Fam. Turdidæ.
2. *Monticola*.	2. *Oreocichla*.
3. *Saxicola*.	3. *Geocichla*.
4. *Pratincola*.	4. *Merula*.
5. *Ruticilla*.	5. *Turdus*.
6. *Cyanecula*.	6. *Daulias*.
7. *Erithacus*.	7. *Erithacus*.
8. *Daulias*.	8. *Cyanecula*.
Sub-fam. Sylviinæ.	9. *Monticola*.
9. *Sylvia*.	10. *Ruticilla*.
10. *Regulus*.	11. *Saxicola*.
11. *Phylloscopus*.	12. *Pratincola*.
12. *Aëdon*.	Fam. Sylviidæ.
13. *Lusciniola*.	13. *Sylvia*.
14. *Hypolais*.	14. *Melizophilus*.
15. *Acrocephalus*.	15. *Aëdon*.
16. *Locustella*.	16. *Phylloscopus*.
Sub-fam. Accentorinæ.	17. *Hypolais*.
17. *Accentor*.	18. *Acrocephalus*.
	19. *Locustella*.
	Fam. Accentoridæ.
	20. *Tharrhaleus*.
	21. *Accentor*.

Here we have one author making three families out of what the other regards as one, while he expands sixteen[1] genera of the former into twenty-one. If specific names were taken into consideration, further discrepancies would be noticeable. Moreover, in many of the other families of birds the two authors do not agree in regard to several of the generic names. For example, in the case of the ruff and reeve Mr. Saunders retains the Cuvierian *Machetes*, while Dr. Sharpe employs the earlier *Pavoncella*.

Such differences and idiosyncrasies are irritating enough to the working naturalist who knows what he is about, but to the amateur and the beginner they must be absolutely maddening. Although personally we are inclined to side with Mr. Saunders in regard to the limits of genera, and with Dr. Sharpe in regard to the adoption of the earliest names for the same, we consider both matters of no importance at all in comparison with uniformity of usage. And it is, we think, high time ornithologists settled upon some uniform working basis. Otherwise, we are of opinion the sooner scientific names are given up the better; they were intended for our tools, and we are rapidly making them our masters.

In the last few paragraphs we have departed rather widely from our text; and, to revert to the same, we may conclude by expressing the hope that the second edition of the "Boy's Yarrell," as the work before us has been not inappropriately termed, may meet with as favourable a reception from the public as has been accorded to its predecessor. R. L.

AS REGARDS REGENERATION.

Thatsachen und Auslegungen in Bezug auf Regeneration. Von August Weismann. Pp. 31. (Jena: Gustav Fischer, 1899.)

PROF. AUGUST WEISMANN'S essay on regeneration, which appeared simultaneously in *Natural Science* and in the *Anatomischer Anzeiger*, has now been published in pamphlet form, and well deserves the careful consideration of biologists. Its contents may be divided into two parts, the first of which is independent of the second. In the first part, Prof. Weismann expounds his previously expressed conclusion that regeneration is an adaptive phenomenon—"that the regenerative power of a part is to be considered, not as a direct and necessary expression of the nature of the organism, but rather as a capability which, though it may be absent, is found wherever it is necessary in the interests of species-preservation." In other words, the power of regenerating lost parts, though depending primarily (like all other vital qualities) on the properties of organised protoplasm, has been defined and perfected in the course of natural selection in those organisms which are in the ordinary course of their life frequently liable to serious mutilation. This is not a new idea, for, as Weismann notices, Réaumur made, in the first half of the eighteenth century, the induction that the power of regeneration was especially characteristic of animals whose brittle body was frequently liable to risk of breakage, and also of those, like earthworms, which are liable to be partially devoured. The Italian naturalist Lessona gave more precise expression to the same induction in what is sometimes called "Lessona's law," while Darwin regarded the regenerative capacity as interpretable on his theory of the selective origin of adaptations.

But since the days of Lessona and Darwin the wide occurrence of regenerative capacity throughout the animal series, till it fades away to almost nothing in mammals, has been more adequately appreciated, and besides observations not a few experiments have been made, so that the literature of the subject is already enormous Weismann, more perhaps than any other, has the credit of having recognised the importance of the problem presented, and of having tried to face the facts with a theory.

The first part of the pamphlet is an argument in favour of the interpretation of the regenerative power as an adaptive phenomenon. (1) It has been objected that regeneration sometimes occurs where the loss could only be called a casualty, and not such as would occur in the ordinary course of nature, *e.g.* a bird's regeneration of a broken beak, or a newt's regeneration of an eye. But as one inquires further into the matter it becomes probable that these injuries are much more frequent than was imagined, and that they cannot be called casualties. (2) It has been objected that internal organs not naturally exposed to mutilation or periodical wearing out are sometimes regenerated. But there seem to be few cases where this has been really substantiated, though some observations—by Vitzou, for instance, on monkeys—lead us to doubt whether Weismann is quite warranted in saying that regeneration of brain-cells in mammals never occurs. (3) T. H. Morgan's experiments on hermit-crabs showed that all the appendages were capable of regeneration, both those most liable to injury and those naturally well-protected, and led him to the conclusion that there is no relation between the frequency of loss and the regenerative capacity. With this case Weismann deals at considerable length and with his wonted ingenuity, calling to his aid especially the idea that the variation of the regeneration-"anlage" may lag behind the phyletic transformation of the part in question. But is it not enough to say that the fallacy underlying Morgan's objection is that of treating an organism as a finished product, and of assuming that an adaptation must be perfect? (4) It has been objected that regeneration does not occur in many cases where it would be very useful, thus its occurrence among reptiles, as regards the tail, is strangely sporadic, one might be tempted to say capricious. But is not this an *argumentum ad ignorantiam*, is it not likely that as we know more about the actual conditions of life in the apparently puzzling cases, the difficulties will disappear? Moreover, must it not be admitted that the absence of regeneration may be explained by the presence of another life-saving adaptation on totally different lines, and that, after all, adaptations are but compromises, and by no means perfect? Thus it is hardly an argument against the generally adaptive character of regeneration in earthworms to cite a case where the mutilated creature grows a second tail instead of a new head. One might as well say that the quickness of cerebral activity was not an effective adaptation because some people sometimes lose their heads.

[1] *Lusciniola*, for Radde's bush-warbler, was not known to be British when Dr. Sharpe wrote.

But we must not prolong our review of this able essay on these familiar lines. Suffice it to say that to those who enjoy this sort of discussion, and who appreciate its serious significance, this last utterance from the renowned biologist of Freiburg—though somewhat more discursive than is his wont—will afford, as the saying is, both pleasure and profit.

The second part of the essay contains an attempt to show, not merely that regenerative phenomena are adaptive, and presumably the outcome of selection, but that they are interpretable, on the ontogenetic theory of "anlagen," "determinants," "neben-Determinanten," "reserve germ-plasm," and the like. This is quite another affair, and altogether too complex to be dealt with in a few lines. But we would venture to insist that the evolutionary or phylogenetic interpretation of regeneration phenomena as adaptive is independent of the subtler developmental or ontogenetic theory of the manner in which the capacity may be supposed to organise and express itself.

It seems to us regrettable that Prof. Weismann should condescend to notice the "invectives, sarcasm, and derision which have been showered upon" him, and that he should regard

> "Such utterances as a not exactly desired, but yet not altogether unsatisfactory, sign that the less noble emotions of human nature—envy and ill-will—have found cause to direct themselves against the results of my work."

No doubt criticism without knowledge is exasperating, but it is also humbug; no doubt invective without appreciation is irritating, but it is mere pettifogging; and why should the immortals concern themselves about either?

A more philosophical temper, which we should regard as more deeply habitual, is indicated in one of the paragraphs towards the end of the pamphlet.

> "One of my critics has compared my 'theories' to 'towns in the Far West,' the houses of which are barely erected when they are taken down again to be rebuilt further out in the unknown land. I accept the simile, provided it be not forgotten that the first house of the advancing pioneer must remain standing and in use for a time before the region beyond becomes accessible to further colonisation."

We would respectfully commend to the illustrious author a motto from a northern University, "They have said, What say they? Let them say." For the author of the "Germplasm" and "Germinal Selection" is surely, among living biologists, the foremost pioneer. J. A. T.

WEST AFRICAN FETISH.

West African Studies. By Mary H. Kingsley. With illustrations and maps. Pp. xxiv + 639. (London: Macmillan and Co., 1899.)

FOR the last three years Miss Kingsley has been known to the scientific world as a careful collector of facts relating to West Africa, while to the unscientific public interested in works of exploration and travel she is known as a writer with an original and very entertaining manner. Her book entitled "Travels in West Africa," which was published in 1896, was the result of two journeys to West Africa, where she had devoted herself to the study of fetish and fresh-water fishes. In the preface to her present volume she tells us that her previous work, which she rather unjustly refers to as "a word-swamp of a book," was of the nature of an interim report. She there confined herself to facts, and eliminated as far as possible any inferences that might be drawn from them, distrusting at the time her own ability to make theories, and intending that ethnologists should draw from her collections of material such facts as they might care to select. The use that has been made of the volume since its appearance has certainly justified Miss Kingsley's method of publication. But there was obviously room for another work on the same subject from her pen. No one was better qualified than herself to form opinions with regard to the beliefs and practices she studied, and we are glad to find that in the present work she has formulated the conclusions at which she has arrived. We welcome the book as a valuable supplement to the first volume of her travels.

The book contains a good deal of very varied information, and while some portions of it appeal to the anthropologist and student of religion, others deal with purely scientific observations, and others again are of a political nature. Miss Kingsley's criticism of the Crown Colony system will doubtless receive the attention it deserves at the hands of those who are responsible for the methods we adopt as a nation in dealing with our tropical possessions. Her chapter entitled "Fishing in West Africa," which has already appeared in the *National Review*, explains the means by which she was enabled to form the collections which won Dr. Günther's admiration; while in the same connection we have an interesting account of the little fishes (*Alestis Kingsleyae*) which have the honour to bear their discoverer's name. The most interesting part of the book, however, which Miss Kingsley herself regards as of greatest importance, is the section which deals with the subject of fetish in West Africa. The word fetish is used by Miss Kingsley in a much wider sense than that in which it is generally employed at the present day. The word was adopted into scientific literature from the writings of the old Portuguese navigators, who were the modern discoverers of West Africa. These men noticed the veneration paid by Africans to inanimate objects, and called these things *Feitiço*, a term they applied to their own talismans and charms. The word is nowadays generally employed in a rather similar sense as a general term for the doctrine of spirits embodied in, or conveying influence through, material objects. Miss Kingsley, however, in spite of a protest from Prof. Tylor, has thrown over this established usage, and employs the word as a convenient synonym for the religion of the natives of the West Coast of Africa where they have not been influenced either by Christianity or Mohammedanism. Using the term with this extended application, Miss Kingsley classifies West African fetish into four main schools: the Tshi and Ewe school, which is mainly concerned with the preservation of life; the Calabar school, which attempts to enable the soul to pass successfully through death; the Mpongwe school, which aims at the attainment of material prosperity; and the school of Nkissi, which chiefly concerns itself with the worship of the power of the earth. These schools of fetish are not sharply defined, and many of the same things are worshipped indiscriminately in each; but Miss Kingsley has shown that in certain schools certain ideas are predominant, and her classification is based on a general survey which can afford to ignore minor inconsistencies. It is interesting to note that, according to Miss Kingsley's observations, the African, to whatever school of fetish he may belong, conceives of a great over-God, who has below him lesser spirits including man. But this fact does not necessarily support Mr. Andrew Lang's recently promulgated theory as to the original purity and elevation of the religious beliefs of primitive races, though Miss Kingsley herself is inclined to identify her own conception of things with that she found current among the peoples she studied. We have merely touched on the principal sections of Miss Kingsley's very interesting work, and have not space to do more than recommend its perusal to all those interested in the religions of the undeveloped races of mankind. The reader will find in it much material of the greatest scientific importance, while its anecdotes and lively style render it one of the most entertaining books of travel and observation that has appeared for many years.

OUR BOOK SHELF.

Catalogue of the Library of the Royal Botanic Gardens, Kew. (London, 1899.)

THE issue of this catalogue fittingly commemorates the development, up to the last year of the nineteenth century, of an adjunct indispensable in the equipment of a centre of botanical research so deservedly famous as the Royal Botanic Gardens at Kew. The many botanists that have enjoyed the access to the library so freely allowed to workers in the Herbarium, and have learned to value the stores of information contained in it, will rejoice to have the catalogue as a guide to render the riches of the library still more accessible than in the past. But not to those alone that can visit Kew Herbarium is it likely to be welcome. Botanists living at a distance that precludes frequent visits to Kew Herbarium will find it most useful for reference as a guide to the literature of botany, and will value it accordingly.

The size of the library may be judged from the fact that a rough calculation shows upwards of 15,000 separate entries of books or papers, besides numerous cross-references. Of course, all sides of botanical research are represented, from the more elementary to the most profound, from the most rigid study of botany as pure science to its practical applications to industries and arts, to folk-lore, and to its manifold links with other fields of study, scientific and literary. Occasionally one meets with a title that at the first glance seems to have little connection with botany, *e.g.* W. Ridgeway's "The Origin of Metallic Currency and Weight Standards," yet these only serve to show the curious relations of botany to other studies.

The entries are divided into four series, each arranged alphabetically:—(1) General, occupying 683 pages; (2) Travels, 43 pages; (3) Periodicals and Serials, 47 pages; (4) Manuscripts, 15 pages, large octavo.

The catalogue has been prepared by Mr. B. Daydon Jackson, and is marked by the accuracy so characteristic of all his work in botanical bibliography. Despite the peculiar risk of errors in transcribing and printing the titles and necessary details, many of which are in very unfamiliar languages, the freedom from errors is very noteworthy.

An introduction to the volume from the pen of the Director of the Gardens gives a brief account of the leading facts in the formation of the library, which originated as a public library in 1852, when Miss Bromfield presented to the Gardens the botanical books that had belonged to her deceased brother, Dr. W. A. Bromfield. Sir William Hooker, on his appointment as Director in 1841, had offered to make his large private library and herbarium available for public use if they were suitably accommodated. This was done in a house provided for him as Director until 1852, when they were transferred to the present Herbarium, though still remaining his private property. In 1854 the late George Bentham, F.R.S., very generously gave his large botanical library to the Herbarium, where in subsequent years he long continued those researches by which he so greatly advanced the science of botany. In 1867, after Sir William Hooker's death, the Treasury sanctioned the purchase for the library of those botanical works that had belonged to him and that the library did not possess.

Valuable legacies and gifts have also been received from other sources, and numerous serials are obtained in exchange; and purchases are made with occasional grants from the Bentham Trust. The sum expended from public funds in the formation of the library has been very small in comparison with its value, and has consisted of a small annual subsidy since 1849, supplemented after some years by free binding by the Stationery Office. One important source of constant additions—the gifts of books and separate papers from the authors—is largely the result of the benefits experienced by the botanists that come from far and near to pursue researches at Kew.

The catalogue would become still more valuable to botanists if there could be added a subject-division, even under large sections, of the multitude of titles that it contains. The difficulties of doing so are indeed considerable, but the aid to workers would be very great.

The Larvae Collector's Guide and Calendar. By J. and W. Davis. Pp. 90. (Dartford: J. and W. Davis.)

THE times of the appearances of the British macro-lepidoptera are given in this little book, together with notes on rearing lepidoptera from eggs, larvæ, and pupæ. Young naturalists should find the volume useful in stocking their butterfly cages, and as a guide to the management of insects in the different stages of development.

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.*]

A Lecture Experiment on the Relative Thermal Conductivities of Various Metals.

MOST lecture experiments on the conductivities of metals occupy too much time to be very effective, and in addition are often somewhat uncertain in their action. The following arrangement may be very quickly and simply put together, and by its aid the relative conductivities of a number of metals may be quantitatively determined in an interval of about a minute, the essential parts of the apparatus being capable of projection on a screen.

A piece of brass tube, about 10 cm. in diameter and 20 cm. in length, is closed at one end by means of a brass disc. A number of holes are bored in this disc to receive the extremities of rods of copper, brass, iron, &c., each rod being 2·5 mm. in diameter and about 15 to 20 cm. in length. The rods are soldered in position perpendicular to the disc.

Each rod is provided with a small index, made from a piece of copper wire of about ·8 mm. diameter, bent into the form shown in Fig. 1, a small arrow-head of blackened paper or mica being attached by shellac varnish. The rings forming part of each index are wound on a rod *very slightly* larger in diameter than the experimental rods.

To start with, the brass vessel is inverted, an index is slipped on each rod, the single ring (Fig. 1) being left in contact with the disc, and a very small amount of paraffin wax is melted round the rings. When the vessel is supported with the rods downwards, as in Fig. 2, the solid wax holds the indexes in position. The arrangement is then placed between the condenser and the focussing lens of the lantern, and boiling water is poured into the brass vessel. When that part of a metal rod, in the neighbourhood of the double ring of the index, reaches the

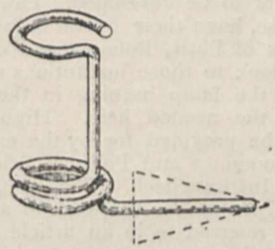

FIG. 1.—Enlarged view of index.

melting temperature of the wax, the index commences to slip downwards, carrying the wax with it, and when the temperatures of the rods have acquired steady values, the indexes will have descended to points on the various rods where the wax just solidifies, and which, therefore, possess equal temperatures. Hence, the conductivities of the various rods are proportional to the squares of the distances from the bottom of the brass vessel to the respective positions indicated by the several arrow-heads.

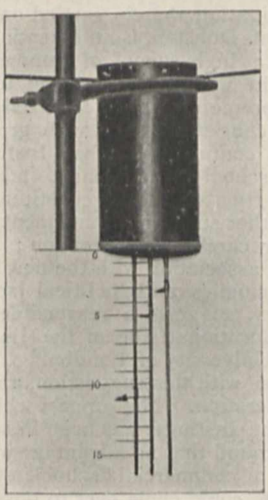

FIG. 2.—Lecture apparatus for demonstrating the relative thermal conductivities of metals. (The left-hand rod is of copper, the middle one of brass, and the right-hand one of soft steel.)

A scale of equal parts, or, better still, a scale of squares, may be drawn on the screen, when the relative conductivities may be directly read off.

In Fig. 2, rods of copper, brass and soft steel are shown with the indexes in the positions acquired at the end of an experiment. It will be seen that the relative conductivities work out to within three or four per cent. of the accepted values for the mean conductivities between 0° and 100° C.

Royal College of Science, July 8. EDWIN EDSER.

The Electrical Resistance of the Blood.

IT is no easy task to measure the electrical resistance of the blood of a living individual. The principal difficulty depends upon the fact that only very small quantities of blood can generally be obtained at a time. During the last five years many attempts have been made by me to obtain trustworthy and consistent results; various methods and forms of apparatus have been employed and subsequently rejected.

The best results were obtained by placing five cubic millimetres of freshly-drawn blood between two cup-shaped electrodes three millimetres in diameter, coated with spongy platinum, and fixed at 0·75 mm. apart.

The average resistance of normal blood at 60° F. measured by Kohlrausch's method in this apparatus is 550 ohms. A striking change may be observed in pernicious anæmia, the resistance in this disease being sometimes diminished to about one-half that of normal blood. The deduction is that the blood in pernicious anæmia contains an abnormal amount of salts, due to the destructive metabolism going on.

DAWSON TURNER.

School Laboratory Plans.

I HAVE long believed that by far the best arrangements of the benches in a laboratory for elementary chemical teaching is the last one suggested by Mr. Richardson, viz. "single benches, cross-ways, like the desks of an ordinary class room."

It must be remembered that qualitative analysis now occupies a secondary place in an elementary course, and a great number of reagents is not required for preparations and simple quantitative experiments. The superstructure of shelving may therefore be replaced by a single rack for the common reagents. This allows perfect supervision from the raised demonstration table in front of the benches, and the work of the class can at any moment be interrupted for explanation or revision of the work done, or for an experiment made by the master himself. It is surely a mistake to divide an elementary course of chemistry into two parts—theoretical and practical; the proposed arrangement allows of the practical work forming a part of the general course.

In this county this arrangement has been successfully carried out. The grammar schools are, however, unwilling to risk the refusal of the Science and Art Department to recognise such a laboratory for earning grants, the old-fashioned benches with uncleanly teak tops and rarely used drawers and cupboards being usually insisted on. T. S. DYMOND.

County Technical Laboratories, Chelmsford.

The Origin of the Doctrine of Compensation of Errors in the Infinitesimal Calculus.

I SHOULD be much obliged if you could help me by inserting a query on this point.

Lazare Carnot, at the end of his "Reflexions sur la Métaphysique du Calcul Infinitésimal," stated that "it is singular that in this indispensable condition of elimination the real character of Infinitesimal Quantities . . . should not hitherto have been discovered."

However, Lagrange (see "Œuvres," t. vii. p. 595) had explicitly stated this doctrine many years before. Very possibly Carnot did not see this note, but Lagrange again stated it in the preface of his "Théorie des Fonctions Analytiques," which Carnot had certainly seen, as he quoted some passages from it in the later editions, at least, of his "Reflexions."

If Carnot has any right to an independent discovery, he could hardly have quoted Lagrange in the first edition of his work. The first edition of both Carnot's and Lagrange's works was dated 1797.

I have been unable to find a first edition of "Carnot" here, so write to ask if any one can tell me whether there is any mention or quotation of Lagrange in it. PHILIP E. B. JOURDAIN.

63 Chesterton Road, Cambridge, June 30.

Robert Browning and Meteorology.

ROBERT BROWNING'S well-known description of Aurora Borealis, in "Easter Day" (c. xv. xvii), is so graphic that it must have been written from personal observation. Probably few persons can fully appreciate its accuracy; but on September 24, in that wonderful Aurora year 1870, just such a display took place, which I had the fortunate opportunity of watching nearly all night from the Welsh hills, when all the phenomena Browning describes, and many others, were abundantly visible. But I can find no account of any such display having been seen in these latitudes earlier in the century, and "Easter Day" dates from 1850.

The lunar rainbow in "Christmas Eve" (c. iv. and vi.), which "rose at the base with its seven proper colours chorded," blending at the summit "in a triumph of whitest white," with a second bow above it, and "a wondrous sequence" beyond that, is evidently the hybrid offspring of fancy and that inaccurate observation of phenomena which seems inevitable without scientific training, especially as, while evening service is going on in Zion Chapel, the moon's "full face" is shining in the West, and the bow appears in "the *empty* other half of the sky," "North and South and East." The effect of "the flying moon" trying to break out of its "ramparted cloud prison" is, however, very graphically described.

But I should like to know when and where the poet could have seen his Aurora. B. W. S.

July 8.

A Plague of Frogs.

THIS afternoon, as I was walking into Lickey Village from King's Norton, I came across innumerable frogs. They lined the hedges and covered the road so thickly that I had to walk on tiptoe. I thus proceeded quite 400 yards, where the phenomenon ended as sharply defined as it had begun. Nowhere else along the road was a frog to be seen. I was particularly astonished, as I knew the nearest water to be the Little Reservoir—quite ¼ mile away. The frogs were about ten days old, very small. A cottage stood about 300 yards from the beginning of this swarm. Upon inquiry I ascertained that the frogs had thus congregated since noon on Monday, that they had literally besieged the house, jumping all over the ground-floor rooms, that the garden and its paths were full of them. The present occupants had lived there 4½ years, but had never experienced anything like this. They have sometimes seen a few frogs cross the road in wet weather. They are now occupied with brushing them out of doors. Can any of your readers explain the cause of this extraordinary spectacle?

King's Norton, Birmingham, July 5. F. H. FORTEY.

THE UNIVERSITY OF LONDON.

AS we went to press last week, an adjourned meeting of the Senate of the University of London was being held to discuss the report of the special committee appointed to consider the offer of the Government to house the University in the Imperial Institute. The history of the negotiations that have taken place may be read in the abridged report published in last week's NATURE; and the facts contained in that statement formed the basis of the discussion in the Senate. In the end the offer of the Government was accepted, the following resolution, proposed by Sir Edward Fry and seconded by Mr. Bryce, being carried by a large majority:

"That the Senate accepts the proposal of Her Majesty's Government as far as it provides in the buildings of the Imperial Institute accommodation for the work hitherto done by the University; and authorises the Committee consisting of the Chancellor, the Vice-Chancellor, and Sir J. G. Fitch to settle the formal terms of agreement with the Government, and the Senate reserves the right of the University to hereafter request the Government to make further provision for such further needs as may arise in the future."

By this resolution the question of the future headquarters of the University is practically settled. The schemes of organisation of the constituent Colleges of the University and future possible teaching centres are now matters of the highest importance, for by them the future work and influence of the University will be determined. An ideal University should encourage the advancement of every branch of knowledge which assists human progress, and it can only do this by admitting into its constitution all subjects with which men of "light and leading" are concerned. It can hardly be held that the University of London has satisfied these conditions in the past, but under the new constitution we may confidently hope that a wider view will be taken of its functions and responsibilities. We have no longer to deal merely with a body authorised to confer degrees by examination, but with a living organisation taking part in the actual work of instruction. The teachers in this great University will feel that the interests of the University are their own interests, and that their work is not to have for its end the preparation of candidates for degrees, but to encourage students to work for the dignity and influence of their *alma mater*.

There are several directions in which the work of the University ought to be developed. Law and medicine should, of course, have their Faculties, as they have in the Universities of Paris, Bologna and elsewhere; and we may surely look to those institutions which have for centuries kept the lamp burning in the absence of a University for the needed help. Higher commercial education can be provided for by the establishment of a School of Economics and Political Science organised at the Imperial Institute itself. The exceptional facilities offered by the Institute for the work of a school of this character were referred to in an article in NATURE of April 20 in the following words:

"The well-arranged collections of Indian and Colonial products, which form a most important part of the equipment of the Imperial Institute, would be found of especial value in illustrating the teaching of that branch of commercial education known as *Waarenkunde*. Nowhere else in London do similar facilities exist for instruction in the technology of commercial products. Within the building, too, has been provided a chemical laboratory, which is now largely used for the examination and analysis of foreign products; and much of the scientific investigation therein carried on, under the able direction of Prof. Dunstan, is an essential feature in the programme of a high school of commerce. Indeed, a large part of the work which entered into the original scheme of the promoters of the Imperial Institute might, it would seem, consistently, and with great advantage to the public, be continued in that Institute under the auspices of a school of economics, industry and commerce, in connection with the reconstituted University of London. Whether such an arrangement can be effected is a matter for careful consideration; but there is no doubt that the association with the new University of a school of 'economics and political science,' under a separate Faculty, suggests a reasonable basis of union between the educational side of the Imperial Institute and the future University of London."

In connection with this suggestion, another point well deserves consideration. The support which the Colonies have given to the Institute has been in some cases withdrawn on the ground that no advantage was derived from it. But with a commercial school at the Institute colonial students could come over to pursue their studies in the midst of collections illustrating the products of their homes, and the training they would receive with such an environment would ultimately be used for the benefit of the Colonies, so that an adequate return would be made for whatever support was given. In fact, it seems that the use of the collections for the purposes of instruction in connection with the new University would satisfactorily settle the question of the service of the Institute to the Colonies, as well as give colonial students an opportunity of obtaining a degree under the very best conditions.

If the example is once set by using the Institute collections to illustrate courses of instruction on colonial products and industries, it is to be hoped that the other special collections which abound in London illustrating many other branches of culture may also be utilised for University purposes. With its new resources and facilities for advanced teaching, the University is given the opportunity of widely increasing its sphere of influence; and friends of education and national progress look to it to make the best use of the opportunities which the new headquarters will afford.

THE LIFE OF A STAR.

A LETTER FROM PROF. PERRY TO SIR NORMAN LOCKYER.

YOU have asked me to examine certain publications on this subject, and to give you my views on the value of such speculations as have been made by mathematical physicists.

Mr. T. J. J. See (*The Astronomical Journal*, Boston, February 6, 1899) states as "one of the most fundamental of all the laws of nature" that gaseous masses follow the law

$$t = \frac{K}{R}$$

where K is a constant for all stars of whatever mass or of whatever kind of gaseous stuff, R is the radius and t is the temperature. Now we have all sorts of temperatures in a star; but whether Mr. See takes average temperature or the temperature of some layer at a definite depth below the surface, he is certainly wrong. Mr. Homer Lane does not express the general results which I shall give presently, nor does Lord Kelvin give them in my form (although he does give them); but from either of these classical papers Mr. See might have inferred them, and seen that his own statement was wrong. Mr. See's arguments are really metaphysical. For example, at the very beginning of the proof of his proposition he speaks of the gravitational pressure at the surface of a star, whereas in physics we do not admit that there can be such a pressure in the absence of outside matter. Thus it is impossible for a mathematical physicist to get to Mr. See's point of view.

Of A. Ritter's articles in *Wiedemann's Annalen* there is a good abstract in the *Astrophysical Journal*, Chicago, December 1898. He assumes that the radiating layer on the outside of a star is of constant mass. He also assumes that the rate of radiation is proportional to the fourth power of the average temperature of this layer. He is dealing with temperatures which are so much greater than the temperatures with which we work in the laboratory, that such assumptions must be regarded as quite arbitrary.

Mr. Homer Lane, in his classical paper on the theoretical temperature of the sun (*American Journal of Science and Arts*, second series, vol. l. p. 57, 1870), makes the assumption that Dulong and Petit's law of radiation is true for solar radiation, and he uses it to calculate the temperature of the radiating layer, which he finds to be 28,000° F. That is, he uses an empirical law, obeyed possibly at laboratory temperatures in radiation from hot solids, to express the radiation at enormous temperatures from a hot layer of gas which has layers of gas of all sorts of temperatures above and below it.

It seems to me that we know too little about the phenomenon of radiation from layers of gas with denser and hotter layers below and rarer and colder layers above to allow of any weight being placed upon these assumptions of Ritter or Homer Lane. In a star we have layers of fluid at all sorts of temperature and density. We have no laboratory knowledge of radiation that is applicable. We know very little about any star except our own sun. During Palæozoic time, many millions of years, there has been life on our earth. Prof. Newcomb is of opinion that the sun's heat received by the earth cannot have varied more than a very little during Palæozoic time. My results will enable us to see what this uniformitarian assumption leads to. It is my own belief (see NATURE, p. 582, April 1895) that there may have been many millions of years during which the sun may have been radiating at only one-third or one-tenth of its present rate. My formulæ will enable us to apply such assumptions as these, and see what they lead to. However different assumptions of this kind may appear to be, they all lead to results which only differ in degree, and not in kind. Assumptions like those of Homer Lane and Ritter may lead to results which are altogether wrong.

All this is speculation, but it is speculation on physical and mathematical lines where criticism is immediately applicable to one's logic and one's premises.

Gaseous Stars.

Homer Lane, Lord Kelvin, Ritter, and all people who have tried to make exact calculations, have assumed that the stuff of which a star is composed behaves as a perfect gas in a state of convective equilibrium. I also assume that this is the case. But if we apply our results to our own sun, we find that at its centre there is a density 33, that is, 50 per cent. greater than the ordinary density of platinum. It seems to me that speculation on this basis of perfectly gaseous stuff ought to cease when the density of the gas at the centre of the star approaches 0·1 or one-tenth of the density of ordinary water in the laboratory.

Let ρ be density, t absolute temperature, p pressure of the gas at the distance r from the centre; the gas is such that $\rho\sigma t = p$, σ being a constant depending on the nature of the gas, and let γ be the ratio of its specific heats. Let there be convective equilibrium, so that

$$\rho t^{1/(1-\gamma)} = c_1, \text{ a constant} \quad \ldots\ldots \quad (1)$$

or

$$p t^{\gamma/(1-\gamma)} = c_3, \text{ a constant} \quad \ldots\ldots \quad (2)$$

Let t_0 and ρ_0 be values at the centre of the star.
If m is the mass inside the radius r, then

$$\frac{dp}{dr} = -a\frac{m}{r^2}\rho \quad \ldots\ldots\ldots\ldots \quad (3)$$

[I introduce the constant a because $\frac{m\rho}{r^2}$ is the gravitational force with which a mass m attracts a mass ρ at the distance r. If we keep $a=1$, all our forces will be in gravitational units. I prefer to have them in laboratory units. If we keep to C.G.S. units throughout, as one dyne is the weight of one gramme at the earth's surface $\div 981$ and the weight of one gramme corresponds to $\frac{M_1}{R_1^2}$ gravitation units, where M_1 is the mass of the earth in grammes and R_1 is the radius of the earth in centimetres; one dyne corresponds to $\frac{M_1}{981\ R_1^2}$ gravitation units, so that

$$a = \frac{981\ R_1^2}{M_1}\Big].$$

Also

$$m = 4\pi \int_0^r r^2\rho \,.\, dr \quad \ldots\ldots\ldots \quad (4)$$

(3) is the same as

$$r^2\frac{c_3}{c_1}\frac{\gamma}{\gamma-1}\frac{dt}{dr} = -am \quad \ldots\ldots\ldots \quad (5)$$

From (4),

$$\frac{dm}{dr} = 4\pi r^2\rho = 4\pi r^2 c_1 t^{\frac{1}{\gamma-1}}.$$

Hence, differentiating (5), we have

$$\frac{d^2t}{dr^2} + \frac{2}{r}\frac{dt}{dr} + \frac{4\pi a(\gamma-1)\rho_0}{\sigma\gamma}\frac{t^{1/(\gamma-1)}}{t_0^{1/(\gamma-1)}} = 0 \quad \ldots\ldots \quad (6)$$

Let us assume that $t = t_0\theta$, and that $r = bx$, choosing b so that x and θ shall not depend upon t_0 or ρ_0, and that the coefficient of the last term is 1, thus we find

$$\frac{d^2\theta}{dx^2} + \frac{2}{x}\frac{d\theta}{dx} + \theta^{1/(\gamma-1)} = 0 \quad \ldots\ldots \quad (7)$$

an equation which is true for any star the γ for whose gaseous stuff is known.

θ which is t/t_0 may be expressed as a sum of powers of

x, and so tabulated. In the same way, ϕ or ρ/ρ_0 might be tabulated. Indeed $\phi^{\gamma-1}=\theta$. Again μ or $\int_0^x \phi x^2.dx$ may be tabulated. Mr. Lane has done this work for several values of γ. Solution by means of series of powers of x can be relied upon only till $x=1$. After that one must work indirectly. Lord Kelvin, in a paper published in the *Philosophical Magazine*, 1887, vol. xxiii. p. 287, gives numbers calculated by his assistant, Mr. Magnus Maclean, from which, with the help of Mr. J. Lister's or Mr. Homer Lane's values at $x=1$, I could give a table like the following for the case of $\gamma=1{\cdot}4$. There are outside limits for x and μ, which Mr. Lane calls x' and μ'. Knowing the value of θ for $x=1$, I find that Lord Kelvin's numbers give x' as 5·24, and the corresponding μ' as 2·165, whereas Mr. Lane gives x' as 5·35, and μ' as 2·188. Mr. Lane does not publish the other values, and his curves are drawn to too small a scale for us to be able to make out tables of the values of θ or ϕ. Lord Kelvin from $x=0$, and Mr. Lane for values beyond $x=1$, obtained their results by methods such that errors may have increased as the work proceeded.

On the whole, I am disposed to take Lord Kelvin's numbers with an x', which is the mean of those just given, or 5·30, and μ' as 2·177.

TABLE I.—*For Gaseous Stuff whose Specific Heat Ratio is* 1·4.

x	θ	ϕ	μ
0	1·000	1·000	0
·795	·904	·777	·136
·883	·884	·734	·184
·993	·857	·679	·252
1·14	·819	·607	·355
1·33	·763	·508	·512
1·59	·681	·385	·758
1·99	·562	·237	1·133
2·65	·384	·0916	1·666
3·97	·141	·0074	2·117
5·30	0	0	2·177

We know now that for any star whose stuff behaves like a perfect gas

$$\left.\begin{array}{l} r=A\left(\frac{t_0}{\rho_0}\right)^{1/2}x,\ m=Bt_0^{3/2}\rho_0^{-1/2}\mu \\ t=t_0\theta,\ \rho=\rho_0\phi \end{array}\right\} \quad \ldots\ldots (8)$$

Where

$$A=\sqrt{\frac{\sigma\gamma}{4\pi a(\gamma-1)}},\ \text{and } B=4\pi A^3.$$

we see that A and B, x' and μ' depend merely on the nature of the gas. We have

$$R=A\left(\frac{t_0}{\rho_0}\right)^{\frac{1}{2}}x' \quad \ldots\ldots\ldots (9)$$

$$M=Bt_0^{3/2}\rho_0^{-\frac{1}{2}}\mu' \quad \ldots\ldots\ldots (10)$$

if R is the outside radius and M is the whole mass.

We may choose values of t_0 and ρ_0, and calculate R and M, or it is easy to see that if we know R and M, we may calculate the internal density and temperature by

$$\left.\begin{array}{l} t_0=\frac{x'}{4\pi A^2\mu'}\cdot\frac{M}{R} \\ \rho_0=\frac{x'^3}{4\pi\mu'}\frac{M}{R^3} \end{array}\right\} \quad \ldots\ldots\ldots (11)$$

It will be noticed that, σ being proportional to the molecular volume (being sixteen times as great in hydrogen as in oxygen), ρ_0 is independent of σ, whereas t_0 is inversely proportional to σ. If we consider our own sun to be made of hydrogen, and if the laws of perfect gases could be applied as we have applied them, $t_0=3{\cdot}25\times10^7$ degrees centigrade, $\rho_0=33$, that is, 50 per cent. greater than the density of platinum (see how I blush). Whereas if it were made of oxygen, ρ_0 is the same as before, but t_0 is $2{\cdot}03\times10^6$ degrees. It is sometimes good to employ, instead of (8)

$$\left.\begin{array}{l} r=\frac{R}{x'}x,\ m=\frac{M}{\mu'}\mu \\ t=\frac{Mx'}{4\pi A^2R\mu'}\theta,\ \ \rho=\frac{Mx'^3}{4\pi R^3\mu'}\phi \end{array}\right\} \quad \ldots\ldots (12)$$

The above tables and these formulæ enable us to find the temperature and density at any point in any gaseous star of any mass, size and material (if γ is 1·4). The curve connecting θ and x is the t, r curve for any star; the curve connecting ϕ and x is the ρ, r curve for any star; the scales of measurement are given in (12).

The *intrinsic energy* (not including any gravitational energy) of the whole mass being h, since the intrinsic energy of unit mass at temperature t is kt, if k is the specific heat (in ergs) at constant volume, and t is $t_0\rho_0^{1-\gamma}\rho^{\gamma-1}$,

$$h=4\pi kt_0\rho_0^{1-\gamma}\int_0^R r^2\rho^{\gamma}.dr$$

or

$$h=4\pi kA^3t_0^{5/2}\rho_0^{-\frac{1}{2}}X$$

if X stands for

$$\int_0^{x'} x^2\theta^{\gamma/(\gamma-1)}dx$$

a known number depending only on the value of γ. Hence

$$h=\frac{kXx'}{4\pi A^2\mu'^2}\cdot\frac{M^2}{R} \quad \ldots\ldots\ldots (13)$$

If W is the *work done by gravitation* in bringing all the stuff into its present position from an infinite distance,

$$W=a4\pi\int_0^R \rho mr.\,dr=aY\frac{x'}{\mu'^2}\cdot\frac{M^2}{R} \quad \ldots (14)$$

where

$$Y=\int_0^{x'} x\mu\phi.\,dx$$

a known number depending only on the value of γ.

We can now speculate on these results. If the pieces of stuff which come together to form the nebula are not mere molecules, but of the size of meteors such as reach our earth, W will not be much less than what is here stated. Indeed, we may say that even when a star ceases to be gaseous, and throughout its whole history the value of W is so nearly what is given in (14), that (14) may be used generally in such speculations as these.

A gaseous star doubles all its temperatures and its intrinsic heat energy when its radius is halved. We see that if all stars are of the same gaseous stuff, the ratio of h to W is constant for all stars at all times. Let us put $W=\alpha\frac{M^2}{R}$, $h=\beta\frac{M^2}{R}$

As $W=h+H$ if H is the total energy lost by the star by radiation, then

$$H=(\alpha-\beta)\frac{M^2}{R} \quad \ldots\ldots\ldots (15)$$

As part of this heat was lost by the stuff before it became a spherical gaseous star, we may take as the heat lost from time T = 0 when the radius was R_0 to the present time T, when the radius is R

$$(\alpha-\beta)M^2\left(\frac{1}{R}-\frac{1}{R_0}\right) \quad \ldots\ldots\ldots (16)$$

In the mass M there are surfaces whose areas are proportional to R^2, and whose temperatures are proportional to $\frac{M}{R}$. I shall assume as quite reasonable, that

$$\left.\begin{array}{r}\text{Total radiation per}\\ \text{year from a star}\end{array}\right\}\propto \text{areas}\times(\text{temperatures})^n \quad .\ (17)$$

where n is some constant.

It may be worth while here to use with this the assumption that our sun, when gaseous, radiated heat of the same amount every year; of course H of (15) or (16) is then proportional to time. (15) is the age of the sun from some zero of time until it had the radius R; (16) is the time taken to contract from radius R_0 to radius R.

Using (17),

$$\text{Rate of total radiation} \propto R^2 \left(\frac{M}{R}\right)^n \quad . \quad . \quad . \quad . \quad (18)$$

we see that n must be 2 for our sun. In our state of ignorance of the phenomenon of radiation from a star it may be presumptuous in me to say that this would be a very reasonable *à priori* assumption. Namely that rate of radiation is proportional to surface and square of average temperature. Anyhow it makes the task of pursuing the uniformitarian assumption less thankless.[1]

For any star then the total radiation in unit time is proportional to M^2, and hence the time taken by any gaseous star in contracting from radius R_0 to radius R is

$$T \propto \frac{1}{R} - \frac{1}{R_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

being the same for any star, whatever its mass may be. How it depends on the nature of its material we do not know, as we are basing these speculations on an assumption as to the sun's radiation. Or counting *age* from some period in the nebulous state, which it is not easy to define.

$$\text{temperature of star} \propto \text{age} \times \text{mass} \quad . \quad . \quad . \quad . \quad (20)$$

We see that stars get to have higher and higher temperatures as they get older, until they cease to behave as gaseous bodies throughout. The temperature outside is 0. The depth below the surface at which there exists a layer of a particular temperature, say 5000° Cent. absolute, is proportional to R^2/M, or if our rule as to time is right, the depth is inversely as the mass of a star multiplied by the square of its age. In a very old, massive star the layer at 5000° is very close to the outside.

It seems to me that this is an important thing. A young star, a truly gaseous star, has great depth of radiating layer. I mean it is probably only at great depths from the free surface that we find the layer from which a continuous spectrum comes. I take it that it is only during collision of molecules that a continuous spectrum is given out; in the free-path state of a molecule it radiates its own light only. Great density and high temperature conduce to the giving out of the continuous spectrum. In old stars, like our sun, the layer of stuff capable of giving out white light is comparatively near the surface of the star. I can imagine a comparatively young star long before its heat energy is a maximum, not radiating energy very fast, but rather giving out bright line spectra light from the greater part of its area; in fact from all but its central parts.

I am very ignorant of your subject, but I take it that any star gives out a continuous spectrum with lines. The continuous spectrum is strong, and the lines relatively dark, in old stars; the continuous spectrum is weak, and the lines bright, in new stars. In both cases the continuous spectrum is most intense, and the lines least intense at the central parts of a star. If a star is very new, so that it is not all gas, it will probably not be spherical, and one may have spectra quite different in different places and at different times.

Stars in General.

I suppose that many people will think the above speculation to be fairly safe. It is correct on the assumptions. One may apply it to any star until the central density approaches 0·1 or one-tenth of that of water or even more. In the case of our sun, the theory may have been applicable from the time when his radius was twenty times what it is now until it was five times what it is now. Near the surface I assume the density and temperature to be very small, and probably there is no substance that will behave as a perfect gas near the zero of temperature even if its density is also nearly zero. But as the mass of stuff in this condition is small, we may, I think, use our hypothesis. Besides, we are neglecting more important things; many possible conditions difficult to specify; heterogeneity; violent convective rushing of stuff like iron vapour to the places of low temperature where it may undergo sudden condensation and fall as iron hail over large regions; also, intense electrical actions are certainly taking place. All this may be said to be superficial, affecting only a small portion of the whole mass. On the whole, then, we may take our theory of gaseous stars to be applicable to some portion of the life of any star.

I am on much less safe ground when I try to trace the history of a star after its material ceases to behave as a perfect gas, and yet, as I take it, this is very much the longest part of its career. I may only vaguely speculate on its long or short life as a nebula; as a confused mass of streams of meteors in which every collision generates gaseous masses at all kinds of temperatures; its record is fairly clear from the time [if there ever is such a period in the truly gaseous state] when it assumes the spherical shape [in all cases I am neglecting rotation] and gets hotter and hotter and smaller and smaller. If the law of radiation is the same in any star as in our sun, and if we take one year's loss of heat energy by our sun as the unit of energy; if our unit of mass is the mass of our sun and if the sun's present radius is our unit of length, I

[1] If total radiation from a star is proportional to surfaces × the nth power of temperatures

$$\frac{dH}{dT} \propto M^n R^{2-n}$$

but from (16),

$$\frac{dH}{dT} \propto -\frac{M^2}{R^2}\frac{dR}{dT}$$

Putting these equal and integrating we find T as the time since the star was of radius R_0

$$T \propto \left(R_0^{n-3} - R^{n-3}\right) \frac{M^{2-n}}{n-3}$$

I. Thus if $n=1$,

$$T \propto M\left(\frac{1}{R^2} - \frac{1}{R_0^2}\right)$$

It follows from this assumption that the rate of increase of temperature per annum is proportional to $\frac{\text{Mass}}{\text{temperature}}$.

II. If $n=2$ as above,

$$T \propto \frac{1}{R} - \frac{1}{R_0}.$$

It follows from this that the rate of increase of temperature per annum is constant and is proportional to the mass of the star.

III. If $n=3$,

$$T \propto \frac{1}{M} \log \frac{R_0}{R}.$$

It follows from this that the temperature increases with time by the compound interest law; that is, the rate of increase of temperature per annum is proportional to the mass × temperature.

IV. If $n=4$,

$$T \propto \frac{1}{M^2}\left(R_0 - R\right).$$

In this case the rate of increase of temperature per annum is proportional to the square of the temperature.

Suppose it to be assumed that the radiation is mainly from an outer layer, that this layer increases in temperature from $t=0$ at its outer surface to $t=t_1$ at its inner surface, the depth or thickness of it is

$$D \propto \frac{\sigma R^2}{M}.$$

Thus the thickness of the layer is greater with stuff like Hydrogen than with Oxygen. As we really know nothing about how the total radiation from such a layer depends upon the thickness, I cannot use this in my calculations. It is however worth noting that from equal surface areas of layers all with the same range of temperature but of different depths or thicknesses D, the radiation per second $\propto \left(\frac{M}{D}\right)^{n/2}$.

Thus in the case above, in assuming $n=2$, we are really assuming that the radiation from unit area of layer is inversely proportional to its thickness.

Suppose we speak of the depth D′ below the surface to reach a layer of a particular density ρ_1 then

$$D' \propto \frac{R^{2\frac{1}{4}}}{M^{\frac{1}{4}}}$$

the depth being independent of whether the stuff is Oxygen or Hydrogen.

find[1] [using Lord Kelvin's popular lecture figures for the present solar radiation] for any star,

$$W = 36 \times 10^6 \frac{M^2}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

$$h = 32{\cdot}4 \times 10^6 \frac{M^2}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

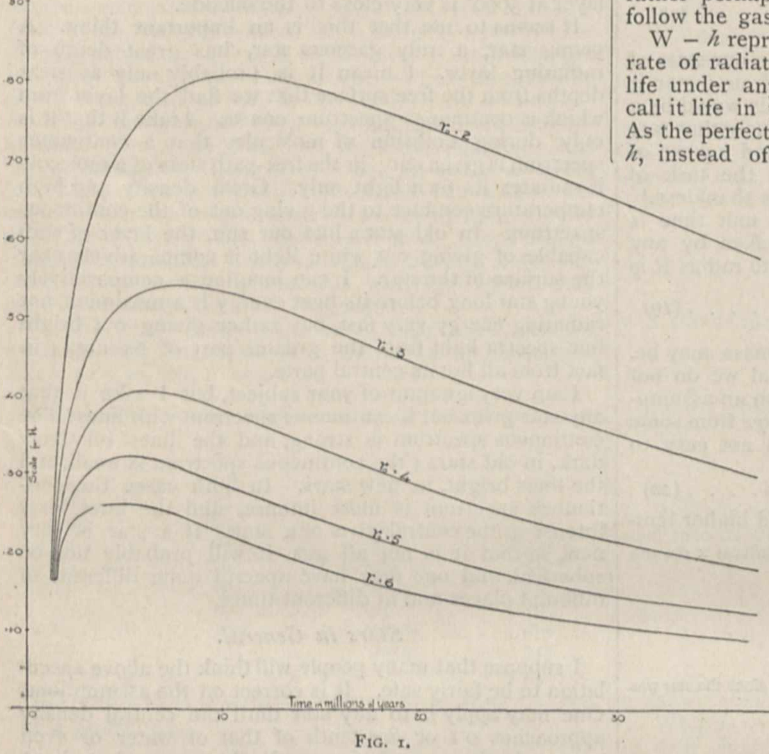

FIG. 1.

I must say that when Mr. Lister first worked out this value of h for me I was greatly surprised, for it has been generally thought that h is always, not merely much less than W, but exceedingly less. But there can be no doubt (see also my final statement) that in a gaseous star the intrinsic or thermodynamic energy in the star is a very large fraction of the whole energy of the gravitating matter. Indeed it is so large that one is tempted to look for some greater original store to account for the enormous amount of radiation which takes place, or rather perhaps to assume that no radiating mass can follow the gaseous law.

$W - h$ represents life in years if we assume a uniform rate of radiation. It has an obvious connection with life under any assumption that we may make. Let us call it life in years, and continue to consider our sun. As the perfect gas law ceased more and more to be true, h, instead of increasing steadily, reached a limiting value and then diminished again, so that eventually h must become zero. In what state is our sun now? Is it still very much like a gas throughout, and getting hotter? It is too much to assume for stuff that would be 50 per cent. greater in density than platinum at the centre. In all probability the change from the law of (22) began before R was 5, was quite marked when R was 4, and h reached its maximum value when R was 4 or $3\frac{1}{2}$ or 3. It is quite certain that h must reach a maximum value in any star, and afterwards diminish gradually, and the simplest mathematical formula expressing this fact may be used instead of (22) to give us useful suggestions in regard to the history of our sun. Such a simple formula is

$$h = 0{\cdot}9W \Big/ \left(1 + \frac{R_0^2}{R^2}\right) \quad . \quad . \quad . \quad . \quad (23)$$

If R is very great (23) is the same as (22). When R is R_0, h reaches a maximum value, and for smaller values of R, h diminishes. The following tables have been calculated, a different assumption being made for each. W is calculated from (21). R_0 is the radius of our sun (as compared with its present radius) when h was a maximum. Thus the table headed $R_0=4$ gives W and h, T and D on the assumption that our sun reached its hottest condition when it was of 4 times its present radius. I take $W-h$ and call it T the age or Time in years, but all these values of T may be multiplied by some constant, W, h and T are given in millions.

D is the depth (from surface) of a layer of stuff, say 10,000° C., taking the depth of such a layer at present as 1.

Fig. 1 shows how the intrinsic heat energy of our sun

TABLE II.—*Based on five different assumptions as to the time when our Sun was at its hottest. Also assuming Radiation at present rate.*

Age of Star in millions of years.	$R_0=6$				$R_0=5$				$R_0=4$				$R_0=3$				$R_0=2$			
T	W	h	R	D	W	h	R	D	W	h	R	D	W	h	R	D	W	h	R	D
0·4	3·15	2·75	11·42	129·9	2·50	2·10	14·39	208·3	2·20	1·80	16·34	270·3	2·52	2·12	14·29	204·1	3·20	2·80	12·87	166·7
0·8	2·93	2·13	12·27	149·3	3·28	2·48	10·96	120·5	3·53	2·73	10·20	104·2	4·12	3·32	8·802	76·34	5·68	4·48	6·398	40·16
1·5	3·94	2·44	9·229	83·33	4·30	2·80	8·433	69·93	4·82	3·32	7·568	55·87	5·65	4·15	6·448	40·65	7·01	5·51	5·173	26·39
2·0	4·52	2·52	8·038	63·69	4·96	2·96	7·337	52·91	5·57	3·57	6·519	42·02	6·50	4·50	5·573	30·77	8·01	6·01	4·515	20·20
3·0	5·59	2·59	6·460	41·49	6·14	3·14	5·898	34·36	6·85	3·85	5·268	27·62	7·94	4·94	4·454	19·69	9·78	6·78	3·699	13·55
4·0	6·61	2·61	5·476	29·67	7·23	3·23	4·975	24·81	8·01	4·01	4·515	20·20	9·19	5·19	3·927	15·38	11·28	7·28	3·198	10·19
5·0	7·60	2·60	4·739	22·47	8·23	3·23	4·367	19·16	9·06	4·06	3·992	15·8c	10·33	5·33	3·508	12·15	12·61	7·61	2·859	8·242
6·0	8·53	2·53	4·219	17·79	9·14	3·14	3·937	15·53	10·03	4·03	3·584	12·89	11·49	5·49	3·137	9·946	13·83	7·83	2·605	6·832
8·0	10·33	2·33	3·484	12·15	10·54	2·54	3·413	11·67	11·91	3·91	3·021	9·219	13·37	5·37	2·698	7·246	16·07	8·07	2·244	5·072
12·0	13·96	1·96	2·577	6·667	14·59	2·59	2·463	6·116	15·52	3·52	2·320	5·376	17·08	5·08	2·126	4·505	20·04	8·04	1·801	3·226
18·0	19·46	1·46	1·848	3·425	20·05	2·05	1·792	3·226	20·96	2·96	1·715	2·950	22·48	4·48	1·604	2·564	25·61	7·61	1·407	1·976
24·0	25·22	1·22	1·427	2·037	25·68	1·68	1·401	1·961	26·44	2·44	1·362	1·855	27·93	3·93	1·291	1·667	31·04	7·04	1·160	1·346
34·1	34·98	0·88	1·028	1·057	35·36	1·26	1·018	1·037	35·99	1·89	1·000	1·000	37·26	3·16	·9754	·9346	40·03	6·03	·9024	·8162

[1] In C.G.S. units (13) and (14) give, if the stuff is like oxygen or hydrogen whose γ is 1·4,

$$h = 6{\cdot}36 \times 10^{-8} M^2/R,$$
$$W = 7{\cdot}079 \times 10^{-8} M^2/R.$$

In obtaining these numbers Mr. J. Lister took the values of θ deduced from Mr. Homer Lane's curves before we discovered Lord Kelvin's paper. It will be seen that he gets $h/W = {\cdot}9$. It is easy to show that this ratio must really be 0·83, but I am not concerned in getting mathematical accuracy here. If our γ is slightly different from 1·4, we may have the above numbers.

has varied with its age on the above assumptions, which are all uniformitarian. The curves and table will suit any star if the unit of energy employed is the heat radiated per year by the star. If a star is twice the mass of our sun, the unit of energy is four times as great as in the case of our sun. A curve connecting R and time is

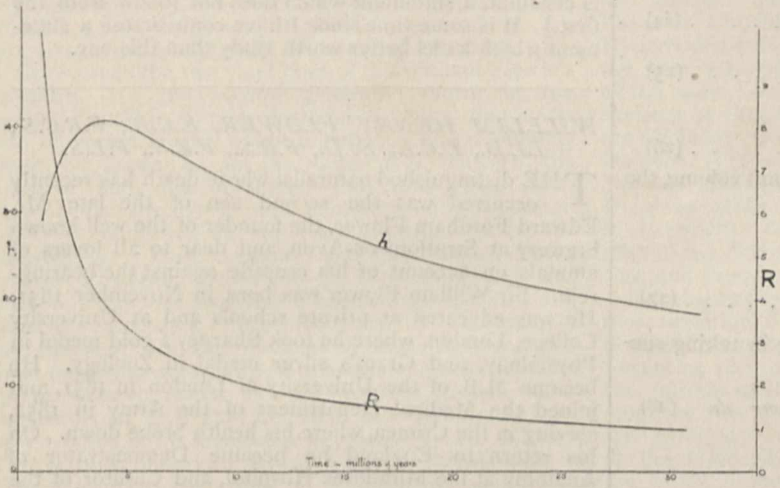

FIG. 2.

the same for all stars, and in the table the sun's present radius is the unit for R.

I take the critical size or size of maximum h in a star to depend upon ρ_0 the central density; if then the critical radius of our sun was 4 (or 4 times its present radius), the critical radius of a star whose mass is M times that of our sun was $4\sqrt[3]{M}$.

Non-Uniformitarian Assumptions.

The numbers in Table II. enable us to find what any assumption as to rate of radiation leads to. Thus, instead of assuming a constant amount of radiation every year, let us assume in the case of our sun that the rate of radiation at any time was always proportional to h. Let us take the supposition that h was greatest for our sun when R was four times its present value. Then as T in the table is no longer to be called time, as it is really $W-h$; let t be time; c being some constant.

$$\delta T = ch.\delta t.$$

Hence

$$t = \int \frac{dT}{ch}.$$

It is quite easy to plot the curve whose ordinate is $\frac{1}{ch}$ and whose abscissa is T of the table; in this way using a value of c, which is suitable, I find

TABLE III.—*Rate of Radiation Proportional to* h.

W – *h*.	$\frac{1}{h}$	Age in millions of years. *t*.	R.	*h*.
1	·342	1·0	9·18	2·92
2	·280	1·78	6·52	3·57
3	·260	1·45	5·27	3·85
4	·250	2·09	4·51	4·01
5	·246	2·71	3·99	4·06
6	·248	3·33	3·58	4·03
8	·256	4·58	3·02	3·91
12	·284	7·28	2·32	3·52
18	·338	11·92	1·71	2·96
24	·410	17·53	1·36	2·44
34	·528	29·26	1·00	1·89

The values of h and of R at the various periods in the life of our sun (or any star) are given in Fig. 2.

The curve for h shows also the rate of radiation. It is assumed to have once been more than twice as great as at present in our sun.

Any other assumption may be tried easily. I myself prefer to think that as a star gets older and as its white light radiating layer gets nearer and nearer its outer surface, its rate of radiation increases. It is quite possible as I have shown in NATURE (p. 582, April 1895), that our sun radiated very little energy during long periods in the past. Without taking an extreme case I will assume that the rate of radiation gets greater just in proportion to age and so find the following table.

TABLE IV.—*Rate of Radiation Proportional to Age of Star.*

W – *h*.	Age in millions of years. *t*.	R.
0·4	7·95	16·34
·8	11·26	10·2
1·5	15·42	7·57
2·0	17·8	6·52
3·0	21·8	5·27
4·0	25·2	4·51
5·0	28·1	3·99
6·0	30·8	3·58
8·0	35·6	3·02
12·0	43·6	2·32
18·0	53·4	1·71
24·0	61·7	1·36
34·0	73·4	1·00

The values of h and of R at the various periods in the life of our sun are given in Fig. 3.

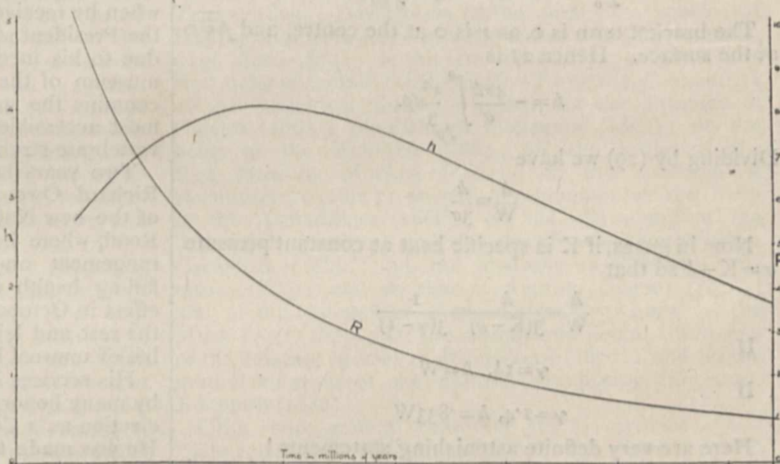

FIG. 3.

On no one of the above assumptions can I see that it is possible to give even a probable limit to the future life of our sun as a light-giving body.

Energy in a Spherical Mass of Gas.

I end this long letter with a very curious statement concerning gaseous masses in space, and I am sorry that my own proper work is demanding so much of my attention that I must leave the following very definite statement without applying it, as I see that it may be applied, to the study of the physical properties of many gases. We have seen that, under convective equilibrium, there is an outside radius beyond which there is no stuff existing. The following statement does not assume convective equilibrium; an outside radius, R, is assumed to exist.

Let temperature, pressure, &c., be functions of r. If m is the total mass bounded by the spherical surface of radius r,

$$\frac{dp}{dr} = -a\frac{m}{r^2}\rho \quad \ldots \ldots \quad (24)$$

$$m = 4\pi\int_0^r r^2\rho \, . \, dr \quad \ldots \ldots \quad (25)$$

the stuff being a perfect gas,

$$\rho\sigma t = p \quad \ldots \ldots \quad (26)$$

If k is the specific heat (in ergs) at constant volume, the total intrinsic energy of the mass is

$$h = 4\pi k\int_0^R r^2\rho t \, . \, dr,$$

$$h = \frac{4\pi k}{\sigma}\int_0^R pr^2 \, . \, dr \quad \ldots \ldots \quad (27)$$

The work that would have to be done in taking successive layers to an infinite distance is

$$W = +a\int_0^R \frac{m}{r}4\pi r^2 \, . \, dr \, . \, \rho = +4\pi a\int_0^R \rho mr \, . \, dr \quad . \, (28)$$

Now (24) is

$$\rho am = -r^2\frac{dp}{dr},$$

so that

$$W = -4\pi\int_0^R r^3\frac{dp}{dr} \, . \, dr = -4\pi\int_{p_0}^0 r^3 dp \quad . \, . \quad (29)$$

Now in (27)

$$\int_0^R pr^2 . dr = \Big[\tfrac{1}{3}pr^3\Big]_0^R - \int_{p_0}^0 \frac{r^3}{3}dp.$$

The bracket term is o, as r is o at the centre, and $p=0$ at the surface. Hence 27 is

$$h = -\frac{4\pi k}{\sigma}\int_{p_0}^0 \frac{r^3}{3}dp.$$

Dividing by (29) we have

$$\frac{h}{W} = \frac{k}{3\sigma}$$

Now in gases, if K is specific heat at constant pressure $\sigma = K - k$ so that

$$\frac{h}{W} = \frac{k}{3(K-k)} = \frac{1}{3(\gamma - 1)}$$

If

$$\gamma = 1\tfrac{1}{3}, \; h = W$$

If

$$\gamma = 1{\cdot}4, \; h = {\cdot}833W$$

Here are very definite astonishing statements!

I must confess that I do not understand how if $\gamma = 1\frac{1}{3}$ we can have $h = W$. It seems to mean that if a mass of this kind of gas gravitates by itself from an infinite distance it retains all its energy. But such gas must surely be imagined to be radiating heat, as it is not at zero temperature. Where can it get such heat? I come to the conclusion that there must be atomic energy available somehow in it, even when we imagine the molecules at an infinite distance from one another, or else there is no such gas possible. *I say* that no substance for which $\gamma = 1\frac{1}{3}$ can behave as a perfect gas.

You will notice that we do not need to imagine our stuff in a state of infinite diffusion. If a gaseous star changes its size or the arrangement of its stuff, the gravitational work done is exactly equal to the additional intrinsic heat energy in the star if γ is $1\frac{1}{3}$. The paradox is greater if we think of coloured diatomic gases such as chlorine, which have values of γ less than $1\frac{1}{3}$. We must either assume that there is more energy available than mere gravitational energy, or else that such substances cannot really behave as perfect gases. [It is to be remembered that by a perfect gas I do not merely mean that $p/t\rho$ is constant, but that k, the specific heat at constant volume is constant, a statement which does not follow from the first.] It is some time since I have come across a statement which looks better worth study than this one.

WILLIAM HENRY FLOWER, K.C.B., F.R.C.S., LL.D., D.C.L., Sc.D., F.R.S., F.Z.S., F.L.S.

THE distinguished naturalist whose death has recently occurred was the second son of the late Mr. Edward Fordham Flower, the founder of the well-known brewery at Stratford-on-Avon, and dear to all lovers of animals on account of his crusade against the bearing-rein. Sir William Flower was born in November 1831. He was educated at private schools and at University College, London, where he took Sharpey's gold medal in Physiology, and Grant's silver medal in Zoology. He became M.B. of the University of London in 1851, and joined the Medical Department of the Army in 1854, serving in the Crimea, where his health broke down. On his return to England he became Demonstrator of Anatomy at the Middlesex Hospital, and Curator of the Museum, intending to practise as a surgeon. Here he published his first work, "Diagrams of the Nerves of the Human Body," and also wrote in Holmes' "System of Surgery" on "Injuries of the Upper Extremities."

In 1861, at the age of thirty, he was appointed to succeed Queckett as Curator of the Hunterian Museum at the College of Surgeons, and later became Hunterian Professor. Thenceforward he abandoned professional work for purely scientific pursuits. Twenty years later, when he received the Royal medal of the Royal Society, the President stated with justice that "it is very largely due to his incessant and well-directed labours that the museum of the Royal College of Surgeons at present contains the most complete, the best ordered, and the most accessible collection of materials for the study of vertebrate structures extant."

Two years later (in 1884), on the resignation of Sir Richard Owen, Prof. Flower was appointed Director of the new Natural History Museum in the Cromwell Road, where he was incessantly occupied with the arrangement and development of the collections until failing health necessitated his resignation, which took effect in October 1898. Unhappily he did not long enjoy the rest and leisure which he had so well earned by a life of unusual industry and devotion to public work.

His services in the cause of knowledge were recognised by many honorary degrees from Universities, and by his election as a Correspondent of the Institute of France. He was made C.B. in 1887, and K.C.B. in 1892, and was President in 1889 of the British Association for the Advancement of Science.

The mere enumeration of the incidents in a man's life does not tell very much about the nature and value of his work. Sir William Flower's chief work was in two directions: firstly, as a director and original artist in museum management; secondly, as an investigator and discoverer in the comparative anatomy of the Mammalia. Besides these two chief lines of work, there were others to which he gave time and care. He was not unheedful of the popular demand for instruction and guidance by lectures. He frequently appeared at the Royal Institution and the London Institution, and always had a weighty and well-considered discourse to deliver. The most original and, from a social point of view, the most important of these was one on "Fashion in Deformity," in which he gave very strong support to those who disapprove of tight-lacing, high-heeled shoes, and other monstrosities of clothing. Another way in which Sir William Flower gave voluntarily a large amount of valuable work to the community was as President first of the Anthropological Institute, and then of the Zoological Society—a post which he held until his death. Such services in our scientific societies are given without any remuneration, and they can only be repaid by the grateful acknowledgment of those interested in the progress of the branches of science thus benefited.

To revert to the two chief lines of Sir William Flower's life-work. He first became generally known in the scientific world by joining the band of young anatomists who supported Huxley in his rejection of the statements made by Owen as to the differences between the brain of man and of apes. Like the other members of that group—Turner, Humphrey, and Rolleston—Flower published an important contribution to the controversy. This memoir, entitled "Observations on the Posterior Lobes of the Quadrumana," was printed in the *Philosophical Transactions* in 1862; and about the same time Flower wrote also on "the brain of the Siamang" in the *Natural History Review*. His most numerous contributions to anatomical science relate to the Cetacea, which was his favourite group. After the deaths of P. J. Van Beneden and Gervais, he was only rivalled in his knowledge of whales by Sir William Turner, of Edinburgh. It was a special satisfaction to Flower to have been able to complete the admirable exhibition of whales at the Natural History Museum before his retirement—an exhibition which is not only unequalled, but is not even attempted in any other museum in Europe or America. Next to the Cetacea, the subject on which Flower worked and wrote most was physical anthropology. His catalogue of the anthropological series in the museum of the Royal College of Surgeons and its introductory chapter have served as classics to English anthropologists, and are the result of an immense amount of patient research. Separate papers by him on the osteology of the Andaman Islanders and of the Fijians are of great value on account of the large amount of material dealt with, and the caution and judgment shown in drawing conclusions. Caution and reticence in generalisation certainly distinguish all Flower's scientific writings. Whilst he was on this account necessarily not known as the author of stirring hypotheses, his statement of fact gained in weight by his reputation for judgment and accuracy. The most important discovery in anatomical science which we owe to him is that of the existence of but one successional molar in the marsupial Mammals. This sharply defined and important fact was only one, but the most striking, of the results of a long, conscientious and painstaking study of the dentition of the Mammalia. The next most striking discovery which we owe to Flower seems to me to be the complete and convincing demonstration that the extinct marsupial called *Thylacoleo carnifex* by Owen was not a carnivor, but a gnawing herbivorous creature like the marsupial rats and the wombat—a demonstration which has been brought home to the eye even of the unlearned by the complete restoration of the skull of Thylacoleo in the Natural History Museum prepared by Dr. Henry Woodward. Another thoroughly original and elaborate piece of work which should, I think, be especially remembered in attempting to survey Flower's anatomical labours, is the attempt to bring order and system into the study of the forms presented by the lobes of the liver in the Mammalia, an effort which has not, perhaps, as yet borne all the fruit of which it is capable.

In such a brief notice as the present a complete bibliography of Sir William Flower's contributions to anatomical science cannot be given, but a fair notion of his great activity in research can be obtained from a selected list. Relating to the Cetacea, I would cite the following papers from the *Proceedings* of the Zoological Society:—On a lesser Fin-whale (Balænoptera rostrata) stranded on the Norfolk Coast (1864); the skeletons of Whales in the Principal Museums of Holland and Belgium (1864); on a new species of Grampus from Tasmania (1864); on Physalus Sibbaldii (1865); on Pseudorca meridionalis, 1865; on a Fin-whale stranded in Pevensey Bay (1865); the probable identity of Balænoptera Carolinæ and Physalus Sibbaldii (1868); on the Whales of the genus Hyperoodon (1882); on the Characters and Divisions of the Family Delphinidæ (1883); then in the *Transactions* of the same Society, the fine illustrated papers on the skeleton of Inia Geoffrensis (1869); on the osteology of the Cachalot (1869); on the skeleton of a Chinese White Dolphin (1872); on Risso's Dolphin (1873); on recent Ziphioid Whales (1878); on two species of British Dolphins (1880); and the translation of and introduction to Eschricht's treatise published by the Ray Society. Also in the *Proceedings* of the Royal Institution, Whales Past and Present, and their probable origin (1883).

Relating to physical anthropology, Sir William Flower's most important works are the following:—The Catalogue of Specimens in the Museum of the Royal College of Surgeons, 1879 and 1884 (already referred to above), in the *Journal* of the Anthropological Institute; the osteology of the natives of the Andaman Islands (1879); the osteology of the Fijians (1880); the osteology of the Mallicolese (1881); the aims and prospects of the Study of Anthropology (1884); the Classification of the Varieties of the Human Species (1885); on the size of Teeth as a character of Race (1886); in the *Proceedings* of the Royal Institution (a Friday evening discourse) on the Native Races of the Pacific (1878); and in the Manchester Science Lectures, a discourse on the aborigines of Tasmania (1866).

Ranging over other groups of Mammals, I would cite the following papers:—On a newly-discovered extinct Mammal (Homalodontotherium) from Patagonia (*Phil. Trans.*, 1873); Description of the skull of a species of Halitherium from the Red Crag of Suffolk (*Quart. Journ. Geol. Soc.*, 1874); on the remains of Hyænarctos in the Red Crag of Suffolk (*ibid.*, 1877). From the *Proceedings* of the Zoological Society: papers on the anatomy of Galago (1862); of Pithecia monachus (1862); on the brain of the Echidna (1864), on the brain of the Red Howling Monkey (1864); on the anatomy of Hyomoschus (1867); on the development of the teeth in the Armadilloes (1868); on the characters of the base of the cranium and the classification of the order Carnivora (1869); on the anatomy of Proteles cristatus (1869); and on that of Aelurus fulgens (1870); and of the two-spotted Paradoxure (1872); and of the Musk Deer (1875); on the cranial and dental characters of the existing species of Rhinoceros (1876); and on the mutual affinities of the animals composing the order Edentata (1882).

Of a more general character are his articles in the "Encyclopædia Britannica":—On the anatomy and zoology of the Horse, Kangaroo, Lemur, Lion, Mammalia, Mastodon, Megatherium, Otter, Platypus, Rhinoceros, Seal, Swine, Tapir, &c. These have formed the basis of a very useful volume on the Mammalia published by Messrs. Black, whilst the compact little volume on the osteology of the Mammalia by Sir William Flower is known to all University students. The last volume which came from his pen is one of the best and most interesting, namely that called "The Horse: a study in natural history," published in 1892.

Having thus indicated (and only "indicated" by no means "enumerated" or "fully set down") the labours of Sir William Flower in anatomical research, I pass to a brief consideration of his work as a museum curator, which probably took up more of his time and energy than he was able to give to original investigations. This is most certainly true of the second portion of his scientific life, which dates from his appointment in 1884 to the directorship of the Natural History Museum, and was preceded by twenty years of work as Hunterian Curator. There can be no doubt in the mind of any man who is acquainted with the present condition of the public galleries of the great museums of natural history in Europe, and with the condition which characterised those of similar institutions in Great Britain previously to the year 1864, that a very great and important change for the better was effected by Flower, first of all at the College of Surgeons, and later in accordance with a further development of his ideas, at the Natural History Museum (British Museum, Natural History). The arrangement and exhibition of specimens designed and carried out by Flower in both instances was so definite an improvement on previous methods, that he deserves to be considered as an originator and inventor in museum-work. His methods have not only met with general approval, and their application with admiration, but they have been largely adopted and copied by other curators and directors of public museums both at home and abroad. In his address as President of the British Association, and also in an address to the Museums Association, Sir William Flower has explained in some detail the theory which he held with regard to the proper selection and arrangement of objects in a public museum. The general conception which Sir William Flower had formed was accepted and developed in detail by that gifted and genial museum-director, Brown Goode, of Washington, U.S.

It is simple enough and convincing. But the work of the museum curator consists not merely in framing theories of museum organisation and arrangement: the more important part of his work is the putting of such theories into practice. To do this, energy and patience in the surmounting of obstacles are necessary, and perhaps as much as or more than any other quality—the artistic sense. Sir William Flower possessed this last quality in a remarkable degree. No pains were spared by him in selecting the proper colour for the background or supports of the specimens exhibited in a case, or in effectively spacing and balancing the objects brought together in one field of view. He took the greatest pains to make the museum under his care a delight to the eye, so that the visitor should be charmed by the harmony and fitness of the groups presented to his notice, and thus the more easily led to an appreciation of the scientific lesson which each object has to tell. There are public galleries in some of the natural history museums of Europe where the specimens are so crowded and ill-placed, where the lighting is so badly designed and the prevailing colour of case and wall so depressing, that the main purpose of the exhibition is defeated by the fact that the visitor becomes seriously attacked by headache before he has been able to ascertain what there is for him to look at, or why he should look at anything at all, in the appalling accumulation spread before him. It was Sir William Flower's merit to have introduced a better way, and so far as opportunity and the brief fourteen years of his directorship allowed him to do so, he put that better way into practice at the national museum of natural history. The first great principle upon which Sir William Flower insisted was that the possessions of a great museum of natural history must be divided into two distinct parts—to be separately dealt with in almost all respects—viz. the public or show-collection, and the special or study-collection, not exhibited to the general public, but readily accessible to all investigators and specially qualified persons. The latter collection, he insisted, should have at least as much space devoted to it as the former. In this way the public galleries would (he showed) be cleared of the excess of specimens which, nevertheless, the museum must carefully preserve for the use of specialists. Then, further, Flower held that every specimen placed in the public or show-collection should be there in order to demonstrate to the visitor some definite fact or facts, and so should be most fully visible, isolated rather than obscured by neighbouring specimens, and ticketed with an easily-read label stating clearly and simply the reason why it is worth looking at—that is to say, what are its points of interest. He would thus have reduced very much in *number* the specimens commonly exhibited in natural history museums, and have increased the *interest* and *beauty* of each specimen selected for the public eye. Another principle which he often insisted upon—but was not able to put fully into practice owing to long-standing arrangements in the museum over which he presided—was that in the public galleries the skeletons of animals should not be placed in one room and the stuffed skins in another, and the soft parts in a third, and the fossilised remains of extinct allied animals in a fourth more or less remote chamber; but that the visitor should see, side by side, the stuffed or otherwise preserved animal (mammal, bird, reptile, fish, mollusc, insect, worm or polyp) and its skeleton and important parts of its internal structure and the remains of its extinct allies. Thus, there would be, not three or four separate zoological collections for the amazed visitor to traverse and bring into correlation by mental effort, but one only, in which the story of each animal is told as completely as possible in one connected exhibit. It is simply a fact that the "art of arranging museums for the public" is in its infancy, and that it was mainly, if not entirely (so far as natural history is concerned) founded by William Henry Flower. Like other originators, he did not live to see the principles which he advocated fully acted upon, nor did he expect to do so. He knew that time is a necessary element in such developments. But he has left an enduring mark on what we may call "museum policy." His teaching and performance are producing, and will continue to produce, progress towards the realisation of his ideals.

Sir William Flower did not train or produce any pupils. He did his own work with his own hands, and I have the best reason to know that he was so deeply shocked and distressed by the inaccuracy which unfortunately crept into some of the work of his distinguished predecessor Owen, through the employment of dissectors and draftsmen whose work he did not sufficiently supervise, that he himself determined to be exceptionally careful and accurate in his own records and notes. In later years, he had the assistance of young anatomists in making the beautiful preparations which are placed in the central hall of the museum. One of his assistants, Mr. Wray, whilst preparing, under Sir William Flower's direction, specimens for the museum to exhibit the disposition of the feathers in the wings of birds, discovered the strange and puzzling fact that the fifth cubital quill is apparently absent—that is to say, there is a gap where it should be—in whole orders and families of birds, whilst it is present in other orders and families. The discovery of the wide-spread occurrence of aquintocubitalism—as it has been called—was thus made in Sir William Flower's work-room, and in connection with his scheme of museum exhibition.

It is well to place on record that Sir William Flower was a convinced Darwinian. At the meeting of the Church Congress at Reading in October 1883, he had the courage to open a discussion on "Recent Advances in Natural Science in their relation to the Christian Faith," his expressed object being to mitigate the prejudices of many of the strongest opponents of the doctrine of evolution amongst the clergy.

Whilst discharging in so many different ways important public duties, and holding up amongst scientific men a high standard of accurate work and unremitting devotion to the progress of zoological knowledge, Sir William Flower found time to extend very largely among the educated classes an interest in the aims and results of zoology by the willing courtesy with which he received visitors at the Museum in Cromwell Road, and explained its contents. His interest in his work there was so sincere that no zoologist ever asked in vain for his help and advice in museum matters. He was so earnest in carrying out his new devices for the effective exhibition to the public of zoological specimens that even on his busiest days he would find a few minutes to show his latest improvements to one who sympathised with his aims and believed in his methods.

Personally, I owe very much to him in this way. I am glad also to be able to acknowledge here the help which he gave to me by supporting in a valuable letter, which was printed and circulated at the time, the re-arrangement of the zoological and anatomical collections in the University Museum at Oxford, which I had proposed and was enabled subsequently to carry out—largely in consequence of the weighty opinion which Sir William Flower gave in its favour. E. RAY LANKESTER.

THE DUTIES OF PROVINCIAL PROFESSORS

DURING the past twenty years numerous centres of university education have grown up all over our country, and much public money has been spent in their endowment. Some of these colleges have already risen to the rank of universities with the power of conferring degrees; others are eagerly pressing forward in the same direction in the hope of competing with their more fortunate rivals. If this multiplication of universities is not to result in lowering the prestige of British university degrees, but to enable us to compete in the matter of scientific education with foreign countries, it is of the utmost importance that the professorial staffs of our younger university colleges should be placed under the most favourable positions for establishing the reputations both of themselves and of their colleges in the matter of higher study and research. The time appears to have come when we must face much more boldly than hitherto the question whether the conditions attaching to provincial professorships and lectureships, even in some of our most successful university colleges, are conducive or inimical to progress in such respects.

In calling attention to the serious and, to our mind, unnecessary disadvantages under which provincial professors are often placed at the hands of their Councils or Governing Boards, our remarks must be understood to be based on a considerable number of experiences of which we have gathered details during some years.

A foreign professor may only lecture five hours a week, and devote the rest of his time to research, and yet be regarded as discharging his duties fully and efficiently. Under such a system German professors have filled their class-rooms with the best students drawn from all parts of the world, German degrees are rising in public estimation year by year, English students are going out of their own country for the higher training they cannot obtain at home, and we are mainly indebted to Germany for our standard literature on every branch of science.

In America university development is more recent, but the majority of universities are lavishly staffed with professors and assistant lecturers, who thus have ample time for research; and the system has been introduced of giving these teachers one free year in seven, in order that they may be able the better to keep themselves abreast with the most recent developments of their science. Under such conditions, America is rapidly pressing forward in scientific research, and American text-books are slowly and surely finding their way into English class-rooms.

As instances of what one university can do in promoting research, even in a single department of science, we need only call attention to the *Communications* from the Physical Laboratory of the University of Leiden, published periodically in English, or the *Physical Review*, brought out under the auspices of Cornell University.

Our modern centres of university education are largely bound down to the policy of attracting the greatest number of students, not by the reputations of their professors, but by the attractions they offer in small bursaries and in facilities for cheaply acquiring pass degrees. Under this system a professor may give fifteen lectures a week or more, and spend most of the rest of the day in the laboratory; but there is no limit to the extraneous work required of him by his Council or Governing Board, beyond that research work forms no part whatever of his obligations. We do not deny that good work is done in this country by many provincial professors, but it is often done under extreme difficulties, and many others are debarred from taking that place in the scientific world for which their abilities qualify them.

With regard to the lectures themselves, these are almost exclusively limited by the syllabus of examinations for pass degrees. Matriculation preparation forms a heavy item in the work of most departments, and one to which great importance is commonly attached. It is the duty of the professor not so much to push forward his best students as to adapt his lectures to the requirements of the average student, and to bring as many as possible up to pass standard. He is held responsible for the attendance and diligence of his students in class, and is bound to make records of these matters; while out of class he and his colleagues are jointly responsible for general discipline, even extending to the rules of athletic clubs. He is required to set and correct exercises and examination papers at frequent intervals. If students have not followed his lectures properly he is expected, often at short notice, to provide tutorial instruction without limit to those whose chances of passing are in danger—an arrangement, by the way, hardly calculated to ensure students giving their best attention to professorial lectures.

We do not imagine that any professor, if left to himself, would be wanting in willingness to give a large amount of his private time to helping students over difficulties, and making his lectures convey the greatest amount of instruction with the least amount of work. But if a professor makes a conscientious stand against cramming, or puts any personality into his professorial work, he runs the serious risk of losing at a few weeks' notice the post he has held for years, at the hands of a Governing Board who misinterpret his action because they have no knowledge of the conditions attaching to a sound teaching of his subject. In such cases students, who are more concerned about getting a degree than about the thoroughness of their training, may be called on to give evidence against their professor. We have knowledge of several instances in which colleges have on insufficient grounds lost the services of men who have been doing good work for them, whose teaching has been acknowledged to be successful, and who, under less disadvantageous conditions, would have done them credit by their scientific work.

The practical result of this system is that our modern university centres, whether chartered or not, are devoting their endowments to competing for cheap pass degrees with one another, and with private institutions and tutors who prepare for London University and similar examinations. The students spend the whole day in class-rooms and in laboratories, and when they have done the exercise work required by their teachers, the day is gone and they are too tired to *think over* what they have learnt. Their professors are thus required to do the thinking for them.

After three years in the mill the students obtain a degree, gained under conditions calculated to minimise what should be one of the most important features in any university training: the learning to think and overcome difficulties for oneself. There is thus a growing annual output of graduates of both sexes who find, often too late, that their qualifications only fit them for one career: that of swelling the ranks of the already overcrowded and underpaid teaching profession. The production of a certain number of schoolmasters is a necessary element in the educational system of every country, but the question is: should this or the advancement of higher learning be the main function of a university endowed with public funds?

Many provincial colleges plead poverty as an excuse for overburdening their staffs with pedagogic and tutorial work. But these colleges are not too poor to vie with each other in the award of small scholarships, many of which go to pass students of no great ability. And experience, both in America and in this country, has shown that if only such objects as endowment of research are prominently brought before public notice, support will not be found wanting.

In conclusion, the directions where reform is most needed include the following:—

(1) Discontinuance of matriculation preparation—work which naturally belongs to the province of schools and crammers.

(2) Recognition of research work rather than tutorial instruction of pass candidates as the main duty of a professor outside his class-room.

(3) Reduction of the hours of class work, both of teachers and students.

(4) Revision of the now precarious conditions under which provincial appointments are tenable.

(5) Attraction of public attention to the importance of providing facilities for professorial research.

(6) The appointment of more and better paid assistant-lecturers and demonstrators.

(7) A more judicious expenditure of scholarship money, which should be restricted to honours students.

If the new university systems of this country are not, in the course of a few years, to take a subordinate position, and their degrees to sink into disrepute, if, in short, we are not to be left in the lurch by our foreign rivals, it becomes the duty of all who are responsible for the management of our provincial colleges and universities to have their attention aroused to a state of affairs which too often results in their professors being sweated and their students crammed.

GOVERNMENT GRANT IN AID OF ANTARCTIC EXPLORATION.

THE following letter, referring to a Parliamentary grant in aid of Antarctic exploration, has been received by Lord Lister from H.M. Treasury, and sent to us by the Secretaries of the Royal Society:—

Treasury Chambers, July 3, 1899.

MY LORD,—I am directed by the Lords Commissioners of Her Majesty's Treasury to inform you that the First Lord has laid before the Board the memorial signed by your Lordship as President of the Royal Society, by the President of the Royal Geographical Society, and by other distinguished representatives of various branches of science, by which memorial application is made for a Government grant in aid of the expedition now being organised by the Royal Society and the Royal Geographical Society for the exploration of the Antarctic regions. This application has received the careful consideration of Her Majesty's Government, and I am directed to inform you that they are prepared to ask Parliament for grants amounting, in all, to 45,000*l*. towards the expenses of the proposed expedition, provided you are able to assure them that not less than an equal amount will be forthcoming from other sources, so as to enable the scheme to be efficiently carried out.

In making this announcement, I am to call attention to the latter part of the speech of the First Lord to the deputation which waited on him on this subject, as indicating that Her Majesty's Government must not be regarded, in making this promise, as inaugurating a new era of more extensive grants than formerly from the Exchequer in aid of scientific enterprises. Rather, it is to be understood that the very exceptional importance of the present scheme, so strongly represented by the deputation, is being recognised by the promise of a special grant.

At the present time, it is only necessary to add that the applications to Parliament for instalments of the grant will be spread over four years, of which 1900–1901 will be the first.

I am to ask you to be so good as to communicate this decision to the other signatories of the memorial.

I am, My Lord,
(Signed) FRANCIS MOWATT.

LORD LISTER,
President of the Royal Society,
Burlington House.

NOTES.

THE Paris Academy of Sciences has been authorised to increase its number of national and foreign Correspondants from 100 to 116.

THE *British Medical Journal* announces that Sir John Burdon Sanderson, Bart., and Prof. Michael Foster, K.C.B., will be entertained at dinner by British physiologists on July 20, to congratulate them on the honours recently conferred on them by the Queen. The dinner will take place at the "Star and Garter," Richmond.

THE Volta Centenary Exhibition at Como, described in NATURE of June 22, has been completely destroyed by a fire, attributed to the fusing of some electric wires. Practically all the precious Volta relics were lost in the flames, notwithstanding the precaution taken to preserve the objects by placing them in a receptacle of solid masonry. The only things saved were a sword of honour presented by Napoleon the First to Volta, a picture by Bertini of Volta explaining his battery to Napoleon, a cast of the great electrician's skull, his watch, and a few personal relics. Volta's books and manuscripts, some of which were recently bought by the Italian Government for 100,000 lire, his collection of batteries, the only authentic portrait of Volta, his will, &c., were all destroyed. In spite of the destruction of the Exhibition, the committee has decided that the *fêtes* in honour of Volta shall be continued. The International Congress of Electricians will be held as previously arranged.

PROF. EWART exhibited a number of his zebra hybrids, their dams, sire, and half-brothers and sisters, at the great Agricultural Show recently held in Edinburgh. The authorities were little prepared for the interest taken in the exhibit, with the result that many thousands either failed to see anything of the hybrids, or had but a passing glance. The Prince of Wales, accompanied by a deputation of the Royal Agricultural Society of England, made a special inspection of the mixed family. From a contemporary we learn the Prince was so greatly interested that he requested Prof. Ewart to make a similar exhibition next summer at the Royal Agricultural Societies' Show at York. Should breeders give up empirical in favour of scientific methods, not a little of the credit will be due to the Prince of Wales recognising the importance of the investigations that have for some years been carried on by the Edinburgh Professor of Natural History.

AN international conference organised by the Royal Horticultural Society for the purpose of discussing "Hybridisation (the cross-breeding of species) and the cross-breeding of varieties" was opened on Tuesday. In opening the proceedings, Dr. Maxwell Masters gave an address on the history of the subject. Papers dealing with the experimental production of plant-hybrids and the scientific significance of the results were read by Mr. W. Bateson, F.R.S., Prof. H. de Vries, Prof. George Henslow, Prof. L. H. Bailey, and Mr. C. C. Hurst.

Science announces that Dr. Milton Updegraff, professor of astronomy in Missouri University, has been appointed, by President McKinley, professor of mathematics in the United States Naval Observatory.

WE learn from the Secretary of the Institution of Electrical Engineers that the reunion of the Institution in Switzerland, from September 1 to 10 next, is likely to be well attended, and that the final arrangements for the visit are now in progress. It is hoped that a circular giving further details may be issued at the end of the current month.

To commemorate the services which the late Mr. H. T. Soppitt rendered to mycological science and to Yorkshire natural history generally, efforts are being made to obtain funds to form a Soppitt memorial library of mycological literature, of which the nucleus should be Mr. Soppitt's own books and herbaria, which the widow and family are willing to part with for such a purpose. Such further funds subscribed as are not required for the purchase of these, are to be laid out in the purchase of mycological reference-books. The library when formed will be presented to the Yorkshire Naturalists' Union.

MR. H. H. HOWELL, who joined the Geological Survey under De la Beche in 1850, retires from the service to-day. Mr. Howell, after surveying some portions of Wales and the south of Scotland, and large areas in the midland counties of England, became District Surveyor of the north-eastern counties of England in 1872, he was appointed Director for Scotland in 1882 (when Sir Archibald Geikie became Director General), and he was further promoted to be Director for Great Britain in 1888.

MR. ERNEST E. L. DIXON, who has for the past two years acted as assistant to Prof. Judd at the Royal College of Science, has been appointed an Assistant Geologist on the Geological Survey of England.

THE annual meeting of the Society of Chemical Industry commenced yesterday at Newcastle-upon-Tyne. In his presidential address, Mr. George Beilby dealt with the question of fuel and smoke. The magnitude of this problem may be judged from the fact that the total coal consumed in the United Kingdom in 1898 was 157 million tons, of which 76 million tons were consumed for the production of power for industrial purposes, 46 million for the production of heat for industrial purposes, and 35 million for the production of heat for domestic purposes. The various remedies which have been suggested to reduce this consumption by using coal more economically are (1) improved appliances for the combustion of raw coal, and distribution of the air supply in furnaces; (2) the transformation of the raw coal into smokeless fuel by preliminary treatment, either by destructive distillation in gas retorts or in coke ovens, or by its conversion into fuel gas by partial combustion in air and steam. Mr. Beilby considered these remedies, and concluded by suggesting that, as a means of bringing all of the different interests which are concerned in this matter into line, the Society should arrange for the holding of a conference on the subject of fuel and smoke, at which the leading technical societies, as well as the actual industries concerned, should be fully represented.—Prof. C. F. Chandler, of New York, was elected president of the Society in succession to Mr. Beilby.

THE death is announced of Sir Alexander Armstrong, K.C.B., author of "A personal narrative of the discovery of the North-West passage" (1857) and "Observations on Naval Hygiene, particularly in connection with Polar service," at the age of eighty-one. From the *Times* we learn that in 1849 the deceased was appointed surgeon and naturalist to Her Majesty's ship *Investigator*, under the command of Captain (afterwards Sir Robert) McClure, which sailed from Plymouth on January 20, 1850, for the Polar Sea in search of Sir John Franklin. After encountering many difficulties, the *Investigator*, in September 1851, was forced into a bay which Captain McClure named Mery Bay. Here both officers and men suffered great hardship and privation, the food being reduced during the second winter to two-thirds of its original quantity, and the sickness increasing to a great extent, when they were rescued from their perilous position by Lieut. Bedford Pim. In the previous April, Captain McClure had taken a party from the ship and, crossing the strait, reached Melville Island, where he left notice in a cairn that the *Investigator* was icebound off Bank's Island. This notice was discovered by a travelling party from Her Majesty's ship *Resolute*, under Captain Kellett, who were stationed off Melville for their winter quarters. It was then that Lieut. Pim volunteered to go in search of the ship, which he reached on April 6, 1853, after a journey of 160 miles, which occupied him twenty-eight days. The *Investigator* was then abandoned, and the officers and crew were transferred to the *Resolute*; but, owing to that vessel being unable to get to the eastward, they were compelled to pass another winter—the fourth—in the ice. Eventually they were transferred to the *North Star*, and reached England on September 28, 1854. By this expedition the existence of a north-west passage was fully established. Sir Alexander Armstrong was appointed Director-General of the Medical Department of the Navy in 1869, and retired from that office in 1880.

AN account of some simple experiments on the best forms of curves for use with gliding or soaring machines for artificial flight has been sent to us by Mr. A. A. Merrill, of the Boston Aeronautical Society, U.S.A. A bicycle wheel was arranged to revolve in a vertical plane upon an axle fastened in a pier. From a point on the wheel a rod projected, and at the end of the rod the surface to be experimented upon was fixed at an observed angle with the plane of revolution of the wheel. The wheel was then started by the fall of a weight joined to the wheel in such a way that when the weight had fallen through a certain distance it became disconnected. After a surface had been fastened to the rod, the wheel was started, and when it had stopped the number of revolutions it had made was shown by a mechanical recorder. Given the same starting force, the number of revolutions would evidently depend upon the facility with which the surface moved through the air. The surface which offered the least resistance to motion was thus obtained. Among other results, the experiments seem to confirm Mr. L. Hargrave's statement that the existence of a wind vortex under a bird's wing is an important factor in soaring.

A SATISFACTORY report of the committee o, the Albany Museum, Cape of Good Hope, for the year 1898, has been issued. While special attention has been given to the development of the South African collections, a number of specimens of general interest have been acquired from foreign countries. Dr. S. Schönland, director of the museum, reports that the kitchen-middens near Port Alfred have again yielded a number of interesting specimens. Amongst them were portions of skulls of some human beings (which still await a careful examination) and a number of animal bones, amongst which was the lower jaw of the Vlakke Vark (*Phacochaerus aethiopicus*). This animal is quite extinct in Cape Colony now, and it was not previously known that it had occurred at all in that neighbourhood. Dr. Schönland has been able to get some light thrown on a question concerning the pottery found in these middens, which has hitherto puzzled many ethnologists. More or less large pieces of pottery, with holes neatly drilled through them, have frequently been found; and the meaning of these holes has hitherto been unexplained. It now appears that these pots with holes were used as miniature kilns, technically known as "saggers" (in which smaller pots were burned), and the need of holes through them becomes obvious when the use of these pots is known.

IN his introductory lecture, Prof. J. A. Thomson, the newly-appointed Regius Professor of Natural History in the University of Aberdeen, gives utterance to a note of warning as to the direction in which our biological studies are tending. "Amid the undoubted and surely legitimate fascinations of dissection and osteology, of section-cutting and histology, of physiological chemistry and physiological physics, of embryology and fossil-hunting, and the like, do we not need to be reminded sometimes that the chief end of our study is a better understanding of living creatures in their natural surroundings?" He even goes so far as to say that it is difficult to see any reason for adding aimlessly to the already overwhelming mass of morphological and systematic detail. And that what we should rather aim at is the understanding of the chief laws of organic architecture, of the certainties and possibilities of blood-relationship among living creatures, and a true conception of what is meant by the term organisation. As has been pointed out elsewhere by Prof. Alfred Newton, such a warning is undoubtedly needed at the present day, when there is far too great a tendency to regard the description of mere structure as the ultimate end of biological research. It is as if some person to whom modern telegraphy were unknown were to describe in great detail the mechanics of the various instruments employed therein without the vaguest conception of their practical use.

THE inexplicable habit of snails occasionally abandoning their shells is again alluded to in the July number of the *Journal of Conchology*. A former instance recorded was that of pond-snails (*Limnea*), but this time it is land-snails (*Helix*) captured at Venice. Here is a case in point illustrative of what is said above—the fact is all very well in its way, but is of no real interest unless we know the reason for such a strange perversity of habit.

THE most generally interesting article in the June number of the *American Naturalist* is one by Prof. Sylvester Judd on the efficiency of some of the protective adaptations of insects in securing their safety from foes. As the conclusions are chiefly based upon the undigested contents of the stomachs of a very large number of birds, it will be obvious that the author has a definite set of facts with which to test the validity of theories—and the facts are by no means always in accord with the theories. Especially is this the case with insects presenting a presumed protective resemblance with the object or ground on which they rest. Grasshoppers, for instance, even when lying still and then most like their surroundings, are snapped up by numbers of birds; as are also the larvæ of "looper" moths which resemble twigs, and likewise weevils. On the other hand, hairs, like those of many caterpillars, and, to a minor extent, the stings of bees and wasps, appear to be much more efficacious for protection. The brilliant colours of lady-birds seem likewise highly protective. "Warning colours" are, however, by no means always effective in this respect; and pungent odours and acid juices (which may be more suited to avian than to human palates) often also fail to save the insects in which they occur.

THE detailed studies that are now being made of the religious ceremonies of various native tribes of North America by trained American anthropologists are worthy of special study by all students of Comparative Religion. It is now possible, as Dr. J. Walter Fewkes points out in his account of "The winter solstice altars at Hano Pueblo" (*American Anthropologist*, n.s., i. p. 251), to trace the effect of one cult upon another in mixed populations. Walpi, for example, commenced as a settlement of Snake clans which had united first with the Bear phratry and subsequently with other phratries of lesser importance. The purport of the winter solstice (*Tuñtai*) rites at Hano is to draw back the sun in its southern declination and to fertilise the corn and other seeds, and to increase all worldly possessions. As at Walpi, strings with attached feathers are made and given to men and women with wishes that the gods may bring them blessings. These strings are also attached to beams of houses, placed in springs of water, tied to tails of horses, burros, sheep, dogs, chickens, and indeed every possession which the Indian has and wishes to increase.

THE experimental psychologists have passed from testing senses to experimenting on sensations, and "The Emotion of Joy" forms the subject of a monograph, by Dr. G. Van Ness Dearborn, in *The Psychological Review*, vol. ii., 1899. The first series of experiments consisted in recording what the subject said he felt like doing, or would probably do under the accession of hypothetical gifts of ten, one hundred, one thousand, ten thousand and one hundred thousand dollars respectively. The more practical experiments consisted in noting unconscious muscular movements during pleasant or unpleasant conditions of sound, light, smell, &c. It was found that somewhat in proportion to its proper pleasantness, an emotional extramotion consists in expansiveness and outwardly in contraction of extensor muscles; this is true of the smile and laugh of joy. Contraction of the extensor muscles is more pleasant in itself than contraction flexors; there is a general tendency to flexion under a (naturally unpleasant) sudden shock.

IN recent years several authors have published expositions of the methods originated by Hansen in dynamical astronomy; the text-books on lunar theory chiefly used in this country—Brown's "Lunar Theory," and the third volume of Tisserand's "Mécanique Céleste"—each devote a chapter to the subject. As the ephemerides of the moon given in the *Nautical Almanac* and the *Connaissance des Temps* are still calculated from Hansen's tables, as corrected by Newcomb, the theory cannot be neglected by astronomers; though in the hopes of mathematicians it has been somewhat displaced by the more fascinating work of living writers. In a memoir (*Ueber die Differentialgleichungen der Mondbewegung*), reprinted from the *Transactions* of the Leipzig Academy, Dr. Scheibner (who we believe is a former pupil of Hansen) develops systematically the numerous and complicated equations which form the basis of Hansen's theory of the moon's motion. The memoir will doubtless be welcome to those German students who have felt the need of something in their own language intermediate in character between the brief account given in Herz's article in the "Handwörterbuch der Astronomie," and Hansen's own exposition in the *Darlegung*.

"SOME Glacial Wash-plains of Southern New England" is the title of an essay by Mr. J. B. Woodworth (*Bulletin* of the

Essex Institute, Salem, vol. xxix.). These "wash-plains" or stream deltas and fans constitute a very important feature in the Pleistocene deposits of the region. They form the lowlands on which the greater number of towns and villages are built. To the early settler, they offered flat ground free from the boulders which are strewn over the uplands; and they yield vast stores of gravel and sand in fairly definite positions. Representing the morainal deposits of a retreating ice-lobe, they comprise the materials spread out at successive stages by streams and rivers which issued from the ice; and these deposits vary according to their original relations to the frozen mass. Hence the coarse gravels and the finest sands may be looked for in particular areas. No definite relations to sea-level are found among the various wash-plains. It is noticed that temporary lakes were at times produced by the local presence of blocks of ice; and it is pointed out that the retreat of the ice from the area was so recent that the general form of the deposits and most of their details remain unaltered. Owing, however, to the decay of some of the basaltic and other stones, the surface of the ground has been somewhat lowered.

HERR A. WEIGEL, of Leipzig, has acquired the last two remaining copies of Kützing's *Tabulae Phycologicae*, in 19 vols., with 1900 coloured plates, which he offers for sale at 2400 m. (Kützing's own copy) and 2000 m. respectively.

MESSRS. DULAU AND CO., of Soho Square, have issued a catalogue of botanical works, consisting entirely of works on Phanerogamia, which are arranged alphabetically in their natural orders. The same firm forwards also a catalogue of books and papers on British botany.

Bulletin 168 of the Cornell University Agricultural Experiment Station is devoted to an account, by Prof. G. F. Atkinson, of three species of Fungi which he regards as valuable from an esculent point of view, *Coprinus comatus*, *C. atramentarius*, and *C. micaceus*, with abundant illustratious.

DR. F. SCHLEICHERT has an interesting note, in a recent number of the *Naturwissenschaftliche Wochenschrift* (June 25) on the observation of phenomena of vegetable physiology in the winter. Many of them, especially those connected with the supply of nutrition, may be followed nearly equally well at that period of the year as in summer.

DR. L. O. HOWARD has published an account or the principal insects affecting the tobacco-plant in America in the *Year-book* of the Department of Agriculture for 1898. Although the plant is said to have no enemies peculiar to itself, it suffers from the attacks of many omnivorous *Lepidoptera*, especially Sphinges and Noctuæ; and from those of various *Coleoptera*, *Hemiptera*, &c.

WE have received parts 10–12 (published in 1898) of the second volume of a journal called *Lavoura*, published by the National Society of Agriculture of Brazil. Among the miscellaneous contents which fill the magazine, we find a coloured plate of the imago and pupa of a butterfly (*Heliconius eucrate*, Hübn.); illustrated articles on a formidable internal parasite (*Anchylostoma*), and on the history of the wheat-plant; a portrait of the late Prof. Aimé Girard; notices and figures of *Eleusina coracano* and *indica* (forage-plants); and much agricultural and statistical information, primarily, of course, of local interest.

THE first number of *Le Mois scientifique et industriel*—a monthly synopsis of scientific information—has been received. To some extent, the new periodical resembles *Science Abstracts*, but it contains more abstracts of engineering papers, and less cf scientific investigations. The abstracts are concise, comprehensive as regards nationality, and well printed; they should, therefore, be of real service to French readers interested in the progress of pure and applied science.

A CAREFUL investigation of tautomeric compounds, *i.e.* substances which react as though each possessed more than one molecular structure, though only represented by *one* substance, has revealed in a few cases the actual existence of the different structural forms. A very interesting example is furnished by diacetylsuccinic ester, which has lately been studied by Prof. Knorr. At the time of its discovery it was regarded as a single distinct individual, having the formula

$$\begin{array}{ccc} CH_3.CO.CH & . & CH.CO.CH_3 \\ | & & | \\ COOR & & COOR \end{array}.$$

According to Knorr the presence of the other structural isomers has been overlooked from the fact that, though not the most stable relatively, the original compound has the highest melting point, and, being the least soluble, has crystallised most readily from solution. Knorr predicted some time ago the existence of seven isomeric compounds, not including optically active forms, and of these he has already succeeded in preparing five, whilst he considers it very probable that the two missing members will be found. These will be represented by the following formulæ:—

$$\begin{array}{cc} CH_3.CO.CH.COOR & CH_3.C(OH):C.COOR \\ | & | \\ CH_3.CO.CH.COOR & CH_3.C(OH):C.COOR \end{array}$$

Keto-form representing two inactive forms. — Enol-form representing three cis-trans-forms.

$$\begin{array}{c} CH_3.C(OH):C.COOR \\ | \\ CH_3.CO.CH.COOR \end{array}.$$

Keto-enol-form representing two inactive forms.

A RECENT issue of the *Transactions* of the Oxford University Junior Scientific Club contains a valuable account, by Mr. A. F. Walden, of the condition of dissolved substances in solutions other than aqueous. The experiments of Carrara have shown that solutions in methyl alcohol exhibit a progressive ionisation, and that the independence of the ions is as clearly marked as in the case of aqueous solutions. Tessarin has also shown that the molecular lowering of the freezing point of formic acid brought about by the chlorides and bromides of the alkali metals is abnormally high, showing that this solvent also behaves like water. Recent experiments by Franklin and Kraus have shown that liquid ammonia acts as a dissociating solvent. In reference to the hypothesis of Nernst that the dissociating influence of a solvent is related to its dielectric capacity, it is to be remarked that the dielectric constants of water, methyl alcohol, acetone, formic acid, and ammonia are all high. It is pointed out also that these solvents, with the possible exception of acetone, are characterised by having "associated" molecules. On the whole, therefore, it may be said that the phenomena which it is attempted to represent by the hypothesis of electrolytic dissociation are not peculiar to aqueous solutions. They are, so far as experimental evidence is available, found to be characteristic of solutions of salts in other solvents possessing high dielectric capacities and complex or associated liquid molecules. According to Thwing, the dielectric capacity is both an additive and a constitutive property. It increases as the temperature is lowered. The factor of association, according to Ramsay and Shields, also increases as the temperature is lowered. These facts have all to be considered in dealing with solutions and in comparing ionisation determinations made by different methods. Thus we have some explanation of the observation that the degree of ionisation of metallic salts dissolved in methyl or ethyl alcohol is uniformly less when estimated by the boiling point method than when measured by the determination of electrical conductivity at a lower temperature.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. J. H. Higgins; two Maholi Galagos (*Galago maholi*) from South Africa, presented by the Hon. Gilbert Johnstone; two Common Badgers (*Meles taxus*), British, presented by Mr. A. Gorham; a Spring-bok (*Gazella euchore*, ♂), a Ring-hals Snake (*Sepedon haemachates*) from South Africa, four Spur-winged Geese (*Plectropterus gambensis*) from West Africa, presented by Mr. J. E. Matcham; two Lanner Falcons (*Falco lanarius*) European, presented by Sir H. H. Johnston, K.C.B.; a Yellow-fronted Amazon (*Chrysotis ochrocephala*) from Guiana, presented by Mrs. G. F. Cote; a Hunting Crow (*Cissa venatoria*) from India, a Black-necked Grackle (*Graculipica nigricollis*) from China, a Larger Rocket-tailed Drongo (*Dissemurus paradiseus*) from India, a Sacred Kingfisher (*Halcyon sancta*) from Australia, a Black Hangnest (*Cassidix orizivora*) from the Amazons, two Blackbirds (*Turdus merula*), European; a Brown Thrush (*Turdus leucomelas*) from South America, presented by Mr. Russell Humphreys; an Arabian Baboon (*Cynocephalus hamadryas*) from Arabia, three Barbary Partridges (*Caccabis petrosa*) from North Africa, three Western Pintailed Sand-Grouse (*Pterocles pyrenaica*), South European, a Grand Galago (*Galago crassicaudata*) from East Africa, three Black-headed Terrapins (*Damonia reevesi-unicolor*), three Reeve's Terrapins (*Damonia reevesi*) from China, a Home's Cinixys (*Cinixys homeana*), a Derbian Sternothere (*Sternothaerus derbianus*) from West Africa, three Reticulated Pythons (*Python reticulatus*) from the East Indies, deposited; four Crested Pigeons (*Ocyphaps lophotes*) from Australia, an Ostrich (*Struthio camelus*, ♂) from Senegal, a Sun Bittern (*Eurypyga helias*) from South America, a Scarlet Ibis (*Eudocimus ruber*) from Pará, purchased; a Japanese Deer (*Cervus sika*, ♂), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

COMET 1899 *a* (SWIFT).—

Ephemeris for 12h. Berlin Mean Time.

1899.		R.A. h. m. s.		Decl. ° ′		Br.
July 13	...	14 13 3	...	+13 50·7	...	0·06
15	...	12 26	...	12 59·9		
17	...	12 1	...	12 12·1		
19	...	11 45	...	11 26·9	...	0·05
21	...	11 36	...	10 44·1		
23	...	11 34	...	10 3·6	...	0·04
25	...	11 40	...	9 25·1		
27	...	11 53	...	8 48·3		
29	...	12 10	...	8 13·3	...	0·03
31	...	12 32	...	7 39·7		
August 2	...	14 12 59	...	+ 7 7·6		

TEMPEL'S COMET 1899 *c* (1873 II.).

Ephemeris for 12h. Paris Mean Time.

1899.		R.A. h. m. s.		Decl. ° ′ ″		Br.
July 13	...	20 31 7·6	...	−14 25 22		
14	...	32 20·5	...	14 55 18		
15	...	33 33·2	...	15 25 46	...	3·418
16	...	34 45·7	...	15 56 42		
17	...	35 58·0	...	16 28 5		
18	...	37 10·2	...	16 59 51		
19	...	38 22·3	...	17 31 59	...	3·566
20	...	20 39 34·3	...	−18 4 26		

The comet is still on the borders of Sagittarius and Capricornus, about 3° west of α and β Capricorni. M. L. Schulhoff points out in *Ast. Nach.* (No. 3574) that it is important to secure as many accurate observations of the comet as possible at observatories of different latitudes during this apparition, as by this means our knowledge of the mass of Jupiter may be considerably improved.

THE NEW ALLEGHENY OBSERVATORY.—A little over a year ago Mr. J. A. Brashear inaugurated a movement to provide for the erection of a new building and an adequate instrumental equipment for the Allegheny Observatory, and the fund, from numerous subscriptions received, has grown to such proportions that the plan shows every sign of success. Prof. F. L. O. Wadsworth, until recently a member of the staff of the Yerkes Observatory, has been appointed to the directorship, and the plans for the new building have been prepared by him. The largest instrument is to be a refracting telescope of 30 inches aperture, with object-glass by Brashear, and special provision is to be made for astrophysical investigations, which will form the principal work of the observatory.

LEEDS ASTRONOMICAL SOCIETY.—The *Journal and Transactions* for the year 1898, lately issued, maintains the excellent standard of former years. Among the many interesting papers mention may be made of "The movements of the moon," "Star temples in Egypt," "Astronomy as applied to navigation." The volume contains two plates, one showing four drawings of Jupiter and one of Saturn made by Mr. H. J. Townshend, and the other a portrait of Mr. T. J. Moore, who has charge of one of the micrometers from the Oxford Observatory, with which he is engaged in measuring the plates for the Astrographic Catalogue. Accompanying this is a very lucid description of the work and scope of the Astrographic Survey, by Mr. Moore.

THEORY OF THE MOTION OF THE MOON.[1]

THE second part of Dr. Brown's "Lunar Theory" contains the calculation of the terms of the third order in the eccentricities, inclination and ratio of the parallaxes. The first part (reviewed in NATURE, November 25, 1897) had already dealt with the general theory, the variation, and the terms of the first and second orders. It will be remembered that the differential equations to be solved are

$$(D+m)^2u+\tfrac{1}{2}m^2u+\tfrac{3}{2}m^2s-\frac{ku}{(us+z^2)^{\frac{3}{2}}}=-\frac{\partial\Omega_1}{\partial s}$$

$$(D-m)^2s+\tfrac{1}{2}m^2s+\tfrac{3}{2}m^2u-\frac{ks}{(us+z^2)^{\frac{3}{2}}}=-\frac{\partial\Omega_1}{\partial u}$$

$$(D^2-m^2)z-\frac{kz}{(us+z^2)^{\frac{3}{2}}}=-\tfrac{1}{2}\frac{\partial\Omega_1}{\partial z}.$$

The notation is sufficiently familiar to render explanation unnecessary.

Dr. Brown's procedure is as follows:—Let

$$u=u_0+u_\mu+u_\lambda,\ z=z_\mu+z_\lambda$$

where u_0 denotes the variational terms

$$u_\mu,\ z_\mu$$

the terms of the orders already calculated

$$u_\lambda,\ z_\lambda$$

the terms of the next order to be calculated.

Then expanding by Taylor's theorem the unknown terms enter in the form

$$\zeta^{-1}(D+m)^2u_\lambda+M\zeta^{-1}u_\lambda+N\zeta s_\lambda,$$

and

$$D^2z_\lambda-2Mz_\lambda,$$

M, N being functions of the known variational terms.

The unknown terms enter under the same form every time, but if a solution with indeterminate coefficients be assumed, the coefficients in the simultaneous equations that result will depend upon the period of the inequality under consideration, and therefore, from the point of view of numerical solution, entirely different nearly every time. All who have had the practical

[1] "Theory of the Motion of the Moon; containing a New Calculation of the Expressions for the Coordinates of the Moon in Terms of the Time." By Ernest W. Brown, M.A., Sc.D., F.R.S. (from the *Memoirs* of the Royal Astronomical Society, vol. liii.).

experience know how laborious is the solution of twenty simultaneous equations. Prof. Brown estimates the solution of the equations at half the labour of obtaining them, in addition to the fact that this portion of the work is peculiarly liable to numerical error. He may therefore be congratulated on having obtained an algebraical solution, reducing the operation of finding fresh terms to mere multiplication of series. The mathematical investigation is referred to as destined for publication elsewhere, and does not appear in the memoir. The underlying principle is that when in a differential equation of the nth order there are $n-1$ integrals known, when the right-hand member of the equation is zero, then a particular integral in the general case can be obtained. In the lunar theory the differential equation is, in effect, of the fourth order, and three integrals are known, two representing the elliptic inequality and the third a variation of the epoch.

Reference number.	Characteristic.	Argument.	Number of terms.	Approximate value in arc of the largest coefficient.	Value of unity in the last figure given, in millionths of a second of arc.
				"	
1	1	0	13	206265	0·0002
2	e	$\pm l$	18	17000	2
3	e'	$\pm l'$	21	350	0·4
4	α	D	9	80	0·05
5	k	F	11	9000	0·01
6	e^2	$\pm 2l$	21	240	3
7	e^2	0	11	340	3
8	ee'	$\pm(l+l')$	21	140	4
9	ee'	$\pm(l-l')$	22	100	4
10	e'^2	$\pm 2l'$	18	6	0·6
11	e'^2	0	10	2	0·6
12	k^2	± 2F	20	400	0·4
13	k^2	0	11	400	0·4
14	$e\alpha$	D $\pm l$	19	12	0·6
15	$e'\alpha$	D $\pm l'$	20	14	0·1
16	α^2	0	9	0·01	0·1
17	ke	F $+l$	10	15	0·06
18	ke	F $-l$	11	45	0·06
19	ke'	F $+l'$	10	1	0·01
20	ke'	F $-l'$	11	0·4	0·01
21	$k\alpha$	D + F	10	4	0·02
22	e^3	$\pm 3l$	17	11	27
23	e^3	$\pm l$	18	11	27
24	e^2e'	$\pm(2l+l')$	17	6	4
25	e^2e'	$\pm(2l-l')$	18	3	4
26	e^2e'	$\pm l'$	19	8	4
27	ee'^2	$\pm(l+2l')$	16	5	0·6
28	ee'^2	$\pm(l-2l')$	15	2	0·6
29	ee'^2	$\pm l$	17	1	0·6
30	e'^3	$\pm 3l'$	13	0·3	0·01
31	e'^3	l'	16	0·1	0·1
32	ek^2	$\pm(l+2$F$)$	15	11	4
33	ek^2	$\pm(l-2$F$)$	17	30	4
34	ek^2	$\pm l$	16	14	0·4
35	$e'k^2$	$\pm(l'+2$F$)$	15	2	0·07
36	$e'k^2$	$\pm(l'-2$F$)$	16	1	0·7
37	$e'k^2$	$\pm l'$	16	4	0·7
38	$e^2\alpha$	D $\pm 2l$	18	0·8	0·6
39	$e^2\alpha$	D	7	1·3	6
40	$ee'\alpha$	D $\pm(l+l')$	16	0·4	1
41	$ee'\alpha$	D $\pm(l-l')$	16	0·8	1
42	$e'^2\alpha$	D $\pm 2l'$	15	0·3	0·02
43	$e'^2\alpha$	D	8	0·4	0·2
44	$k^2\alpha$	D ± 2F	16	0·5	0·1
45	$k^2\alpha$	D	8	3	0·1
46	$e\alpha^2$	$\pm l$	16	0·03	0·1
47	$e'\alpha^2$	$\pm l'$	16	0·002	0·02
48	α^3	D	8	0·001	0·03
49	k^3	3F	9	1	0·2
50	k^3	F	8	0·2	0·2
51	ke^2	F $+2l$	10	10	1
52	ke^2	F $-2l$	10	9	1
53	ke^2	F	10	4	1
54	kee'	F $+l+l'$	10	5	0·2
55	kee'	F $-l-l'$	10	3	0·2
56	kee'	F $+l-l'$	11	2	0·2
57	kee'	F $-l+l'$	11	4	0·2
58	ke'^2	F $+2l'$	10	0·8	0·03
59	ke'^2	F $-2l'$	10	0·08	0·3
60	ke'^2	F	10	0·4	0·03
61	$ke\alpha$	D + F $+l$	10	0·1	0·2
62	$ke\alpha$	D + F $-l$	10	0·2	0·2
63	$ke'\alpha$	D + F $+l'$	10	0·2	0·003
64	$ke'\alpha$	D + F $-l'$	10	0·5	0·003
65	$k\alpha^2$	F	8	0·004	0·06

For forming the right-hand sides of later stages, the quotient of each set of terms by the variation terms is required. As divisions are troublesome, these quotients are the quantities sought in the first instance: the new set of terms can then be obtained by a multiplication. The quotients referred to are given algebraically as the sum of four products, each product being that of two series. It is inconvenient, in the numerical application of the above method, that small coefficients often appear as differences of comparatively large numbers. Dr. Brown gives as an example a case where a coefficient 2 arises as the sum of separate coefficients

$$-6418 + 6496 + 316 - 392$$

from the above-mentioned four products.

Terms of long period require a special treatment, but the general methods apply to the other terms of the group. The loss of accuracy is reduced to that due to the first, instead of the second, order of the small divisor.

When the period is that of the elliptic inequality, a new part of the motion of the perigee has to be determined. Calling this new part $c_{\lambda/e}$ a new unknown term $\zeta^{-1}(\mathrm{D}+m).u_e c_{\lambda/e}$ appears, and is transposed to the right-hand side of the equation, so that the quantities A, which in other cases are completely known, now appear in the form $\mathrm{B}+c_{\lambda/e}b$, where B, b are known. Dr. Brown has already shown in the first part how $c_{\lambda/e}$ may be obtained before the coefficients of the inequalities are calculated. When this has been done, one of the equations becomes redundant. Another is already redundant, until the meaning of the arbitrary constant denoting the ellipticity is defined with further precision. Dr. Brown defines the arbitrary constant so that $\epsilon_0 - \epsilon_0' = 1$ to all orders; hence $\lambda_0 = \lambda_0'$. The other coefficients λ_ι, λ_ι' consist of three parts, one proportional to $c_{\lambda/e}$, and arising from the quantities b, a second arising from the quantities B, and a third proportional to λ_0. The two equations for which $\iota = 0$ then give a double determination of λ_0, and furnish a check upon the numerical accuracy. Many of the quantities that occur in this arrangement of the computations are of service at subsequent stages.

The treatment of the third coordinate follows the same lines, and only differs in being more simple.

The foregoing table exhibits the extent of the calculations already performed, and the results of the first part are for convenience included in it.

The decrease of accuracy of the terms in the twenty-second and twenty-third groups is due to the period of one term approximating to the synodic period. Even in these cases, the coefficients are given to less than one-thousandth part of the least quantity that could be detected by observation.

P. H. C.

INVESTIGATIONS OF DOUBLE CURRENTS IN THE BOSPHORUS AND ELSEWHERE.[1]

AS my books and papers are published chiefly in the Russian language, they are not very well known in this country. A short account of some of my results may therefore not be without interest. I cannot, in the course of my address, make you familiar with all my works, and wish at the present moment only to draw your attention to the interesting phenomena of double currents in the Straits of Bosphorus, Gibraltar, Bab-el-Mandeb, Formosa, and La Pérouse.

The Strait of Bosphorus joins the Black Sea and the Marmora Sea. The Black Sea water has in it—roughly speaking—half the quantity of salt found in the water of the Mediterranean.

[1] Abridged from a paper by Vice-Admiral S. Makaroff in the *Proceedings* of the Royal Society of Edinburgh (vol. xxii. No. 4, 1899).

The water of the lower strata of the Marmora Sea has the same composition as the water of the Mediterranean. The upper strata, say from ten fathoms upwards, contain water of intermediate salinity between the water of the Mediterranean and the water of the Black Sea. This difference in the salinity of the water is the chief reason of the enormous double current of the Bosphorus. Let us imagine that at a certain given moment the level of both seas is at the same height. The pressure of the column of water in the Marmora Sea will be greater than that in the Black Sea; the difference would increase with the depth, and it would disappear at the surface. For this reason, the water in the lower strata of the Marmora Sea rushes into the Black Sea, keeping close to the bottom. That rush of water after a certain time will raise the level of the Black Sea, producing a difference in the level of the two seas, which causes a superficial current to flow out of the Black Sea in the opposite direction to the under current. Here we see distinctly that the principal reason for the double current is the difference in the salinity of the water, and should that difference in salinity cease the double current would be discontinued. The fact is that in the Black Sea evaporation does not exceed the quantity of water supplied by rains and streams, and this excess of fresh water maintains the difference of salinity in the waters of the Black Sea and Mediterranean.

The existence of double currents in the Bosphorus was known long ago, and Marsilli in 1681, in his letter to Queen Christina of Sweden, has described them. Later they were somehow forgotten, and some interesting papers have been published, in which the authors try to prove that the double current was legendary. Rear-Admiral Sir W. J. L. Wharton (who is now at the head of the Hydrographic Office) was the first to show by direct observations that a double current existed in the Bosphorus. I was there a few years after him, commanding the stationary steamer *Taman*. I began to take observations of the specific gravity of the water at different depths, and I found out that the water forming the lower strata contained twice as much salt as the water of the upper strata; after this, a double current was quite evident to me.

I do not wish to detain you with an account of the different results referring to the velocity of both currents, and will only point out to you that the lower current is similar in many details to an ordinary river, while, on the contrary, the upper current differs much from an ordinary river, probably for the reason that, while the surface of it is falling gradually down, the bottom rises constantly.

The difference of level of the Black Sea and Marmora Sea, calculated from the difference in the specific gravity of the water, I found for the month of July 1882 to be 1·396 feet.

In the Strait of Gibraltar I had only five stations, and made my observations one day only. I had no opportunity of measuring the velocity of the current, but the phenomenon is very similar to what I found in the Bosphorus. The water of the Atlantic rushes into the Mediterranean, the difference between the surface levels being, according to my calculations, 0·54 foot.

The evaporation of water from the Mediterranean is greater than the quantity supplied by rivers and rains. For this reason, the water becomes more dense, settles down, and goes back to the Atlantic by the under current.

I wish to point out here that the temperature of the lower strata of the Mediterranean coincides with the mean winter temperature of the air in the eastern part of the sea. This is quite evident, because in winter the temperature of the water to a great depth corresponds to the temperature of the air. In summer, the surface water is much warmer, but this high temperature cannot penetrate to a great depth. I am sorry that I have not time to discuss more fully this question, but in the Straits of Bab-el-Mandeb we have the same phenomena as in the Gibraltar Strait and Mediterranean. Here again—by my observations—the temperature of the lower water strata coincides with the winter temperature of the air at the place where the water settles down.

In the three straits already mentioned we have a double current: superficial and bottom current. In the Straits of Formosa and La Pérouse there are also two currents, but both are superficial.

I ought to mention that the influence of the rotation of the earth on the direction and velocity of the currents cannot be over-estimated. I shall not discuss this question fully, but the fact that in every salt inland sea there is a circular rotation of the water in a direction opposite to the apparent movement of the sun, shows that the rotation of the earth has very much to do with the direction of the currents. In the vicinity of islands, for the same reason, the water follows a direction coinciding with the apparent movement of the sun. It is for this reason also that the water alongside the Chinese coast flows to the south during the north-easterly monsoon as well as during the south-westerly monsoon. The Kuro-Siwo current going to the north and north-east cannot touch the Chinese coast because there is brackish water flowing to the south-west.

In the Strait of Formosa the specific gravity and temperature of the water at the Chinese coast are quite different from what is observed off the coast of Formosa. This difference in the temperature and specific gravity may give to a sailor a good guide for a fair passage through the Strait. The temperature of the water, say, in the month of February at the Chinese coast is 11° C., while at the coast of Formosa it is 20°. If the captain will try during the month of February to follow the line of the temperature of 15° he will pass at a good distance from the dangers of both coasts. Moreover, at the Chinese coast in winter it is possible to find water at less than 1·0240 $\left(S\frac{17·5}{17·5}\right)$, while at the coast of Formosa it is seldom less than 1·0265.

Every sailor knows how difficult is the passage through the Strait of Formosa. During the north-easterly monsoon the weather is very thick, and the depth of the sea cannot in these places be regarded as giving a good means for determining the position of the ship. It may happen that after a ship leaves, say, Nagasaki the captain never knows his position until he runs on the Chinese coast and wrecks his ship. My opinion is that a regular temperature service should be arranged from Turnabout Lighthouse; everyday a pilot boat should put to sea, taking temperatures both going out and returning, and the temperature of the water should be wired to all Chinese and Japanese ports for the information of the captains. By these means many ships would be saved from danger.

The currents in the Strait of La Pérouse are very complicated. There is a very narrow and long strip of cold water, which lies in the direction from N.W. to S.E.; a vessel crossing that strip in July may have temperatures of 18° C., then 5°, and again 16° or 18°. It would take me too long to explain the source from whence the cold water comes, and why it is constantly there; it is the cause of fogs which render navigation in that place very difficult. I may briefly say that the Kuro-Siwo current partly enters the Sea of Japan, and the excess of water escapes partly through the Strait of La Pérouse into the Okotsk Sea. Due to the rotation of the earth, the current turns to the south-east and flows alongside the Island of Yezo. This water is warm and dense, having much salt in it. The water of the Okotsk Sea—particularly in the vicinity of the Island of Saghalien—is in summer also pretty warm, but it is much lighter than the water of the Kuro-Siwo, and thus while the denser water sinks down, the lighter water tries to rise on the top of it. The difference of level which is produced hereby brings to the surface the cold water of the lower strata.

I studied this Strait in 1887 and 1888, and published the results of my study, but when I came to the Pacific again in 1895, as the Admiral commanding the squadron, I was very anxious to go to the Strait of La Pérouse to re-investigate the currents, and now I am in possession of very valuable material on this subject, which is almost ready for publication.

I do not propose to take up more of your time at present with particulars of these five straits. I only wish to remind you what important information the thermometer and hydrometer can give in the study of the different parts of our so little-known planet. You know better than I that studies in that direction ought to be continued, and no nation in the world has been so liberal as England, which found means to send out for four years the *Challenger* with a scientific staff to explore the deep sea. But it is not always possible to find such means, and it is advantageous to associate ordinary seamen with that kind of work.

I should be very glad if oceanographers would come to certain definite opinions with regard to the mode of collecting the information about the temperature of the surface water. It would be a great advantage to knowledge to divide the study of the sea with regard to the temperature. Suppose Russia should take Okotsk Sea, Bering Sea, or Sea of Japan, Black Sea, White Sea, Kara Sea, and the Finnish Gulf, England takes the Atlantic, United States takes Northern Pacific, Germany takes Indian Ocean, France takes South Pacific, Sweden and Norway take North Sea, Baltic Sea and the Arctic Sea. Every nation should extract the information in regard to the temperature from ships' log books, put it in tables of approved description, and send it to the corresponding nation; this will give means to collect enormous information. The observations of every ship in a certain square ought to be placed on a separate card. Boxes containing these cards, say for the North Pacific, would not occupy more space than can be found in a good-sized book-case.

When a new journal of a ship is received, temperatures of sea water observed on board that ship should be placed on the cards, and the cards put in their corresponding place. In this way we should, each year, become richer in the knowledge of the temperature of the surface water, and no observation would be lost. Every observation would increase our knowledge of the temperature of sea water. It would be a real pleasure to see that progress of knowledge, and if ever this system or any other system be accepted, it will help us to study many details which, up to the present time, are unknown.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. R. L. JACK, Government Geologist, Queensland, now on a visit to this country, is to receive the honorary degree of LL.D. of Glasgow University on July 20.

MR. E. A. MINCHIN, Fellow of Merton College, Oxford, has been elected to the Jodrell Professorship of Zoology in University College, London, in succession to Prof. W. F. R. Weldon.

THE Bill for establishing a Department of Agriculture and Technical Instruction in Ireland was read for a second time in the House of Commons on Thursday last, and referred to the Standing Committee on Trade.

FOR the purpose of encouraging the study of botany, the London Technical Education Board have had the botanical gardens in Battersea, Ravenscourt and Victoria Parks laid out upon an organised plan. Good collections of plants, representing various natural orders, have been obtained, and suitable arrangements have been made for the convenience of teachers and students. The more important trees and shrubs in the parks have been labelled, and lists have been supplied for insertion in the botanical guide which the Board proposes to issue shortly for the convenience of students. Teachers of botany can obtain tickets for themselves and pupils for admission to the botanical gardens at the Battersea, Ravenscourt and Victoria Parks by application to the Secretary of the Board.

BY the recent gifts of Mrs. Stanford (*Science* states), Leland Stanford Jr. University becomes the richest university in the world, far surpassing in its resources Harvard, Columbia, or any other university. The resources of the University consist of three great farms, aggregating 95,000 acres of land, deeded by Act of Legislature. On one of these farms, which constitutes the University Campus, buildings to the value of one million dollars were erected before Senator Stanford's death. By his will the University received 2,500,000 dollars in cash, invested in interest-bearing bonds. During the litigation following his death, Mrs. Stanford gave to the University (by deed) her own private fortune, amounting to about a million dollars. By her recent gift she transferred the residue of the estate to the University, it being necessary to do this by deed of gift under the laws of the State. The property just transferred has a commercial value—judging from the revenue stamps put upon the deeds—of 35,000,000 dollars. What its actual value may be only the future] can determine. The income arising from this final gift is at present relatively small, as by agreement among the railroads, in bonds and stock of which it largely consists, the earnings are for a time to be used in freeing the property from debt and in making improvements.

AT the annual dinner of the Old Students' Association of the Central Technical College, held on Thursday last, Prof. W. E. Ayrton, in proposing the toast of the Association, referred to the progress of the College and the insufficiency of accommodation due to the continued increase in the number of students. He announced that the electrical department would soon be greatly extended by the erection of a large new dynamo room nearly six times the size of that at present in use, and occupying a considerable part of the ground floor of the new building of the Royal School of Art Needlework adjoining the College. The accommodation for this department would be further increased by the completion of a new drawing office and a new lecture theatre. Sir Philip Magnus, in proposing the toast of the College and its professors, remarked that the College was that day entering on a new period in its career, for it was likely to become an integral part of the new University of London, which had decided the day before to move into new quarters at the Imperial Institute next door to the College. The needs of the College were recognised in the new University by the decision to appoint a faculty of engineering for the first time in the history of University education, and by the variation of the University matriculation examination to suit the requirements of different classes of students. Prof. Armstrong, in replying to the toast of the Chairman, alluded to the research work done at the College, especially in relation to its value as a means of mental training.

SCIENTIFIC SERIALS.

Bulletin of the Amerian Mathematical Society, June.—Prof. F. N. Cole reports the April meeting of the Society held in New York City, and summarises the thirteen papers which were contributed. He also indicates where the papers themselves may be or will be found.—Surfaces of revolution in the theory of Lamé's products is a paper which was read by Dr. Safford at the February meeting. It is a review of an article by Haentzschel (reduction der Potentialgleichung), in which that writer criticises results obtained by Wangerin in the *Berliner Monatsberichte* (February 1878). Dr. Safford agrees with Wangerin in the results he gets, and so, in his opinion, invalidates Haentzschel's criticisms.—The next article is an enthusiastic review by Mr. Arthur Berry of Picard's "Théorie des Fonctions Algébriques de deux Variables indépendantes."—Another review is one of Jules Tannery's "Leçons d'Arithmétique théorique et pratique," by Prof. J. Pierpont. This latter is pronounced to be the first work on arithmetic which the reviewer has seen which, while intended entirely for secondary instruction, is written in accordance with the new ideas regarding the number concept and the need of rigour. Thus it is a pioneer of a revolution in secondary instruction.—Dr. L. E. Dickson contributes a note on Page's ordinary differential equations (*cf.* a review of this by Prof. Lovett in the *Bulletin*, April 1898).—The usual notes and new publications close the number.

IN the *Journal of the Royal Microscopical Society* for June, besides the usual summary of current researches in zoology, botany, and microscopy, is a further instalment of Mr. F. W. Millett's report of the recent Foraminifera of the Malay Archipelago; and an article by the president, Mr. E. M. Nelson, on the rackwork coarse adjustment, in which he traces the history of the application of rackwork to the focussing of the microscope from the time of Bonannus in 1691 down to the most recent improvements.

THE *Journal of Botany* for July contains an article, with illustrations, on a new British fresh-water alga, by Dr. A. B. Rendle and Mr. W. West, jun. The alga is a new species of the interesting genus *Pithophora*, first found by Wittrock in a tank in Kew Gardens. Like Wittrock's species, however, it has no claim to the title of "British" beyond the fact that it was found in a canal near Manchester, where it had unquestionably been introduced with cotton-bales. The remaining papers in both the June and the July numbers appeal to those interested in descriptive and geographical botany.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, July 3.—M. van Tieghem in the chair.—Considerations on the physical constitution of the moon, by MM. Lœwy and Puiseux. A summary of conclusions arrived at from recent photographic study of the moon. Certain comparisons are drawn between the structure of the moon's surface and that of the earth, and evidence is adduced of the existence, at the present time, of a remnant of the original lunar atmosphere.—Examination of sea-water drawn from different depths: variation of iodine compounds therein, by M. Armand Gautier. Examination of water taken from the surface of the Mediterranean shows, as has been previously found to be the case with the Atlantic Ocean, the entire absence of iodides and iodates, the whole of the iodine present being contained partly in microscopic organisms and partly in combination with a complex organic substance which contains nitrogen and phosphorus, and is capable of dialysis. The total amount of iodine present is nearly the same for all depths, but the form in which it exists varies considerably. Thus, at the bottom of the sea iodine exists in the form of iodides and iodates to the extent of 0·305 milligramme per litre, and the quantity decreases with decreasing depth until it disappears altogether at the surface. On the other hand, the iodine contained in living organisms is greatest in amount at the surface, and gradually diminishes as the depth increases. The iodine present in the form of soluble organic compounds is much more constant in amount, the maximum quantity being found at a depth of 880 metres. The water of the Mediterranean appears to be somewhat poorer in iodine than that of the Atlantic, the total quantities found being 2·25 and 2·40 milligrammes per litre respectively.—Observations of Swift's comet (1899 *a*) made with the Brunner equatorial at the Lyon Observatory, by M. J. Guillaume.—On the suppression of trial methods in the calculation of parabolic orbits, by M. L. Picart.—On the transformation of surfaces, by M. E. O. Lovett.—On the surfaces of Voss, by M. C. Guichard.—The groups of the order $16p$, p being an odd prime, by M. Le Vavasseur.—On the development of a uniform branch of analytic functions in a series of polynomials, by M. Paul Painlevé.—On two integrable equations of the second order, by M. E. Goursat.—On a class of equations to partial derived functions, by M. Ivan Fredholm.—Considerations on the works of MM. S. Lie and A. Mayer, by M. N. Saltykow.—Wandering globular sparks, by M. Stéphane Leduc. When two fine metallic points are connected with the poles of an electrostatic machine, and placed in contact with the sensitive film of a photographic plate resting on a metal surface, an effluvium is produced around the positive point, and a luminous globule appears at the negative point. This globule increases in size, detaches itself from the negative, and slowly wanders towards the positive, point; on reaching the latter the luminosity ceases, and the machine is found to be discharged. The phenomenon suggests a comparison with globular lightning.—The frequency of nervous oscillations, by M. Auguste Charpentier.—On the nature and cause of the phenomenon of coherers, by M. Thomas Tommasina. An account of further experiments on the formation of conducting chains of metallic particles in coherers.—On the position of the points of magnetic transformation of nickel steels, by M. L. Dumas. The influence of chemical composition on the magnetic properties of steels is described and discussed.—On the volumetric estimation of zinc, by M. Pouget. In the new process here described the solution of zinc is treated with hydrogen sulphide and the precipitated zinc sulphide decomposed with a known amount of iodine solution, the excess of the latter being subsequently determined by titration with thiosulphate.—On the preparation and properties of the arsenides of strontium, barium, and lithium, by M. P. Lebeau. The arsenides of the metals in question were obtained by the reduction of the corresponding arsenates with carbon at the temperature of the electric furnace. They are reddish-brown substances presenting a crystalline fracture, and are rapidly decomposed by water with evolution of hydrogen arsenide and formation of the hydroxide of the metal.—A study of methylic oxymethylene-cyanacetate and some of its homologues, by M. E. Grégoire de Bollemont. Methylic, ethylic, and amylic oxymethylene-cyanacetates have been prepared from the corresponding ethereal salts, which have been previously described. These compounds exhibit the characteristics of strong monobasic acids, and may be looked upon as substitution derivatives of formic acid.—The use of tetrachlorohydroquinone for the characterisation and separation of fatty acids, by M. L. Bouveault. Tetrachlorohydroquinone reacts with one and two molecules of the chlorides of fatty acids to form stable, well-crystallised compounds which are easily purified, and thus eminently adapted for the identification, and in some cases for the separation, of the acids. The physical properties of some of these compounds are described.—On the presence in the animal organism of a soluble ferment which reduces nitrates, by MM. E. Abelous and E. Gérard. Experiments are described which show that the various organs of the body contain, in different proportions, a soluble substance of the nature of a ferment which reduces nitrates to nitrites. A temperature of 20-40° is most favourable to the reaction, which ceases altogether at 72°.—On the reducing power of urine, by M. Henri Hélier. The author determines the reducing power of urine by titration with potassium permanganate solution in the presence of sulphuric acid, the result being expressed with reference to urine of normal concentration, as measured by the amount of urea present. In many diseases, the reducing power is characteristically higher or lower than the normal.—Contribution to the study of the bark of *Rhamnus purshiana* (Cascara Sagrada), by M. Leprince. The presence is demonstrated of chrysarobin, chrysophanic acid, and emodine.—Direct transformation of acetamide into ethylamine by hydrogenation, by M. Guerbet. The reduction is effected by means of metallic sodium in the presence of boiling amylic alcohol.—On the secretion of diastases, by M. Dienert.—Peculiarities of the eruption of Vesuvius, by M. Matteucci.

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