THURSDAY, JUNE 5, 1890.

TEA IN JAPAN.

Researches on the Manufacture of Various Kinds of Tea. Bulletin of the Imperial College of Agriculture and Dendrology. By Y. Kozai, Assistant in the Agricultural Chemical Laboratory. (Tokio, 1890.)

Y. KOZAI is a Japanese chemist who performed his researches under the control of Dr. Kellner, the Director of the Chemical Laboratory at Tokio. His paper includes the chemical constitution of tea, the effect of tea on mankind, the principal methods of manufacture employed in Japan, and the methods of preparing tea for consumption. These subjects are all treated mainly from the point of view of the analytic chemist. The author appears fairly well acquainted with what the German chemists have done in the matter of tea.

We need not abstract much of his account of the constitution and properties of tea, as it is largely taken from European sources. "The chief action of tea, after it has got into the blood, is to excite the nervous system; it thus harmonizes the mind, drives out drowsiness, and awakens thought, stops hunger, and cures repletion, refreshes the body, and prevents head-ache"—and (it might be added) if taken too strong keeps you awake half the night. As to its constitution, tea contains (besides the common plant-constituents) theine, a volatile oil, and tannin. Theine is a rank poison, in toxic doses causing convulsions and paralysis, in lethal doses death; but in small quantities is (like strychnine) a delicate tonic. Of the volatile oil, Y. Kozai can affirm little beyond its well-known exciting action upon the organs of taste and smell; nor is it easy to follow it analytically through the processes of manufacture; the hot steaming employed (at near boiling temperature) in the green-tea manufacture does not appear to diminish the volatile oil sensibly, though Y. Kozai intimates that preparing green tea by boiling does dissipate the aroma. As to the properties of tannin, it is an astringent remarkable for its strong affinity for the albuminoids; hence, if taken in excess, it may, by precipitating the ferments of the digestive fluids, cause indigestion.

The account of the chief Japanese methods of manufacture is of more interest and instruction to the European planter.

We may premise that there are two (main) kinds of tea, viz. black and green. In the manufacture of black tea there are four essential processes, viz. (1) withering; (2) rolling, (3) fermenting, (4) drying. In the manufacture of green tea, the fermenting is omitted, and in Japan (for some kinds of green) the rolling also.

For the manufacture of black tea there is no real difference between the Japanese method and that practised by English planters in Bengal. The fresh picked leaf (*i.e.* tips of the young shoots) must be first withered, or the petioles and leaves break under the rolling; the exposure of an hour or two in strong sun withers the leaf sufficiently; if there is no sun, the leaf must be withered by the aid of fire-heat. The rolling is done, even in Japan, by the aid usually of a box, and in Bengal often by steam-power (and very roughly). The juices are thus expressed, and the leaf given a "nice" twist, *i.e.* a twist pleasing to the fancy of the tea purchaser. What perhaps renders rolling so essential in the manufacture of black tea (for it is not esssential in the manufacture of green), is that it masses the leaf in a state conducing *without delay* to fermentation. Neither Y. Kozai nor the best Bengal authorities like to lose the juices more than can be helped. He also hazards the view that, by rolling, the juice is expressed from the cellular tissues of the leaves and impregnated upon their surface; thus is produced fine aroma, and the leaves are more easily infused. Fermentation is the most important point in the manufacture of black tea, and by it (*fide* Y. Kozai) the leaves lose their raw smell, and the tea acquires its fine flavour. The fermentation is really only carried a very little way: Y. Kozai says it should be allowed, in a temperature of 104° F., to proceed only for about an hour. He thinks the process is a true fermentation, because if permitted to run too far the tea acquires an acid taste. He thinks it probable that the ferment is caused by a living organism, but he adduces very slight ground for this opinion; and it has, in fact, been questioned whether there is any true fermentation in the process at all. But the English tea-makers are agreed with the Japanese in the importance of stopping the fermentation exactly at the proper point by drying the tea, which is usually done by placing it first in the sun and turning it over till it is fairly dry, and then thoroughly drying it by fire-heat.

The result of all the Bengal experience is that the black tea is at least as good when these four processes are done simply and rapidly, as when much labour and time are expended in complicating them. In the early days of tea manufacture by Anglo-Indians, great pains were taken to imitate with tedious minuteness the careful hand-processes (and repetitions of portions of the processes) as practised in China; but all planters now follow rapid short cuts to the finished tea.

The manufacture of green tea is nothing more than drying the leaf; it is so little practised in British India as to be of no commercial interest there, but Y. Kozai describes in detail three kinds of green tea manufactured in Japan.

(1) *Japanese* (not China) *green tea.* In this, the leaf is steamed in order to remove the raw flavour; it is then rolled and fire-dried, the two last processes being usually done together.

(2) *Chinese green tea.* In this, the leaf is roasted (while stirred with a stick) in an iron pan over a fire, then rolled a little, then roasted again; these processes being repeated even six or eight times, and the tea is then finally dried off.

(3) *Flat tea*, the highest class tea of all. For this tea, the shrubs are usually kept shaded for three weeks before picking, so that the leaf is partly etiolated. The choicest leaves are selected before the manufacture is commenced. They are steamed, but never rolled; nor, indeed, touched by hand at all, but carefully turned by the aid of a bamboo stick. After sufficient steaming they are simply dried.

The author finds by analysis that there is 30 per cent. more theine in etiolated leaves than in the leaves of the same plants grown in the light. He tried many experiments to test the chemical effect of the manufacturing processes. Among other tables given by him is the following; a quantity of leaf was divided into three portions, whereof one portion is A, another portion is manufactured into green tea B, the third portion is manufactured into black tea C. Y. Kozai analyzses A, B, C, and finds—

	A.	B.	C.
Crude protein	37·33	37·43	38·90
Crude fibre	10·44	10·06	10·07
Ethereal extract	6·49	5·52	5·82
Other nitrogen-free extract	27·86	31·43	35·39
Ash	4·97	4·92	4·93
Theine	3·30	3·20	3·30
Tannin	12·91	10·64	4·89

He remarks that the general result of the green-tea manufacture is merely to dry the leaf; the black-tea manufacture alters materially its chemical constitution. The principal change is the remarkable diminution of the tannin. He does not explain how this is brought about, nor is it easy to see how the incipient fermentation should affect the tannin.

The only teas exported to Europe from Japan are of low class; they are frequently "faced," and sometimes mixed with the leaves of various Japanese plants. Any plentiful leaf, not too unlike the leaf of tea, will do for this adulteration; the leaves actually employed are (Y. Kozai assures us) all harmless, and several contain tannin, but none of them any theine. As to the "facing," he says it can hardly be called adulteration; the quantity of Prussian blue employed to improve the appearance of green tea is (according to Y. Kozai) about 0·001 per cent. the weight of the tea, perfectly innocent, and pleasing to a purchaser.

The author concludes with an account of the different ways of taking tea in Japan, with some analyses of the prepared liquor.

(1) In the case of flat tea, or of the very finest quality of Japanese green tea, the tea is ground to fine powder, and the whole infusion drunk.

(2) In the case of superior (*i.e.* from the Japan point of view) tea, the leaves are infused for two minutes in water at 120°–150° F.

(3) In the case of a medium tea, the leaves are infused for one minute in boiling water.

(4) In the case of inferior tea, the leaves are boiled in water.

The object to be aimed at in the preparation is to get the largest possible quantity of theine without dissipating the aroma, and accompanied by only a moderate amount of tannin. Y. Kozai gives analyses to show that this is effected (in the case of superior teas) by the infusion in water at 120°–150° F. for two to five minutes. By superior teas, he understands teas worth five to seven shillings a pound in Japan. It is probable, therefore, that the highest class teas we ever have to deal with in England come under the medium teas of Y. Kozai, which require infusion in boiling water—for one minute at least. The majority of English people like a good deal of chicory with their coffee, and probably a majority also like a good deal of tannin with their tea; and to them the analyses and recommendations of the Japanese writer are of small importance.

The paper will be of more use as food for reflection to the Anglo-Indian planter than as direct instruction. The palate of the Englishman is as yet only very roughly educated in tea. There can be very few Englishmen who would greatly prefer the superior teas of Japan and China to the ordinary Kumaon or Ceylon tea; most persons used to drinking the latter would probably prefer it to the most expensive tea made—say China tea worth forty shillings per pound in China. The English planter in Bengal has a tea-garden of 200 acres (possibly still larger). His object is, by the aid of a steam-engine or other coarse help, to put his tea through—to keep his factory clear when he has a strong flush on. He has to carry the daily make through by the aid of uncivilized labourers and overseers. He must reduce every step of his manufacture to a routine; he must have no special tea separately and differently manufactured, and no current experiments. Few planters have made much profit by Pekoe; and the green tea hardly exists commercially in India. There are no doubt many Englishmen who, having not a plantation but (literally) a garden with some tea in it in India, have manufactured, not unsuccessfully so far as the flavour of the tea is concerned, green tea, Pekoe, &c., but this has been a fancy article for their own drinking or for presents, and has never been put in any quantity on the market. To plant successfully in India, the Englishman has to proceed on a broad scale; his large cost and high expected profit cannot be got out of the close superintendence of elaborate hand manufacture. Or, at least, it will be a long time before the public tea taste at home is sufficiently elevated to be willing to pay so large a price for such teas as would remunerate the English planter. For the present, the object of the planter must be to produce the maximum quantity of tea that the English grocer can sell at 1*s.* 6*d.* to 2*s.* 6*d.* a pound. Hence to planters the utility of the paper of Y. Kozai must be mainly future.

CATALOGUE OF BRITISH FOSSIL VERTEBRATES.

A Catalogue of British Fossil Vertebrata. By Arthur Smith Woodward and Charles Davies Sherborn. Pp. i.-xxxv., 1-396. (London: Dulau and Co., 1890.)

A WANT long felt by all students of the fossil Vertebrates of the British Islands has been supplied by the issue of the present volume, which, so far as we have been able to examine it, is noteworthy alike for the absence of misprints, the accuracy of the references, and the care which has been taken in the selection of the correct names for the various genera and species, as well as for the orthography of the names themselves. The last edition of the late Prof. John Morris's "Catalogue of British Fossils" was published as far back as 1854, and the advances made by this branch of palæontology since that date—and more especially during the last ten years—have naturally rendered that work quite out of date. It is true, indeed, that the first part of Mr. R. Etheridge's "Catalogue of the Fossils of the British Islands," and the British Museum Catalogues of Fossil Vertebrates, have afforded some assistance to students of this subject;

but since the former deals with the Vertebrates of one particular epoch, while some of the latter include only such of the British fossil Vertebrates as are represented in the National Collection, they in no way cover the ground occupied by the present work.

It is, of course, needless to say that the work before us is essentially a technical one, and therefore appeals only to students of this particular branch of science, or to those stratigraphical geologists to whom it is important to know the correct horizon, localities, and nomenclature of the fossil Vertebrates of the British strata. So far as completeness and accuracy are concerned, the work is beyond criticism; but we trust we shall not be accused of any carping spirit if we venture in the course of our notice to indicate a few points in which, according to our judgment, it might be improved.

The greater part of the introduction is occupied by an entirely new and very valuable history of the chief collectors and collections of the fossil Vertebrate remains found in the British Isles. Then we have a careful explanation of the general plan of the work; followed by some judicious remarks as to the harm that has been done to the science by the publication of a host of undefined names. When, however, the authors hold "a single University Museum" "responsible for no less than seventy meaningless terms," we venture to think that the individual or individuals by whom such names were proposed should rather have been held responsible for the same. Following the introduction, a table (for which the authors are indebted to Mr. W. H. Brown) of the dates of publication of the fasciculi of Agassiz's "Recherches sur les Poissons fossiles" will be found of especial value, as fixing the date of many genera of fossil fishes. Scarcely less valuable is the determination of the respective dates of appearance of the three parts in which Sir R. Owen's well-known "Odontography" was originally issued.

In the table of the stratigraphical distribution of British fossil Vertebrate genera, which concludes the prefatory portion of the volume, we must take exception to the very insignificant deposit known as the "Forest-bed" being allowed to take rank as the *Forest Bed Series*, as though it were of equal importance with the Pliocene and Pleistocene; under one of which it should have been included as the *Forest-bed Stage*.

In regard to the plan of the work itself, the various genera and species are arranged alphabetically under the classes to which they respectively belong—a mode of arrangement in which the authors follow the Morrisian Catalogue. They depart, however, from the latter in not mentioning the order to which each genus is commonly referred. Here, we think, the innovation is not an improvement, since in the case of stratigraphical geologists, who may have occasion to consult the work, it would often be an advantage to know at once to what large group any particular genus belongs; and even a student of one particular class of Vertebrates may well be at a loss to know the ordinal position of a genus belonging to another class with which he is less intimately acquainted.

It also strikes us that it would have been advisable to state the authority for regarding various genera and species as synonyms of others; for, as it stands at present, there is no evidence to show whether such references are made for the first time on the authority of the authors themselves, or whether others are responsible. Thus, under the head of *Hyracotherium leporinum* (p. 356) we find *Pliolophus vulpiceps* given as a synonym, without any guide to the authority for such reference. In this particular instance we believe the identification of *Pliolophus* with *Hyracotherium* was first made by Prof. W. H. Flower in his article "Mammalia," published in 1882 in the latest edition of the "Encyclopædia Britannica," and some reference to this should have been made.

On the whole, the authors appear to have exercised a wise discretion in not amending for the first time the spelling of such generic and specific names as are obviously incorrect according to a true Latinized orthography. We cannot, however, follow them in their refusal to accept emendations which have already been published in other works, more especially as they are not consistent in either adopting or rejecting such emendations. Thus, for instance, they adopt the name *Machærodus* (p. 366) as amended from the original *Machairodus*; but they refuse to accept *Ælurus* in place of *Ailurus* (p. 311), although the amended name has been published more than once.[1] Again, they retain *Leiodon* (p. 245) and *Platecarpus* (p. 264), although the amended *Liodon* and *Platycarpus* have been published—the latter, we admit, but recently. The authors seem, indeed, to have a rooted objection to the transliteration of the Greek *ει* into the Latin *i* (as may be noticed in the root *Cheir* instead of *Chir* under the head of Pisces); but this transliteration, as every student of our Greek Testament knows, is just as binding as that of *αι* into *æ*, or *ου* into *u*, and if the one change is rejected the others ought not to be adopted.

As a rule, the authors have paid attention to the gender of generic names, which is too often neglected. They regard compound generic names as substantives, and, therefore, bring the gender of the specific name into accord with that of the terminal portion of the generic one. They state, however, on p. 395, that they have not followed this rule in regard to names ending in *lepis*, where they have allowed the specific names to remain with the masculine termination. They appear to have adopted the same course with regard to the termination *batis* (*Aëtobatis*, p. 9); but in the case of *aspis* the authors seem to have been unable to make up their minds, since on p. 79 we find *Eukeraspis pustuliferus*, while on p. 129 we have *Odontaspis cuspidata*.

As features of especial value in the work before us, we may notice that in every instance where it can be ascertained the place of preservation of the type specimens is indicated; while all the recorded localities are given under the head of the various species.

The compilation of a work like the present is a labour which only those who have had the misfortune to try it can fully comprehend, and the thanks of every student are therefore due to Messrs. Woodward and Sherborn for the production of a book which is absolutely indispensable to all those who are engaged in the pursuit of this branch of palæontology.

R. L.

[1] See Flower, Proc. Zool. Soc., 1870, p. 752; and Blanford, "Fauna of British India—Mammalia," p. 189 (1888).

AN EPHEMERIS.

Connaissance des Temps. Extrait à l'usage des Écoles d'Hydrographie et des Marins du Commerce. Pour l'an 1891. (Paris: Gauthier-Villars et Fils, 1889.)

THE *Connaissance des Temps* has, within the last few years, by successive improvements, been made quite the most convenient Ephemeris for general use. The information it contains is conveniently given, and almost excessive in amount; and the result of course is that the pages of tabular matter are a good deal crowded, in order to make the annual volume of reasonable size. For travellers whether by sea or land it, like our own *Nautical Almanac*, is not, however, quite what is wanted. Much of the information it contains is of no use to them, and the size and weight of the book is excessive for their purposes. This appears to have come to the notice of the Ministry of Marine, who, in 1887, directed the publication of a pamphlet of extracts from the *Connaissance* containing the necessary information for Navigators and students for certificates as Masters, a copy of which is now before us.

In making this effort to meet the wants of a very large class of practical men the French have but followed the example of other countries. Some forty years ago the Prussian Government caused to be compiled a *Nautisches Jahrbuch*, which in its present form appears to be the best adapted of those we have seen for geographers and voyagers. It is manifestly copied, as to form, from the *Nautical Almanac*, avoiding all the matter useless to geographers, which is relegated to the well-known *Berliner Jahrbuch*; the contents are all given with an accuracy sufficient for the purposes for which it is intended: a thoroughly practical mind seems to have guided the whole arrangement, and the changes which seem desirable are but small. The American Government next published an *American Nautical Almanac*, which is practically a reprint of those parts of their larger Ephemeris which are supposed to be required at sea. It is needlessly accurate in its data, and needlessly bulky, but no doubt fulfils its object. And again, just before the French, the Austrian Government published at Trieste a Nautical Ephemeris founded on our *Nautical Almanac*, but almost identical in contents with that of the German Government before spoken of. This, it would seem, is published with the text and headings in more than one language.

The French work approaches most nearly in type to the American: it is mainly a reprint. That part which is not so is the Ephemeris of the Moon, and here convenience is sacrificed to a small gain of space. Not only are the pages crowded unduly, but the arguments (being at 12-hour intervals) are so far apart that interpolation becomes inconvenient.

Before closing we would like to point out that while all these Governments have provided an Ephemeris for their Nautical men and Travellers which is meant to be specially suited to their limited wants; England alone, which owns probably half the sea-going ships in the world, and furnishes no small proportion of the explorers, makes no special provision for them. It is not that there is no want felt: for there are several almanacs which, availing themselves of the *Nautical Almanac*, give astronomical data, together with various other matters useful to seamen. Our *Nautical Almanac* took its present form on the report of a committee of the Royal Astronomical Society, to whom reference was made by the Admiralty in 1830. No great change has been made since then, and it is beginning to be thought time that its contents should be revised: if this is done, we trust it may be considered whether the wants of navigation and geography should not be specially taken into account. If we are right in believing that the Austrian Government have founded on our *Nautical Almanac* a publication which admits of all the tabular matter, which is so difficult and expensive to put in type, being combined with a text in varying languages, it might be possible by the adoption of a suitable form, to supply the wants of other nations as well as our own. Our *Nautical Almanac* in its present form is used, we believe, extensively by those maritime peoples who adopt Greenwich as a prime meridian, and it would, we think, not be difficult to arrange with their Governments for impressions suited to each language.

OUR BOOK SHELF.

The Wimshurst Electrical Influence Machine. By W. P. Mendham. (Bristol: King, Mendham, and Co., 1890.)

THIS little book, which partakes somewhat of the nature of a trade catalogue, briefly describes and illustrates the construction and action of the Wimshurst machines made by the firm of King, Mendham, and Co., and of the accessory pieces of apparatus needed for use with these machines in performing the antiquated experiments so much in vogue with the dabbler in frictional electrical science. The study of high tension electricity is coming to the front so much just now, that it is a great pity Mr. Mendham has not utilized his opportunity better, and given to the class of readers for whom this book is intended some notion of the many instructive and easily performed experiments on the disruptive discharge, and on electrical oscillations, which we owe to Hertz, Lodge, and others. The only concessions made to modern discoveries are in the descriptions of apparatus to show the action of the electric discharge on smoke, and of the Thomson quadrant electrometer. The latter, however, had better have been left alone, for the description is too meagre to enable the action of the instrument to be appreciated, and the reader may be apt to imagine that the quadrants are intended to be connected up directly to the terminals of a Wimshurst machine. We need scarcely say this would be very hard on the instrument. H. H. H.

Pawnee Hero-Stories and Folk-Tales. By George Bird Grinnell. (New York: Forest and Stream Publishing Company, 1889.)

THE Pawnees were at one time what Mr. Grinnell calls "a great people." They roamed over a vast territory, and enjoyed considerable material prosperity. Now, their numbers are greatly reduced, and the few who remain give a very inadequate idea of the vigour of the original stock. The author of the present book knew the tribe intimately twenty years ago. He used to camp and hunt with them in Nebraska, and at night they told him hero-stories and folk-tales which had been handed on to them from their forefathers. Many of these narratives he carefully translated and wrote down at the time; and quite lately he visited his old friends for the express purpose of inducing them to extend his collection. They were eager to meet his wishes, and so he was able to bring together the stories which he has now published. He claims that they are recorded exactly as he himself heard them, and that they may therefore be regarded as faithfully reflecting the Pawnee character. As genuine documents, throwing light on the ideas and habits of a primitive people, the stories are of some scientific value; and students of anthropology will find in them a good deal that is interesting and suggestive. Mr. Grinnell adds various notes, in which he gives much well-arranged information as to the history, racial affinities, and institutions of the Pawnees.

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.*]

The Influences at Work in producing the Cerebral Convolutions.

DR. G. JELGERSMA, of Meerenberg, has recently published two remarkable papers,[1] in which he endeavours to explain the influence which leads to the production of the convolutions on the surface of the cerebrum and cerebellum. Many theories have been advanced to account for these. Several authorities have ascribed their presence to mechanical forces operating upon the brain from without, whilst others have sought to explain them by the supposition of different degrees of growth-tension acting upon the brain-surface; but in every case these theories, when submitted to the test, have broken down, in so far that it is impossible, by means of any of them, to show how it comes about that small animals have smooth brains, and large animals convoluted brains; how, in short, we should find in the beaver —an animal remarkable for its intelligence—a cerebrum almost entirely smooth, and in the sheep—an animal, shall we say remarkable for its dullness?—a brain with a high convolutionary system. Jelgersma not only explains this, but makes the apparent discrepancy the strongest pedestal of support to his theory. Briefly put, his views are as follows:—

The grey cortex of the cerebrum, which in different forms of the same animal group preserves a tolerably constant thickness, increases by surface extension. Now, if we extend the surface of a smooth-brained animal say four times, we must provide eight times as much white matter to fill the interior of the grey capsule, if we desire to keep the surface even; or, to put it in different terms, if we lengthen out the radius of the brain say ten times, we acquire a surface extension one hundred times greater, and an internal capacity one thousand times greater. The geometrical law involved is simply this, that in the growth of a body the surface increases with *the second*, but the interior with *the third* power of the radius.[2]

Such being the case, it is very evident, seeing that the proportion of internal white matter and external grey matter is in all cases a uniform one, that in the evolution of a large animal out of a small animal, a disproportion between the grey capsule and the white core of the cerebrum must result. This is compensated for by the extended cortex placing itself in folds or puckers, and thereby reducing the capacity of the capsule to a degree which brings it into correspondence with the white contents. Consequently, "the formation of the convolutions and furrows is simply the result of the tendency on the part of the superficial layer to increase by surface extension and of a mutual space-accommodation (*Raumaccommodation*) of the grey substance and of the white conducting paths."

I have not written this short account of Jelgersma's views—important though they be—simply for the purpose of giving them a wider circulation through the pages of NATURE, but with the object of stating that the theory advanced has received independent testimony in its favour at the hands of my colleague, Prof. George F. Fitzgerald. For two years or more I have been engaged in a research bearing upon the growth of the cerebral hemispheres, and have constantly had occasion to appreciate the unsatisfactory nature of the current theories as to the formation of the convolutions of the brain. Consequently, in February last, before I had read Jelgersma's first article, and before the appearance of the second, I explained to Prof. Fitzgerald, as far as I could, the conditions of cerebral development, and asked him if he could offer any geometrical explanation which would account for the appearance of the convolutions. The views which he then advanced were identical with those of Jelgersma, and further, they were expressed in very similar terms. I feel that this adds greatly to the weight of the hypothesis.

But Prof. Fitzgerald went further than Jelgersma, because the latter states that he is unable to explain why the fissures and convolutions should, within certain limits, assume the same formation in different animals. Fitzgerald, however, saw the importance of his theory in regard to the localization of function in different areas of the cerebral cortex. The surface extension of the cerebrum cannot be a uniform one: the bulgings out in the shape of the convolutions must necessarily be connected with the functions which the areas involved have to perform. Therefore if a given area of grey matter increases it must pucker out, unless an undue quantity of white matter grows all over the inside of the grey cortex.

D. J. CUNNINGHAM.
Anatomy School, Trinity College, Dublin,
May 24.

[1] "Über den Bau des Säugethiergehirns," *Morphologisches Jahrbuch*, June 1889; "Das Gehirn ohne Balken: ein Beitrag zur Windungstheorie," *Neurologisches Centralblatt*, March 1890.

[2] It is right to state, although, indeed, Jelgersma does not mention it, that many years ago Baillarger ascribed the increase of the convolutions with the increase in the size of the animal to the same geometrical law.

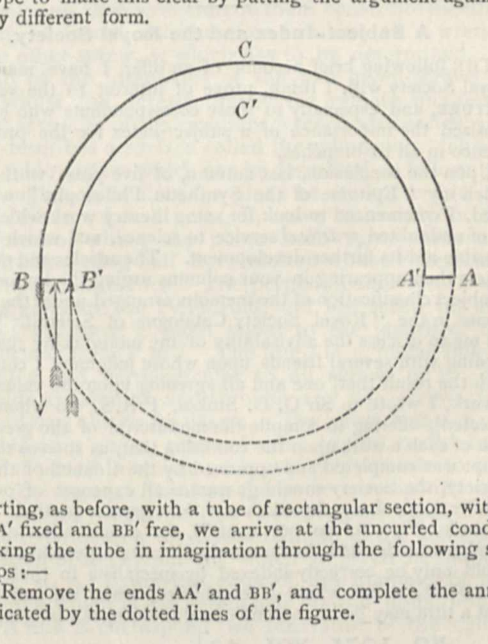
The Bourdon Gauge.

FROM Prof. Greenhill's letter on this subject in NATURE, vol. xli. p. 517, as well as from that of a writer in *Engineering*, I gather that I did not succeed by my letter (NATURE, vol. xli. p. 296) in making quite clear the point of my explanation of the action, since Prof. Greenhill argues that consideration of the longitudinal stresses in the walls leads to the conclusion that the tube would curl up under internal pressure rather than uncurl.

Towards the top of the second column on p. 296 in my letter I used the words "Consider now the equilibrium of any portion . . . when the internal pressure is applied and before uncurling takes place." Perhaps it would have been clearer to have written "*after the internal pressure has been applied*," &c. In the last figure on the same page the tension T is that exerted by the outer wall *of the already distended gauge* as it contracts, while P is the thrust of the inner wall, each on the part BC supposed solidified.

I desire specially to emphasize the words italicized, for my method of explanation amounts to an artifice for taking the distension into account. It is because Prof. Greenhill has overlooked this that he arrives at an opposite conclusion, and wishes apparently to reverse the forces in the figure referred to.

I hope to make this clear by putting the argument again in a slightly different form.



Starting, as before, with a tube of rectangular section, with the end AA' fixed and BB' free, we arrive at the uncurled condition by taking the tube in imagination through the following series of steps:—

(1) Remove the ends AA' and BB', and complete the annulus as indicated by the dotted lines of the figure.

(2) Now apply internal pressure. This distends the tube, stretching the roof and floor. The inner wall is compressed with a longitudinal thrust, and the outer wall stretched with a longitudinal tension, but the change in the diameter AB, or in the diameter A'B', will be practically unobservable.

The action on the original gauge and its enclosed fluid of the added part and its fluid, consists now of the forces indicated in the figure, and which amount, as I have in my previous letter pointed out, to a couple (counter-clock-wise in the present figure).

(3) Now replace the ends at AA' and BB' (this makes no difference in the equilibrium), and holding AA' fixed, remove the added part.

The gauge will now uncurl, for we are removing the counter-clock-wise couple necessary to maintain equilibrium. Or, to put it in other words, the outer wall ACB, on being released from the tension at B shortens, while the inner wall being released from the pressure at B' becames longer, thus causing the gauge to uncurl.

As to Gauss's purely geometrical theorem, I fail to see how it is to be of any use in the analysis of the forces, which I take to be the real problem. All that Gauss says to us by his theorem is, "Pure bending in your gauge means uncurling; if, therefore, you can prove that the forces are such as to produce pure bending, you prove that they produce uncurling." But this is exactly what we cannot prove. Indeed, it is admitted that the bending is not pure. And it is, I think, of no use to urge, with Lord Rayleigh, that the bending is *nearly pure* on account of the comparative inextensibility of the material, for that argument would apply equally to the gauge with both ends fixed, or to a complete annulus which obviously cannot uncurl. In fact, if we could go back to Gauss and ask, "Is it any use showing that the bending is 'nearly pure'?" he would ask us what we meant by "nearly," and before we could answer that we should have to analyze the whole action. It is for these reasons that I consider the reference to Gauss's theorem not only unfruitful but misleading.

If we apply the method I have suggested to a tube of elliptical or other than rectangular section, we see that unless longitudinal stresses such as I have dwelt upon would exist in the walls were the annulus completed, the distended gauge will not uncurl on the removal of the added part, and the only reason for considering the curvature of either wall in a plane perpendicular to the circular axis, is that such curvature may, on account of the properties of the material by which it is able to distribute stress in different directions, lead to additions to or subtractions from (and conceivably therefore reversals of) the longitudinal thrust or tension that would exist in a tube of rectangular section. But this is obviously a question of the structure of the material and not of pure geometry. A. M. WORTHINGTON.

R.N.E. College, Devonport, May 14.

A Subject-Index and the Royal Society.

THE following brief account of an offer I have made to the Royal Society will, I think, prove of interest to the readers of NATURE, and especially to those correspondents who have emphasized the importance of a subject-index for the progress of science in all its branches.

Upon the conclusion, last autumn, of five years' work, during which my "Epitome of the Synthetic Philosophy" was compiled, I commenced to look for some literary work which would be of undoubted *practical* service to science, and which would if possible aid its further development. The articles and numerous letters then appearing in your columns urging the importance of a subject classification of the memoirs arranged under the authors' names in the "Royal Society Catalogue of Scientific Papers," led me to discuss the advisability of my undertaking such a proceeding with several friends upon whose judgment I could rely; with the result that, one and all agreeing upon the value of such a work, I wrote to Sir G. G. Stokes, P.R.S. (to whom I was directed), offering to compile the manuscript of the greater portion of such a work upon the condition that, as soon as the manuscript was completed and approved by the Council of the Royal Society, the Society should guarantee all expenses of print and publication. I was forced to say "the greater portion" of such a work ("70 to 80 per cent."), for examination of a large number of titles had shown me that a certain percentage of them could only be correctly indexed by specialists in their own departments, a fact which is emphasized when we call to mind that a title may be in any one of eight European languages.

After several interviews with Sir G. G. Stokes, and a somewhat protracted correspondence, I agreed to arrange a sample index of some 2000 entries upon a plan suggested by him, and warmly approved by that eminent bibliographer Dr. Garnett, of the British Museum, the plan being to take the leading word or words in the title of each paper, with a reference to the volume, page, author's name, and number of the paper, in the Royal Society's Catalogue, for subsequent arrangement in alphabetical order, by which means the subject-key would occupy but a quarter of the bulk of the Catalogue as now published. It would extend—that is, approximately—to three quartos of the size of the present volumes, in similar type, &c.

In the early part of May this plan was discussed by the Catalogue Committee of the Royal Society, when the following resolution was passed:—"That the offer of Mr. Collins be declined, and that the President be requested to convey to Mr. Collins the best thanks of the Committee for the trouble which he has taken."

The foregoing account will be sufficient to show that, contrary to an opinion expressed more than once in these pages, something more is needed than an offer to compile the subject-index. Were the manuscript now completed, and approved by the Royal Society, there would still be wanting a sum sufficient to bring it before the public.

In conclusion, I should like to express my warm thanks to Sir George Stokes for the kind and courteous way in which he has assisted me in my endeavour to develop what I am still convinced would be of immense service to science in all parts of the civilized world; and not only to science, but to many industries besides. For would not the chemical manufacturer and the dyer profit by a complete list of all the papers that had been written on the coal-tar colours; the agriculturist, by knowing the researches which had been undertaken to ascertain the nutritive powers of the bones and phosphates, and the fattening properties of the various cakes and foods; the engineer, the analyses of iron and steel with their accompanying properties; the physician, the physiological action of the various drugs; and the electrician, all the papers, for instance, which had been written upon that little understood subject, induced currents? Finally, how many millions might have been saved in the construction of harbours all over the British Empire had all the scattered information upon the flow of water in rivers and tidal estuaries been so gathered together as to make reference possible, not to say easy? F. HOWARD COLLINS.

Churchfield, Edgbaston.

Stream Lightning.

IF a candle-flame is put between the poles of an electrical machine, while it is giving rough angular sparks, the discharge at once changes into a smooth single line of very easy curvature: it suggests the difference between sinuous and stream lightning: it is not merely that the spark is as if shortened by the conducting flame; the whole nature of the discharge is changed. If the flame is held two inches beneath the poles, the spark will go down to it. W. B. CROFT.

Winchester College, May 30.

Atmospheric Circulation.

ON March 9 and 10, 1887, the barometer rose to 30·92 inches over Iceland—a very exceptional height for that locality at that time of the year. The United States daily maps of the northern hemisphere show that a storm to the southward of this great anticyclone was carried westward a distance of over six hundred miles within twenty-four hours, in a manner similar to that in which West Indian hurricanes follow the course of the trade winds in August and September, although this storm was located in latitude 40° N., or in the usual situation of the anti-trades. Other instances of a similar character have been noted, but this one was unusually well defined, and throws much light upon the laws governing the atmospheric circulation.

Lyons, N.Y., May 20. M. A. VEEDER.

Testing for Colour-Blindness.

IN answer to Prof. Lodge's query (May 29, p. 100), why those concerned in testing for colour-vision do not avail themselves of instruments like Lord Rayleigh's, having tested some thousands in this city, I may state that experience has shown that they are not suited for testing uneducated persons. A similar instrument, introduced by Chibret and Meyer, of Paris, is to be found in ophthalmic hospitals.

I may further remark that I do not consider any test satisfactory unless made by an ophthalmic surgeon, as he alone is accustomed to deal with such people every day of the week, and can alone eliminate such errors as refraction-disease and stupidity.

D. D. REDMOND.

14 Harcourt Street, Dublin, May 3.

The Green Flash at Sunset.

YOUR correspondents (vol. xli. pp. 495, 538) seem to imply that this phenomenon is only seen at sea, but I observed it on May 17 while walking from east to west, near Worms Heath (Warlingham, Surrey). It had been an exceptionally fine day, since the morning, and about 8 p.m. there was not a cloud in the sky, except to westward, where strips of cloud were rapidly forming, and covering up the glow of sunset; the sun had sunk behind a hill, when, suddenly, my companion and I both saw a flash of green light against the thickest cloud; it lasted 1 or 2 seconds, just long enough for there to be no doubt about it. We compared it to the glare thrown by "green fire," extending over an area whose diameter appeared about four times that of the moon.

At 12 p.m. the same night it was raining.

I think this observation definitely negatives the sea-wave theory, while the appearance was seen at least in association with the condensation of aqueous vapour. Perhaps the reason it was not *bluish*-green was that this vapour absorbed the blue rays?

T. ARCHIBALD DUKES.

16 Wellesley Road, Croydon, June 2.

THE THEORY OF SCREWS.[1]

THE book before us, a large octavo volume of over 600 pages, gives in a connected form the results of Sir R. S. Ball's investigation in the theory of screws, as contained in his "Theory of Screws" and a series of publications in the Proceedings and Transactions of the Royal Irish Academy. But as its scheme is that of a text-book on theoretical mechanics, it begins with a chapter on the postulates and methods of mechanics; whilst chapter vii. is on the theory of moments of inertia; chapter viii. on impulsive forces capable of imparting to a rigid body a given state of velocity; and chapter x., on kinetic energy, contains a number of propositions from analytical dynamics. Here expressions for the kinetic energy, for its change in consequence of an impulse, Lagrange's equations of motion in generalized co-ordinates, Hamilton's principle of least action, and various other propositions, are developed in the usual form—that is to say, without the use of screws. The rest of the book relates to the theory of screws and its applications. This alone, as forming the characteristic feature of the book, concerns us here, and of it we shall try to give an outline.

In order not to be unintelligible to those who have no knowledge of Ball's creation, it will be necessary to begin with the very elements of the subject; and in order to form a just idea of the scope and importance of the new method, it will not be sufficient to give a sketch of the results obtained—it will be necessary to take a wider view of the subject. We shall then be able to form some idea of the inherent capabilities of the theory. These I believe to be very great—very great indeed. One of its peculiarities lies in this, that all the results obtained in modern algebra and geometry, as distinct from analysis, seem to be directly applicable to it.

Friends of synthetic geometry and of graphical methods, too, will find here a wide field for investigations. Grassmann's "Ausdehnungslehre" has already been pressed into its service, and the theory of vectors and quaternions is easily applicable. Clifford, in fact, has generalized the latter theory into that of biquaternions to embrace screws.

Mr. Cartesius, to make use of Sir Robert's personifications, has been dethroned, and Mr. Anharmonic together with Mr. One-to-one reign in his place.

Poinsot, whose investigations form the starting-point of the theory of screws, has proved that a rigid body can always be transferred from one position to any other by a rotation about a certain perfectly determined axis, together with a translation along this axis. These two motions combine to a motion identical with that of a nut on a screw. It is completely determined if the angle through which the rotation takes place, together with the ratio of the translation to the rotation, is given. This ratio—*the "pitch" of the screw*—characterizes the screw. As the motion does not at all depend upon the diameter of the screw, we may suppose this to become infinitely small, and then we have the notion of Sir R. Ball's *screw*.

A screw, therefore, is a line in space which has connected with it a certain pitch—*i.e.* a certain length, as the pitch is a linear magnitude. The compound motion considered is called a "twist" about a screw, and is known if the screw and the "amplitude" of the twist, *i.e.* the amount of rotation, is given. In the same way a system of forces can, according to Poinsot, always be reduced, and that in one way only, to a single resultant and a couple turning about the resultant; and these two dissimilar parts Ball combines to a "wrench on a screw," the line of action of the resultant force being the axis of the screw and the ratio of the moment of the couple to the force giving the "pitch," whilst the magnitude of the resultant force is called the "intensity" of the wrench.

We have thus a new entity—the screw—and its introduction forms the characteristic distinction of the theory. Connected with it is a kinematical and a kinetic entity—the twist about a screw, and the wrench on a screw.

If we now consider a rigid body under the action of any forces, then the latter combine at every moment to a wrench on some screw, whilst the motion itself is always a twist about some other screw. If the body is constrained in any manner, then the reactions due to the constraint will also at every moment combine to a wrench about some screw.

The problem first to be solved is that of the combination of twists and wrenches. Let any two screws, α and β, be given, then wrenches on them constitute together a system of forces, and therefore combine to a wrench on some other screw, γ, which has to be determined. If the ratio of the intensities of the two given screws be varied whilst the screws themselves remain unaltered, then the screw, γ, of the resultant wrench also varies, and its axis describes a surface called the cylindroid. This is a ruled cubic surface which can be described as follows:—Let through a fixed line, l, a plane be drawn, and in it a circle be taken. Let a point, P, move uniformly in the circumference, whilst the plane itself turns uniformly about l, completing half a revolution whilst P describes the whole circumference. The perpendicular from P to l will then generate the cylindroid, and the screw on any generator will have a pitch equal to the length of the perpendicular from P to l. The line l is a nodal line of the surface and perpendicular to all screws on it. All cylindroids are similar, and through any two screws one cylindroid can always be drawn. The projections of all generators on a plane, perpendicular to the nodal line, form a flat pencil in which each ray corresponds to one screw. Also to each point on the circle corresponds one screw. We may here mention that this generation of the cylindroid stands in a very close relation to the plane representation of the cylindroid which is given in chapter xx. For if A, B are the ends of the diameter of the above circle which is perpendicular to the nodal line l, then to A and B correspond two generators of the cylin-

[1] "Theoretische Mechanik starrer Systeme auf Grund der Methoden und Arbeiten, und mit einem Vorworte von Sir Robert Ball, Royal Astronomer of Ireland." Herausgegeben von Harry Gravelius. (Berlin: Georg Reimer, 1889.)

droid which meet at right angles. Let the corresponding screws be α and β. Then if the circle when in a plane with α be turned about its diameter through a right angle it will be parallel to the plane of the pencil and may be taken to coincide with it. In this position we get the circle used in chapter xx. We recommend the reader to go through the first pages of this chapter when reading the third and fourth.

To combine two wrenches on two screws, α and β, we have to construct the cylindroid containing the screws and the flat pencil spoken of. If on the two rays in this pencil which are the projections of α and β the intensities of the wrenches be set off (they are the forces which together with couples constitute the wrenches), then their resultant gives not only the intensity of the resultant wrench, but it lies on the ray which is the projection of the screw of the resultant wrench. From this follows at once: Any two wrenches on screws of a cylindroid combine to a wrench whose screw lies again on the cylindroid; and conversely, a wrench on a screw belonging to a cylindroid can be decomposed into two wrenches on any two given screws on the cylindroid. Also, on any three screws of a cylindroid wrenches can be determined which are in equilibrium. It need scarcely be stated that the ratios only of their intensities are determined; but it is of importance to remember this.

The above results for the composition of wrenches hold also for twists about screws, provided that their amplitudes are very small, in conformity with the well-known fact that small rotations are combined in the same manner as forces. For this reason Sir R. Ball has limited his investigations to cases where the twist velocities have infinitely small amplitudes. These include equilibrium, beginnings of motion due to impulses and small oscillations. He also supposes the forces always to have a potential. Within these limits his results are of absolute generality.

The remarkable analogy between forces and rotations which appears in analytical mechanics rather as an accidental, though interesting, circumstance, is raised in the theory of screws to a principle of paramount importance.

If a rigid body acted on by a wrench receives a small twist, then the work done by the wrench is the product of the intensity of the wrench, of the amplitude of the twist, and of a geometrical factor which depends solely upon the two screws of the wrench and twist. Half this factor Ball calls "*the virtual coefficient of the two screws.*" If the screws meet it is proportional to the cosine of the angle between them; if the pitches of both screws vanish, or more generally if their sum vanishes, it becomes the moment of the two lines on which the screws lie. It partakes, therefore, of the nature of both these quantities, and its analogies to the cosine especially are, in many cases, very marked. If the virtual coefficient vanishes, then no work is done by the wrench in consequence of the twist. Now the virtual coefficient of two screws, α and β, depends symmetrically on both, hence if a wrench on α does no work when the body is displaced by a twist about β, then also a wrench on β does no work during a twist on α. For this reason two screws whose virtual coefficient vanishes are called *reciprocal*.

An immediate consequence of the definition of reciprocal screws is this, that a screw which is reciprocal to two screws, α, β, is reciprocal to all screws on the cylindroid determined by α, β. For a twist about any screw, γ, on the cylindroid can be decomposed into two about α and β; but the wrench can do no work against these, and therefore it can do no work against a twist about γ.

It is also proved that through every point in space there pass a single infinite number of screws, which are reciprocal to a cylindroid. These lie on the generators of a cone of the second order. Similarly, all screws in a plane which possess the property in question envelop a conic, and in chapter xxi. it is shown that this is always a parabola.

Two screws which meet can be reciprocal only if they meet at right angles or if the sum of their pitches vanishes. This gives rise to one of the most powerful methods for finding reciprocal screws. Thus, as every line meets a cylindroid in three points, and therefore cuts three screws on it, and as the cylindroid contains only two screws of equal pitch, it follows a screw, α, reciprocal to a cylindroid must cut one screw on it at right angles, and the two others which it meets must have equal pitches, viz. these must be equal and opposite to the pitch of α; and from this, again, it is easily deduced that every line which meets one screw on a cylindroid at right angles cuts, besides, two others which have equal pitch; for if on this line a screw be taken with a pitch equal to one of the two remaining screws which it cuts, it will be reciprocal to the cylindroid.

Just as two wrenches on screws α and β always combine to a wrench on a screw lying on a certain cylindroid, so three wrenches on screws α, β, γ, which do not lie on a cylindroid, combine to a wrench on a fourth screw which is connected with the three given ones, and which depends on the two ratios only of the intensities of the three given wrenches.

The entirety of all the screws which are got by varying these ratios forms a system of a double infinite number of screws, which has been called a screw-complex of the third order.

If any four screws belonging to such a complex are selected, then a wrench on one of them can be decomposed into three wrenches on the others. It is also always possible to determine wrenches on the four screws which are in equilibrium, and the ratios of their intensities alone are then determined. Similarly, five independent screws, *i.e.* screws which do not belong to a complex of lower order, give rise to a complex of order five, and six independent screws to a complex of order six. To this latter complex all screws in space belong, for in chapter v. it is shown that in general any wrench can be decomposed into six wrenches on six arbitrarily selected screws. A screw-complex of order two is nothing but a cylindroid, and a complex of order one consists of one single screw. That a complex of order six exhausts all screws in space, says only that the number of all screws is ∞^5, if ∞^1 denotes the number of points in a line, or the number of values which a single real variable, x, may assume. That the number of all screws is ∞^5 is also at once evident if we consider that the number of lines in space is ∞^4, and that on each line we have a single infinite number of screws which are obtained by giving its pitch all possible values from $-\infty$ to $+\infty$.

There is an important theorem that the screws which are reciprocal to all screws in a complex of order n form themselves a complex of order $6-n$.

One of the chief uses made of these results consists in the introduction of screw co-ordinates, viz. six independent screws are selected as co-ordinate screws. Then the intensities of the components of a wrench on these six screws are taken as the co-ordinates of the wrench. In the same way the co-ordinates of a twist are obtained. Lastly, by the co-ordinates of a screw are understood the co-ordinates of a wrench of unit intensity on the screw, or those of a twist of unit amplitude about it. To get, then, the co-ordinates of any wrench on, or a twist about, a screw, the co-ordinates of the latter have only to be multiplied by the intensity of the wrench or the amplitude of the twist. Between these screw co-ordinates exists, however, an equation of the second degree, just as between the ordinary homogeneous point co-ordinates there exists a linear equation. A screw is thus completely determined by the ratios of its six co-ordinates, *i.e.* by five numbers, which again shows that there are ∞^5 screws in existence. Having established the notion of these co-ordinates, there are next given, in chapter v., expressions in terms of the co-ordinates for the resultant of a number of wrenches or twists, for the work done by a wrench on one screw during a twist on another, and so on. These expressions are much simplified by selecting the screws of reference in a particular manner, viz. so that any two of them are reciprocal, and such a system of "co-reciprocal" screws is afterwards always used.

The expression for the virtual coefficient of two screws is in general a lineo-linear function of the co-ordinates of both screws. But this is simplified for the special system of co-ordinate screws just mentioned, in reducing to an expression of six terms only, each being the product of the co-ordinates of the two screws relating to the same co-ordinate screw into the parameter of this screw. This expression must vanish if the two screws shall be reciprocal. Hence the condition that a screw shall be reciprocal to a given screw is expressed as a linear equation between its co-ordinates, and it is important to add that every linear equation between its co-ordinates can be interpreted as meaning that the screw is reciprocal to some other screw. But one linear equation enables us to express one of the co-ordinates in terms of the others, so that all the co-ordinates of all screws which are reciprocal to a given screw can be expressed in terms of five co-ordinates, in other words, a screw in a complex of order five is determined by five co-ordinates. In the same way two linear equations limit a screw to a complex of order four, and so on, till we come to five equations as determining one single screw; which also shows that there is always one screw which is reciprocal to five given screws.

We leave for the moment the line followed by Ball and Gravelius, in order to indulge in some very general speculations, in close connection with chapter xix., which seem best suited to give, in as short a compass as possible, a clear insight into the nature of the whole system of screws.

We are accustomed to express the fact that the number of points in a plane is ∞^2 by saying a plane, or in fact any surface, is of two dimensions if we consider the points as elements. Space is, in the same sense, of three dimensions, whilst it is of four dimensions if we consider the lines as elements.

We may extend this language, and say the aggregate of all screws forms a space of five dimensions, or as Clifford would have said, it is a five-way spread. If we now assume between the co-ordinates one equation, we may speak of the locus of screws whose co-ordinates satisfy this equation. It will be a four-way spread, or a space of four dimensions. This locus is called by Ball a screw-complex of order five and degree *m*, if *m* is the degree of the equation. The complexes spoken of before are of the first degree.

The geometrical theory of screws becomes thus identical with the geometry of a space of five dimensions, which latter we may call the screw-space.

Let us consider now two such complexes of 1st degree, one of order *m*, the other of order *n*. The first is determined by a set of $6 - m$ linear equations between the co-ordinates, the second by $6 - n$ such equations. All screws common to both have therefore to satisfy $12 - m - n$ equations, and in case that this number is not greater than six, they will constitute a complex of order $6 - (12 - m - n) = m + n - 6$. Thus a complex of order 4 and a complex of order 5 will have a complex of order 3 in common, whilst two complexes of order 3 will in general have no screw in common, though they may have a single screw or a whole cylindroid in common.

The geometrical theory of screws as the geometry of a particular space of five dimensions is not a mere extension of the ordinary Euclidian geometry. The six homogeneous co-ordinates of a screw are, as has already been mentioned, connected by an equation. This is of the form $R = 1$, where R is a quadratic expression of the co-ordinates. All elements at infinity in our screw-space are given by the equation $1 = 0$ or by $R = 0$. The *absolute* is thus a quadric locus, and therefore we have to deal with non-Euclidian geometry.

The advantage to the theory of screws to be derived from a study of this geometry are apparent at every step. We may in our screw-space conceive curves and surfaces of from 1 to 4 dimensions, by taking one or more equations between the co-ordinates. Of these, equations of the first degree determine the screw-complexes. But equations of the second degree, which determine quadric complexes, or as Ball calls them screw-complexes of second degree, are also constantly of use. Such an equation may be taken in a complex of order *n*. In the treatise before us they appear in congruences of the 3rd and 6th order. We will give here one illustration.

Let $p_1, p_2, \ldots p_n$ be the pitches of the *n* co-reciprocal co-ordinate screws, and let $\alpha_1, \alpha_2, \ldots \alpha_n$ be the co-ordinates of a screw α with pitch p_α. Then is p_α given by the equation

$$p_\alpha = p_1\alpha_1^2 + p_2\alpha_2^2 + \ldots\ldots + p_n\alpha_n^2.$$

This equation can be made homogeneous by aid of $R = 1$, and becomes

$$Rp_\alpha = p_1\alpha_1^2 + p_2\alpha_2^2 + \ldots\ldots + p_n\alpha_n^2,$$

where R also is supposed to contain *n* of the α only, the others being replaced by aid of the linear equations which determine the complex of order *n*. It follows that the absolute $R = 0$ is the locus of screws of infinite pitch, whilst

$$p_1\alpha_1^2 + p_2\alpha_2^2 + \ldots\ldots + p_n\alpha_n^2 = 0$$

is the locus of screws of zero-pitch. Both are quadrics.

If we take a screw β, we may form its polar with regard to any quadric. If we select the last quadric mentioned, the polar is

$$p_1\alpha_1\beta_1 + p_2\alpha_2\beta_2 + \ldots\ldots + p_n\alpha_n\beta_n = 0.$$

But this equation is also the condition that α and β are reciprocal screws. In each complex the quadric of zero-pitch becomes thus of special importance, reciprocal screws being conjugate poles with regard to them.

As we cannot directly realize a space of more than three dimensions, it becomes of importance to represent the elements in such a space by other elements in ordinary space, and, when possible, by elements in a plane. That this is always possible is clear.

For instance, as all conics in a plane are ∞^5 in number, we have as many conics in a plane as there are screws in space, and we may therefore represent each screw by a conic in a plane. To screws on a cylindroid would then correspond all conics in a pencil. We might then speak of the cross-ratio of four screws as given by the cross-ratio of the corresponding conics in the pencil. All screws belonging to a complex of order 3 would be represented by conics forming a net, *i.e.* by conics having a common polar triangle.

We thus get a graphical representation in a plane, and can obtain our results by constructions in a plane. But the geometry of conics in a plane has scarcely been far enough developed to make general use of them, and for screw-complexes of lower order simpler representations may be found. Thus the screws on a cylindroid can be represented most conveniently by the points on a circle which stands in close relation to the cylindroid and gives rise to a graphical solution of problems relating to a body with two degrees of freedom. This is done in chapter xx., full of interesting detail. Again, screws in a complex of order 3, whose number is ∞^2, can be represented by points in a plane. This has been worked out in chapters xxi. and xxii. In fact, here the screw co-ordinates, three in number, are simply taken as tri-linear co-ordinates of a point. It follows at once that the locus of points with equal pitch must be a conic, the "absolute" being the locus of pitch ∞, and one conic relates to zero-pitch. This latter may, without loss of generality, be made a circle.

It is of interest to notice that for a screw-complex of order 3 the screws which have a given pitch form themselves a quadric surface, viz. they form one set of generators on a hyperboloid, the other set of generators having pitch $-p$, and containing thus screws in the complex reciprocal to the others.

Other quadrics enter the theory, especially one containing the locus of screws about which a body may twist without receiving kinetic energy, and which is, of course, imaginary; and one connected with the potential. These last two determine the principal screws of inertia, of which more later on.

For screw-complexes of order 4 no graphical representation is given. The difficulty lies here in this—that the dynamics require constantly metrical relations, and these are not very simple in the plane representation, by conics for instance. It is here that the non-Euclidian character of the geometry comes out.

These speculations are in close connection with the contents of chapter xix., where projective relations between two congruences of the same order are investigated. It is here that Herr Gravelius has more particularly introduced original work of his own in bringing Sir R. Ball's Mr. One-to-one more prominently to the foreground.

Up to this we have considered chiefly the geometry of systems of screws. It is now time to consider the kinematics of a rigid body and the action of forces on it.

If a body is perfectly free it can twist about every screw in space. As these can be decomposed into six twists about the co-ordinate screws, the body is said to have six degrees of freedom. If the body is constrained in any manner—and here the generality of the nature of the constraint has to be noticed—then it will not be able any longer to twist about all screws. But we have seen already if it can twist about n screws it can twist about all screws belonging to the complex of order n derived from them. The freedom of a body is therefore fully characterized by the complex which contains all screws about which the body can twist. If this is of order n, then the body has n degrees of freedom. An attempt to twist the body about any other screw will evoke a reaction due to the constraint which will reduce to a wrench upon some screw. Such a wrench cannot do any work against a possible twist of the body, hence the screws on which wrenches of constraint are possible must be reciprocal to the screws which determine the freedom of the body; they form, therefore, the reciprocal complex. We thus get the very general theorem about the equilibrium of a body. If a body has n degrees of freedom then it will be in equilibrium under the action of all wrenches on screws of a certain complex of order $6 - n$. This complex may be called the complex of constraint.

Again, if a body is subjected to an impulsive wrench upon a screw, η, not belonging to the complex of constraint, it will begin to turn about some screw, α, called the instantaneous screw. At the same time an impulsive wrench of constraint will be evoked. Conversely, in order to produce a twist on α as instantaneous screw we may apply an impulsive wrench on η, but with this we may combine a wrench on any one of the screws belonging to the complex of constraint. As the latter is of order $6 - n$, all screws derivable from these, together with the screw η will form a complex of order $7 - n$. This complex of order $7 - n$ and the complex of order n which determine the freedom have $7 - n + n - 6 = 1$ screw in common (see above). This screw is called the reduced impulsive wrench.

We thus have proved if a body has freedom of order n, then there is always one and only one screw, η, in the complex which determines the freedom, such that an impulsive wrench on it makes any given screw, α, the instantaneous screw. The converse, also, is evidently true. Between the impulsive and instantaneous screw in the complex exists, therefore, a one-one correspondence, or, to express this differently, the complex of instantaneous and that of impulsive screws are projective. They are also coincident. But if we have two coincident projective spaces of $n - 1$ dimensions, then there are always n screws in one which coincide with their correspondents. This proves if a body has n degrees of freedom, then there exist n screws, and in general only n, such that an impulsive wrench on one of them produces a twist on the same screw. These n screws—and the discovery is one of the triumphs of the theory—are called the principal screws of inertia, as they depend on the distribution of matter in the body. These screws are also co-reciprocal, and may therefore be taken as co-ordinate screws. They are a generalization of the principal axes of inertia in the ordinary theory; and to show their importance it is sufficient to point to the importance of the principal axes of inertia in the ordinary theory of a free body, or of a body of which one point is fixed, and to remember the simplification obtained by taking them as axes of reference.

For a free body the screws of inertia lie on the principal axes of the body which pass through the mass-centre, two on each, with pitches equal to the corresponding radius of gyration, taken positive for the one and negative for the other. The ordinary theory has no analogon to this if the body is constrained, excepting in the few cases where a point or an axis of the body is fixed, or where the body has plane motion only.

It is in such generalizations that the theory of screws excels. It has given us here the best and simplest co-ordinates for all cases of the motion of a single rigid body acted on by any forces and constrained in any manner conceivable.

We will now suppose that the co-ordinates thus pointed out are used, and find the instantaneous screw corresponding to any given impulsive wrench. Each component wrench produces a twist about its own screw, whose amplitude depends in a very simple manner on the intensity of the impulsive wrench; so that the intensities of the component twists are known, and these give the resultant twist.

We next consider the kinetic energy, T, of the body due to a twist on a screw, α. Let α_1, α_2, . . . be its components, p_1, p_2, . . . the pitches of the co-ordinate screws, and $\dot{\alpha}$ the twist velocity. It is then shown that, M being the mass of the body,

$$T = M\dot{\alpha}^2(p_1^2\alpha_1^2 + p_2^2\alpha_2^2 + \ . \ . \ . \ + p_n^2\alpha_n^2).$$

Denoting the expression in the brackets by u_α^2, we have $T = M\dot{\alpha}^2 u_\alpha^2$. The quantity u_α is a length; the expression for T is therefore of the same form as that for the rotation of a body about an axis with angular velocity $\dot{\alpha}$, the radius of gyration being replaced by $u_\alpha/\sqrt{2}$. This last expression deserves a name. If we adopt Clifford's word "spin-radius," instead of radius of gyration, the name twist-radius suggests itself as suitable for u_α or $u_\alpha/\sqrt{2}$.

We now come to consider the problem of small oscillations. Let there then be a body of n degrees of freedom in a position of equilibrium under a system of forces which have a potential V. Let A denote the complex defining the freedom. If the body be displaced by a small twist about a screw, α, belonging to the complex A, then the forces are not any longer in equilibrium; hence they will give rise to a wrench on some screw λ. This wrench may be combined with any wrench of constraint; but just as in case of impulsive wrenches there is one single screw λ belonging to the complex A, hence now also we have in the complex A a one-one correspondence between the screws *a* and the screws λ. There are therefore, again, *n* screws *a*, which coincide with their corresponding screws λ. These have got the name of "principal screws of potential." They depend on the system of forces or on the potential V, just as the screws of inertia depend on the distribution of matter. These *n* screws, again, are co-reciprocal. They have the property that a twist about one of them evokes a wrench on the same screw, the wrench being due to the applied forces. To show the importance of these principal screws of potential it will be sufficient to remark that the potential is, under the circumstance explained, a homogeneous function of the second degree of the *n* co-ordinates by which the displacement is defined. This function becomes the sum of *n* terms containing the squares only of the co-ordinates if the principal screws of potential are taken as co-ordinate screws.

Now, suppose that the body has been displaced by a twist about a screw *a*, this could be done by a wrench upon the screw η, which as impulsive screw corresponds to *a* as instantaneous screw. At the same time this displacement calls a wrench on a screw λ into play due to the potential V. To every screw *a* corresponds thus one screw η and one screw λ. Hence the latter are also connected by a one-one correspondence, and there are therefore *n* screws *a* such that the corresponding screws η and λ coincide. The screws *a* thus obtained are called "harmonic screws." They possess this property: A twist about a harmonic screw evokes a wrench which in its turn tends to produce a twist on the original harmonic screw. Hence if the equilibrium is stable this wrench will tend to twist the body back to the position of equilibrium, and thus produce small oscillations about the harmonic screw. From this we get the following theorem, distinguished again by its great generality:—

If a rigid body having *n* degrees of freedom is in a position of stable equilibrium under the action of a system of conservative forces, then it can, on being disturbed, perform *n* distinct oscillations, which consist each of a twisting about a single screw. Every other oscillation is a combination of these.

These are the chief results which so far have been obtained by the theory of screws as applied to a single rigid body. They form the contents of chapters vi. to xii. These general results are, in the next six chapters, applied and considered more in detail for each of the six possible cases of degrees of freedom which a rigid body may have. Then there follow four chapters on graphical methods, already referred to.

All the former investigations relate to one single rigid body. But Sir R. Ball, in 1881, published a paper in which he extends his theory to systems of rigid bodies by a method as beautiful as it is suitable to the purpose.

The bodies, of which we suppose there are μ, are taken in a definite order. Every body of the system will at every moment twist about some screw. We thus get a et of μ screws, about which at any moment the bodies twist. If we take two consecutive twists, then their resultant depends only on the ratios of the two amplitudes, and conversely the screw of the resultant determines this ratio. If the screws about which two consecutive bodies twist are given, and also the screw on which their resultant lies, then the amplitude of the first twist determines that of the other. If, therefore, the screws about which the μ bodies twist at any moment are given, and besides the $\mu - 1$ screws on which the resultant twists of consecutive bodies lie, then the amplitude of the first determines that of every other twist. The set of $2\mu - 1$ screws thus obtained is called a screw-chain, and it is said that the system of bodies twists at any moment about a certain screw-chain.

In case of systems of rigid bodies, the screw-chain has to be considered as the fundamental entity, which takes the place of a screw in case of a single body.

In a finite number of bodies we get a screw-chain of a finite number of screws. These will, in the screw-space of five dimensions, be represented by a finite group of points (elements). If, however, the number of bodies increases and becomes infinite, as in the case of the molecules of a fluid, this group of points may form a continuous locus of one or more dimensions. We may thus get, instead of screw-chains, continuous curves and surfaces of screws, and their geometry will be that of a group of points in five-dimensional non-Euclidian space.

This suggests an enormous field for investigation, and it is of interest to see that every progress in the algebra and geometry of such a space must indicate also progress in dynamics.

But these are speculations far beyond the contents of the book under review.

All results obtained for twists can at once be transferred to wrenches. Accordingly a system of forces acting on a system of bodies can be reduced to a wrench upon a screw-chain.

There are reciprocal screw-chains, screw-chains of inertia, complexes of screw-chains, complexes of freedom and of constraint, and complexes reciprocal to them. In fact, the screw-chain seems now to take in every respect the place of the screw in the theory of a single body. These screw-chains in their kinematical and dynamical applications to systems of rigid bodies form the contents of the chapters xxiii. and xxiv.

The last two chapters in the book give Sir R. Ball's theory of content, in which the author tries successfully to overcome the difficulty which offers itself in the determination of metrical relations without any reference to measuring a length. By "content" is understood the aggregate of all elements in what Clifford called a three-way spread. The investigation is carried on quite algebraically by aid of the methods of Grassmann's "Ausdehnungslehre." In the book before us this is worked out, partly with reference to Clifford's theory of biquaternions, and ends with the introduction of Clifford's vectors in non-Euclidian space.

It will be asked what progress in the science of dynamics, and through dynamics in natural philosophy, has been made by Ball's creation. The theory of screws is a mathematical speculation full of life, full of interest and charm for the mathematician who likes to find new physical interpretations for geometrical and algebraical results and methods. The physicist, however, may say that the theory does not increase our power over Nature. But I am inclined to think that when further developed it will be a great, perhaps a very great, help to progress. Does not every molecule of a fluid having rotational motion twist about some screw? And does not a vortex-line suggest a screw-chain containing an infinite number of elements?

The theory of screw-chains, containing a finite number of elements belonging to a system of bodies with one degree of freedom, seems to indicate a truly scientific classification of mechanisms, and may conceivably render great aid in the invention of mechanisms which answer a given purpose.

The essentially geometrical character of the new method seems particularly well adapted to give graphical solutions of dynamical problems, and thus a "graphical dynamics" appears to find here a sound foundation. In this direction much has been done already, but much remains to be done. Also the restrictions of infinitely small amplitudes of the twists has to be broken through, and the infinitesimal calculus has to be pressed into the service.

Meanwhile, we congratulate Sir Robert Ball on the results which his persevering labours have achieved, and Herr Gravelius on the courage which led him to undertake the task of writing a text-book on this subject, and on the success with which he has accomplished it. The book ought to give a great impulse to the study of this theory, and to enlist many friends in its service.

O. Henrici.

THE SIXTH SCIENTIFIC CRUISE OF THE STEAMER "HYÆNA" WITH THE LIVERPOOL MARINE BIOLOGY COMMITTEE.

THE Liverpool Salvage Association having kindly placed their s.s. *Hyæna* once more at the disposal of the Liverpool Marine Biology Committee, a four-days' dredging cruise was arranged and successfully carried out at Whitsuntide. The old gunboat left the Mersey on Friday, May 23, and steamed to the Menai Straits. Some of the party spent the afternoon and evening collecting on the shore at Puffin Island, off which the *Hyæna* was anchored for the night. On the following morning, after a few hauls of the dredge near Puffin Island, and between Penmon Point and Beaumaris, and again off Port Dinorwic, the steamer went through the straits to Carnarvon Bay, and commenced working along the southern coast of Anglesey.

The dredges and various kinds of tow-nets, surface and bottom, were used at intervals. Mr. W. E. Hoyle's deep-water closing net, which has now been modified so that its movements of opening and closing are effected by the passage of an electric current, was experimented with frequently during the cruise—not so much with the object of collecting specimens, as for the purpose of detecting and remedying any possible defects in the construction, and of guarding against conditions which might interfere with the proper action of the apparatus. On the whole the net worked satisfactorily, the causes of occasional failures were discovered, and when the improved form of frame used by the Germans has been adopted, the apparatus will no doubt be a most useful addition to the implements of the marine biologist.

The *Hyæna* anchored for the night in a small rocky bay, Porth Dafarth, on the south side of Holyhead Island, Anglesey, and half the party of over twenty biologists were landed to sleep on shore. After dark those who remained on board commenced tow-netting by electric light, and repeated with some modifications the experiments which had been made during the last two cruises of the *Hyæna* at the Isle of Man (NATURE, vol. xxxviii. p. 130, and vol. xl. p. 47) in 1888 and 1889. The large arc lamp was hoisted over the side of the ship so as to throw a strong glare on the water, and Edison-Swan incandescent lamps were sent down to the bottom in tow-nets which were hauled up at intervals. Comparatively few Cumacea, Amphipoda, and Schizopoda were obtained this time, but shrimps and young fishes were—for the first time in our experience—attracted by the light to the surface, and some of them were caught and preserved. One of the ship's boats was kept in the area illuminated by the arc lamp, and by leaning over her side the small objects in the surface-layer of water could be most distinctly seen, and particular animals picked out and captured with a hand-net as they darted about in the neighbourhood of the light.

Two of the party got up at 3 a.m., and took a surface tow-netting about dawn, which was afterwards found to contain a much greater number of Copepoda, and more variety, than any of the other tow-nettings, either day or electric light, surface or bottom. Amongst other interesting things it contained a large number of *Peltidium depressum*, which had not been taken at all during the day, and only in very small numbers with the electric light bottom net. This same species has recently been taken in quantity at Puffin Island by leaving a tow-net out all night attached to a buoy. It is usually found sticking on *Laminaria* in the day-time, but evidently comes to the surface in abundance late at night or early in the morning.

The following day was spent in steaming slowly about off the southern coast of Anglesey, dredging and tow-netting at frequent intervals. The surface life was found to be very poor—comparatively few Copepoda and almost no representatives of other free-swimming groups being obtained; but Mr. Thompson noticed the relative abundance in all the tow-nettings, both surface and bottom, during the day, and also with the electric light, and at dawn, of unusually large specimens of *Dias longiremis*, and also the prevalence of the somewhat uncommon *Isias clavipes* in all the surface gatherings, though none were taken in the bottom ones.

The dredging results were fairly good: some very fine sponges were obtained, and Ascidians were plentiful. One patch of rich ground was discovered near Rhoscolyn Beacon, where *Comatula* was brought up in abundance along with various Tunicata, Holothurians, Nudibranchs, Zoophytes, Polyzoa, and large sponges. After dark, in Porth Dafarth, the electric lights were again used for a couple of hours. This time the large arc lamp was taken to the stern and suspended close to the surface of the water, but as it was not working steadily one of the incandescent submarine lamps was lowered over the side and kept a few inches under water, and this proved most effective in attracting animals to a stationary tow-net or a hand-net beside it. On the fourth day the *Hyæna* returned through the Menai Straits to Liverpool. As usual the specimens collected have been distributed to specialists, and the detailed reports upon the various groups will appear in the next volume of the "Fauna of the Liverpool District."

W. A. Herdman.

W. S. DALLAS.

THE death of this genial and accomplished man will awaken feelings of no ordinary regret, not only among geologists, but among naturalists all over the country. For two-and-twenty years his tall, handsome person has been the most familiar figure at the rooms of the Geological Society in Burlington House. Always at his post, with a pleasant smile of welcome, ever ready with assistance from his large treasures of knowledge and experience, knowing more intimately than anyone else the affairs and traditions of the Society, proud of its history and keenly sensitive for its scientific reputation, he had come to be looked upon as a kind of *genius loci*—the living embodiment of the Society's aims and work.

Of those who knew Mr. Dallas only in his later years, and saw his whole-hearted devotion to the geological labours intrusted to him, probably few were aware that he was not always a geologist. He began life with zoological inquiries, and devoted his attention more especially to insects. His early papers appeared in the Transactions of the Entomological Society, but he prepared also a Catalogue of the Hemipterous Insects in the British Museum, which was published as far back as the years 1851–52. Yet he did not confine himself to one branch of zoology; on the contrary, his reading and knowledge ranged over a wide domain in natural history. In the year 1856 he published his "Natural History of the Animal Kingdom," by far the best work of the kind in its day, which rendered important service to biology, in making the study of living forms more attractive, and in providing for that study a much more accurate groundwork than had ever before been obtainable. The value of his labours was recognized not long afterwards by his being appointed Curator of the Yorkshire Philosophical Society's Museum at York—an office which he held for ten years, until in 1868 he obtained the post which he held up to the last—that of Assistant Secretary, Librarian, and Curator to the Geological Society of London.

After his return to reside in London he found the duties of the office he had undertaken so engrossing, and the cares of domestic life so exacting, as to leave him little or no spare time for original inquiry. He devoted such leisure as he could command to translating, editing, and other scientific labour of a literary kind. Biologists will especially remember the appearance of his translation of Fritz Müller's "Facts and Arguments for Darwin," shortly after the beginning of the controversy aroused by "The Origin of Species." His wide range of knowledge in natural science, and his literary tact and experience, made him an unrivalled editor of a scientific periodical. The volumes of *The Quarterly Journal of the Geological Society* for the last twenty years will remain as a memorial of the accuracy, skill, and punctuality of his work. It will be difficult to find another assistant secretary so deft and helpful as he: it will be, however, still harder to discover one who to ample scientific acquirements and long experience will unite a nature so gentle and kindly as his, and a character so honourable and sincere. Mr. Dallas may be said to have died in harness. Though for some time he had been growing gradually feebler, he attended the evening meeting of the Geological Society only a fortnight ago. But the hand of death was then visibly upon him. Two days afterwards he was struck down with paralysis, and, after lingering a week, died on the morning of May 28, at the age of sixty-six. Last Monday his associates of the Geological Society laid him in his grave in the Norwood Cemetery. A. G.

NOTES.

BESIDES the death of Mr. W. S. Dallas, the Assistant-Secretary of the Geological Society, the ranks of the geologists of this country were further thinned last week by the loss of another well-known and most esteemed student of geology—Mr. John Gunn, of Norwich. Though not distinguished as a writer on geological subjects, he has long been looked up to as the chief authority on that most interesting deposit—the Cromer Forest-bed; and as the most indefatigable and successful collector of its organic contents. He had, moreover, an extensive knowledge of all the geological formations of East Anglia. He was, likewise, fond of antiquarian researches, and in early life did good service among the archæological and ecclesiastical antiquities of his county. But while always eagerly seeking fresh information and gathering a vast store of facts in many departments of inquiry, he refrained from rushing frequently into print, while on the other hand, with generous self-abnegation, he was ever ready to place his materials at the service of science and the public. Every honest inquirer was always welcome to any information or assistance he could give. After amassing a magnificent suite of fossils, illustrating especially the mammalian life of Pliocene time in England, he presented it to the Norfolk and Norwich Museum, where it forms one of the most attractive and instructive features of the collection, and fills what is called after him the "Gunn Room." Mr. Gunn had reached his eighty-ninth year.

WE are glad to gather from the statement made in the House of Commons on May 22 by Sir John Gorst, in reply to a question from Sir Henry Roscoe, that the new regulations which will shortly be issued by the Civil Service Commission for the competitions for admission to the higher branch of the Indian Civil Service are, in the opinion of Sir John Gorst, likely to satisfy the desire which is widely felt at the Universities and elsewhere that they "shall secure more equal prospects of success for those whose chief studies have been in science than are at present accorded in these competitions." Those who are interested in this important educational question will be glad that Sir Henry Roscoe has directed the attention of the authorities at the India Office to this matter, and they will hope that if the new regulations are not found to satisfy the necessities of the case, he will continue his exertions. We do not wish to be prophets of evil, but experience unfortunately shows that the Civil Service Commissioners are by no means likely to put science subjects on anything like a fairly equal footing with classics except under considerable pressure from public opinion. It will therefore be important that prompt combined action shall be taken in support of Sir Henry Roscoe by those who have interested themselves in the question, if the new regulations do not prove to be of a satisfactory character. If the present opportunity of securing that the conditions of admission to this important service be put on a proper footing be lost, it may be long before another occurs. Such action has, however, succeeded in other cases, and ought to do so in this case also.

IN moving the Education Estimates on Tuesday evening, Sir W. Hart Dyke gave an elaborate and most careful account of the new Code, the leading provisions of which we have already discussed. Among the speakers who took part in the subsequent debate or conversation was Sir Henry Roscoe, who congratulated the Vice-President on having for the first time carried out some of the recommendations of the Royal Commission on which he had had the honour to serve. He welcomed the proposal to give a grant for manual instruction. He was also pleased to learn that the Vice-President took to heart one of the recommendations which laid the foundation for technical instruction—a foundation which many of them for a long time had hoped would be laid. It was gratifying to learn that already great progress had been made in several of the larger towns with regard to technical instruction. He hoped that the question of drawing would progress. He thought the specialization of science ought not to be made before the fourth standard. The question of training teachers was one which referred to probably the most important portion of the Code. He welcomed all that it was proposed to do. He believed that the new Code would mark an era in the educational progress of the country. Mr. Mundella, in the course of a short speech, said he had risen only to express his thanks to the Vice-President of the Council for the liberal provisions of his Code. He regretted, however, that these provisions had not been somewhat extended. Why had the Vice-President not gone somewhat further with respect to the recommendations of the Royal Commission as to raising the standard of age, and extending the school life of the child? They might make the best and most liberal arrangements for education, but if the child's school life was to end at ten years of age, they were wasting their money. In large towns there were thousands of children who went to full-time labour after the fourth standard. In many rural districts, especially in the west, the second standard was the half-time standard, and two years ago that had been the case in Bradford. Why could not the right hon. gentleman screw up his courage and adopt the recommendation of the Royal Commission, and do for England what was done in Scotland? They should have a minimum standard for half-time. He hoped that later on the right hon. gentleman would be able to announce that he had made some provision for meeting the suggestions which had been offered with regard to raising the age at which the school life of the child should end, and raising the full and half-time standards.

A DEPUTY Linacre Professor of Human and Comparative Anatomy is to be appointed at Oxford. He will hold office during the continuance of Prof. Moseley's illness. Candidates must send in their applications on or before June 21.

GOOD progress has been made with the arrangements for the fifty-eighth annual meeting of the British Medical Association, under the presidency of Dr. W. F. Wade, senior physician to the Birmingham General Hospital, to be held in Birmingham on July 29, 30, and 31, and August 1 next. There will be three addresses—an address in medicine, by Sir W. Foster, M.D., M.P., of Birmingham; an address in surgery, by Mr. Lawson Tait, of Birmingham; and an address in therapeutics, by Dr. William Henry Broadbent, of London. The scientific part of the meeting will be carried on in twelve sections. It is now fifty-six years since the Association first held its meeting at Birmingham.

AT a meeting of the London Committee of the Edinburgh Exhibition on Tuesday, Mr. S. Lee Bapty, the general manager of the Exhibition, said the visitors during the first month had numbered 470,000. This was largely in excess of his most sanguine anticipations, and was all the more remarkable considering the state of the weather during most of the month. If the same number of visitors continued each month till October, there would be a total of over four millions. A very important exhibit of electrical appliances from forty manufacturers in France had just arrived, and these would be on view at the time of the approaching visit of the Lord Mayor and Sheriffs of London to Edinburgh.

AT the meeting of the Society of Arts on May 15, Mr. C. Washington Eves read a valuable paper on Jamaica and its forthcoming Exhibition. Apparently there is good hope that the Exhibition will be a decided success. The exhibits will be divided into six groups—raw materials; implements for obtaining raw materials; machines and processes used in preparing and making up the raw materials into finished products; manufactured goods; educational appliances; fine arts, literature, and science. The section devoted to science will include maps and charts of the West Indies, and objects relating to engineering, sanitation, gas, electricity, astronomy, and anthropology. After the reading of the paper there was a discussion, in the course of which Mr. Morris, of Kew, said there was every indication that makers of machinery and others would send out appliances, and there was but little doubt that immense good would result to the island from the Exhibition.

THE last Friday evening discourse at the Royal Institution will be given on June 13, by Prof. Silvanus P. Thompson. The subject will be "The Physical Foundation of Music."

THE authorities of Wadham College, Oxford, announce that in the election to one of several exhibitions which are open to competition preference will be given to any candidate who shall undertake to read for honours in natural science from the time of his admission into College, and to proceed to a degree in medicine in the University of Oxford.

THE *American Naturalist* states that the Marine Biological Laboratory at Boston, U.S.A., has issued a satisfactory annual report. The laboratory was crowded last summer, and the trustees appeal for donations to the amount of 7000 dollars for additions to the building, an increase in the library, and a steam-launch.

THE Botanical Society of Regensburg—one of the oldest societies of the kind in Germany—celebrated its hundredth anniversary on May 15.

THE late Herr M. Winkler, of Görlitz, has bequeathed his fine herbarium, comprising 150,000 specimens, and his botanical library, to the Botanical Garden at Breslau.

THE members of the German and Austrian Alpine Club have elected a scientific committee, consisting of Prof. Penik, Vienna, Dr. Finsterwalder, Munich, Councillor Hann, Vienna, Prof. Partsch, Breslau, and Prof. Richter, Graz. This committee will investigate scientific questions relating to the Alps, devoting especial attention to glaciers and mountain streams. The results will be made known in the official publications of the Club.

THE new Zoological Garden and Park at Rock Creek, Washington, to which we referred the other day, will be under the direction of Mr. W. T. Hornaday. It is stated that Prof. Frank Baker will be prosector, and will have charge of the department of comparative anatomy in the United States National Museum.

TELEGRAMS received at New York on June 3 stated that shocks of earthquake had been felt at Lima on the previous morning. The earthquake was one of the severest that had been experienced there for years. There were three distinct shocks.

WE learn from *Science* that the *Princess Louise*, which arrived at Victoria, B.C., from Skidegate and way ports, on the evening of April 24, brought news that on February 24 an earthquake shock was felt on all the islands around Skidegate, especially on the west coast of Queen Charlotte Islands, where a few old shanties were levelled to the ground. The totem-poles of the Indians shook like leaves, and in some places the earth was cracked. The shock lasted for about thirty seconds, during which time the Indians were wild with fright. A number of them ran to the church and crowded in. Since that time there have been about twenty different shocks, the last one being on April 12, although none was nearly so severe as the first. A very slight shock was felt at Skeena.

DR. DAVID P. TODD, writing to the *Nation* from the U.S.S. *Pensacola*, at Ascension, on March 16, refers in terms of high appreciation to the work done in meteorology by his colleague Prof. Abbe. A "nephoscope" was specially constructed for the Expedition on board the *Pensacola*. Prof. Abbe has elaborated a method for the use of this instrument in determining the actual height and velocity of clouds by combining observations made when the vessel or observer moves successively in two different directions, or with two different velocities; and he calls this the "aberration method," to distinguish it from ordinary parallax methods. His main work has been a determination of the motions of the atmosphere from a study of the lowest winds and the successive strata of clouds; and, to this end, he has maintained daily observations with the nephoscope at sea, and when possible on shore. The visible clouds, he concludes, give little or no information as to the motions of the atmosphere in the widest sense, but prove that the atmosphere is everywhere divided into local systems of currents, so that we have winds circling around a storm-centre, a high barometer, an ocean, or a continent; and, at least in the Atlantic, have no winds that circulate exactly as they would do on a rotating, uniform, smooth globe. The angles of inflow and outflow have been determined for three or four successive strata of air in mid-Atlantic; also the relations of the cloud-appearances to distant storms, squalls rains, and changes of wind, with such accuracy that on many occasions predictions of such phenomena have been made and verified.

MR. S. H. C. HUTCHINSON, Meteorological Reporter for Western India, has written an excellent "Brief Sketch of the Meteorology of the Bombay Presidency in 1888-89." The meteorology of that year was characterized, Mr. Hutchinson says, by strongly marked deviations from the weather conditions of an average year. Of these, the most noteworthy were, a general rise of abnormal barometric pressure for a considerable period, a general deficiency of rainfall in September, and the scanty rainfall throughout the year. Mr. Hutchinson points out that all these variations are of much practical importance, and, from a scientific point of view, of considerable interest, inasmuch as they confirm the laws or principles deduced from the meteorological data of many past years. These laws or principles are, that the rainfall is deficient when barometric pressure is above the normal height, and excessive when the barometric pressure is lower than usual; that at or about the epochs of minimum solar spotted area, high abnormal barometric pressure movements make their appearance, and that at or about the epochs of maximum solar spotted area, abnormally low pressure movements take place in India and over greater part of the tropics; that cyclones are formed in the trough of a relatively minimum barometric pressure; and lastly, that the number of atmospheric disturbances is great at the epoch of minimum sunspots.

IN Dr. A. Petermann's *Mitteilungen* (Heft v., 1890), Dr. A. Supan gives some particulars respecting Emin Pasha's meteorological journal, which will shortly be published. The registers extend from August 1, 1881, to February 27, 1890, and, omitting the interruptions, contain observations for seven years and ten months. They are said to have been taken with great care, and may be divided into three periods: August 1, 1881, to April 24, 1885, at Ladó; July 13, 1885, to December 5, 1888, at Wadelai; and March 1 to December 4, 1889, during the march with Stanley to the coast. On the latter date Emin Pasha met with his serious accident, but so great was his desire to continue the observations, that he resumed them on January 5, 1890, in the German hospital at Bagamoyo. Dr. Supan regrets the non-publication of Mackay's observations at Rubaga (Uganda), which were sent to the Royal Geographical Society in 1886, as they promise to be the most important contribution to the climatology of the interior of tropical Africa.

A CHEAP bunsen burner is being sold by Messrs. John J. Griffin and Sons, which possesses many advantages over the ordinary burner, with central gas jet constructed so that the gas and the air may be simultaneously regulated. In the new patent burner the gas passes into the tube through a way cut in the side of the tube, which is therefore open from top to bottom. Such an arrangement is a considerable improvement, inasmuch as there is no jet to become choked. The burner can also be easily taken apart in order to clean the tube when corroded. To regulate the flow of gas under varying gas pressures small movable disks are provided, which, however, are little better for the purpose than the older method of rotating a cylinder concentric with that containing the air-inlets. Combinations are also made in which each burner can be regulated or extinguished separately, thus rendering them very suitable for combustion furnaces.

AN elaborate Report on the Natal forests, by Mr. H. G. Fourcade, has just been issued. He arrives at the following conclusions:—(1) The Natal forests, more particularly the timber forests, are well worth preserving, whether from an economic or climatic point of view, and the Government alone is competent to undertake the work. (2) The condition of the forests is, for the most part, lamentable, and the result of past abuses; their destruction is proceeding apace, and the following measures are recommended to insure their preservation and utilization to the best advantage: (*a*) The survey and demarkation of the principal forests. (*b*) Their protection from fires, from depredations, from destruction by natives or cattle, by means of suitable measures, such as the clearing of fire-belts, the establishment of small wattle plantations, the prohibition of wattle-cutting and cattle-grazing, with the aid of proper supervision and special legislation. (*c*) The closure of the forests pending survey, demarkation, and settlement. (*d*) The adoption of sound methods of forestry to secure a steady yield, improvement of the forest, and most profitable management. (*e*) The utilization of colonial woods for railway sleepers. (3) Plantations of conifers and hard woods, designed to supply the future requirements of the country, can be made profitably along railway lines in the upland and the midland districts. (4) The most urgent work of a Forest Department in Natal would be to save what is left of the native forests, and plantation work should be deferred till it can be undertaken without detriment to the progress of survey and demarkation.

IN the new number of the *Zoologist* there are some interesting notes, by Mr. R. J. Ussher, on crossbills in the county of Waterford. This spring he has had exceptionally good opportunities of observing the breeding habits of these birds, as four of their nests were found in his neighbourhood, three of them being within fifteen hundred yards of his house. Of the four male birds, three were red, or red interspersed with brown. One had yellow plumage, similar to that of a specimen which Mr. Ussher presented last year to the British Museum. This bird had all the appearance of having arrived at full maturity, being large, active, vigilant, and with mandibles conspicuously crossed. When Mr. Ussher climbed to the nest, both male and female perched within four feet of him, "calling excitedly." "On April 17," he says, "these crossbills were seen to carry bits of something in their mouths to the nest, as if to feed their young. The nature of the food has not been ascertained, but is suspected to be largely composed of the green opening buds of the larch, on which I have repeatedly seen the male feeding—*e.g.*, on April 4." Mr. Ussher thinks that crossbills are on the increase in Ireland at present.

IN the Journal of the Bombay Natural History Society (vol. iv. No. 3) Mr. E. Giles records a curious fact which ought to have some interest for entomologists. In June 1888 he was standing one morning in the porch of his house, when his attention was attracted by a large dragon-fly of a metallic blue colour, about 2½ inches long, and with an extremely neat figure, who was cruising backwards and forwards in the porch in an earnest manner that seemed to show he had some special object in view. Suddenly he alighted at the entrance of a small hole in the gravel, and began to dig vigorously, sending the dust in small showers behind him. "I watched him," says Mr. Giles, "with great attention, and, after the lapse of about half a minute, when the dragon-fly was head and shoulders down the hole, a large and very fat cricket emerged like a bolted rabbit, and sprang several feet into the air. Then ensued a brisk contest of bounds and darts, the cricket springing from side to side and up and down, and the dragon-fly darting at him the moment he alighted. It was long odds on the dragon-fly, for the cricket was too fat to last, and his springs became slower and lower, till at last his enemy succeeded in pinning him by the neck. The dragon-fly appeared to bite the cricket, who, after a struggle or two, turned over on his back and lay motionless, either dead, or temporarily senseless. The dragon-fly then, without any hesitation, seized him by the hind legs, dragged him rapidly to the hole out of which he had dug him, entered himself, and pulled the cricket in after him, and then, emerging, scratched some sand over the hole and flew away. Time for the whole transaction, say, three minutes."

A CATALOGUE of the Birds in the Provincial Museum, N.W.P. and Oudh, Lucknow, has been printed by order of the Museum Committee. Like the previous catalogue, it records the purely Indian birds in the Museum, now 783 in number, represented by 5360 specimens. Mr. George Reid, who is in honorary charge of the natural history department of the Museum, says no pains have been spared to make the work both accurate and complete. "It contains, he believes, in a convenient form, all the information requisite to enable workers at a distance to avail themselves, if necessary, of the contents of the Museum; while it places in the hands of all an absolutely trustworthy record of localities for a considerable number of species, and so contributes to an accurate knowledge of their geographical distribution, which, after all, is, or ought to be, the primary object of all local catalogues."

MR. L. FLETCHER, F.R.S., contributes to the current number of the *Mineralogical Magazine* a valuable paper on the meteoric iron of Tucson. The other contents of the number, in addition to abstracts and a review, are:—The hemimorphism of stephanite: the crystalline form of kaolinite, by H. A. Miers; on zinc oxide from a blast-furnace, by J. Tudor Cundall; on zinc sulphide replacing stibnite and orpiment—analyses of stephanite and polybasite, by G. T. Prior; index to mineralogical and petrographical papers, by H. A. Miers.

THE Marine Biological Association of the United Kingdom has issued the third number of its Journal, and we need scarcely say that the papers present a record of much valuable work. The following are the contents:—The Director's Report, No. 3; the sense-organs and perceptions of fishes, with remarks on the supply of bait, by W. Bateson (with plate); notes on oyster culture, by Dr. G. Herbert Fowler (with plate); the generative organs of the oyster, by Dr. P. P. C. Hoek—abstract by G. C. Bourne (with plates); letter on oyster culture, by Lord Montagu of Beaulieu; flora of Plymouth Sound and adjacent waters (preliminary paper), by T. Johnson (with a woodcut); report of a trawling cruise in H.M.S. *Research* off the south-west coast of Ireland, by Gilbert C. Bourne; notes on the Echinoderms collected by Mr. Bourne in deep water off the south-west coast of Ireland in H.M.S. *Research*, by Prof. F. Jeffrey Bell; anchovies in the English Channel, by J. T. Cunningham (with an illustration in the text); notes and memoranda (with plate); and price list of specimens. In his Report, Mr. G. C. Bourne mentions that Dr. Dohrn, the founder and Director of the Naples Zoological Station, writing to Prof. Ray Lankester about the choice of a site for the laboratory of the Marine Biological Association, said that the source from which the sea-water was derived was not of so much importance as the size of the storage reservoirs, for no water that could be drawn from the sea would be as suitable for hatching and rearing delicate marine organisms as that which had been for some time in the reservoirs. "Our experience," says Mr. Bourne, "proves the wisdom of Dr. Dohrn's advice."

MESSRS. FRIEDLÄNDER AND SON, Berlin, have issued two numbers of *Abhandlungen und Berichte* of the Zoological and Anthropological Museum of Dresden. The first number includes an elaborate report, for the year 1887, of the ornithological stations in the Kingdom of Saxony, by A. B. Meyer and F. Helm; a paper on *Sus celebensis*, by A. Nehring; Lung Ch'üan-Yao, or old Celadon porcelain, by A. B. Meyer; Coleoptera collected in the years 1868–77 during a journey in South America by A. Stübel, arranged by T. Kirsch; and an obituary notice of T. Kirsch, by A. B. Meyer. The second number consists of a monograph, by Dr. K. M. Heller, on "Der Urbüffel von Celébes: *Anoa depressicornis* (H. Smith)." Both numbers are admirably printed and illustrated.

MESSRS. WILLIAM WESLEY AND SON have issued No. 100 of their "Natural History and Scientific Book Circular." It contains a list of works relating to entomology and botany.

MESSRS. JOSEPH TORREY, JUN., AND EDWIN H. BARBOUR, in a letter dated Iowa College, Grinnell, May 9, have sent to *Science* an account of a remarkable meteor, or meteoric shower, which passed over the State of Iowa on Friday, May 2, at 5.40 p.m. In spite of the brightness of the sun, shining at the time in a nearly cloudless sky, the light of the meteor was very noticeable. Its great size, powerful illumination, discharge of sparks, comet-like tail 3° to 5° in length, and the great train of smoke which marked its course for fully ten minutes after its passage, made a strong and lasting impression on the minds of all who saw it. Unfortunately the clamour over an exciting game of ball prevented the many members of the college who saw it from making as careful observations as they would otherwise have done; so it was impossible to tell whether its passage was accompanied by sound or not, but farmers in the neighbourhood report a faint hissing noise. It appeared to enter the atmosphere about 20° to 30° south of the zenith, and descending at an angle of about 50° to 60°, passed below the horizon north-north-west of Grinnell. By telegraphing, one small meteorite, weighing one-fifth of a pound, and several fragments from a 70-pound one, were secured, and analyses and microscopic sections at once made. They contain a large amount of metal for the "stone" class of meteorites. The following is the analysis of the matrix of the 70-pound meteorite: silica, 47·03; iron oxide, 29·43; oxide aluminium, 2·94; lime, 17·58; magnesia, 2·96; total, 99·94.

MR. GEORGE F. KUNZ, writing to *Science* from New York on May 8 about the same meteor, says it was seen over a good part of the State of Iowa at 5.15 p.m., standard western time. According to his account, the passage of the meteor was accompanied by a noise like that of heavy cannonading or thunder; and many people rushed to the doors, thinking it was the rumbling of an earthquake. The meteor exploded, he says, about eleven miles north of Forest City, Winnebago County, in the centre of the northern part of Iowa, lat. 43° 15′, long. 93° 45′ west of Greenwich, near the Minnesota State line. The fragments were scattered over a considerable surface of ground, and a part of the main mass was believed to have passed down into Minnesota. Up to the time at which Mr. Kunz wrote his letter, there had been found masses of 104 pounds, 70 pounds, and 10 pounds, and a number of fragments weighing from one to twenty ounces each. The pieces are all angular, with rounded edges. Mr. Kunz says the meteor is apparently of the type of the Parnallite group of Meunier, which fell February 28, 1857, at Parnallee, India. "The stone is porous, and when it is placed in water to ascertain its specific gravity, there is a considerable ebullition of air. The specific gravity, on a fifteen-gramme piece, was found to be 3·638. The crust is rather thin, opaque black, not shining, and, under the microscope, is very scorious, resembling the Knyahinya (Hungary) and the West Liberty (Iowa) meteoric stones. A broken surface shows the interior colour to be gray, spotted with brown, black, and white; the latter showing the existence of small specks of meteoric iron from one-tenth to four-tenths of a millimetre across. Troilite is also present in small rounded masses of about the same size. On one broken surface was a very thin seam of a soft black substance, evidently graphite (?), and soft enough to mark white paper; a felspar (anorthite ?) was also observed, and enstatite was also present." Mr. Kunz points out that this is the fourth meteorite that has been seen to fall in Iowa. The other three falls were as follows: at Hartford, Linn County, February 25, 1847; at West Liberty, Iowa County, February 12, 1875; and the great fall of siderolites at Estherville, Emmet County, May 10, 1879, which fall comprised over two thousand pieces weighing from a tenth of an ounce to 400 pounds.

A VALUABLE contribution to the study of the natural causes which check the tendency of plants and animals to increase in too great numbers appears in a recent issue of the *Bulletin* of the Moscow Naturalists (1889, No. 3). It is by Mr. Alexander Becker, whose ideas on the subject are based upon direct observation. For several years, various species of grasshoppers appeared in great quantities in South-East Russia (about Sarepta), but then came one year of sudden death for most of them: they were seen sitting motionless on the grasses, and dying. A few years ago the butterfly, *Melithæa Phœbe*, var. *ætherea*, appeared in immense numbers, and it was expected that in the following year it would be still more numerous, but in reality it became exceedingly rare. The like was true of *Zegris eupheme*, which suddenly became most numerous in 1883, and disappeared in 1884; even in 1883 its caterpillars could hardly be found on the plants they usually feed upon. Some hostile influence had prevented its further multiplication. Similar facts have been observed in the case of Mammalia as well. The *Spermophilus citillus* is usually met with about Sarepta; but sixty years ago it suddenly disappeared in the course of one summer—probably succumbing to some contagious disease. During the following years it could hardly be found, but by and by it multiplied again to such an extent that each inhabitant of Sarepta had to undertake to kill every year a certain number of the *Spermophilus.* Their numbers were diminished, but still they are very numerous in the steppes, thus illustrating the small importance of even a systematic attempt at extermination, as compared with the importance of natural checks. Many birds suddenly appear in great numbers, and as suddenly disappear. The *Merula rosea* for several years nested in very great numbers at Sarepta. Mr. Becker also mentions interesting facts as to a yellow dust which spread over Saratoff in April 1864, and must have been brought from Central Asia. Under microscopical examination, it was found to contain a great number of germs and Infusoria. The seeds of *Typha stenophylla,* which formerly was never found at Sarepta, must have been imported quite recently by wind, either from Caucasia or Siberia. In the course of one summer this pretty plant became numerous in a pond in the Ergheni Hills, but it disappeared next year. As a rule, a decrease of all kinds of insects is noticed about Sarepta, and it can be explained only by the general conditions of weather resulting in indifferent crops, and a general diminution of hay-crops in the surrounding steppes.

A COMPREHENSIVE paper upon the simpler derivatives of hydroxylamine, NH_2OH, by Drs. Behrend and Leuchs, will be found in the current number of *Liebig's Annalen* (p. 203). The great interest with which hydroxylamine derivatives have recently been invested by the discovery among them of geometrical isomers, and the considerable importance of hydroxylamine as a reagent for investigating the constitution of organic compounds, rendered it very desirable that something more definite should be ascertained regarding the compounds obtained by replacing the hydrogen of hydroxylamine by simple organic radicles, than the few isolated facts hitherto acquired. There are five types of derivatives possible, which are classified as follows, R representing a monad radicle: $H_2N—OR$ α-monalkyl, $RHN—OH$ β-monalkyl, $RHN—OR$ α-dialkyl, $R_2N—OH$ β-dialkyl, and $R_2N—OR$ trialkyl hydroxylamine. In the case of the radicle benzyl, $C_6H_5—CH_2—$, a complete series of such compounds have been prepared and fully investigated. The first member of the series, α-benzylhydroxylamine, $H_2N—OC_7H_7$, was prepared some time ago by Janny, and Drs. Behrend and Leuchs utilized Janny's reaction, improved very considerably in its details, in order to prepare this substance in quantity. The reaction consists in warming hydrochloric acid with the benzyl derivative of the well-known acetone compound of hydroxylamine, acetoxin, $(CH_3)_2C{=}NOH$. Its course may be represented by the equation $(CH_3)_2C{=}NOC_7H_7 + HCl + H_2O = H_2N—OC_7H_7 . HCl + (CH_3)_2CO$. The hydrochloride thus obtained crystallizes in large, flexible, lustrous plates, which sublime at 230°–260° C. without fusion. The free base itself, α-benzylhydroxylamine, $H_2N—OC_7H_7$, is a liquid which cannot be distilled at the ordinary pressure without decomposition, but at a pressure of 30 mm. distils unchanged at 118°–119°. It may also be safely distilled in steam. α-dibenzylhydroxylamine, $H(C_7H_7)N—O(C_7H_7)$, is readily obtained from the mono-compound just described by the limited action of benzyl chloride. It is also liquid at the ordinary temperature, and more difficultly volatilizable even in steam than the mono-compound. Its hydrochloride crystallizes well from alcohol in glittering needles. The di-compound is readily transformed by further action of benzyl-chloride into tribenzylhydroxylamine, $(C_7H_7)_2N—OC_7H_7$. The tri-compound is likewise a liquid, and is not volatile without decomposition even *in vacuo.* Its hydrochloride is readily and completely decomposed by water. The β-mono-compound, $(C_7H_7)HN—OH$, is obtained by boiling the α-di-compound with concentrated hydrochloric acid, or heating the two together in a sealed tube to 130°. $(C_7H_7)HN—O(C_7H_7) . HCl + HCl = C_7H_7HN—OH . HCl + C_7H_7Cl$. The free base, which is liberated as an oil upon addition of sodium carbonate solution to the concentrated solution of the hydrochloride, crystallizes on standing, and gives well-developed crystals on recrystallization from petroleum-ether. It also reduces Fehling's solution, in these two points differing markedly from the liquid α-mono-compound. The β-di-compound is best obtained by boiling hydroxylamine hydrochloride, benzyl chloride, and soda crystals with alcohol for an hour, using a reflux condenser. On cooling, crystals of the solid base are deposited, which melt at 123°. The preparation of this complete series shows in a very striking manner the different effects of substituting alkyl radicles for the hydrogen attached to nitrogen or for the hydroxylic hydrogen. The α-compounds are both liquids, while the β-derivatives are solids. The alkyl radicle replacing hydroxylic hydrogen is also very much more easily detached by the action of hydrochloric acid than that attached to nitrogen. It is also interesting to note that the basic character of hydroxylamine diminishes with the number of alkyl radicle groups introduced.

THE additions to the Zoological Society's Gardens during the past week include a Masked Parrakeet (*Pyrrhulopsis personata*) from the Fiji Islands, presented by Mr. Geo. Lawson; a Lanner Falcon (*Falco lanarius*), European, presented by Miss Marjorie Barnard; three Common Vipers (*Vipera berus*), British, presented by Mr. A. W. Cotton; two Andaman Starlings (*Sturnia andamanensis*) from the Andaman Islands, three Ceylon Fish-Owls (*Ketupa ceylonensis*) from Ceylon, six Tufted Ducks (*Fuligula cristata* 3 ♂ 3 ♀), European, purchased; a Great Bustard (*Otis tarda* ♀), European, received in exchange; two Japanese Deer (*Cervus sika* ♂ ♂), two Barbary Wild Sheep (*Ovis tragelaphus* ♂ ♀), a Burrhel Wild Sheep (*Ovis burrhel* ♂), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich at 10 p.m. on June 5 = 14h. 57m. 6s.

Name.	Mag.	Colour.	R.A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) G.C. 4045	—	—	15 0 54	+ 2 2
(2) G.C. 4058	—	—	15 3 24	+56 11
(3) 342 Birm.	4·5	Reddish-yellow.	14 55 50	+66 22
(4) v_1 Serpentis	5	Reddish-yellow.	15 20 41	+15 49
(5) μ Virginis	4	Whitish-yellow.	14 37 18	− 4 49
(6) R Ursæ Majoris ...	Var.	Reddish.	10 36 51	+69 21

Remarks.

(1) The spectrum of this nebula has not been recorded. In the General Catalogue it is described as: "Very bright; pretty large; round; pretty suddenly much brighter in the middle to a nucleus; following of two." The companion is apparently very faint.

(2) This is a bright oval nebula under the body of Draco. Smyth states that it is "rather faint at the edges, but not so as to obscure the form." The General Catalogue description is "Very bright; considerably large; pretty much extended in the direction 146°; gradually brighter in the middle." In 1848

Lord Rosse observed a longitudinal rift, but this has not been confirmed by later observations. According to Dr. Huggins, the spectrum is continuous, but it is not at all unlikely that further observations may show that it is not entirely so. The whole nebula appears to resemble that in Andromeda, even to the dark rift, and we now know that the spectrum in that case is not perfectly continuous. Intending observers of this class of nebula spectra will do well to examine the spectrum of Comet Brooks, which was referred to in last week's notes. The spectrum of the comet is apparently continuous at first sight, but careful observation shows beyond question the existence of the usual flutings of carbon. These flutings may also be expected in the nebulæ having so-called "continuous" spectra.

(3) D'Arrest likens the spectrum of this star to that of β Pegasi, but Dunér thinks it more like α Herculis. All the bands 1–9 are very strongly marked, and are wide and dark. Observations similar to those suggested for other stars of the group are required.

(4) According to Vogel, this star has a well-marked spectrum of the solar type, but Dunér classes it with stars of Group II. He states that the bands 1–8 are seen, but that they are narrow and not very dark, 4 and 5 appearing as lines. He also suggests that the spectrum is an intermediate one between Group II. and Group III. As I have pointed out on previous occasions, it is these intermediate stages which require a detailed study. It is pretty certain that the passage from one group to another will not be abrupt, but that there will be intermediate stages between each successive two. The star in question is probably slightly less advanced in condensation than Aldebaran.

(5) This is a star of Group IV. (Konkoly), but in addition to the hydrogen lines, D and *b* are distinctly visible. The usual observations are required.

(6) The range of this variable is from 6·0–8·1 at maximum to 13·2 at minimum, in a period of about 302 days. The increase of light is very rapid, whilst the decrease is slow and irregular (Sawyer). The spectrum is a fine one of Group II., the bands 1–9 being wide and dark; 7 and 8 are especially remarkable (Dunér). The usual bright lines which are now expected to appear at the maxima of stars of this class should be looked for. The maximum will occur about June 12.

A. FOWLER.

ACTINIC LIGHT OF THE SOLAR CORONA.—Prof. Frank H. Bigelow, in *Bulletin* No. 15 of the United States Scientific Expedition to West Africa, dated April 19, 1890, gives an interesting note on the law of distribution of the actinic light of the solar corona. His paper on "The Solar Corona, discussed by Spherical Harmonics," noted in NATURE, vol. xli. p. 595, assumed that the surface distribution of the electro-magnetic potential was expressed by $C \cos \theta$, the constant representing the maximum, and θ the angular distance from the coronal pole; the visible lines of the corona being shown to coincide in direction with the lines of force generated under these conditions. It is now suggested that the corresponding equipotential lines denote the position and direction of the surfaces of iso-actinism as referred to the same pole, or, in other words, that the actinic brightness is directly proportional to the potential. From the discussion it follows that the poles become the critical points for examination as to the actinic intensity of the corona; the sky in the neighbourhood should also be examined with great care; these two results, combined with the visible linear distance of the contour of merging of the polar rays in the sky light, in terms of the radius of the sun corrected from the covering lunar disk when taken in combination with the formula for these surfaces, will enable the whole of the coronal light to be discussed as simple phenomena.

ON THE ROTATION OF THE SUN.—Prof. N. C. Dunér has made a series of observations of the displacement of lines in the spectrum at the eastern and western edges of the sun for the purpose of deducing the time of rotation (*Astr. Nach.*, 2968). The observations were made from 1887–89 with a Rowland grating spectroscope of high power attached to the refractor of Lund Observatory, the distances between several lines in the a group of the solar spectrum at opposite edges of the sun being micrometrically determined. The results of the measures are given in the following table, where ϕ is the heliocentric latitude of the points on the sun's edge, v the velocity in kilometres with which the point on the edge approaches the earth, ξ the angle of rotation in 24 hours, and n the number of measures made in the different years:—

ϕ. °	v.	$\xi \cos \phi$. °	ξ. °	n.
0·4	1·98	14·14	14·14	107
15·0	1·85	13·19	13·66	104
30·0	1·58	11·31	13·06	104
45·0	1·19	8·48	11·99	106
60·0	0·74	5·31	10·62	107
74·8	0·54	2·45	9·34	107

These values of ξ, deduced from spectroscopic observations, show that the equatorial zone of the solar surface has a shorter time of rotation than zones in higher latitudes, the results agreeing with those found from sun-spot observations. The advantage of the method used by Prof. Dunér, however, lies in the fact that it allows observations of rotation to be made in the neighbourhood of the poles. A comparison of the spectroscopic and the spot observations shows that the former gives a slightly smaller velocity of rotation than the latter.

It may be remembered that the work done under the direction of Prof. Rowland at Baltimore showed that "the absorbing layer of gases by which the Fraunhofer lines are formed does not behave like the sun-spots, but is slightly retarded at the sun's equator."

PULKOVA OBSERVATORY.—The magnificent volume issued in commemoration of the jubilee of the Pulkova Observatory has been received. In the volume an account is given of the 30-inch refractor and the Astro-physical Laboratory, and the twelve plates which illustrate it are worthy representations of an enviable reality. It is hardly necessary to say that the history of the Observatory is fully delineated, and that technical descriptions of the instruments are given, whilst Hermann Struve gives a long account of the determination of the instrumental constants. A *résumé* is also given of the work done in the Astro-physical Laboratory, and a comprehensive bibliography of the various astronomical, geodetical, and other studies that have been completed. Indeed, the whole of the splendidly finished work is a fitting memento of the jubilee that it celebrates.

TELLURIC LINES OF THE SOLAR SPECTRUM.—M. J. Janssen presented a note to the Paris Academy, on May 27, relative to some results he has obtained during a stay in Algeria, where he has been for about four months investigating the action of the atmosphere on the solar spectrum by means of photographs taken when the sun is on the meridian and horizon. The photographs were taken with the aid of a Rowland's grating, and isochromatic plates were used in order to obtain records of the less refrangible portions of the spectrum. The work is not yet finished, but M. Janssen notes that, without the purity of the heavens in Algeria and the continuance of favourable days, it would have been impossible to obtain any results.

BROOKS'S COMET (*a* 1890).—The following ephemeris computed by Dr. Bidschof is given in *Astronomische Nachrichten*, No. 2969:—

1890.	R.A. h. m. s.	Decl. ° ′	Log r.	Log Δ.	Brightness.
June 4	18 56 29	+60 46·8	0·2816	0·1958	3·57
5	48 0	61 28·7			
6	39 9	62 7·9			
7	29 54	62 44·3			
8	20 17	63 17·8	0·2820	0·1978	3·53
9	10 20	63 48·1			
10	0 3	64 15·1			
11	17 49 30	64 38·7			
12	38 44	64 58·6	0·2827	0·2027	3·44
13	27 48	65 14·8			
14	16 44	65 27·5			
15	5 37	65 36·6			
16	16 54 31	65 42·1	0·2837	0·2102	3·31
17	43 29	65 44·0			
18	32 35	65 42·6			
19	21 53	65 37·7			
20	11 25	65 29·5	0·2849	0·2200	3·15

The brightness at discovery has been taken as unity.

NEWTON'S INFLUENCE ON MODERN GEOMETRY.

IN the appendix to his "Arithmetica Universalis" Newton states that a study of the ancient philosophers had led him to the inevitable conclusion that those early pioneers of science had introduced geometry in order to escape from needlessly long and laborious calculations. So, too, the author of the "Principia" had a predilection for graphic as distinguished from analytic methods. Indeed, anyone who has perused that great work will readily endorse the truth of this assertion. Yet Newton was born some forty years after the death of Viète and only eight before that of René Descartes, whose writings gave such a wondrous impulse to analytical studies.

During the closing period of the seventeenth, and nearly the whole of the eighteenth century, analysis reigned supreme; whilst graphic methods languished from the wilful neglect, nay even undisguised contempt, of the new philosophers. But at length men grew weary of abstract thought, and, as was quite natural after an undue pursuit of one branch of science to the exclusion of all others, a strong reactionary current in favour of concrete geometrical studies supervened. Then, as now, the question of the respective merits of the two methods gave rise to serious, not to say heated, controversy. But why sane people should quarrel and then fall out over a purely mathematical difference of this sort is quite as incomprehensible to a sober-minded critic as the passionate resistance shown to the postal reforms of Sir Rowland Hill was to the placid and imperturbable mind of Lord Melbourne.

The general weariness of the scientific mind, brought on by an excess of analytical work, prepared the way for a great revival of the graphic *culte*. Carnot, following to a certain extent the previous example of Simpson, courageously resolved to continue the work of Pascal, Newton, and Desargues. In consideration of his treatises on projective geometry and the theory of transversals, Carnot has a definite claim to be deemed the leader of this modern insurrection against the excessive use of analysis. Contemporary with him we find Monge, one of whose pupils, Poncelet, may be justly termed the author *par excellence* of modern methods. Since Poncelet's time the further

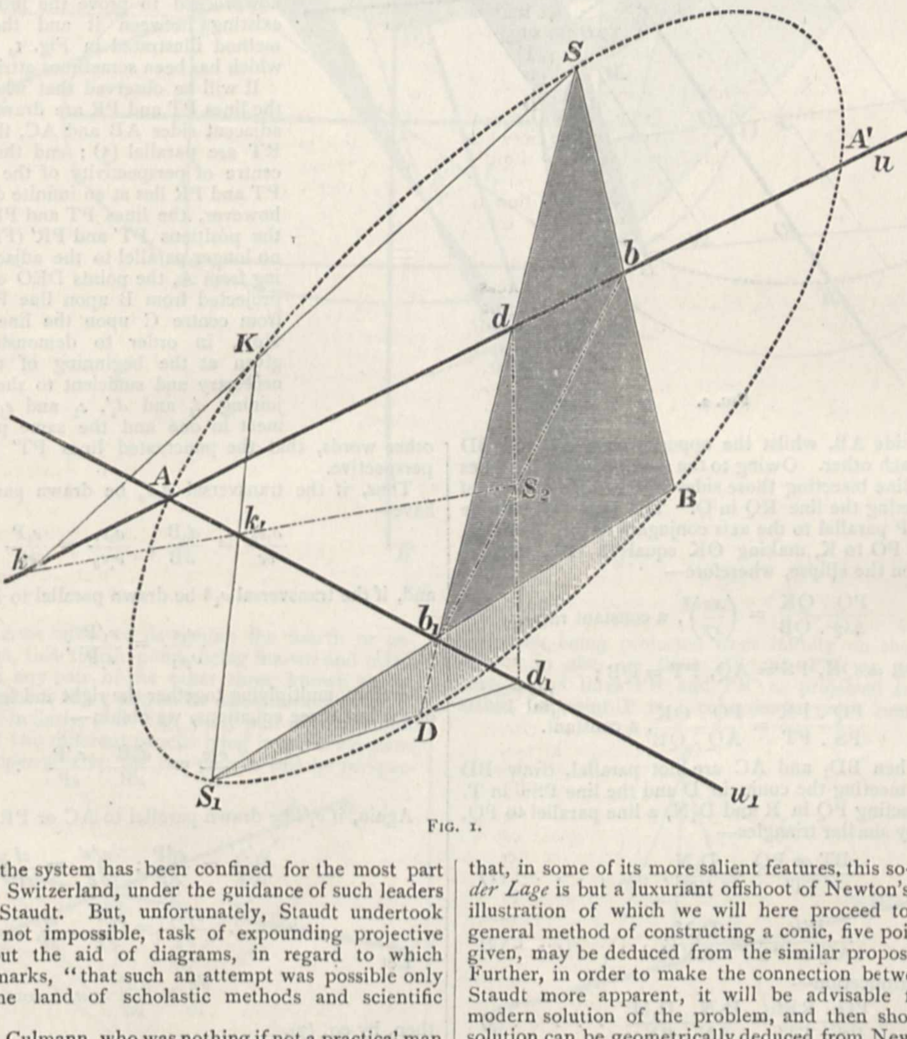


FIG. 1.

development of the system has been confined for the most part to Germany and Switzerland, under the guidance of such leaders as Steiner and Staudt. But, unfortunately, Staudt undertook the arduous, if not impossible, task of expounding projective geometry without the aid of diagrams, in regard to which Hankel well remarks, "that such an attempt was possible only in Germany, the land of scholastic methods and scientific pedantry."

Strange to say, Culmann, who was nothing if not a practical man of science, presupposes a knowledge of Staudt's geometry in all who would rightly understand his own epoch-making work on graphic statics.[1] Luckily, however, it is possible to understand every line of Culmann without having read a single word of Staudt. Now it is precisely the object of this paper to show that, in some of its more salient features, this so-called *Geometrie der Lage* is but a luxuriant offshoot of Newton's "Principia," in illustration of which we will here proceed to prove how the general method of constructing a conic, five points on which are given, may be deduced from the similar proposition in Newton. Further, in order to make the connection between Newton and Staudt more apparent, it will be advisable first to give the modern solution of the problem, and then show how the same solution can be geometrically deduced from Newton's principle.

SOLUTION.—Take any two of the given five points, for instance S and S_1 (Fig. 1), as centres of projection. Through a third point, A, draw any two lines u and u_1. Then, from the centre S_1, project the remaining two points B and D by rays S_1B and S_1D intersecting line u_1 in the points b_1 and d_1.

Similarly, from the second centre S, project the same two points B and D by rays intersecting the line u in b and d. Join bb_1 and dd_1, meeting in the centre of perspectivity, S_2, of the lines u and u_1.

Then, to find a sixth point on the curve, draw any ray through

[1] Published in the year 1864, not, as was recently stated in a contemporary, in 1866. The date is of importance when discussing priority of discovery in the matter of reciprocal figures; for Maxwell's paper on the subject in the *Philosophical Magazine* was also published in 1864. The question cannot, however, be discussed in a footnote.

S_2, intersecting u and u_1 in k and k_1; and project k from S and k_1 from S_1 by rays meeting in K, a point on the required curve.

PROOF.—Newton has solved this problem for a particular case, of which we will now give a short account, and thence deduce the more general modern method just described.

CASE I.—Let ABCD (Fig. 2) be a quadrangle inscribed in an ellipse, and P a point on the ellipse outside of the quadrangle; then, if PS and PQ be two chords meeting the sides of the quadrangle in S and T, R and Q respectively, the ratio

$$\frac{PR \cdot PQ}{PS \cdot PT}$$

will be constant for all positions of P. For, in the first instance, let PR and PQ be parallel to the side AC, PS and PT parallel

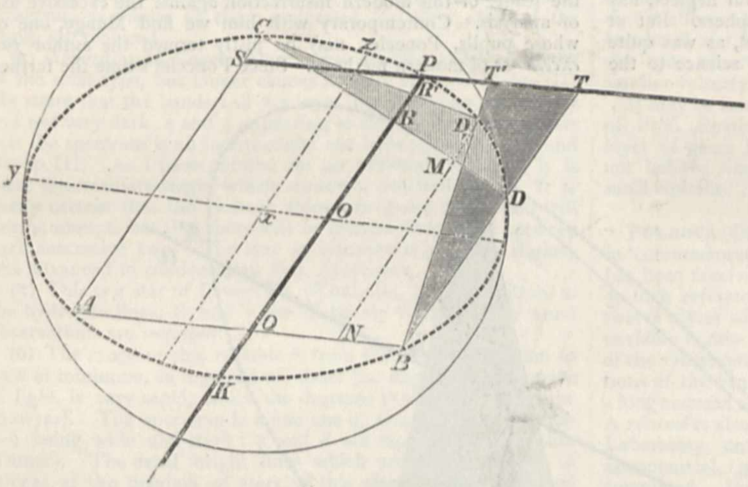


FIG. 2.

to the adjacent side AB, whilst the opposite sides AC and BD are parallel to each other. Owing to the parallelism of the sides AC and BD, a line bisecting those sides will be a diameter of the ellipse, bisecting the line RQ in O. The line PO will be the ordinate of P parallel to the axis conjugate of this diameter.

Now produce PO to K, making OK equal to OP; then K will be a point on the ellipse, wherefore—

$$\frac{PQ \cdot QK}{AQ \cdot QB} = \left(\frac{xz}{xy}\right)^2, \text{ a constant ratio.}$$

But

$$PR = QK,\ PS = AQ,\ PT = QB;$$

therefore—

$$\frac{PQ \cdot PR}{PS \cdot PT} = \frac{PQ \cdot QK}{AQ \cdot QB}, \text{ a constant.}$$

CASE II.—When BD_1 and AC are not parallel, draw BD parallel to AC, meeting the conic in D and the line PST in T. Join CD, intersecting PQ in R and D_1N, a line parallel to PQ, in M. Then, by similar triangles—

$$\frac{BT \text{ or } PQ}{TT'} = \frac{D_1N}{BN}; \quad \ldots\ldots\ldots (1)$$

also—

$$\frac{R'R}{AQ \text{ or } PS} = \frac{D_1M}{AN}; \quad \ldots\ldots\ldots (2)$$

whence, by multiplication—

$$\frac{PQ \cdot RR'}{PS \cdot TT'} = \frac{D_1N \cdot D_1M}{AN \cdot BN}. \quad \ldots\ldots (3)$$

But, by Case I., since D_1 is a point on the ellipse and similarly situated with respect to M and N as P is with respect to R and Q, we have—

$$\frac{PQ \cdot PR}{PS \cdot PT} = \frac{D_1N \cdot D_1M}{AN \cdot BN}. \quad \ldots\ldots (4)$$

Hence, from equations (3) and (4)—

$$\frac{PQ \cdot RR'}{PS \cdot TT'} = \frac{PQ \cdot PR}{PS \cdot PT};$$

or, by subtraction—

$$\frac{PQ \cdot RR'}{PS \cdot TT'} = \frac{PQ}{PS}\left(\frac{PR - RR'}{PT - TT'}\right)$$

$$= \frac{PQ \cdot PR'}{PS \cdot PT'};$$

wherefore—

$$\frac{PR'}{PR} = \frac{PT'}{PT}. \quad \ldots\ldots\ldots (5)$$

Thus, the lines R'T' and RT are parallel; so that, in order to construct the ellipse, it is necessary to divide the two lines PT and PQ by a series of parallel lines, meeting them in points T and R, which, being projected from the centres B and C respectively, will determine, by means of the points of intersection of corresponding rays, any number of points on the required conic.

Such is Newton's method of constructing a conic five points on which are given. We will now proceed to prove the intimate connection existing between it and the more modern method illustrated in Fig. 1, the discovery of which has been sometimes attributed to Pascal.

It will be observed that when, as in Fig. 2, the lines PT and PR are drawn parallel to the adjacent sides AB and AC, the rays R'T' and RT are parallel (5); and that, therefore, the centre of perspectivity of the punctuated lines PT and PR lies at an infinite distance. When, however, the lines PT and PR are shifted into the positions PT' and PR' (Fig. 3), being then no longer parallel to the adjacent sides branching from A, the points DEO on the ellipse are projected from B upon line PT' in $d_1e_1o_1$, and from centre C upon the line PR' in $d_1'e_1'o_1'$. Now, in order to demonstrate the method given at the beginning of this paper, it is necessary and sufficient to show that the lines joining d_1 and d_1', e_1 and e_1', o_1 and o_1', all meet in one and the same point, S; or, in other words, that the punctuated lines PT' and PR' are in perspective.

Thus, if the transversal o_1d_0 be drawn parallel to PT, we have—

$$\frac{o_1e_0}{oe} = \frac{d_0B}{dB}; \quad \frac{o_1e_1}{o_1e_0} = \frac{e_1P}{eP};$$

and, if the transversal $o_1\delta$ be drawn parallel to PR', we have—

$$\frac{o_1\epsilon}{o_1e_1} = \frac{e_1'P}{e_1P};$$

wherefore, multiplying together the right and left hand members of the last three equations, we obtain—

$$\frac{o_1\epsilon}{oe} = \frac{d_0B}{dB} \cdot \frac{e_1'P}{eP} \quad \ldots\ldots (6)$$

Again, if $o_1'l$ be drawn parallel to AC or PR, we have—

$$\frac{o_1'e_1'}{o_1'\epsilon'} = \frac{e_1'P}{e'P}; \quad \frac{o_1'\epsilon'}{o'e'} = \frac{sl}{sP};$$

$$\therefore \frac{o_1'e_1'}{o'e'} = \frac{e_1'P}{e'P} \cdot \frac{sl}{sP} \quad \ldots\ldots (7)$$

Let

$$\frac{o'e'}{oe} = \frac{o'd'}{od} = n, \text{ a constant;}$$

then, by eq. (7),

$$\frac{o_1'e_1'}{oe} = n\frac{e_1'P}{e'P} \cdot \frac{sl}{sP}; \quad \ldots\ldots (8)$$

and, from equations (6) and (8),

$$\frac{o_1\epsilon}{o_1'e_1'} = \frac{1}{n} \cdot \frac{d_0B}{dB} \cdot \frac{e'P}{eP} \cdot \frac{sP}{sl}$$

$$= \frac{d_0B}{dB} \cdot \frac{sP}{sl} = k.$$

By a similar process of reasoning it can be shown that

$$\frac{o_1\delta}{o_1'd_1'} = k,$$

wherefore—

$$\frac{o_1\epsilon}{o_1'e_1'} = \frac{o_1\delta}{o_1'd_1'};$$

so that the lines e_1e_1' and d_1d_1' must meet in the same point on line o_1o_1', which point of convergence is therefore the centre of perspective, S.

The perspectivity of the punctuated lines PT′ and PR′ may be deduced from the projective relations of Fig. 3 by means of the following two well-known theorems of projective geometry.

THEOREM I.—If the correlative or coharmonic points a and a_1 of the punctuated lines u and u_1 (Fig. 4) coincide with their common point of intersection, forming what may be termed a coharmonic point, the lines u and u_1 are in perspective. For, let bb_1 and cc_1 be any other two pairs of coharmonic points, and meet in the centre S; then S will be the centre of perspectivity of the two lines u and u_1; seeing that in a harmonic or other system of ratios, any three members of a compound proportion

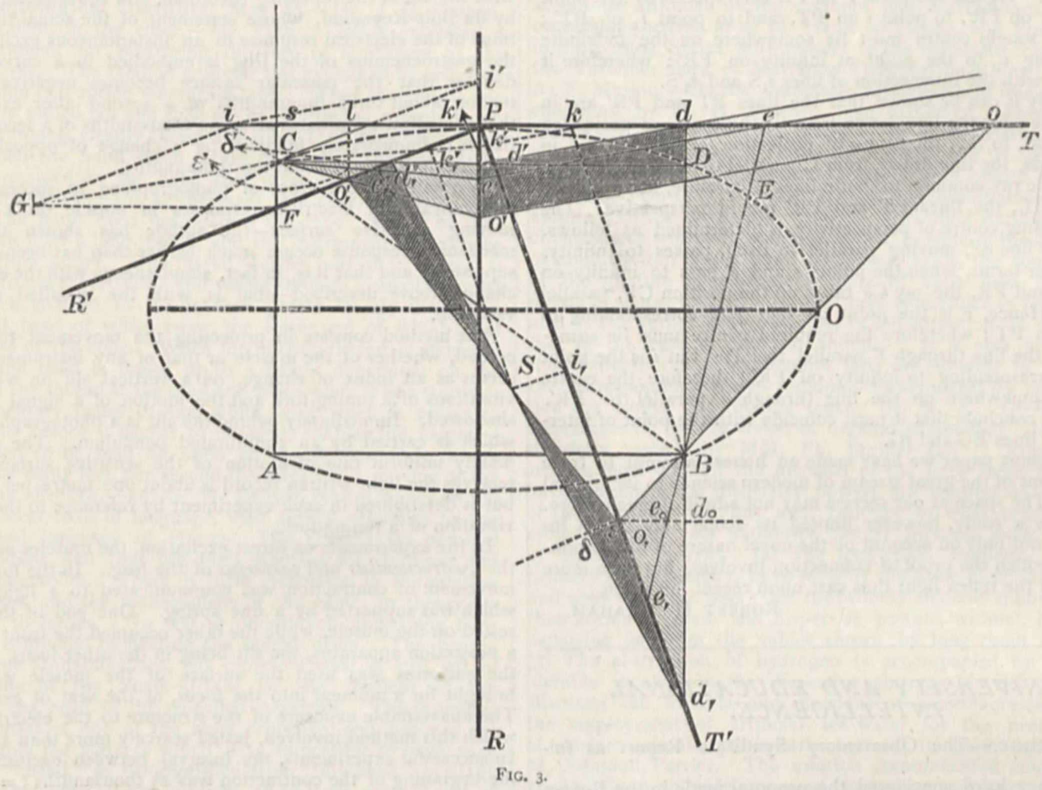


FIG. 3.

consisting of four terms suffice to determine the fourth or unknown term. Then, this fourth point, being known and taken in conjunction with any pair of the other three known terms, will serve to determine a fifth; and so on *ad infinitum*.

THEOREM II.—Similarly, if in Fig. 5 any pair of coharmonic rays Sa and S_1a_1 of two different pencils lying in the same plane are coincident or coperspective, the two pencils will be perspective of the same line, and consequently perspective of each other. For, let the coharmonic rays Sb and S_1b_1 meet in a point B, and the rays Sc and S_1c_1 in C; then the line BC will be perspective of each pencil; seeing that, if three coharmonic rays of the pencils meet upon the line BC, it necessarily follows that a fourth pair of such rays will meet upon the same line.

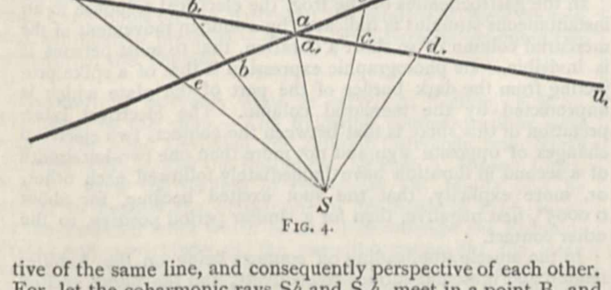


FIG. 4.

Now it will be observed that lines PT and PR (Fig. 3) are in perspective, being projected from infinity on the right of the figure. So also are lines PT and PT′ as projected from centre B, and lines PR and PR′ as projected from centre C. Further, the point P is a coharmonic point common to lines PT′ and PR′ as projected from centres B and C respectively; for it will be seen that P does not change its position when projected through centre B from line PT to line PT′, nor does it change when projected, first from infinity parallel to dd', ee', &c.

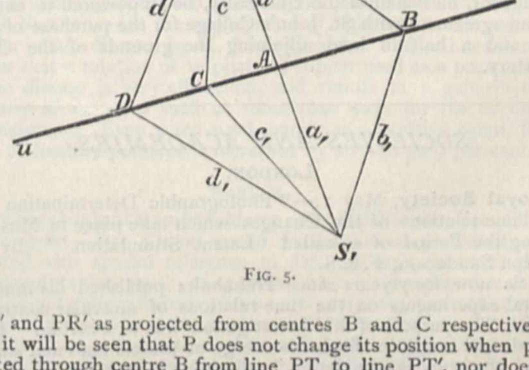


FIG. 5.

from line PT to line PR, and thence through centre C upon line PR′. Moreover, the point P is the point of intersection of lines PT′ and PR′; wherefore, by Theorem I., the lines PT′ and PR′ are in perspective.

In order to find the centre of perspectivity of lines PT′ and PR′, we have the point k on line PT correlative of the point at infinity on PT′, k being determined by drawing Bk parallel to PT′. The point k_1' on PR′, correlative of k on PT, is found as before by projecting k first upon PR in k' and thence upon PR′ in k_1'. Thus, the required centre of perspectivity must lie somewhere on the indefinite line joining k_1' with the point at infinity upon PT′. Again, the point i' on PR corresponds to the point at infinity on PR′, to point i on PT, and to point i_1 on PT′; hence the sought centre must lie somewhere on the indefinite line joining i_1 to the point at infinity on PR′; wherefore it coincides with the intersection of lines i_1S and k_1'S.

Similarly it can be shown that the lines PT and PR′ are in perspective; for the line drawn from C, the centre of projection for line PR′, to S_∞, the centre of projection for line PT, or, in other words, the line drawn from C parallel to dd', ee', &c., is a coharmonic ray common to both lines; therefore, according to Theorem II., the lines PT and PR′ are in perspective. The corresponding centre of perspectivity is determined as follows. When the line oo', moving parallel to itself, passes to infinity, or, in other terms, when the points o and o' pass to infinity on lines PT and PR, the ray Co' takes up the position CF, parallel to PR. Hence, F is the point on line PR′ corresponding to infinity on PT; wherefore the required centre must lie somewhere on the line through F parallel to PT. But i is the point on PT corresponding to infinity on PR′; therefore the centre must lie somewhere on the line through i parallel to PR′. Hence we conclude that it must coincide with the point of intersection of lines FG and iG.

In this short paper we have made an honest attempt to trace one filament of the great stream of modern science to its original source. The space at our service may not admit of much more. Still, such a study, however limited its scope may be, is interesting, not only on account of the novel nature of the demonstrations which the proof of connection involves, but even more because of the reflex light thus cast upon recent invention.

ROBERT H. GRAHAM.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Observatory Syndicate Report as follows:—

That they have considered the proposal made in the Report of the Newall Telescope Syndicate for the purchase of an acre or an acre and a half of land adjoining the grounds of the Observatory for the erection of the Newall telescope and its appurtenances, and they are of opinion that, in view of possible future requirements of the Observatory, it will be desirable to secure now the larger area—namely, an acre and a half.

They have consulted the Bursar of St. John's College, and have learnt that the College is willing to sell to the University an acre and a half at the price of £250. Further, Prof. Adams has offered to contribute £100 towards expenses.

Under these circumstances the Syndicate recommend that Prof. Adams's generous offer be accepted, and that the Vice-Chancellor, on behalf of the University, be empowered to enter into an agreement with St. John's College for the purchase of an acre and a half of land adjoining the grounds of the Observatory.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 1.—"Photographic Determination of the Time-relations of the Changes which take place in Muscle during the Period of so-called 'Latent Stimulation.'" By J. Burdon Sanderson, F.R.S.

It is now forty years since Helmholtz published his fundamental experiments on the time-relations of muscular contractions. The purpose of this investigation was to ascertain "the periods and stages in which the energy of muscle rises and sinks after instantaneous stimulation"; the word energy being defined as the "mechanical expression of activity"; and one of the most important conclusions of the author was that, in the muscles investigated by him, contraction does not begin until nearly one hundredth of a second after excitation. This interval has, by subsequent writers, been called the period of "latent stimulation."

Helmholtz subsequently (1854) showed, by experiments of surpassing ingenuity, that during this period an electrical change of very short duration occurs, which culminates at about one two-hundredth of a second after excitation. The fact discovered by Helmholtz was further investigated by Bernstein in 1866, with the aid of the repeating rheotome, and subsequently (1875) by du Bois-Reymond, whose statement of the actual time-relations of the electrical response to an instantaneous excitation of the gastrocnemius of the frog is embodied in a curve which denotes that the muscular surface becomes negative to the tendon about three thousandths of a second after excitation, that this effect culminates at seven thousandths of a second, and that it is immediately followed by a change of opposite sign, which culminates at about ten thousandths.

By a new method—that of photographing in succession the mechanical and electrical responses in muscle on a rapidly moving sensitive surface—the author has shown that the mechanical response occurs much earlier than has been hitherto supposed; and that it is, in fact, simultaneous with the electrical change above described—that is, with the so-called negative variation.

The method consists in projecting the movement to be recorded, whether of the muscle or that of any instrument which serves as an index of change, on a vertical slit on which the vibrations of a tuning-fork and the motion of a signal are also shadowed. Immediately behind the slit is a photographic plate, which is carried by an equilibrated pendulum. The approximately uniform rate of motion of the sensitive surface which receives the light-written record is about one metre per second, but is determined in each experiment by reference to the rate of vibration of a tuning-fork.

In the experiments on direct excitation, the muscles used were the *gastrocnemius* and *sartorius* of the frog. In the former the movement of contraction was communicated to a light index, which was supported by a fine spring. One end of the index rested on the muscle, while the other occupied the front focus of a projection apparatus, the slit being in the other focus. When the sartorius was used the surface of the muscle was itself brought for a moment into the focus, at the seat of excitation. The unavoidable exposure of the structure to the electric light, which this method involved, lasted scarcely more than a second. In successful experiments, the interval between excitation and the beginning of the contraction was $2\frac{1}{2}$ thousandths ($= \frac{1}{400}$) of a second.

For measurement of the delay in indirect excitation, the gastrocnemius (with the index) only was used, the exciting electrodes being applied either at 12 or at 37 mm. from the muscle. The results were not so constant. Corrected for loss of time by propagation along the nerve, the intervals between excitation and beginning contraction varied from 0·0025″ to 0·0035″.

In the experiments for determining the time after excitation at which the electrical response begins and culminates, the capillary electrometer was used, as in the author's experiments on the heart and on the leaf of *Dionæa*, as a signal, but with much improved apparatus for recording.

In the gastrocnemius of the frog, the electrical response to an instantaneous stimulus is indicated by a sudden movement of the mercurial column of so short a duration, that to most persons it is invisible. Its photographic expression is that of a spike projecting from the dark border of the part of the plate which is unprotected by the mercurial column. The electrical interpretation of this spike is that between the contacts two electrical changes of opposite sign and not more than one two-hundredth of a second in duration have immediately followed each other, or, more explicity, that the spot excited became, for about 0·0005″, first negative, then for a similar period positive, to the other contact.

In the muscle (the leading off contacts being on the Achilles tendon and muscular surface respectively, and the nerve excited at a distance of 12 mm.) the electrical response begins at 0·004″ and culminates at about 0·012″ after excitation. Deducting the delay due to transmission along the nerve, we have, as the time between excitation and response, 0·0035″. It is thus seen that the electrical response, instead of preceding the mechanical, is contemporary with it. The electrical change *may* therefore so far as concerns the time at which it occurs in muscle, be immediately connected with that sudden change of the elastic properties of muscle of which the contraction is the sign.

The author exhibited at the Society photographs in proof of all the facts above stated. Further details, particularly those relating to the character of the "electrical response" to instantaneous stimulation, for which the photographic method of recording the movements of the capillary electrometer on a rapidly moving surface has afforded new facilities, will be the subject of a later communication.

Anthropological Institute, May 13.—Dr. J. G. Garson, Vice-President, in the chair.—Mr. Francis Galton exhibited a new instrument for measuring the rate of movement of the various limbs. The method adopted was explained by referring to the action of a spring measuring-tape. When the end of one of these is pulled out and then let go, it springs sharply back, the tape running cleanly through a slit. If it runs back more quickly than the hand could follow it, then, if the end of the tape be retained in the hand that gives the blow, the tape will run through the slit at the exact rate at which the blow is given. The hand need not be near the tape; it may be connected with it by a long thread, and the instrument will thus be guarded from injury. The thread, during part of its course, is arranged to travel vertically, and passes through a small inverted cone which is fixed to it; it then passes loosely through a cylindrical bead of white ivory, the lower end of which rests on the base of the cone. When the moving thread is suddenly arrested, the bead is tossed up to a height dependent on the velocity of the thread at the time and place when it was stopped. The momentary pause of the white bead when it ceases to ascend, and before it begins to descend, enables the height it has attained to be read off upon an appropriate scale, which tells at how many feet per second the thread was moving at the time it was checked.—Dr. G. W. Leitner read a paper on the ethnographical basis of language, with special reference to the customs and language of Hunza. The Hunzas are nominal Mohammedans, and they use their mosques for drinking and dancing assemblies. There is little restriction in the relation of the sexes, and the management of the State, in theory, is attributed to fairies. No war is undertaken unless the fairy gives the command by beating the sacred drum. The people are not true Mohammedans, but represent what is still left of the doctrine of the Sheik-ul-Jabl, or the Ancient of the Mountain, the head of the so-called Assassins. The language of the Hunzas is one of the most primitive, and has not yet emerged from the state in which it is impossible to have such a word as "head," as distinguished from "my head," or "thy head, or "his head;" for instance, *ak* is "my name," and *ik* is "his name." Take away the pronominal sign, and *k* alone is left, which means nothing. *Aus* is "my wife," and *gus* "thy wife." The *s* alone has no meaning, and in some cases it seemed impossible to arrive at putting anything down correctly; but so it is in the initial stage of a language. In the Hunza language that stage is important to us as members of the Aryan group, as the dissociation of the pronoun, verb, adverb, and conjunction from the act or substance only occurs when the language emerges beyond the stage when the groping, as it were, of the human child between the *meum* and *tuum*, the first and second persons, approaches the clear perception of the outer world, the *suum*, the third person.—Mr. A. P. Goodwin read some notes on the natives of the interior of New Guinea, and exhibited a fire-stick.—Mr. G. F. Lawrence exhibited two crania from the Thames.

Geological Society, May 21.—Dr. A. Geikie, F.R.S., President, in the chair.—The following communications were read:—On some Devonian and Silurian Ostracoda from North America, France, and the Bosphorus, by Prof. T. Rupert Jones, F.R.S. After the reading of this paper Dr. Hinde said he wished to express the obligations of geologists to Prof. Jones for the excellent work which he had done amongst the Entomostraca; and particularly on the present occasion, for the clear manner in which he had explained the wide distribution of some of the species. The President alluded to the long years of arduous labour which Prof. Jones had bestowed on these minute fossils, and to the interesting results he had obtained from them. —On the age, composition, and structure of the plateau-gravels of East Berkshire and West Surrey, by the Rev. Dr. A. Irving. —Further note on the existence of Triassic rocks in the English Channel off the coast of Cornwall, by R. N. Worth.—On a new species of *Coccodus* (*C. Lindströmi*, Davis), by J. W. Davis.

PARIS

Academy of Sciences, May 27.—M. Hermite in the chair. —Note on the works of M. Louis Soret, by M. A. Cornu.— On the recent work done in Algeria, by M. J. Janssen (see Our Astronomical Column).—On meteorological observations made at mountain stations in Europe and the United States, by M. H. Faye. The author discusses some observations of temperature at various altitudes during cyclones and anticyclones, and the conclusions arrived at by M. Hann at Vienna, and Prof. Hazen in the United States, with respect to the variations found.—On the Turonian flora of Martigues (Bouches-du-Rhône), by M. A. F. Marion.—On the automatic resolution and integration of equations, by M. H. Parenty. An extract of a memoir presented by the author is given.—On the nutation of the axis of the earth, by M. Folie.—On the theory of heat, by M. Appell.—On the elliptical double refraction of quartz, by M. F. Beaulard.—On the conductivities of compounds of ammonia and aniline with the oxybenzoic acids, by M. Daniel Berthelot. One circumstance worthy of attention is that, in spite of the difference of conductivities of the three oxybenzoic acids, the conductivity of the mixture of equivalent parts of each acid and ammonia is almost the same for the three isomerides as for benzoic acid. The author has previously called attention to a similar fact in the case of salts of sodium. It is also noted that the conductivities of ammonium salts are superior to those of the corresponding salts of sodium.—Experiments on magnetization by single and double touch, by M. C. Decharme.— Researches on the dispersion of organic compounds (alcohols of the fatty series), by MM. Ph. Barbier and L. Roux. The authors show—(1) In the alcohols of the fatty series that they have examined, the dispersive powers are continuous functions of the molecular weights, and, contrary to what occurs in the aromatic series, *the dispersive powers increase with increase of molecular weight.* (2) The long-chain isomeric alcohols, primary and secondary, have sensibly the same dispersive power and obey the same laws; but the primary alcohols studied, other than normal, possess less dispersive powers, without, however, departing far from the values shown by long-chain alcohols. (3) The abstraction of hydrogen is accompanied by a considerable increase in the dispersive power.—M. Ed. Grimaux discusses the formula and reactions of homofluoresceın.—On the employment of artificial sea-water for the preservation of marine animals, particularly oysters, in great aquaria, by M. Edmond Perrier. The solution recommended contains 81 grams sodium chloride, 7 grams magnesium sulphate, 10 grams magnesium chloride, and 2 grams potassium chloride, dissolved in 3 or 4 litres of water.—Observations on submarine vision, made in the Mediterranean by means of a diving apparatus, by M. H. Fol.—Two new hermaphrodite *Pélécypodes*, by M. Paul Pelseneer.—On the chemical examination of mineral waters from Malaysia; the formation of tin ore, note by M. Stanislas Meunier. An incrustation from the hot spring of Azer-Panas possesses the following composition: SiO_2, 91·8; H_2O, 7·5; SnO_2, 0·5; Fe_2O_3, 0·2; and traces of alumina. This is the first instance of the present formation of a tin-ore.—Observations on the structure of some ferruginous deposits of the Secondary rocks, by M. Bourgeat.—Discovery of a Turonian flora in the neighbourhood of Martigues (Bouches-du-Rhône), by M. G. Vasseur.—On the employment of copper salts as a remedy for the potato-disease, by M. Aimé Girard. The author demonstrates that a solution of sulphate of copper used as a preventive of the disease is very efficacious, and results in a gain in the quantity of the crop such as more than pays for the expense of treatment. Even when used purely as a curative agent, the yield of healthy potatoes is increased by 20·2 to 22·9 per cent.

BERLIN.

Meteorological Society, May 5.—Prof. Schwalbe, President, in the chair.—Dr. Kiewel spoke on the diurnal periodicity of the wind with special reference to Dr. Sprung's theory of the rotation of its direction. It appeared from his investigation that in addition to the influence of the sun's radiation, the variations of barometric pressure also produce a distinct effect, as also does the difference in the rate of the wind in the upper and lower layers of the atmosphere. A discussion followed, in which Dr.

Sprung took part.—Dr. Wagner announced that arrangements had been made for endeavouring to take simultaneous photographs of flashes of lightning at widely separated stations during the approaching summer. It was hoped that by this means, if successful, it would be possible to obtain some idea of the spacial and dimensional relations of the flash.

Physical Society, May 16.—Prof. du Bois-Reymond, President, in the chair.—Dr. Köpsel exhibited and described an apparatus for the calibration of the torsion-galvanometer of Siemens and Halske. The magnet which is used in that form of the galvanometer which is employed for technical purposes, frequently changes its magnetism in presence of other powerful magnets or currents, hence the instrument requires constant calibration and adjustment. Dr. Köpsel explained his method of effecting this with the help of a Clarke element. He further described a new form of resistance to be used in the measurement of very powerful electric currents. The older form, consisting of a brass tube filled with water, in communication with a reservoir of water, had proved useless in practice. The new resistances consist of nickel wires, surrounded by an insulating layer, inserted into a tube of lead and immersed in water. These wires were not rendered incandescent by currents of 80 to 90 amperes, and have been proved to be practically useful.

Physiological Society, May 23.—Prof. du Bois-Reymond, President, in the chair.—Prof. Falk gave an account of a case of a man who was found dead, and who must have died suddenly. A *post-mortem* examination showed that all the tissues and organs were in a normal state with the exception of the pancreas, which was infiltrated with blood. This he regarded as the cause of death, although it is as yet impossible to suggest how the lesion leads to death. Rupture of a blood-vessel in the pancreas is of rare occurrence.—Dr. Heymans had recently tested Engelmann's statement that the ureters contain ganglia at their upper and lower ends, but no nerves, employing the ureters of mice. Using gold chloride he observed, with low powers of the microscope, nerve-fibres accompanying the blood-vessels which surround the ureters. After removing the peritoneum and spreading out the excised ureters, he also found fine fibres between the muscle-cells, some of which appeared, under high magnification, to be attached directly to the muscle-cells. He was not able to make out that a nerve-fibril supplies each muscle-cell.—Dr. Bruhns gave an account of his researches on adenin and hypoxanthin, with a view to determining their chemical constitution; in this he has not as yet been more than partially successful. During his researches he came across a compound of adenin and hypoxanthin, whose properties explain many opposing statements of the less recent authors. The silver salts, with picric acid of the above bases, are the ones most suited for discriminating between them. Their salts with mercury are also extremely interesting from a chemical point of view, owing to their close resemblance to the amido-compounds of mercury.—Prof. Zuntz described a modified form of intestinal fistula which he and Dr. Rosenberg had recently applied.

BRUSSELS.

Royal Academy of Sciences, April 3.—M. Stas in the chair.—The following communications were made:—Researches on the volatility of carbon compounds, by M. Louis Henry.—On monocarbon derivatives, by the same author.—Reply to a note by General Liagre relative to M. Ronkar's work "On the Mutual Impulse between the Crust and Interior of the Earth on account of Internal Friction," by M. Folie. The criticism referred to appeared in *Bulletin* No. 3 of this year, and in reply to it M. Folie adduces proofs of diurnal nutation.—On the extent of the curative action of hypnotism: hypnotism applied to alterations of the visual organ, by M. J. Delbœuf, with the collaboration of M. J. P. Null and Dr. Leplat. An extended account is given of the treatment of a patient suffering from an eye-disease which was completely cured by hypnotism.—A new Nematoid of a Galago from the coast of Guinea, by M. P. J. Van Beneden.—Note on the law existing between unit of variation of vapour tension and absolute temperature, by M. P. De Heer.—On the structure of the equatorial bands of Jupiter, by M. F. Terby.—On the thickness of the earth's crust deduced from diurnal nutation, by M. E. Ronkar. From an extended investigation it is concluded that the thickness of the earth's crust does not exceed $\frac{1}{10}$ of the radius.—On the mutual impulse between the crust and interior of the earth on account of internal friction (second note), by the same author.—Experimental methods for determining whether polarized light, of which the plane of polarization is in vibration, exercises any influence on a magnetic field, by M. H. Schoentjes.—Experiments on the absence of bacteria in the ducts of plants, by M. Emile Laurent.

STOCKHOLM.

Royal Academy of Sciences, May 14.—On the discovery of Tertiary volcanic rocks near Lake Dellen in Helsingland and Lake Mien in Smaland, Sweden, by Dr. N. O. Holst and Dr. F. N. Svenonius. Specimens exhibited and commented upon by Baron A. E. Nordenskiöld.—Report on an entomological tour in Norrland and Jemtland, chiefly for the study of the Poduridæ of these countries, by H. Schött.—Some observations on the distribution of the sexes in the galls of *Andricus ramuli*, by Prof. C. Aurivillius.—On the Graptolithidæ of the island of Gotland, by Dr. G. Holm.—On the employment of indefinite determinants within the theory of linear differential equations, by H. von Koch.—Invariant expressions for the generalized substitution of Poincaré, by F. de Brun.—On a generalization of the functions of Klein of the third family, by G. Cassel.—The form of the integrals in linear differential equations, by A. M. Johanson.—Contributions to the knowledge of the Chlorophyceæ of Sweden, by O. F. Andersson.—Helminthological researches from the west coast of Norway, Part I., Cestoda, by Dr. E. Lönnberg.—Some Muriceidæ of the genera Acanthogorgia, Paramuricea, and Echinomuricea in the Zoological Museum of Upsala, by T. Hedlund.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A Synonymic Catalogue of the Recent Marine Bryozoa: E. C. Jelly (Dulau).—The Colours of Animals: E. B. Poulton (K. Paul).—Rambles and Reveries of a Naturalist: Rev. W. Spiers (C. H. Kelly).—Pond Life; Algæ and Allied Forms: T. S. Smithson (Sonnenschein).—Faune des Vertébrés de la Suisse; Vol. v., Histoire Naturelle des Poissons, 2me. Partie: Dr. V. Fatio (Genève, H. Georg).—Gesammelte Mathematische Abhandlungen, 2 vols: H. A. Schwarz (Berlin, J. Springer).—Hints on Reflecting and Refracting Telescopes, &c., 5th edition: W. H. Thornthwaite (Horne).

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