THURSDAY, APRIL 20, 1899.

A SCIENCE OF THE SCIENCES.

The Groundwork of Science; a Study of Epistemology. By St. George Mivart, M.D., Ph.D., F.R.S. (The Progressive Science Series.) Pp. xvii + 331. (London: John Murray, 1898.)

INASMUCH as science is an organised knowledge of the phenomena of nature and the laws which govern these phenomena, and since this knowledge is acquired through the senses and interpreted by the intellect of man, it is obvious that the groundwork of science must be sought for in the human mind. To many this may seem a self-evident proposition, but it nevertheless furnishes Dr. Mivart with material for the ten chapters of which the present work is composed. The aim and objects of the book are set forth in a preliminary way in the introductory chapter, from which we give the following extract as fairly representing the author's position:

"It is not enough for the true man of science to be acquainted with many sciences, and to reflect on the knowledge he so possesses. The rational mind sooner or later seeks to know what is the basis of his own knowledge and the ultimate groundwork of all science. It thus calls for a science of science, and cannot rest satisfied without a pursuit of Epistemology, or the study of the grounds of all the learning the mind of man can acquire" (p. 2).

In the second chapter the author sets out with the object of discussing the classification of the sciences, but wisely comes to the conclusion that instead of classifying it is sufficient to simply enumerate the sciences as being the raw material with which epistemology has to deal. The arguments which lead to the conclusion that it is futile to attempt to classify the sciences in any satisfactory way are ingeniously marshalled, and will, we imagine, be convincing to most scientific readers. After all there is only one science of nature; all our divisions are more or less arbitrary, and necessitated only by the finiteness of the human intellect.

In the third chapter, entitled "The Objects of Science," Dr. Mivart discusses at great length the idealism of Bishop Berkeley, to whose influence he traces "the whole of the philosophy of Germany and Holland, from Spinoza to Hartmann." So fairly does the author state the case for the idealists, that the reader might at first be disposed to imagine that Dr. Mivart is identifying himself with that school. It is not till we reach p. 43 that the first breath of realism appears, and from thence on to the end of the chapter we find ourselves in a healthier scientific atmosphere. Here again the arguments used against the pure idealist, although somewhat unnecessarily lengthy, are well considered and cannot fail to leave the reader in a more rational state of mind as regards his scientific position:

"The conviction, then, that science is really concerned not alone with thoughts, but also with external, independent, and extended realities, is so far justified" (p. 64).

Having arrived at this conclusion, and having incidentally (p. 84) disposed of the new Monism, the author sums up the chapter by describing in general terms the objects of science as mental, physical and metaphysical; and in the fourth chapter he discusses the methods of science, which methods are summed up under ten fundamental propositions (pp. 106-107). The author considers that the truth and certainty of these propositions is implied by the methods of science; and we do not suppose that many scientific men will join issue with him here. Some of the said propositions—such as "nothing can at the same time both be and not be" and "some axioms are self-evident"—may appear to many readers as truisms.

In the fifth chapter, having the title "The Physical Antecedents of Science," the author sets out from the proposition that since knowledge consists of mental states or feelings, and since feelings are the result of physical organisation, it is necessary to have an acquaintance with the physiological machinery by which psychical results are made possible. This chapter accordingly deals with what may be described as an outline sketch of classification and morphology with more special reference to the structure of the nervous system of man. In discussing instinct the author states that "instinctive movements differ from reflex actions in that they are not merely responsive to a stimulus felt, but respond to that stimulus in such a manner as to serve a future unforeseen purpose" (p. 127). The same definition is expanded at greater length on p. 132. The sixth chapter discusses the psychical antecedents of science, and opens with the following paragraph:

"The time has now come to leave behind us, as far as may be, questions of mere physics and physiology, and turn our attention to what concerns the declarations of our own consciousness with respect to our feelings and cognitions" (p. 139).

In other words the real business of the book begins here, and the five chapters which the reader is supposed to have mastered by the time he reaches this point must be regarded as dealing more or less with preliminary considerations. One of the main features of this chapter is the discussion of the differences between the lower and higher mental processes, the former comprising mere feelings or sensations, and the latter the intellectual perceptions. It is conceded that the lower psychical faculties exist in animals other than man. It is suggested that the term *consentience* should be applied to the unconscious manifestation of sensuous impulses of diverse kinds in the individual. The question whether animals possess the higher faculties, lower in degree, but similar in kind to those possessed by ourselves, is answered by Dr. Mivart in the negative. He denies them the faculty of reasoning, and the ethical or moral sense, and considers that "consentience" explains all their actions. The human faculty of reason is considered to be different in kind from anything possessed by lower animals (p. 162). In support of this contention some pages are devoted to arguing away those acts of animals which have been and are still considered by many psychologists to be due to intelligence. The subject of instinct is again discussed in this chapter, and the theory of natural selection is considered to be inadequate both for the explanation of the origin of the instincts of animals and the "lowest psychical powers" of man. The general conclusion is that there is a distinction in kind between man and animals, and the crucial difference is expressed by the statement that "men speak but animals are dumb." From this we are led to the seventh chapter, on "Language and Science."

Regarding speech, whether expressed by mere sounds, by articulation, or by gesture, as an expression of intellectual faculties of the higher order, the author will not allow that animals possess any power of intercommunication beyond the lower form of emotional language; and he devotes some pages to an adverse criticism of the views of the late Dr. Romanes on this subject. With respect to the origin of language, Dr. Mivart offers no theory of his own, but concludes that intellectual thought was in man antecedent to language; in other words, that thought is the cause of language, and not language the cause of thought. The general idea which the reader will gather from this chapter is that, in the author's opinion, there occur from time to time breaches of continuity or new departures in the order of nature, and that the transition from non-living to living matter, from nonsentient to sentient beings (*e.g.* plants to animals), or from sentient organisms to the intellectual organism, *i.e.* from animals to man, are cases in point.

The eighth chapter is entitled "The Intellectual Antecedents of Science," and begins with a demolition of the ultra-sceptical intellectual nihilist whose mind has no certainty as to the truth of anything which cannot be proved. The author insists

"that the mind of each one of us . . . already possesses absolute certainty about some things, and that his [the reader's] intellect declares that things which are clearly seen to be evident in and by themselves, possess the greatest certainty which it is possible for the human mind to attain to, and that such certainty is abundant" (p. 225).

Further on (p. 227) it is pointed out that this certainty is attained ultimately by thought and not sensation, and that intellectual perception or intuition is the supreme and ultimate criterion of truth. The reality of the ego and the difference between the objective and the subjective is considered to be proved in the former case, and bridged over in the latter by the memory. The power of memory is, in fact, regarded as proof of the continuous existence of the individual and the reality of "objectivity." It is conscious memory which unites the past with the present, and enables the individual to declare "I am." This faculty of conscious memory is considered by the author to be another profound distinction between man and other animals (p. 240).

In the following chapter, which deals with the "Causes of Scientific Knowledge," Dr. Mivart begins by quarrelling with the old statement that "everything must have a cause," which he considers to be quite untenable because it would lead us to "a *regressus ad infinitum*." He replaces the ancient dictum by the statement that we do see "that every change or new existence is, and must be, due to some cause." Presumably this is based on the idea that the question of "causation" only arises when some change or new state in the existing order of things is observed. By "causation" it must be understood that the author means something more than mere sequence; he argues for a "force" or "power" as a primary ultimate idea which cannot be resolved into simpler conceptions (p. 261). This force or power is not physically perceptible by the senses, but is intellectually perceptible Herein Dr. Mivart of course finds himself in antagonism to Mr. Herbert Spencer. This kind of causation is subsequently (p. 263) exalted into a law—"a necessary and universal truth which carries with it its own evidence"—and out of this law is further evolved the great principle which underlies all science, viz. the uniformity of nature. The reader will at once confront this principle of uniformity with the statements in Chapter viii. concerning the breaches of continuity in the order of nature to which we have already called attention. Was the law of uniformity broken, for example, when "inorganic" matter became living? According to Dr. Mivart discontinuity must be regarded as part of natural uniformity (p. 288).

In this chapter there is discussed also the theory of natural selection in so far as it bears upon epistemology. The author's views respecting the Darwinian theory have long been before the scientific public, and are reiterated in this work in such statements as the following:—

"By this system, then, unreason may be regarded as practically lord of the universe, and the source of all the beauties and harmonies which exist in organic nature" (p. 273).

The inadequacy of natural selection to account for the genesis of our perceptions of an extended external world is considered at some length, and it is contended that there are many other kinds of knowledge or "intuitions" which cannot be attributed to natural selection. The general drift of the chapter may be, perhaps, summed up in the statement that the universe is an orderly and not a disorderly arrangement, and that since order suggests intelligence and reason there is such an intelligence and reason underlying it all. The "breaches of continuity," such as the passage from non-living to living matter, from the insentient to the sentient, from the irrational to the rational (p. 296), are considered by the author to require "an eternal and ever-present reason latent in all the phenomena of which we can take cognisance." It may be added that the combination of hydrogen and oxygen to produce something so very unlike its constituents as water (p. 285), and the discontinuous variations (? monstrosities) treated of by Bateson in his work on variation (p. 288) are pressed into the service as "new departures" calling for special explanation, and so Dr. Mivart slips an external intelligence into the cosmos.

The tenth and concluding chapter is entitled "The Nature of the Groundwork of Science." In discussing the matter of science, or the field wherein scientific workers have to labour, the author comes to some very paradoxical conclusions respecting matter, motion, space and time. The breaches of continuity or new departures again figure as reasons for recognising

"that the universe is pervaded . . . by something which our intellect reveals to us as having necessarily some analogy with our own reason and intelligence, however inconceivably greater it may be" (p. 310).

Besides the physical, there is the psychical subject-matter with which science has to deal; so that, as the author sums it up, the worker in science is concerned with things and thoughts.

Respecting the tools which the science workers must use, there are, of course, only the senses and the intellect. The intellectual weapons are those fundamental principles which were laid down in the fourth chapter, and which are here recapitulated. In this last chapter also there are discussed some highly abstract possibilities as to the structure, composition and nature of the universe—whether there is anything more than an "intelligent energy," whether there is only one "essential kind of matter with intrinsic motion," and so forth. In fact, by ringing the changes upon various possibilities and conceivabilities, the author at this stage makes a strain upon the assimilative faculty of his reader, which will leave the latter in a state of hopeless bewilderment, unless his (the reader's) mental digestion is in perfect working order. The chief definite conclusions which are drawn are that it (the universe) cannot consist of one kind of energy only, that it is impossible that intellect can have been evolved from mere physical force, and that animals show no signs of latent intellectuality. It is further insisted

"that the portion of truth which we are able to attain to in our investigations of the cosmos, is but an unimaginably small portion of the whole" (p. 317);

a statement which will, we imagine, not be seriously challenged by workers in science. To the latter, viz. the science workers, Dr. Mivart devotes some attention in the concluding pages of his book. The narrowing effect of extreme specialism upon the mind is an undoubted evil, as the author points out. But there is the opposite evil of becoming diffuse to the extent of a practically useless attenuation of the mental faculties. Between these two extremes the active worker in modern science will find it difficult to pursue his course if he desires to keep pace with the development of science generally, as well as to advance his own subject in particular.

In a kind of summing-up the author elaborates further his ideas as to the "intelligent activity" which pervades the universe. The results of this activity harmonise with our reason, but yet it acts in ways different to those which we should adopt in order to arrive at similar ends. It is a "non-human rationality" (p. 321). There is no such thing as waste in nature. Dr. Mivart does not say so explicitly, but he implies that all apparent waste is unseen economy. The groundwork of science is defined (p. 322) as:—

"The work of self-conscious material organisms making use of the marvellous intellectual first principles which they possess in exploring all the physical and psychical phenomena of the universe, which sense, intuition and ratiocination can anyhow reveal to them as real existences, whether actual or only possible."

The non-human intellect which pervades the universe is finally put forward as the foundation of the groundwork of science.

We have endeavoured, as concisely as possible, to give an account of the contents of this bulky volume. It is by no means an easy task to act the part of a reviewer towards what professes to be a kind of philosophy of science, since mere dissent from the author's conclusions is not in itself a legitimate ground of criticism. For the philosophical student it may be fairly said that Dr. Mivart has provided material for endless controversy. For the worker in science he has raised many important questions which are well worth pondering over. Of course we agree generally that there is in reality only one science, and that the various divisions are matters of convenience necessitated by limited brain power. There is, in fact, a real need for a science of the sciences or Epistemology, but the treatment of the subject in the present work appears to the writer to be disappointing. There seems to be a continual working up towards some great generalisation which never comes off. There is over-elaboration in some parts of the treatment, and there are sudden jumps in others. The use of "new departures" or "breaches of continuity" as arguments for the existence of an external non-human intelligence appears to be a relapse towards the state of knowledge which interpolated a "guiding spirit," or an "occult principle," or an "innate tendency," to explain anything we did not understand. It is a dangerous principle in science to attempt to hide ignorance by devices of this kind. The coupling of discontinuous variations in animals and plants with the production of a chemical compound having different properties from its constituents as examples of such "new departures" is singularly unfortunate, even from Dr. Mivart's own point of view.

There is much in the work which will repay thoughtful perusal, since any attempt to make scientific workers take a philosophical view of science is to be commended. But the great defect of diffusiveness, which is so conspicuous throughout the book, will, we are afraid, deter many readers from following the author throughout the laboured and reiterated statements which lead up to his conclusions. R. Meldola.

THE UGANDA PROTECTORATE.

Under the African Sun: a Description of Native Races in Uganda, Sporting Adventures, and other Experiences. By Dr. W. J. Ansorge. Pp. xiv + 355. (London: Heinemann, 1899.)

THE complaint has often been made against travellers that in their books they tell us most about the subjects of which they know least. The latest contribution to the literature of the Uganda Protectorate illustrates the truth of this remark. From the list of qualifications after the author's name in the title-page, the book might be expected to prove a valuable contribution to the knowledge of the many obscure diseases endemic in the Uganda Protectorate.

Occasional medical experiences are recorded, but they deal with mere matters of minor surgery. The important problems connected with tropical diseases, to which so much attention is now being devoted, are passed unnoticed. Most of this bulky volume is devoted to experiences in sport, war and civil administration, such as we might expect from a soldier, rather than from a man with a scientific training. The main value of the book is that it gives an account of the Uganda Protectorate and the Uganda Road between the years 1894 and 1898. It shows that considerable progress has been effected with the railways, that hotel accommodation has been provided at Mombasa, and that the late Captain Sclater's well-constructed road has greatly facilitated communications with the interior. The road, however, has not been of so much use as it might have been, owing to the collapse of the transport service during the past three years. The author's numerous records of massacred caravans, tribal wars, and tragic deaths of Europeans show that the country has not yet reached the peace expected in a British possession.

The most interesting of Dr. Ansorge's medical observations is a note on the effect of poisoned arrows. Four years ago a jubilant telegram announced that one of the doctors of the Uganda staff had discovered a certain antidote for wounds made by these once dreaded weapons. According to Dr. Ansorge's account this was no great medical triumph; for in some cases which he observed the arrow poison was of no serious strength, and left to itself merely set up a slight local irritation.

The book is mainly of interest scientifically, from its side-lights on anthropological questions. Those who advocate the study of anthropology as a branch of political economy may find many examples in support of their case. The following incident may be quoted, as it has a certain anthropological as well as a political significance. The incident occurred during an attack on one of the Kavirondo villages by the Government forces.

"Two little urchins, four or five years old, attempted to escape from one of the gates; but finding the enemy present everywhere they ran round the village along by the trench, trying to find a means of re-entry. In the meanwhile two of our Masai allies had rushed forward from the besieging hordes . . . and darted in pursuit of the two naked urchins, who, turning round and finding themselves hard pressed stopped running and held out entreating hands to their pursuers. The Masai were jerking their spears horizontally, with the peculiar thrusting movement used in striking a victim. Friends and foes stopped fighting to watch this sudden side-act. One of the Masai did not strike his captive, but . . . the other villain poised his spear and struck the poor trembling child full in the chest. As the boy fell backwards in the grass the Masai gave one more lunge with his spear, and then darted back to where our friendlies stood."

The author tells us on the same page as that on which this horrible deed is described, that after the capture of the first village, members of the British force cut off the hands of the enemy "in order more quickly to possess themselves of the coveted iron bracelets."

Vasco da Gama's men collected bracelets in the same way when he visited Mombasa at the end of the fifteenth century; but we thought that method of making anthropological collections was out of date.

The scientific value of this book is seriously lessened by the absence of reference to other literature on the same country. No official Blue Book could ignore other work more completely. This trait seems characteristic of the author's general attitude; for he seldom mentions his colleagues and comrades by name. This isolation lessens the interest of his narrative, while it is fatal to the anthropological value of his book. For instance, Dr. Ansorge tells us that the Wahima are the aboriginal inhabitants of Uganda, and that they were conquered by the Waganda, under whom they took service as herdsmen. But according to the traditions reported by Stanley, and accepted by nearly all subsequent writers, the facts were exactly the reverse. It was the Wahima who conquered the original Bantu inhabitants of Uganda, and by intermarriage with the conquered people formed the Waganda race. Dr. Ansorge may have good reasons for his belief; but he has only himself to blame if his view is dismissed as a simple mistake.

So far, as the author is describing what he has actually seen, he appears to be accurate; but a rash generalisation leads him occasionally into error; as when he tells us that very few natives eat the flesh of the "croc," to use the inelegant abbreviation by which the crocodile is frequently referred to. This expression illustrates the author's literary style. The only element of humour in the book is contributed by some of the involved sentences. The illustrations, however, are often admirable and instructive, especially in the chapter on Kavirondo. But they would have been of more interest had reference been made to Hobley's memoir on the Kavirondo, some of the points in which they illustrate. The photographs are, however, of unequal merit, and some of them are difficult puzzle-pictures. There is, for example, on p. 128 a picture of a native labelled "A Fishmonger": there are no recognisable fish in the picture, and no notice to the effect that goods are kept elsewhere during the hot weather. It would have saved some perplexity if we had been told whether that particular Uganda fishmonger had retired from business, or whether he was sitting on his stock-in-trade. The picture is not self-explanatory.

The last part of the book consists of a reprint of descriptions of the various mammals and insects collected by the author in British East Africa, and of a valuable list of birds by Dr. Hartert. The list includes 216 species, and it gives some idea of the extent of our knowledge of the avifauna of the district, that this extensive collection only includes three new species and one new variety. Dr. Hartert's list is new, but the descriptions of the mammals and insects are reprinted from the technical journals. It would have been more useful if the pages occupied by these quotations had been devoted to some account of the habits of the animals. The technical descriptions are of no interest to the general reader, while the specialist must refer to the original place of publication. But one of the prices paid for competition in systematic zoology is that it too often turns the naturalist into the collector.

OUR BOOK SHELF.

The Wild Fowl of the United States and British Possessions; or, the Swan, Geese, Ducks, and Mergansers of North America. By D. G. Elliot. Pp. xxii + 316, illustrated. (London: Suckling and Co., 1898.)

With this volume the author completes his "trilogy" of popular manuals of American birds of sport; the plan of treatment being the same as in the previous volumes, which have already been noticed in this journal. In the land of their birth the volumes on "Shore Birds" and "Gallinaceous Game Birds" have been received as the standard works for the sportsman and amateur naturalist on the subjects of which they treat; and there can be no hesitation in saying that the present issue is in all respects the equal of its forerunners. Not only will it be acceptable to American sportsmen, but it will be of still more value to those of their British brethren who are desirous of trying wild-fowl shooting on the further side of the Atlantic.

In the old days the author is of opinion that North America contained more wild fowl than any other part of the world; and it is a matter of unfeigned regret to hear that the great armies of these valuable birds are at the present day represented only by a relatively small number of survivors. If, indeed, active measures are not taken for the protection of such survivors, there is but too much reason to fear that in many districts wild fowl will become as extinct as the bison. It is to be hoped, therefore, that the two Governments concerned will at once take the necessary steps to prevent such a deplorable result.

Not the least important part of Mr. Elliot's volume is to be found in the protest against the excessive splitting characteristic of modern zoological work, especially in America. It may candidly be admitted that in years past zoologists erred in not according sufficient recognition to local races and varieties; but it is equally evident that at the present day the pendulum is swinging too far in the opposite direction.

"I consider it," writes the author, "most unwise and injudicious to create even a sub-species whose only character is that of size, especially when it is attempted to separate birds of different lands which are so exactly alike as not to be distinguished apart till the tape-line is applied; and even then the test fails at times, as they are often found to be of the same dimensions. . . . The fact that a species is found in Europe and America is no reason whatever that the specimens from the two hemispheres must be specifically, sub-specifically, or in any other degree separable, simply because they come from different localities." Although it may be old-fashioned, this (in spite of an illogical statement in the concluding sentence), in our opinion, is sound common sense, and should give pause to some of the species-makers in the States.

The illustrations, for the most part by Mr. Edwin Sheppard, maintain the high standard as regards accuracy of detail of the earlier volumes; but they appear to us somewhat flat and wanting in tone. If we except American peculiarities of spelling, the work is all that can be desired from the reader's point of view; although we note a few misprints, as *ungus* for *unguis* on p. xviii., and gadwell in place of gadwall on p. 278. Moreover (p. 276), the author has not followed the admirable example of Mr. Evans in adopting the spelling *Dendrocycna* in place of the common *Dendrocygna*, whereby a hybrid term is converted into a classical compound. R. L.

An Introduction to Stellar Astronomy. By W. H. S. Monck, M.A., F.R.A.S. Pp. 203. (London: Hutchinson and Co., 1899.)

THE contents of this book are very different from what the title led us to expect. We have failed to discover in what sense it can be regarded as an introductory work, unless it be an introduction to "arm-chair" researches in astronomy, or to the author's views on certain astronomical subjects. A perusal of the book leaves us with the uncomfortable feeling that the author looks upon practical observers as so many of his subordinates, and considers himself in a much better position than they to discuss the results of observations. Accordingly the book deals very largely with the author's opinions, and the words "I think" occur so often as to prove wearisome.

Nevertheless, as is well known, the author is an earnest thinker, and some of his suggestions may be helpful in directing future inquiries. Some of his views, however are not likely to prove acceptable to astronomers who are capable of connected thought as well as of making observations. Among these may be mentioned the idea that the cooling of a star like the sun may result in a star with a spectrum approaching that of Sirius (p. 101), or that some of the different stellar types may be evolved from different kinds of nebulæ (p. 160).

In dealing with matters involving an intimate acquaintance with stellar spectra, the author would do well to make himself familiar with the published photographs, and not to attach undue weight to very broad classifications. It would be greatly to the advantage of readers, too, if some pictorial representation were given of the different stellar types to which reference is so frequently made.

The book furnishes further testimony to the great value of the work of Dr. Isaac Roberts, not only to the science of astronomy, but also for purposes of book illustration.

Electrolysis and Electrosynthesis of Organic Compounds. By Dr. Walther Löb. Translated by H. W. F. Lorenz, A.M., Ph.D. Pp. xiii + 103. (New York: John Wiley and Sons. London: Chapman and Hall, Ltd., 1898.)

IN view of the many interesting results which have recently been obtained by the application of electrolytic methods to organic chemistry, the publication of this little work in the English language is distinctly opportune. As a guide to the literature relating to the electrolysis of organic compounds it will be of especial service to the investigator, containing, as it does, a practically complete list of references to the original memoirs (including patent specifications). The account of the contents of these is, however, generally very brief, in some cases so brief that it amounts to little more than a subject-index. The electrolysis of each compound, or group of chemically similar compounds, is considered separately, and a list of the products obtained under various conditions given. The conditions are not, however, specified in most cases with sufficient exactitude to permit of the repetition of the experiment, even when these conditions are given in the original memoir, and are of primary importance. Greater attention to this point would have considerably enhanced the value of the book, although, of course, it would have added to its bulk. The general impression left by the perusal of this interesting little work is that the whole subject is yet in its infancy, and that the careful study of the influence of E.M.F., temperature, nature of the solvent, and of the electrodes and of other factors on the electrolysis of organic compounds will yield, as in a few cases it has already yielded, most interesting results.

The translation, although on the whole satisfactory, would have been better if the translator had not adhered so closely to the original; "syntheticized" (p. 11), "strong concentrated solutions" (p. 39); and contractions such as "Brown-Walker," "Mulliken-Weems," are not very happy. The electrical nomenclature is also loose: "the potential of the electric current" is written several times when the potential difference between the electrodes is meant, and on p. 1 we find, "Being poor conductors, the alcohols require *strong currents* for their electrolysis," the current here being confused with the potential difference. The translator has added a good index. T. E.

Report of Observations of Injurious Insects and Common Farm Pests during the Year 1898, *with Methods of Prevention and Remedy*. Twenty-second Report. By Eleanor A. Ormerod, F.R.Met.Soc., &c. Pp. viii + 138. (London: Simpkin, Marshall, Hamilton, Kent, and Co., Ltd., 1899.)

MISS ORMEROD'S useful reports are too well known to need any commendation from us; and we are pleased to learn that she proposes to commence a new series with the next volume, with a slight alteration of plan, and to continue the work as long as her health will permit, which all entomologists will hope may be for many years yet. She is also about to issue a general index to the contents of the twenty-two parts of the first series.

Thirty-seven insects of various orders are mentioned in the present report, among the most interesting being fleas, which have been met with in some places in extraordinary abundance; the forest fly, which has latterly been very troublesome in various parts of Wales; and the "murrain worm," or the larva of the elephant hawk moth (*Choerocampa elpenor*), which is said to be the cause of disease among cattle in various parts of Ireland. As this larva is frequently found in plants growing near water, Miss Ormerod suggests that the mischief may perhaps be caused by some poisonous plant, such as water dropwort or water hemlock (*Oenanthe crocata*), growing in the neighbourhood of the plants on which the caterpillars feed.

Notes from a Diary: kept chiefly in Southern India, 1881–1886. By the Right Hon. Sir M. E. Grant Duff, G.C.S.I. In Two Volumes. Vol. i., pp. xii + 373; vol. ii., pp. 373. (London: John Murray, 1899.)

These books are the fifth and sixth volumes of notes from the diary kept during the half-century now almost complete, by Sir M. E. Grant Duff. These pages, dealing with the years during which the author was Governor of Madras, are largely filled with extracts from the letters received from friends in Europe and elsewhere, interspersed with interesting information concerning the flora of Southern India.

Many of the items afford evidence of the interest which the author has always taken in botany.

Sir W. T. Thiselton-Dyer and Prof. Asa Gray, amongst others, reaped some of the fruits of this enthusiasm. On February 23, 1884, it is recorded that the former wrote: "Seeds have descended upon us in a perennial shower. The fountain was mostly sealed to us till your vigorous wand smote the rock of seclusion. We have distributed the residue punctually, as you wished." On July 19 of the same year was entered: "By last mail came several pamphlets from Asa Gray, to whom I have been sending Nilgiri and other seeds." Not the least interesting feature of these pleasantly-written experiences are the references to several men of science with whom Sir M. E. Grant Duff has come into contact. One of the most marked characteristics of both volumes is the collection of good stories; some are old friends, it is true, but many are new.

Fertilisers: the Source, Character and Composition of Natural, Home-made, and Manufactured Fertilisers; and Suggestions as to their use for different Crops and Conditions. By E. B. Voorhees. Pp. xiv + 335. (New York: The Macmillan Company. London: Macmillan and Co., Ltd., 1898.)

Probably more popular text-books have been issued on the use of manures than on any other part of the subject of agriculture. The present book is carefully written. It gives the reader a good general view of the reasons which make it advisable to apply artificial manures to the land, it describes the principal American fertilisers, and offers prescriptions for all American crops. The recommendations have the appearance of being generally theoretical. There is a great lack of examples showing the actual effects under known conditions of different applications of manure. The important subject of the effectiveness of the residues of previous manuring is scarcely touched. R. W.

LETTERS TO THE EDITOR.

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Further Notes on Recent Volcanic Islands in the Pacific.

In Nature (vol. xli. p. 276, and in vol. xlvi. p. 611) I gave notes on an island in the Tonga Group, called Falcon Island, which had risen from the sea as the result of an eruption in 1885, when it was about two miles long and 250 feet high, and which had in 1892 been greatly diminished in size by the wash of the sea.

The site was again examined in 1898 by Captain Field in H.M.S. *Penguin*, and the island has now wholly disappeared, leaving a breaking shoal in its place.

It will be very interesting to watch this shoal in the future, and observe to what depth the sea is able to cut it down, if a fresh eruption does not again reinstate it as an island. I have stated my belief that the sea in this part of the ocean is able to cut such a protuberance down to over twenty fathoms. This island will afford an opportunity of testing the facts.

Metis Island, 75 miles N.N.E. from Falcon Island, also a volcanic product, first seen in 1875, has likewise been reduced to a shallow bank, under water, and will furnish another illustration of the erosive powers of the sea.

Metis Island was reported as a rock 29 feet high in 1875, subsequent eruptions raising it to 150 feet; but, from the fact of its total disappearance in twenty-four years, it would seem that it was, like Falcon Island, all ash, with no solid plug or lava. W. J. L. Wharton.

April 15.

Mosquitoes and Malaria.—The Manner in which Mosquitoes intended for Determination should be Collected and Preserved.

The widespread interest now being taken by English medical men and others in all parts of the world, in the dissemination of malaria parasites by means of mosquitoes, which would seem to have been placed beyond dispute by the recent researches of Major Ross, I.M.S., in India, and of the Italian school represented by Drs. Grassi, Bignami, and Bastianelli at Rome—an interest due to the fact that, as a price of world-wide empire, the English race suffers more than any other from the malaria scourge—renders it highly desirable that there should be in the British Museum in London a collection of carefully preserved and accurately determined Culicidæ of the world. Such a collection, when once worked out, would be invaluable for settling the identity of any species that might become an object of suspicion, and the specimens composing it would be at all times available for comparison. Most of the existing descriptions of Culicidæ leave much to be desired (having been based too often upon insufficient material), and are but rarely accompanied by figures of any kind. A collection such as is suggested would, however, enable us to amend or amplify existing descriptions: or, if these should be found altogether unrecognisable, to prepare new ones based upon types in satisfactory preservation; it would also be possible to publish coloured or other plates of the more important species. For all these purposes it is absolutely necessary to have specimens in the best possible condition. Like a large number of other Diptera, mosquitoes from various quarters of the globe differ but little in outward appearance, and even to the eye of a Dipterist a *Culex* or *Anopheles* from Calcutta may look remarkably like a specimen from Chelsea. But when it is found that the hæmatozoa of malaria, while capable of development in one or more species of a genus, are not so in others, although closely allied—in view of the hoped-for practical outcome of the present investigations, the necessity for the accurate and trustworthy determination of the species of mosquitoes becomes doubly manifest. Unfortunately (from the present point of view, which is scientific as well as practical), a mosquito is among the most delicate of Diptera, with its wing-veins and legs clothed with scales, which inevitably come off if rubbed, while the legs themselves part company with the body on the slightest provocation. Since it is upon the scaly covering of the mosquito that we have chiefly to rely for its specific characters, especially valuable features being often furnished by the banding of the legs (and palpi also in some species of *Anopheles*), any method of collecting, preserving, and sending home specimens that does not take account of these points is likely to be of little use.

In November last year, by desire of Prof. Ray Lankester, the writer drew up a series of instructions for the collecting of mosquitoes, which were forthwith printed by the British Museum in pamphlet form, under the title "How to Collect Mosquitoes." Copies of this pamphlet have been forwarded by the Museum to possible helpers in all parts of the globe; while the Colonial Office, which is taking a great interest in the matter, has furnished other copies (accompanied by injunctions to collect) to the medical officers under its control throughout the empire. It is hoped that ere long, in response to these preliminary measures, consignments of properly collected mosquitoes will commence to flow steadily into the British Museum.

The pamphlet of instructions contains a list of the articles required, and a detailed statement of the proper method of collecting, killing, and preserving mosquitoes intended for determination. The most important points in the technique of mosquito-collecting are that the insects, when captured in the open, must be brought home alive in pill-boxes of a special kind, must on no account be put into spirit, but be killed by being placed for a few moments in a cyanide bottle, and then immediately pinned on an exceedingly fine pin (known to English entomologists as a "No. 20"), which, in order to protect the insect's legs, is thrust through a disc of card, the latter being finally supported by being transfixed by, and drawn rather more than half-way up, an ordinary or toilet pin. The pamphlet concludes with directions for the transmission to England of specimens intended for the British Museum. It may be added that copies of the pamphlet can always be obtained on application to the Director, the British Museum (Natural History), Cromwell Road, London, S.W.; while, if further information on any point is desired, I shall be happy to supply it myself.

Unfortunately, widely as the pamphlet has been circulated, it has not yet reached the hands of *all* mosquito-collectors; and I, therefore, avail myself of the present means of making its existence more extensively known, the impulse to do so having been supplied by certain recent arrivals. From the nature of the present movement very many collectors—perhaps the majority—are medical men who, unfortunately, seem endowed with a sort of natural instinct prompting them to preserve everything by placing it in a bottle of spirit or glycerine. Mosquitoes when treated in this manner reach England in sorry plight. Sundry bottles of specimens from the West Indies and the Far East are now before me. The latter are in the worse condition; continual shaking in the course of the long journey home has precipitated most of the legs to the bottom, which is quite covered with them. Since all previous descriptions of mosquitoes, as indeed of all other Diptera, have been prepared from *dried* specimens, a mosquito "preserved" in this fashion must be removed and dried before any comparison can be made of it. Such a specimen, with its scales either washed away or matted, and its body shrunken and shrivelled, is a bedraggled-object indeed. There may, perhaps, to some people, be a peculiar appropriateness in the idea that the last state of the sharp-tongued mosquito should be similar to that of a victim of the old-time ducking-stool, but the scientific value of the specimen so treated is little greater than if it had been crushed with the hand.

A bottle of mosquitoes in spirit from one West Indian locality is not only thick with floating scales and fragments of legs and wings, but is also distinguished by a turbidity unpleasantly suggestive of putrefaction.

Another method recently adopted is to dry the mosquitoes and send them home in small tubes containing cotton-wool; the results are nearly or quite as disastrous as when glycerine or spirit is used. It seems to be forgotten that because specimens may be practically perfect when put into a tube, it by no means follows that they will reach London in the same condition. Mosquito legs adhere to cotton wool, and inevitably get pulled off in numbers; while if any space is left between the specimens and the wool, the former by dint of constant shaking become reduced to a sort of coarsely granulated powder. This is the actual condition of two tubes of specimens recently received. As an instance of misdirected energy it may be worth while to quote one collector's description of this method; he writes as follows:—

"I am making a collection for you of all the different mosquitoes that occur here; they are put into a tube after having been killed in the cyanide bottle, a bit of cotton wool pressed against them, and then kept in the exsiccator over anhydrous chloride of calcium—this to free them of moisture, and thus prevent mould; afterwards corked up.

"Upon arrival remove cork and allow the tube to remain a day in a damp chamber; this can be easily made by inverting a tumbler over a piece of wet blotting-paper; the insects will absorb some moisture, and can afterwards be handled without being broken, mounted on cards or otherwise set up."

Now, when it is absolutely impossible to pin specimens, according to the method prescribed in "How to Collect Mosquitoes," there is just a chance that they may reach London in a more or less useful condition if treated as described in the foregoing extract, provided that a plug of *thin tissue-paper* is substituted for the cotton-wool; this plug should be pressed down until it is in close contact with the specimens, while the latter are still soft; the tubes should be as narrow as possible—preferably not more than ⅓ inch in diameter, and must of course be tightly corked; they should be packed in a tin box filled with cotton wool, so as to reduce all shaking to a minimum.

I would, however, strongly urge no one to adopt this method who can obtain the articles necessary for pinning specimens in the manner prescribed in the pamphlet of instructions, since the latter is *the only really satisfactory plan*. Specimens thrown into spirit are absolutely useless; masses of material entangled in cotton are nearly as bad. It is a pity that so much well-intentioned labour should be thrown away.

ERNEST E. AUSTEN.

British Museum (Natural History),
Cromwell Road, London, S.W., April 14.

Sunspots and Rainfall.

THE question of sunspots and air-temperature was recently considered in these columns with the aid of a method in which each month since 1841 (at Greenwich) was first characterised as + or −, according as the temperature was above or below the normal; a year with *more* than the average number of plus months being considered *warm*, and with *less*, cold.

Rainfall data may of course be treated similarly, and your readers may perhaps be interested to see how the method works out in this case. The values are those for Greenwich, extending as far back as 1815; but those previous to 1841 are to be thought less trustworthy than the others. Two sets of averages have been employed for the two periods (before and after 1841).

Taking 5·4 as the average number of wet months in a year for the whole period, and so 27 as the average number in 5 years, let us now consider the five-year groups about maximum and minimum sunspot years, noting how the number of wet months in each of these groups differs from the average.

Max.	5-year group.	Wet months.	Difference from average.
1. 1830	1828–32	33	+ 6 *e*
2. 1837	1835–39	27	0
3. 1848	1846–50	23	− 4
4. 1860	1858–62	27	0
5. 1870	1868–72	25	− 2
6. 1884	1882–86	23	− 4
7. 1894	1892–96	22	− 5
		Sum.	− 9

Min.	5-year group.	Wet months.	Difference from average.
1. 1823	1821–25	32	+ 5
2. 1833	1831–35	34	+ 7
3. 1843	1841–45	31	+ 4
4. 1856	1854–58	20	− 7 *e*
5. 1867	1865–69	34	+ 7
6. 1879	1877–81	30	+ 3
7. 1890	1888–92	26	− 1 *e*
		Sum.	+ 18

A pretty distinct contrast appears in these two tables.[1] There seems to be (at Greenwich) a greater tendency to wetness in years about sunspot *minima*, than about maxima. Thus in seven maximum groups we find only one (*e*) with an excess of wet months; while in the seven minimum groups an excess appears to be the rule, to which there are two exceptions (marked *e*).

[1] A still better contrast, I think, comes out on comparing the five years ending with a minimum, with the five years following a minimum.

With regard to those exceptions, it may be worth noting that the two in the minimum series of groups (viz. the group for 1856, and that for 1890) occur just about the middle of dry periods in the 35 years' cycle of weather.

Now, the *régime* of rainfall is often different in the north and south of this island. A year that is wet in London may be dry in the north, and *vice versâ*. The following figures may throw light on the extent of this.

Compare the annual rainfall at Greenwich, from 1841 to 1897, with that at Rothesay (N.B.), calling each year with excess of rainfall *wet*, and each with deficiency *dry*.

We find a distribution as follows:—

Gr. wet. Roth. wet. } 11	Gr. dry. Roth. dry. } 19	Gr. wet. Roth. dry. } 14	Gr. dry. Roth. wet. } 13

Thus the rainfall has been opposite in character in 27 out of those 57 years (nearly one-half).

Now, with reference to the sun-spot cycle, it would appear that at Rothesay, it is the years about *maxima* that tend to be the wetter. I am not at present in a position to treat the Rothesay data as those for Greenwich have been treated above. But let us take the annual rainfall, marking each year as + or −, as that has been above or below the average. Then, taking five-year groups about maxima or minima since the beginning of this century, we get the following tables:—

Max.		5-year groups.	Wet.	Dry.
1. 1804	...	1802–1806	2	3 *e*.
2. 1816	...	1814–1818	3	2
3. 1830	...	1828–1832	3	2
4. 1837	...	1835–1839	3	2
5. 1848	...	1846–1850	4	1
6. 1860	...	1858–1862	3	2
7. 1870	...	1868–1872	3	2
8. 1884	...	1882–1886	3	2
9. 1894	...	1892–1896	2	3 *e* ?
Sums.	...	...	26	19

Min.				
1. 1810	...	1808–1812	2	3
2. 1823	...	1821–1825	1	4
3. 1833	...	1831–1835	2	3
4. 1843	...	1841–1845	2	3
5. 1856	...	1854–1858	1	4
6. 1867	...	1865–1869	2	3
7. 1879	...	1877–1881	1	4
8. 1890	...	1888–1892	2	3
			13	27

Thus, in the former case (nine max. groups) there is one valid exception [1] to the rule of a preponderance of wet years; while the eight minimum groups show throughout a preponderance of dry years.

The same thing might be shown with more or less distinctness for other stations in the north.

In the eyes of some, a contrariety in rainfall, like that just indicated, doubtless seems fatal to the idea of sunspot influence. But the best thought in meteorology to-day, if I mistake not, would hesitate to affirm that it is so. The same influence, indeed, acting under different conditions, may produce different and even opposite effects.

Discussing the question of sunspots and temperature in his recent admirable "Traité elémentaire de Météorologie" (1899), M. Alfred Angot points out that the relation is probably a complex one. "On pourrait concevoir," he proceeds, "que les taches solaires influent, par exemple, sur la position des centres de hautes et de basses pressions, et il serait alors facile de comprendre que ces déplacements produisissent des variations de température d'un certain sens dans une region, d'un sens opposé dans un autre, et nulles enfin dans d'autres encore. Il est possible qu'en reprenant ces études dans cet ordre d'idées on arrive a concilier les résultats, contradictoires en apparence, que l'on a obtenus jusqu'ici." The same thing should obviously apply to rainfall.

Is there any evidence that rain-bringing depressions take, on the whole, a more northerly path across this island (in going E. or N.E.) about the time of maxima sunspots, and a more southerly path about minima? Perhaps something of this kind might account for the oppositeness in rainfall we have considered.

[1] The "homogeneity" of the record before and after 1890 seems a little doubtful.

My object in this letter, however, is rather to call attention to facts than to affirm this or that influence as accounting for them, and it is possible that further inquiry might dissipate the notion that sunspot influence is concerned in those phenomena.

ALEX. B. MACDOWALL.

Periodic Tides.

UNDER the above heading, Prof. A. W. Duff, in NATURE of January 12, describes the character of the periodic tides, or secondary tidal undulations, on the eastern coasts of Canada, and offers an explanation for these based upon observations in the Bay of Fundy. Without entering into any discussion of the explanation suggested, I wish to point out that the basis of fact upon which he rests his descriptions for most of the places named, is so meagre and insufficient as to render these dsscriptions quite misleading.

Prof. Duff has visited St. John in the Bay of Fundy, and has had access to the tide gauge there established by the Tidal Survey. The observations at Quaco and on the St. John river are his own. But with regard to the other places mentioned, his descriptions of the character of the oscillations are entirely based upon a few examples of simultaneous tides, in sets of only four days each, published to illustrate a paper of mine in the *Transactions* of the Royal Society of Canada, and reproduced in one of the reports of progress of this Survey. These were selected to show the character of the main tides, without respect to the minor undulations. On one illustration it was even noted that the tides there represented were unusually free from secondary undulations which appear as a rule at that station. These few illustrations cannot, therefore, properly be employed as a basis for a comparative description of the usual character of these undulations; and it is not right to make this use of them when valuable continuous records from recording gauges exist, by which the subject could be investigated thoroughly as it deserves.

The other places outside the Bay of Fundy named by Prof. Duff are all tidal stations of this Survey, which is being carried on by the Department of Marine, under my direction. There are eight principal stations in the region, extending from Quebec to Halifax, and from Yarmouth at the south end of Nova Scotia to the Strait of Belle Isle. In this region, which includes the Gulf of St. Lawrence and the Bay of Fundy, the tides range from the highest in the world to so flat a tide as to be almost inappreciable except at the springs. At these stations, from two to four years of continuous tidal record has already been obtained, accompanied by meteorological returns from ten stations in the region, and supplemented by a complete file of daily weather charts showing the isobars, issued by the Meteorological Service, which is another branch of the Marine Department. At three of the tidal stations themselves a barograph record is also secured. The monthly charts issued by the Hydrographic Office of the United States, which show the tracks of all the important storms, are also available for purposes of comparison. In addition to these principal stations, there are now fifteen secondary stations, which have been in operation for three or four months during the summer season in the Gulf of St. Lawrence and the Bay of Fundy, at which simultaneous tidal comparisons have been obtained on recording gauges.

At some of these stations the secondary undulations are persistent and continuous; at others, they appear about half the time; while at others again, usually towards the head of estuaries, they seldom (if ever) appear.

The excellent field thus afforded for the investigation of the question was pointed out in a "Note" on the subject, communicated by me, in May 1895, to the Royal Society of Canada (*Trans.* Roy. Soc. of Canada, vol. i., Second Series, 1895–96). The question of the origin of these undulations has been examined by Mr. F. Napier Denison, of the Meteorological staff; his endeavour being to establish a relation with the fluctuations of the barometer. With this in view, he has examined some part of the tidal record as above, and also the tidal record from our Pacific coast stations. The results of his investigations, as far as he has yet carried them, are published in the *Proceedings* of the Canadian Institute, Toronto; paper read January 16, 1897. He has also made an investigation of similar short-period undulations in the Great Lakes (see *Proceedings Canadian Institute;* paper read February 6, 1897). This, with the references given by Prof. Duff to his own papers, completes the study yet given to the subject in Canada.

It is unlikely that better conditions exist anywhere than in the region above referred to. Some of the waters are land-locked, some open to the ocean; the great variety in the range of the tide, tending to magnify the undulations where the range is great, and leaving scarcely anything else but these undulations and the effect of storm disturbance, where the tide is flat; the completeness of the meteorological data and the well-charted storm tracks, furnish ample material for comparison. The investigation has not yet been taken up by this Survey, which has to be carried on with so little means and assistance as to confine it at present to the direct practical issues in the preparation of tide-tables, &c. But where such good material exists, it is very unfortunate that descriptions of the phenomena from a few illustrations should be given as an average account of their characteristics, or that conclusions should be founded upon too narrow and incomplete a basis.

W. Bell Dawson,
Engineer-in-Charge of Tidal Survey.

Ottawa, February 10.

Mr. Dawson characterises my letter as "misleading," and yet, in the course of his own letter, quite neglects to point to an incorrect statement in mine. This is certainly unfortunate.

To show how little Mr. Dawson's remarks touch the substance of my letter, permit me to briefly re-state my position. (1) The oscillations are regular where the basin is fairly regular. This is not questioned by Mr. Dawson, and, as regards the Bay of Fundy, it is amply confirmed by my own observations and the records of Mr. Dawson's department. (2) The oscillations are of irregular period in markedly irregular basins, such as the Gulf of St. Lawrence. This is also not questioned by Mr. Dawson. It is founded on records of four days each from seven different points on the Gulf of St. Lawrence (see the Tidal Report referred to by Mr. Dawson and quoted in my previous letter). Mr. Dawson's only criticism is that he has many other records from the same places; but he does not tell us whether they contradict the published ones. It would certainly be surprising if they did. (3) The period is determined by the dimensions of the basin, and can be calculated from those dimensions, as I have tried to show. (4) The cause of the initial disturbance is probably atmospheric. This point is discussed by Mr. Napier Denison in a short but valuable paper that reached me after my first letter was published. Mr. Denison confines his remarks to the cause of the initial disturbance.

That the period of these oscillations should be determined by the atmosphere seems to me quite incredible. It is surely sufficient refutation that, within a radius of twenty miles from St. John, we have three points at which the regular periods are 35 seconds, 12½ minutes, and 43 minutes respectively, and at one of these points the 35-second and 43-minute oscillations coexist.

Perhaps I have misunderstood Mr. Dawson. If his purpose was to call attention to the valuable materials being gathered by the Canadian Tidal Survey, which Mr. Dawson directs, then I must express my hearty approval, and add the hope that the excellent work may continue and receive efficient support. May I add that my interest is not that of a casual visitor to St. John (as implied by Mr. Dawson), but of a Canadian, most of whose life was passed in St. John? A. Wilmer Duff.

Purdue University, Lafayette, Ind., U.S.A.

The Natural Prey of the Lion.

Jean Baptiste Tavernier, in his "Travels in India" (translated by V. Ball, 1889, vol. ii. p. 397), mentions a case similar to what Mr. Crawshay describes under this heading in your last number (p. 558). "At a distance of two or three leagues from the fort [at the Cape], the Dutch found a dead lion which had four porcupine's quills in its body which had penetrated the flesh three-fourths of their length. It was accordingly concluded that the porcupine had killed the lion. The skin is still kept with the spines sticking in the foot." Thereon it is noted by the English translator that "numerous cases are recorded of tigers having died in India from this cause, and also of occasionally having been found when shot to have porcupine's quills sticking in them." The old Chinese motto, "*the hedgehog defeats the tiger*, and the serpent stops the leopard" (in Liu Ngan, "Hwui-nan-tsze," second century B.C.), is probably founded on observations allied to these. Kumagusu Minakata.

7 Effie Road, Walham Green, S.W., April 15.

THE PRESENT STANDPOINT IN SPECTRUM ANALYSIS.

In a former article I referred to some of the difficulties encountered by the earlier researchers in spectrum analysis. In the present one I propose to pass over the history of nearly twenty years' work with all its attendant doubts and difficulties, and deal with what that work has brought us, a perfect harmony between laboratory, solar and stellar phenomena.

It has been proved beyond all question that not only are both fluted (or channelled-space) spectra and line spectra visible in the case of most of the elements, but that many of the metallic elements with which I shall have to deal in the sequel have at least two sets of lines accompanying, if not resulting from, the action of widely differing temperatures.

It is important to mention that the different chemical elements behave very differently in regard to the action of heat and electricity upon them as we pass from the solid to the liquid and vaporous forms; that is, the two different forms of energy are apt to behave very differently, the permanent gases as opposed to the elements which generally exist in the solid form is the first differentiation, the elements of low atomic weights and low melting point as opposed to the rest, is the second.

In the cases in which heat-energy can go so far, we first get an increase in the free path of the molecules, and ultimately the latter are made to vibrate.

In the case of electricity, on the other hand, increase of free path is scarcely involved, and hence we may have effects similar to those produced by high temperature, with scarcely perceptible effects of heat in the ordinary sense.

Conversing on this subject with my friend Clifford, many years ago, we came to the conclusion that the energy imparted to a molecule might cause (1) an extension of free path; (2) a rotation, and (3) a vibration. To get concrete images of these effects we spoke of *path-heat*, *spin-heat*, and *wobble-heat*. The facts seemed to show that heat energy had no effect in producing line-spectra until the two first results had been obtained, and, further, that in all gases and many metals it had no effect in producing vibrations; while, on the other hand, electrical energy generally acted as if it began at the third stage, and is effective in the case of every chemical substance without exception.

However this may be, we now know that many elements present changes at several widely differing stages of heat. The line spectra of elements like sodium, lithium, and others may be obtained by the heat of the flame of a spirit lamp, or an ordinary Bunsen's burner, the substance being introduced into the flame by a clean platinum wire twisted into a loop at the end.

This temperature has no effect upon iron and similar metals. To get any special spectral indication from them a higher temperature than that of the Bunsen is required, the blowpipe flame may be resorted to; in this a stream of air is blown through the centre of a flame of coal gas burning at the end of a cylindrical tube.

We get in this way what is called a "flame-spectrum," in which flutings and some lines are seen. In order to obtain the complete line-spectra of some of the less volatile metals, like iron and copper, we are driven to use electrical energy and employ the voltaic current, and (for choice) metallic poles which are so strongly heated by the passage of the current that the vapour of the metal thus experimented on is produced and rendered incandescent.

We may say generally that no amount of heat-energy will render visible the spectra of gases. These are obtained by enclosing the gases in glass tubes and illuminating them by means of an electric current. We may go further and say that the ordinary voltaic current used in laboratories is equally inoperative. We must have the induced current, and with different tensions different spectra are produced.

We have then arrived so far. Heat-energy, which does give us line-spectra in some cases when metals are concerned, fails us in the case of the permanent gases and many metals. A voltaic current gives us spectra when metals are in question, but, like heat-energy, it will not set the particles of the permanent gases vibrating.

But when both metals and the permanent gases are subjected to the action of a strong induced current—that is, a current of high tension when an induction coil with leyden jars and an air break are employed, we get this vibration; gases now become luminous, a distinct change in the spectra of the metals is observed, a change as well marked, or perhaps better marked, than any of the previous lower temperature changes to which I have already drawn attention.

When the tension is still further increased, the differences in the spectra are most marked in the case of gases, for the reason that, being enclosed in tubes, they cannot escape from the action of the current; all the molecules are equally affected. *The spectrum is sometimes* NOT *a mixed one.* In the case of the metals the spark is made to pass between two small pointed poles, and the region of most intense action is a very limited one; we get from the particles outside this region the spectrum obtained with a lower degree of electrical energy. *The spectrum* IS *a mixed one.* Even when we take the precaution of throwing an image of the spark on the slit of the spectroscope, the outer cooler layers pierced by the line of sight add their lines to the spectrum of the centre.

Not only so, but the individuality of the various chemical elements comes out in a remarkable manner.

To take one or two instances. I will begin with the gases with a weak and strong induced current. Hydrogen gives us what is termed a structure spectrum, a spectrum full of lines; this changes to a series. Oxygen gives us series which change into a complicated line-spectrum in which no series has been traced. Nitrogen gives us a fluted spectrum which changes into a complicated line-spectrum.

I next pass to the metals, and again, for brevity's sake, I will deal with three substances only. In the case of magnesium, iron and calcium, the changes observed on passing from the temperature of the arc to that of the spark have been minutely observed. In each, new lines are added or old ones are intensified at the higher temperature. Such lines have been termed *enhanced lines.*

These enhanced lines are not seen alone: as in the case of the spark, so in the arc outside the region of high temperature in which they are produced, the cooling vapours give us the lines visible at a lower temperature.

Bearing in mind what happens in the case of the gases, we can conceive the enhanced lines to be seen alone at the highest temperature in a space sufficiently shielded from the action of all lower temperatures, but such a shielding is beyond our laboratory expedients; still, as I shall show, in the atmospheres of the stars we have probably the closest approximation open to our observation of that equally heated space condition to which I have referred.

The enhanced lines are very few in number as compared with those seen at the temperature of the arc. In the case of iron thousands are reduced to tens.

The above statements are only general: if we include the non-metals, more stages of temperature are required, and it then becomes evident that different kinds of spectra are produced at the same temperature in the case of different elements; in other words, at many different heat-levels changes occur, always in one direction but differing widely for different substances at the lower temperatures. At the highest temperatures—at the limit—there is much greater constancy in the phenomena observed if we disregard the question of series. If considered from the series point of view, there is no constancy at all.

It is obvious that with all these temperature effects observed in a large number of elements, very many comparisons are rendered possible. All these suggest that if dissociation is really in question, in some cases, at least more than two simplifications in the line stage are necessary to explain the facts. It is possible that the effects at first ascribed to quantity may be due to the presence of a series of molecules of different complexities, and that this is the true reason why "the more there is to dissociate, the more time is required to run through the series, and the better the first stages are seen."[1]

After this general statement of the changes in spectra observed to accompany change in the quantity and kind of energy used in the experiments, I propose to refer briefly to the most recent work on this subject, touching the changes observed on passing from the arc to the spark in the case of many of the metallic elements. By the kindness of Mr. Hugh Spottiswoode, the photographs of the enhanced lines have been obtained by the use of the large induction coil, giving a 40-inch spark, formerly belonging to Dr. Spottiswoode, P.R.S. I am anxious to express here my deep obligation to Mr. Hugh Spottiswoode for the loan of such a magnificent addition to my instrumental stock-in-trade.

The spark obtained by means of the Spottiswoode coil is so luminous that higher dispersions than those formerly employed can be effectively used, and in consequence of this, the detection of the enhanced lines becomes more easy; their number therefore has been considerably increased.

At the higher temperature enhanced lines have been found to make their appearance in the spectra of nearly all the metals already examined. Lithium is one exception.

Neglecting then all changes at the lowest temperatures, but including the flame spectrum, four distinct temperature stages are indicated by the varying spectra of the metals; for simplicity I limit myself to iron as an example. These are:—

(1) The flame spectrum, consisting of a few lines and flutings only, including several well-marked lines, some of them arranged in triplets.

(2) The arc spectrum consisting, according to Rowland, of 2000 lines or more.

(3) The spark spectrum, differing from the arc spectrum in the enhancement of some of the short lines and the reduced relative brightness of others.

(4) A spectrum consisting of a relatively very small number of lines which are intensified in the spark. This, as stated above, we can conceive to be visible alone at the highest temperature in a space efficiently shielded from the action of all lower ones, since the enhanced lines behave like those of a metal when a compound of a metal is broken up by the action of heat.

Each line of each element at whatever temperature it is produced, can at once be compared in relation to position in the spectrum with the lines visible in celestial bodies with a view of determining whether the element exists in it.

At the time at which the earlier inquiries of this kind were made it was only possible for the most part to deal with eye observations of the heavenly bodies. The results were, therefore, limited to the visible spectrum.

During the last few years photographs of the spectra of the brighter stars and of the sun's chromosphere during eclipses have been obtained; it became of importance, therefore, to extend the observations of terrestrial spectra into the photographic regions for the purpose of

[1] *Proc. Roy. Soc.*, 1879, No. 200.

making the comparisons which were necessary for continuing the inquiry.

The recent work has been done with this object in view.

The way in which the enhanced lines have been used is as follows. Those belonging to some of the chief metallic elements have been brought together, and thus form what I have termed a "test-spectrum." This has been treated as if it were the spectrum of an unknown element, and it has been compared with the various spectra presented by the sun and stars.

How marvellous, how even magnificent, the results of this inquiry have been, I shall show later in detail; but I may here say by way of anticipation that the test-spectrum turns out to be practically the spectrum of the chromosphere; that is, the spectrum of the hottest part of the sun that we can get at, and that a star has been found in which it exists almost alone, nearly all the lines of which had previously been regarded as "unknown."

This last result is of the highest order of importance because it should carry conviction home to many who were not satisfied with the change of spectrum as seen in a laboratory, where, of course, the enhanced lines when seen in the spectrum of the centre of the spark have alongside them the lines in the spectrum of the outer envelope, which of course is cooling, and in which the finer molecules should reunite. For twenty years I have longed for an incandescent bottle in which to store what the centre of the spark produces. The stars have now provided it, as I shall show.

Although I have promised to pass over the history of the work generally, I must still point out that the enhanced lines in the test-spectrum actually include all those first studied years ago when everything was dim, and we were seeing through a glass darkly; not as we are now, face to face. To show the rigid connection of the new with the old, it is desirable to refer briefly to some of the work undertaken in relation to some of the first anomalies noted.

One advantage of this method of treatment is that it shows that the immense mass of evidence now available supports all the conclusions drawn from the meagre evidence available a quarter of a century ago.

Some of the anomalies were as follows: they are given as specimens of many.

(1) Inversion of intensity of lines seen under dfferent circumstances.

I showed in 1879 that there was no connection whatever between the spectra of calcium, barium, iron, and manganese and the chromosphere spectrum beyond certain coincidences of wave-length. The long lines seen in laboratory experiments are suppressed, and the feeble lines exalted in the spectrum of the chromosphere. In the Fraunhofer spectrum, the relative intensities of the lines are quite different from those of coincident lines in the chromosphere.

(2) The simplification of the spectrum of a substance at the temperature of the chromosphere. To take an example, in the visible region of the spectrum, iron is represented by nearly a thousand Fraunhofer lines; in the chromosphere it has only two representatives.

(3) In sun-spots we deal with one set of iron lines, in the chromosphere with another.

(4) At the maximum sun-spot period the lines widened in spot spectra are nearly all unknown; at the minimum they are chiefly due to iron and other familiar substances.

(5) The up-rush or down-rush of the so-called iron vapour in the sun is not registered equally by all the iron lines, as it should be on the non-dissociation hypothesis. Thus, as I first observed in 1880, while motion is sometimes shown by the change of refrangibility of some lines attributed to iron, other adjacent iron lines indicate a state of absolute rest.

Laboratory work without stint has been brought to bear, with a view of attempting to explain the anomalies to which attention has been directed.

I only refer here to the work done on iron, magnesium and calcium, to show that in those metals the anomalies were to a large extent due to the lines now termed enhanced—that is, the lines seen to considerably change their intensities when the highest temperatures are employed.

Iron.

In the course of my early observations of the spectrum of the chromosphere, I discovered on June 6, 1869, a bright line at 1474 on Kirchhoff's scale, which I stated to be coincident with a line of iron. On June 26 I discovered another at 2003·4 of the same scale.

The later researches on the spectrum of iron have shown that the iron line which I observed in 1869 to be coincident with the bright chromospheric line at 1474 on Kirchhoff's scale, having a wave-length of 5316·79, is an enhanced line, agreeing absolutely with Young's latest determination of the wave-length of the 1474 chromospheric line.

Similarly the line at 2003·4 of Kirchhoff's scale, with a wave-length of 4924, is also an enhanced line of iron.

The first experiments were made to explain my own and the Italian observations of the chromosphere which proved the presence of only these two lines of iron in the part of the spectrum ordinarily observed; the ordinary spectrum of iron in which 460 lines had been mapped at that time was entirely invisible.

The anomalies were investigated in the experimental work with sparks produced by quantity and intensity coils with and without jars in the circuit. The outcome of these experiments was to show that the chromospheric representatives of iron were precisely the lines which were brightened on passing from the arc to the spark, while the lines widened in spots corresponded to a lower temperature.

The next anomaly observed was that in a sun-spot the iron line at 4924 often indicated no movement of the iron vapour, while the other iron lines showed that it was moving with considerable velocity.

It seemed perfectly clear then that in the sun "we were not dealing with iron itself, but with primitive forms of matter contained in iron, which are capable of withstanding the high temperature of the sun, after the iron observed as such, has been broken up, as suggested by Brodie."[1]

On this view, the high temperature iron lines of the chromosphere represent the vibrations of one set of molecules, while the lines which are widened in spots correspond to other molecular vibrations. Similarly, the idea of different molecular groupings provides a satisfactory explanation of the varying rates of movement of iron vapour indicated by adjacent lines, the lines being produced by absorption of different molecules at different levels and at different temperatures.

Magnesium.

In 1879 I passed a spark through a flame charged with vapours of different substances. In the case of magnesium the effect of the higher temperature of the spark was very marked; some of the flame lines being abolished, while two new ones made their appearance, one of them at 4481. The important fact was that the lines special to the flame did not appear among the Fraunhofer lines, while those of the spark did appear.

This line at 4481 now takes its place among the enhanced lines like those of iron previously mentioned; special cases now form part of the more general one.

Here again the experiments pointed to varying degrees of dissociation at different temperatures as the cause of the non-appearance of some of the magnesium lines in the Fraunhofer spectrum.

[1] *Proc. Roy. Soc.*, vol. xxxii. p. 204.

From these experiments, the results of which were subsequently mapped in relation to the various heat-levels indicated by solar phenomena, I drew the following conclusions in 1879:—

"I think it is not too much to hope that a careful study of such maps, showing the results already obtained, or to be obtained, at varying temperatures, controlled by observations of the conditions under which changes are brought about, will, if we accept the idea that various *dissociations* of the molecules present in the solid are brought about by different stages of heat, and then reverse the process, enable us to determine the mode of evolution by which the molecules vibrating in the atmospheres of the hottest stars *associate* into those of which the solid metal is composed. I put this suggestion forward with the greater confidence, because I see that help can be got from various converging lines of work."

Calcium.

In 1876 I produced evidence that the working hypothesis that the molecular grouping of calcium which gives a spectrum having its principal line at 4226·9 is nearly broken up in the sun, and quite broken up in the spark, explained the facts which are that the low temperature line loses its importance and practically disappears from the spectrum of the sun, in which H and K are by far the strongest lines.[1]

I summed up the facts regarding calcium as follows:[2] "We have the blue line differentiated from H and K by its thinness in the solar spectrum while they are thick, and by its thickness in the arc while they are thin. We have it again differentiated from them by its absence in solar storms in which they are almost universally seen, and, finally, by its absence during eclipses, while the H and K lines have been the brightest seen or photographed."

I afterwards attempted to carry the matter further by photographing the spectra of sun-spots. In all cases H and K lines were seen reversed over the spots, just as Young saw them at Sherman, while the blue calcium line was not reversed.[3] The oldest of these photographs which has been preserved bears the date April 1, 1881.

The experimental results in the case of calcium, therefore, followed suit with those obtained from iron and magnesium, and indicated that the cause of the inversion of intensities in the lines of a substance under different circumstances is due to the varying degrees of dissociation brought about by different temperatures.

Both in the case of iron, magnesium and calcium the high temperature lines involved are not seen at all at lower temperatures, and even in the case of calcium, when photographic exposure of 100 hours' duration have been employed. It should be sufficiently obvious to everybody then that temperature alone is in question.

Finally, then. The similar changes in the spectra of certain elements, changes observed in laboratory, sun and stars are simply and sufficiently explained on the hypothesis of dissociation. If we reject this, so far no other explanation is forthcoming which coordinates and harmonises the results obtained along the different lines of work.

NORMAN LOCKYER.

HIGHER COMMERCIAL EDUCATION AND THE UNIVERSITY OF LONDON.

OUR knowledge of what is needed for the improvement of commercial education has undoubtedly been amplified and better defined by the action of the London Chamber of Commerce and of the Technical Education Board of the London County Council. The important conference held in June last at the Guildhall settled certain points beyond further controversy, and cleared the way for a new departure in those directions in which improvement is practicable and possible. The "Summary of Results" published by the Chamber will serve as a useful guide to educational authorities desirous of adapting school teaching to the requirements of our mercantile classes. The special Committee, appointed in May 1897 by the Technical Education Board, were actively engaged during the greater part of the year 1898 in taking evidence from merchants, bankers, teachers, and organisers of commercial classes, and their valuable report, recently published, gives some interesting extracts from the evidence of the expert witnesses they consulted, together with their own conclusions and recommendations. The report also contains a summary of the notices, previously published in various other reports, of the facilities provided in foreign countries for commercial education of different grades.

For many years there has been a growing feeling in this country, that the mercantile classes are placed at a disadvantage in competition with their foreign neighbours, owing to the absence of any specialised schools of commerce, such as exist in other parts of Europe. The reports of our consuls abroad went to show, that in the distant markets of the world agencies were being established with continental manufacturing firms, and that England was being gradually driven to the wall, in consequence of the greater activity, and the special aptitudes of commercial travellers, representing mercantile firms in Germany, Belgium, and Switzerland. It was also shown, that owing to their special business qualifications and to their knowledge of foreign languages, foreigners were preferentially employed in business houses in this country, and it was generally assumed, that although there might be other causes of an industrial and economic character, which helped this result, the defects of our educational system were mainly responsible for the gradual displacement in many important markets of English wares for those produced in other countries.

It is possible there may have been some exaggeration in the facts on which these conclusions were based; but there is no doubt that a strong *à priori* case for inquiry was established, and the report of the London County Council, and of the conference at the Guildhall, supplemented by further evidence from our consuls, and from other persons who have independently investigated the subject, has shown the extent to which foreign nations have benefited by their special schools, and the directions in which improvements may be looked for in our own methods. A very important item of evidence was furnished by Mr. Powell in his consular report on this subject of November 1898, which has undoubtedly modified the views of some of our educational reformers. Mr. Powell brought into prominence the fact, that the alleged pre-eminence of Germany was in no way due to her commercial schools; but that the movement, now in progress, for developing commercial education had followed, and had not preceded the rapid advance in her industrial operations. The wide publication of this fact has been useful in directing attention to other causes than the absence of special commercial schools in this country, for the explanation of the undoubted ability of German clerks and commercial agents to succeed where Englishmen too often fail. The inquiry instituted last year will serve to prevent the repetition of vague statements about the comparative excellence of commercial schools abroad, and shows the extent of the changes that are needed in our present educational system to give us all the advantages that commerce can be expected to gain from special schools or new methods of instruction.

The recommendations in the report of the London County Council are in general agreement with the con-

[1] *Roy. Soc. Proc.*, vol. xxiv. p. 352. [2] *Ibid.*, vol. xxviii. p. 171. [3] *Ibid.*, vol. xxxvi. p. 444.

clusions of the conference, and deprecate any attempt to teach the practice of commerce as a part of general education in any of our secondary schools. The language of some of the recommendations in the report of the County Council is perhaps a little misleading, owing to the fact, that where the report speaks of "commercial education," what is really intended is "training adapted to commercial life"; and from the evidence given in the report, and emphasised at the conference, such a training should be general rather than special, and the subjects of instruction should be so taught as to encourage independence of thought and the power of original investigation. It is the habits that such a training affords rather than any special knowledge, beyond that of foreign languages, that have helped the German schoolboy, and cannot fail to prove useful to the future business man It is important, however, that the education should be of a modern type. Physical science, including geography, mathematics and drawing, English composition and modern languages, should form the principal subjects of instruction in our secondary commercial schools; but the subjects should not be taught with any special view to mercantile practice, but by scientific methods equally applicable to the study of other subjects, and to the instruction of pupils destined for other occupations.

It is recognised that in all schools above the primary, different weight may be given to different branches of study, and that the teaching, even on the modern side, may be differentiated without being specialised. But the basis of such an arrangement should be found in the different amount of time given to the different studies, and not in the introduction of any specialised teaching. For instance, whilst the prevalent system of teaching foreign languages to all classes of pupils is generally recognised as susceptible of improvement, it will be readily admitted that pupils on the commercial side of a school might devote more time to the study than those intended for the medical or engineering professions. It is equally evident that the experimental method of teaching elementary science, as sketched out in the regulations of the Joint Scholarships' Board, are serviceable not only, nor indeed especially, to future technical students, but equally to all boys and girls, whatever the career they may eventually follow. Indeed, recent inquiries at home and abroad have shown the desirability not only of improving our methods of school teaching, but also of introducing system into our school organisation. It is mainly owing to the absence of any distinct aim or purpose in the teaching given in so many of our schools, that the secondary education of this country fails to satisfy the requirements of persons training for different careers, or to afford a fitting preparation for the different branches of industrial life. Suggestions with a view to the organisation needed are contained in the County Council's report; and it is hoped that when the machinery contemplated in the new "Board of Education Bill" shall be completed and in good working order, our secondary education may be sufficiently elastic to adapt itself to the various wants of industrial life. This is evidently what Prof. Hewins refers to when he says: "The most serious difficulty that has to be dealt with in the organisation of commercial education is to be found in the unsatisfactory state of secondary education in England."

One thing, recent inquiries will certainly have shown, viz. that in its higher developments the theory of business is a subject capable of being treated as a branch of higher education; and those who read the reports of the conference and of the Technical Education Board's Committee will find no difficulty, as regards trade, in agreeing with what Emerson wrote nearly sixty years ago: "I look on trade and every mechanical craft as education also."

It is, however, in the University stage of education, if anywhere, that specialisation with a view to a commercial career seems to be justified. The conditions of modern trade and commerce show, that for those who are to direct industrial concerns, and equally for those who are to discharge the important functions of consuls in different parts of the empire, the ordinary education of a good public school, even on the modern side, needs to be followed up by a special training in the theory of commercial science. It is well known that for many years excellent schools of this higher type have flourished in France, Belgium and Italy, and more recently in Switzerland. In Paris there are two institutions, one established by the Chamber of Commerce and another by private enterprise, in which commercial education of university grade is given. These institutions are well attended, the age of the students ranging from sixteen years upwards. It is true that the recognition of these schools by the State, as exempting the students from a part of the obligatory military service, has had an important influence upon the attendance, parents preferring that their sons, destined for a commercial career, should spend two years in a school of commerce than in barrack life. But, apart from this consideration, there is no doubt, that in France and Belgium, the value of a special commercial training for youths over sixteen years of age, before going into business, is fully recognised by merchants and bankers. In Germany, too, the recent establishment of a High School of Commerce in connection with the University of Leipzig, is strong evidence of the importance, which those who may be regarded as the best educational authorities in Europe attach to such specialised teaching.

In London, the great success of the School of Economics, under the direction of Prof. Hewins, has shown that studies connected with the business of commercial life admit of being treated in such a way as to claim recognition as part of a university education. No one can look through the general course of study pursued in that school, in which there are now over four hundred students, without coming to the conclusion, that the aim of the teaching is distinctly educational and scientific, and that the students' work is such as demands the exercise of intelligence and thought, leading up to practice in methods of investigation and research. What was previously regarded as merely possible and advisable, viz. the treatment of economics in relation to the theory of commerce, as a subject of university training, has been proved to be both practicable and useful. By higher commercial education is now understood a system of education "which provides a scientific training in the structure and organisation of modern industry and commerce, and in the general causes and criteria of prosperity, as they are illustrated or explained in the policy and experience of the British Empire and foreign countries." Among the subjects which such a course of education embraces, and in which fresh investigations are encouraged, are the study of statistics with application to the machinery of business, including banking, insurance, the theory of exchange; transport and the means of communication; industrial law, factory and other legislation, and the principles of international law; the history of economics and trade; commercial geography including trade routes; systems of taxation; the study of commodities, &c. The machinery of modern commerce offers any number of applications of the general principles underlying the consideration of such subjects; and what is usually understood by university education is well exemplified in the serious study of the facts, which the careful investigation of the phenomena bearing upon these matters helps to elucidate. It is in this spirit of inquiry that the course of instruction at Leipzig and in London has been arranged; and a glance at the programme of either of these schools will serve as a sufficient reply to those, who are disposed to question the possible connection between the practice of business and the academic training which we associate with university education.

The London School of Economics has had, so far, a very successful career. In its temporary home in Adelphi Terrace are found lecture-rooms and class-rooms, in which a staff of over twenty teachers give instruction; also a well-furnished library containing over 10,000 volumes on economic subjects. The growing importance of the study of economic science in its relation to international trade and commerce, and the success of the attempt to establish in London a special high school for the teaching of the subject will be regarded as justifying the University of London Commissioners in recommending the addition of a faculty of economics to the other faculties of the University; and it may reasonably be hoped that the present school will in the near future be greatly developed, and become more closely associated with the new University.

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

As a consequence of the proposed recognition of economics and commerce as a separate faculty of the University, the London County Council have offered, under certain conditions, to allocate to its maintenance a yearly sum of 2500*l.*, being part of their promised contribution to the funds of the University. By the aid of such an endowment, increased as it probably will be from other sources, the present School of Economics might enter upon a wider sphere of usefulness with new resources and facilities for advanced teaching, and might become a very important part of a teaching university.

It is now generally understood that a modern university must differ in many essential features from the university of former centuries. Such a university must gather up not only the wisdom stored of ages, but the newest knowledge in its application to the industrial requirements of modern life. The indebtedness of pure science to the investigations and experiments of astronomers, physicians and engineers is generally recognised, and shows how inquiries originally undertaken with a view to some practical end have often led to the discovery of new scientific truths. What is true in physical science is found to be the case also in economic science; and the establishment of a school for inquiry into economic and industrial phenomena; the better definition of our existing knowledge of the subject for the purposes of instruction; the organisation of systematic methods of investigation and research; and, above all, the recognition of the teachers, as constituting a separate university faculty, with common aims and objects, will certainly give a new impulse to the study of the laws of productive industry, and will add largely to our knowledge of the conditions under which trades are fostered, and nations are able to compete with one another in the struggle for new markets.

The establishment of a Faculty of "Economics and Political Science (including commerce and industry)" by no means implies the granting by the University of a corresponding degree. A University degree in any faculty is only supposed to indicate that a student has undergone a systematic course of instruction in a certain department of knowledge, and the precise title of the degree is a matter of comparative indifference. It is essential that, in any new university, there should be distinct and separate avenues to a degree, through the study of the special groups of subjects, in which the student elects to receive his training; and it is enough that the degree should certify that he has undergone such a training. There is no necessary connection between a faculty and a degree. In London, a candidate can take the M.B. or B.S. degree in the Faculty of Medicine, and the M.A. or D.Lit. in the Faculty of Arts. In the Faculty of Science, there are already several different paths along which a student may proceed to graduation, and it is a matter of no great moment whether students in the Faculty of Economics should take the B.Sc. degree, or whether a new title should be invented. Indeed, it may be hoped that, both in engineering and in economics, considerable freedom will be given to the recognised teachers of the university, and that different combinations of subjects, provided they involve an equivalent academic training, will be accepted by the Academic Council of the new university for the degree examination.

The existence in London of a high school of commerce in close connection with the reorganised university, will not only give an impetus to the study of subjects bearing directly upon the development of our manufacturing trades and commerce, but will exercise an important influence upon the curriculum of our secondary and higher grade schools. As the "Board of Education Bill" provides, in the first place, for the organisation of the central authority and of the Consultative Committee, and leaves to a later date the constitution of local authorities, so it will be found that, if a commercial school of university rank is successfully established, the first step will be made towards the organisation of a system of commercial education for schools of a lower grade.

The proposal of the Statutory Commissioners to establish a Faculty of Economics and Political Science in connection with the new university, is the opening of a new era for commercial education in this country; and the recommendation will be welcomed, as showing that the Commissioners fully recognise the importance of bringing the new University of London into close relation with the varied educational requirements of the present day.

Philip Magnus.

WILLIAM RUTHERFORD.

THIS distinguished physiologist was a son of the border. He was born at Ancrum in Roxburghshire in 1839, and he died in Edinburgh on February 21, 1899. About thirty-six years of his busy life, from the date of his graduation in 1863, were spent in the pursuit of physiological science. After studying at Berlin, Vienna, and Paris, he became assistant to the late John Hughes Bennett, who then filled the chair of Physiology in Edinburgh. For many years Bennett had taught histology and the use of the microscope to voluntary classes, and among his pupils may be mentioned the well-known names of Redfern, Carter, and Dobie, who have each made their mark in this branch of science. It was not, however, until the early sixties that practical physiology, as now understood, was developed in the Edinburgh school. Bennett's great contemporary, John Goodsir, the anatomist, brought under his notice the new experimental school of Germany, and in a short time the ingenious instruments of Helmholtz, Du Bois-Reymond, and Ludwig made their appearance in Edinburgh, probably before they were known in any other school in Great Britain. The first assistant who dealt with such matters, and who added a short course of instruction in physiological chemistry, was Dr. Argyll Robertson, the eminent ophthalmologist. After him came Rutherford, who threw himself into the work with characteristic ardour, and who amplified the course from year to year. In 1869, he became Professor of Physiology in King's College, London; in 1871, Professor of Physiology in the Royal Institution of Great Britain; and, in 1874, he returned to Edinburgh to occupy the chair of his old master. For twenty-five years he laboured unremittingly as a teacher, and he was able, as few men could have done, to cope with the enormous classes which for several years characterised the Edinburgh school. During the winter session, the systematic class frequently numbered five hundred students, while about two hundred and fifty obtained instruction in practical physiology, partly in the winter but mostly in the summer session.

It has always been the tradition that the occupant of a Scottish chair is expected to do two things: he must, in the first place, be a successful teacher, and, in the next, he must contribute to scientific progress; and it may be at once said that many eminent men have not found the two classes of duties to be incompatible. Rutherford is a typical example of such a successful combination, although, no doubt, he will be best remembered as a teacher. In this department of his work he was indeed a master. No one understood better the arts of clear exposition and of successful demonstration. It may be said his lectures were demonstrations from beginning to end. He devised ingenious methods by which fundamental phenomena might be successfully shown to large numbers of students, and his lectures were always copiously illustrated by diagrams. He did not trust much to text-books, nor to students finding out for themselves by laboratory work. He believed that the average student requires to be guided; that he must have the subject placed before him in such a way that he can grasp its leading principles; and that, without careful supervision and almost elementary drill, he will probably lose time in bungling laboratory work. Rutherford, therefore, took immense pains in leading the student on step by step, both in systematic teaching and in the laboratory. It is probable that from the highest point of view he erred in his method, or, rather, carried it too far, but he was eminently successful in training the average man.

Recognising that physiology is a composite science, a science that rests on the triple foundation of anatomy, physics, and chemistry, his own predilections were towards the first. He was thoroughly conversant with histology, as a branch of anatomy, and in his lectures perhaps undue prominence was given to this subject. He spent more time than was necessary in minute morphological details, with the physiological significance of which he was unacquainted; but he held that physiology must begin with an intimate knowledge of the structure of the cell and of the fibre. In this he was right. Histology, for ordinary students, must be taught from the physiological standpoint, but it is high time that the physiologist was relieved from teaching the technique of the subject. Rutherford's earlier training prevented him from grasping with equal firmness the applications of chemistry and physics to physiological problems. Here he was not so much at home. It only remains to be said that, taking him all round, he was one of the most successful teachers that ever adorned the northern school.

As an original investigator, Rutherford accomplished not a little, although it must be admitted that the time he devoted to teaching was often at the expense of that which might have been given to original work. It is also too true that when we sum up a man's work, as a rule it seems insignificant. Even the most skilled and diligent labourers lay only a few stones in the building of the temple. Rutherford did good service to histology by the invention of the freezing microtome, an instrument, however, that has served its day, and, except for special work, must give place to more modern and better methods. In his earlier years he paid much attention to electrophysiology, expounded electrotonus, and discussed various points connected with the excitability of nerve. One of his most important communications was made in 1870, on the influence of the vagus on the circulation. From 1872 to 1879 he laboured much on the physiological action of drugs on the secretion of bile, an investigation originated during Bennett's life-time, and then carried on largely by Rutherford and Dr. Arthur Gamgee. Rutherford, in his later researches, and assisted by a young Frenchman, William Vignal, went over the old ground, and extended its area. He investigated the subject by a most laborious and troublesome method, and no doubt laid solid foundations for our knowledge of the actions of various substances on the formation of bile. This work, owing largely to the unreasonable criticisms of those who objected to observations on animals, was the cause of much annoyance and worry, embittering for a time his social life, while it did not bring to him the credit that subsequent years will show it deserved.

In his later years, Rutherford expounded a theory of muscular contraction that has excited not a little attention, and given rise to much criticism. He was also much interested in the question of the functions of the cochlea in the appreciation of tone, and he advanced the "telephone" theory in opposition to the analytic theory of Helmholtz. Latterly he had grave doubts of the accuracy of Johannes Müller's doctrine of the specific energy of nerves, and had he lived he would probably have written on this subject.

Rutherford was a man of strong personal characteristics. A mannerism impossible to describe, acquired in early manhood, became a second nature, and was at first repellent and liable to be misunderstood. If his criticisms were sometimes severe, his scorn of an opponent scathing and bitter, and his assumption of dignity bordering on the grotesque, those who knew something of the inner life were aware that he did good by stealth, and that behind all the formality there was a simple, kindly nature. Animated by a deep love of science, possessed with a sense of duty that was unsparing in its demands on all his energies, imbued with a love of the beautiful that found its delight in painting and music, a warm friend, a stern and unyielding foe, as if some of the blood of the old borderers lingered in his veins, Rutherford was a man who made his mark, and who will not soon be forgotten.

J. G. M.

NOTES.

A FINE monument of Pasteur was unveiled at Lille on April 9. The new buildings of the Pasteur Institute at Lille were opened on the same day.

SIR RICHARD THORNE THORNE, K.C.B., F.R.S., has been elected a member of the Athenæum Club, under the rule which empowers the annual election of nine persons "of distinguished eminence in science, literature, the arts, or for public services."

THE Council of the Iron and Steel Institute has received the intimation that Her Majesty the Queen will be graciously pleased to accept the Gold Medal of the Institute, founded by Sir Henry Bessemer. The first duty of Sir William Roberts-Austen, on taking the chair as president of the Institute on May 4, will be to express the great satisfaction with which this announcement will be received by metallurgists throughout the empire. A main feature of Her Majesty's reign has certainly been the extraordinary development in the production and application of steel.

ACTIVE efforts are being made to secure the establishment of a zoological garden in Edinburgh. The committee that has the matter in hand have decided to approach the Government with a view to ascertaining whether a piece of ground for the proposed garden can be obtained within the Arboretum.

THE relations of the Society of Chemical Industry to chemical engineering and to industrial research will form the subject of an address to be delivered on Monday next by the president of the Society, Mr. George Beilby.

WE regret to see the announcement of the death of Sir William Roberts, F.R.S., the well-known consulting physician. From an obituary notice in the *Times* we learn that he was born on March 18, 1830, and educated at Mill-hill School and at University College, London. He was made a Fellow of the Royal College of Physicians in 1866, when he was selected to deliver the Goulstonian lectures, and he also delivered before that college in the year 1880 the Lumleian lectures, choosing for his subject "The Digestive Ferments and Artificially Digested Food." In continuation of his work in regard to the function of digestion he delivered a series of five lectures at Owens College, Manchester, in 1885, on "Dietetics and Dyspepsia." These two courses of lectures, with other contributions on cognate subjects, he re-issued in a collected form a few years ago in a book entitled "Digestion and Diet." In 1892 he was appointed Croonian Lecturer of the College, and delivered a course of three lectures on the "Chemistry and Therapeutics of Uric Acid, Gravel, and Gout." In 1897 he gave the Harveian oration before the college, delivering an address on "Science and Modern Civilisation," in which he embodied and epitomised the results of the labour and thought of many years. In 1877 he was elected a Fellow of the Royal Society, and in 1879 the Cameron prize was awarded to him by the University of Edinburgh in recognition of the value of his investigations on the subject of the treatment of digestion as a scientific contribution to practical therapeutics. In 1892 he became a member of the Senate of the University of London. He was appointed medical member of the Royal Commission on Opium in 1893, and contributed a memorandum on the general features and the medical aspect of the opium habit in India, which was published as an appendix to the report of the Commission. In 1896 he was appointed to represent the University of London on the General Medical Council. His last official appointment was in connection with he movement to establish a teaching University in London. When by Act of Parliament a statutory commission was ppointed to initiate such an institution, he was selected to serve on that commission as representing, with Dr. Michael Foster, the interests of science and medicine.

A MEETING of the Institution of Mechanical Engineers will be held on April 27 and 28. Sir William H. White, K.C.B., F.R.S., president of the Institution, will occupy the chair on both days, and will deliver his address at the first meeting. On April 28, a paper by Mr. H. G. V. Oldham, on evaporation condensers, will be read.

As already announced, the annual meeting of the Iron and Steel Institute will be held on Thursday and Friday, May 4 and 5, commencing each day at 10.30 o'clock a.m. The following are the subjects and authors of papers to be read and discussed during the meeting:—The diffusion of iron, Prof. J. O. Arnold and Mr. A. McWilliam; on the Gellivare iron ore mines, Mr. H. Bauerman; the use of blast-furnace and coke-oven gases, Mr. E. Disdier; the Wellman tilting furnace, Mr. A. P. Head; the solution theory of iron and steel, the Baron H. Jüptner von Jonstorff; exploring for iron ore with the magnetic needle, Prof. H. Louis; theories and facts relating to cast iron and steel, Mr. Bertrand S. Summers; the manufacture of steel direct from the ore in the blast furnace, Mr. D. Tschernoff; the use of hot blast in the Bessemer process, Prof. J. Wiborgh.

THE death is announced of Dr. William Frazer, one of the most prominent members of the medical profession in Ireland, and an eminent authority on Irish antiquities.

WE learn from *Science* that the Union Pacific Railway has offered to transport geologists and palæontologists without charge from Chicago or San Francisco to Wyoming, for the purpose of making explorations during the coming summer.

DR. MARTIN, who is now in Siberia investigating the recent reports regarding the fate of the Andrée expedition, has sent Prof. Nordenskjöld a telegram in which he states that they are without foundation.

THE *British Medical Journal* states that the council of the medical faculty of Bucharest has expressed its approval of a scheme for the establishment of a new institute of bacteriology and experimental medicine in that city. It is proposed to place Dr. Cantacuzino, at present assistant in the Institut Pasteur of Paris, at the head of the new institute.

THE Trout Fishing Annual Close Time (Scotland) Bill was read a second time in the House of Lords on Tuesday. The object of the Bill is to establish a close time for trout in Scotland, during which period it will not be legal to fish for or take trout in any lake, river, or loch in Scotland by net, rod, or line, or to have possession of such trout, or expose them for sale. The period proposed for the close time is to begin on October 15, and to end on February 28.

THE King of the Belgians, as Sovereign of the Congo Free State, has contributed 200*l*. towards the establishment of the London School of Tropical Medicine and the enlargement of the Branch Hospital of the Seamen's Hospital Society. The Archbishop of Canterbury has also contributed 50*l*. to the same object. Lord Lister, P.R.S., is to be the principal guest on the occasion of the inaugural dinner in connection with the Liverpool School for the study of tropical diseases on Saturday, April 22. A sum of 1700*l*. has been promised towards the expenses of the Liverpool School.

THE seventy-first meeting of German Naturalists and Physicians will be held at Munich on September 18-23. Prof. Boltzmann, Vienna, will deliver a lecture upon a subject not yet announced; Prof. Förster, Berlin, will describe some of the changes in astronomical thought during the present century; and Dr. Nansen will give an account of explorations of the north polar regions and the results obtained. In medicine, Dr. V. Bergmann, Berlin, will discourse on the value of radiography in surgery; Dr. Birch-Hirschfeld, Leipzig, on science and medicine: and Prof. Dr. Klemperer, Berlin, on Liebig and his influence on medicine. General meetings of the Association will be held on Monday, September 18, and Friday, September 22.

AT a meeting of the general committee of the National Sea Fisheries Protection Association, held on Tuesday, it was resolved: "That representation be made to Her Majesty's Government urging the necessity of telegraphic communication with the Faröe Islands and Iceland, and requesting them to join other Powers in subscribing the amount asked for by the Great Northern Telegraph Company of Copenhagen as an annual subscription for the transmission of meteorological and other Government information; and to appoint a representative to attend the Meteorological Congress to be held in St. Petersburg in August next."

THE third plague epidemic, which has caused the most terrible ravages in Bombay, is, happily, on the decline. Referring to the mortality which has marked its progress, the *Times* states that five weeks ago the populace were dying at the rate of 350 daily. At least 250 of these deaths were due to the plague. During the past week, however, the hot weather has set in steadily, and the plague generally retreats before a sustained high temperature, the decline being immediately noticeable when the thermometer verges upon the nineties. On Monday the mortality fell to 193, of which probably about 100 were plague cases. As to the protective value of inoculation against plague, it is stated that in the town of Hugli 33,000 persons were inoculated with the Haffkine fluid, while 6000 remained uninoculated. In one week there were 371 deaths among the uninoculated, while only 41 occurred among those who had been inoculated. All inoculations were voluntary. The results obtained from Prof. Lustig's curative serum are, however, unfavourably reported upon by the municipal commissioners of Bombay.

WHETHER the pen be mightier than the sword is not for us to discuss at the present moment; but that the camera is mightier than the pen, and follows very closely after the sword, will be conceded when the eye glances over the snap-shots taken during recent campaigns. We learn now that the United States Government is very wide awake as to the advantages of photography for recording events of national or historical interest. According to the *British Journal of Photography* (April 14), the U.S. War Department has undertaken the compilation of a photographic history of the war with Spain. To ensure the thoroughness of the scheme, a circular letter has been addressed to all the officers in the service, asking them to contribute such prints, films or negatives as they may have in their possession, promising to return such loans in good condition. It is further requested that the names of all persons who were known to have carried cameras in the regions of active operations should be communicated, so that their aid might be obtained in completing the record. It is proposed to produce in a single volume every obtainable feature and photograph bearing on the subject; and as it is generally known that the camera was extensively used, the publication of such a volume will be looked forward to with great interest.

Bulletin No. 3 of the Blue Hill Meteorological Observatory contains an account, by Mr. S. P. Fergusson, of the progress of experiments with kites during the years 1897–8, with photographic illustrations of the beginning of an ascent, of the steam power windlass, and of kites carrying meteorograph. In 1884, Mr. D. Archibald succeeded in elevating anemometers to a height of 1500 feet in this country. Mr. W. Eddy devised a simple but efficient kite, about ten years later, which reached a height of about 2000 feet. Since that time the work at Blue Hill, under the able superintendence of Mr. A. L. Rotch, has steadily advanced, until within the last two years the meteorographs have been repeatedly carried to heights exceeding 10,000 feet. The greatest height was reached on February 28 last, viz. 12,507 feet, by means of the Hargrave kite, with improvements by Mr. H. H. Clayton; this pattern being the most stable of those in use, has been adopted in all experiments since the spring of 1897. The vertical height is computed by means of the formula

$$H = (\sin h)\, lx,$$

in which H represents the height; h the angular altitude above the horizon, obtained by observing the kite with a surveyor's transit placed near the windlass; l the length of the line, read from the dial attached to the windlass; and x is a constant quantity determined experimentally as a correction for the sag of the line, &c. This computation is made in about a minute, and the results are accurate within one per cent. Kites are much less expensive than balloons, and the exposure of the instruments is better than can be obtained in manned balloons.

MR. F. NAPIER DENISON has made a special study of the minute undulations recorded upon the self-registering tide gauges, and has compared them with the curves of the self-registering barographs for a number of points on the Atlantic coast of Canada, and within the Gulf of St. Lawrence and the smaller bays. He finds that these minute undulations in the water are due to the direct action of atmospheric waves or billows, or, more properly speaking, oscillations of barometric pressure passing over the harbours and bays. Prof. Cleveland Abbe, the editor of the U.S. *Monthly Weather Review*, suggests that it would be much better to study the barometric oscillations directly as a meteorological problem, and, subsequently, to study their effect on the tides as an oceanic problem; but Mr. Denison recommends the reverse order of treatment. Mr. Denison's last paper appears in the *Proceedings* of the Canadian Institute for November 1898.

A NOTE by Prof. H. V. Hilprecht, in the *Bulletin* (January) of the Free Museum of Science and Art, Philadelphia, states that the new Babylonian expedition of the University of Pennsylvania resumed active work a short time ago. The excavation of the lowest strata of the temple of Bel or Enlil—"the father of the gods"—the exploration of certain quarters of the ancient city proper, and the determination of the precise site of the chief gates of Nippur, form the chief task of the expedition at present. A small number of generous and intelligent citizens of Philadelphia have provided the necessary means for a two years' campaign in Babylonia, with Prof. Hilprecht as scientific director, and Dr. J. H. Haynes as the director of operations in the field. It is hoped that the expedition will settle a number of vital archæological and chronological questions.

AT a meeting of the Royal Statistical Society, held on April 18, Mr. Martineau read a paper on the "Statistical Aspect of the Sugar Question." He began by pointing out that though this question originated some thirty years ago with the bounty on the exportation of refined sugar from France and Holland, it had now been extended to the general consideration of the production of beetroot sugar, both raw and refined, on the continent of Europe, stimulated as it is alleged by bounties. How striking had been the progress of the beetroot industry he showed by comparing the sugar production of the world at intervals during the last quarter of a century. In the first decade the cane sugar production was increased by 266,000 tons, and the beetroot production by 640,000 tons. In the second, cane went up 668,000 tons, and beetroot 1,718,000 tons. In the last five years, up to 1897, cane had decreased 474,000 tons, and beet increased 1,415,000 tons. Among the conclusions drawn from the paper are that cane sugar can be produced cheaper than beetroot; that cane sugar can be profitably produced and sold in this country at a price materially lower than the average price of the last fourteen years of alternate depressions and reactions; and that under free and open competition the world would cease to be dependent on the vicissitudes of the European beetroot crop.

THE issue of *Science* for March 3 contains a paper by Mr. E. D. Preston, Executive Officer to the Superintendent, on the work of the United States Coast and Geodetic Survey. The survey was first authorised in the year 1807, began serious work in 1832, and attained its present permanent status in 1843. Regular work has thus been carried on for over fifty years. Besides the ordinary trigonometrical and astronomical work, covering 350,000 square miles, the Survey has sounded and prepared charts of 164,000 square miles of sea, and has made extensive investigations into hypsometry, magnetism, gravity, and physical hydrography. The measurement of an arc of the ninety-eighth meridian is amongst the works at present in hand, and negotiations are in progress for extending the measurements of certain arcs into Mexico and Canada.

A TRANSLATION of a paper by Prof. Otto Pettersson, originally published in *Ymer*, appears in Nos. 12 and 13 of the current volume of *Die Natur*. An excellent summary is given of the aims and methods of the investigations carried on in the Baltic, the North Sea, and the North Atlantic, by Prof. Pettersson and his colleagues during the last six years, and the application of the results to meteorology, and to the study of fishery questions, is described. The paper is important in view of the proposals for further international co-operation at present under consideration, as it enters more into technical details than was possible in Prof. Pettersson's recent article in the *Nineteenth Century*.

"THE mechanics of the centrifugal machine" is treated very simply by Mr. C. A. Matthey in a paper in the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland. The author, after referring to the great loss of power due to uneven balancing in separators revolving in fixed bearings, points out the superiority of the Weston machine, in which the separator is suspended from above, and its axis kept within limits by india-rubber buffers. The stability of the arrangement is rightly attributed by the author to the imperfect elasticity of the rubber buffers, which by diminishing the precessional motion tends to bring the axis of rotation towards the vertical.

MR. JOSEPH MANNING has written a paper, published by Messrs. Swan Sonnenschein and Co., Ltd., on "The future of the metric and imperial systems of weights, measures and coinage." In it the author advocates a new system of units identical with the metric units but under different nomenclature, and a system of decimal coinage, according to which 1000 farthings would go to the pound. With regard to the former, we fail to see any advantage in using the new names "chor" and "grav" to denote units already known as the "stere" and "tonne," while it hardly seems desirable to use the name "ar" to represent the hundredth part of the metric "are." As further proof of the growth of popular interest in the metric units, we notice that *Science Gossip* for April has lent its pages to a description of the system, contributed by Mr. James Quick.

AT a recent meeting of the Society of Arts, an instructive paper was contributed by Sir Marcus Samuel on liquid fuel, in which an interesting account is given of the difficulties met with in the first attempts made to popularise the use of oil as a fuel. When the oil fields of Dutch Borneo were first opened up, the oil was not allowed to be carried in bulk through the Suez Canal, and there was not a single port in which obstacles were not placed in the way of its introduction. Now vessels carrying 6500 tons, and capable of discharging over 500 tons of oil per hour, pass through the canal regularly, and at ports such as Bombay great facilities are now given for the rapid discharge and distribution of oil cargoes, experience having demonstrated its perfect safety. The advantages claimed for high-flash oil as against coal are convenience of storage, safety, reduction of labour in stoking, and rapidity of discharge. Owing to the regularity with which it can be fed into the furnace, the alternate contraction and expansion of the fire bars and steam tubes, unavoidable when coal is used as fuel, and to which so many boiler accidents can be traced, is altogether stopped, although perhaps the risk of over-heating may be set off against this. Oil fuel is in actual use on the Great Eastern Railway, on railways in the south of Russia, in Paris, Southern California, and in South Africa; it has also been partially adopted in the Russian, German, and Italian navies. The only obstacle to its more general use is the doubt that exists as to whether the price would remain at its present level if the demand were greatly increased.

IN the *Communications* from the Physical Laboratory of the University of Leiden, No. 45, Dr. J. Verschaffelt describes measurements on the system of isothermal lines near the plait-point, and especially on the process of retrograde condensation of a mixture of carbonic acid and hydrogen. The paper is illustrated by two large diagrams representing the isothermals and condensation lines respectively.

MESSRS. TAYLOR, TAYLOR, AND HOBSON have just issued a new catalogue of photographic lenses, containing several noteworthy features. An instructive paper on "The Principles of a Lens Action" is included, and a new form of tables of conjugate foci has been added. In addition to particulars concerning the Cooke portrait lenses, the catalogue now includes the smaller Cooke lenses. A new and neat focussing mount is described, and also the Cooke extension lenses. The catalogue will interest all photographers who see it.

A PAMPHLET on "Ventilation," containing extracts from a paper on "Hospital Construction," recently read by Dr. John W. Hayward before the Liverpool Architectural Society, has been reprinted from the *Builders' Journal and Architectural Record*. The subject is an important one; and the method of ventilation and warming described by Dr. Hayward appears to meet all reasonable requirements.

"THE International Geography," upon which Dr. H. R. Mill has been engaged during the past two years, will shortly be published by Mr. George Newnes. The work is truly international in character, no less than seventy distinguished home and foreign geographers having contributed to it. Each contributor has intimate knowledge of the part of the world with which he deals, and great care has been taken to secure uniformity of plan and method; so that the work will be a concise encyclopædia of geography, suitable alike for reference or as a book for students. Among the authors we notice the names of Dr. D. Aïtoff, Prof. Grenville A. J. Cole, Sir W. Martin Conway, Prof. W. M. Davis, Dr. A. M. W. Downing, Prof. Th. Fischer, Dr. H. O. Forbes, Dr. J. W. Gregory, Prof. A. Heilprin, Sir H. H. Johnston, Dr. Scott Keltie, Prof. A. Kirchhoff, Prof. A. de Lapparent, Sir William Macgregor, Sir Clements Markham, Sir John Murray, Dr. Nansen, Prof. A. Penck, Count Pfeil, the late Sir Lambert Playfair, Prof. L. Raveneau, Sir G. S. Robertson, Dr. Th. Thoroddsen, Sir C. W. Wilson, and many others well known in the scientific world. Judging from the strong and representative list of contributors, the forthcoming work will be a very valuable addition to the literature of geography.

IN two papers recently presented to the American Academy, Prof. Richards, in collaboration with Dr. Cushman and Mr. Baxter, returns to the question of the atomic weights of nickel and cobalt. Both papers bear the stamp of highly accurate and searching work, and, in addition to a discussion of the main question, contain many subsidiary features of interest. Complete analyses of nickelous bromide and cobaltous bromide were undertaken, the salts being reduced by moist hydrogen, and the metals weighed as such. The bromine was determined as silver bromide. The final result for nickel was 58·706, and for cobalt 58·995. As the result of a critical examination of earlier determinations in the case of nickel, the authors select as the most trustworthy the numbers of Zimmermann, 58·694, and of Winkler, corrected by them to 58·69, so that the value 58·70 may be taken as final. As the authors' results for cobalt show less concordance than those for nickel, the extreme values being 58·955 and 59·021, fresh experiments involving different methods are being undertaken. The evidence of all the work is said to strongly support "Winkler's contention that nickel and cobalt, as we knew them of old, cannot contain more than an infinitesimal amount of any unknown element." Several radically different methods of preparation and many fractionations led to atomic weights, constant within a reasonable limit of experimental error. Cobalt has a higher atomic weight than nickel, although this conflicts with the inference to be drawn from the position of rhodium and palladium in the periodic classification. Amongst the minor matters involved in the above investigations the following may be mentioned:—Nickelous bromide and cobaltous bromide, when sublimed in porcelain tubes, are slightly contaminated with sodium bromide. The bromides are more easily reduced by moist than by dry hydrogen; the metals so prepared do not occlude an appreciable amount of hydrogen, possibly on account of the trace of sodium bromide present. Both nickel and cobalt are acted upon appreciably by water, giving colloidal solutions of the hydrates. This circumstance and also the use of glass apparatus, leading to siliceous residues, account mainly for Krüss's supposed discovery of "gnomium." The colloidal solution of cobaltous oxide absorbs oxygen from the air, and deposits cobaltic hydrate; no such action was observed in the case of nickel.

THE additions to the Zoological Society's Gardens during the past week include a Common Badger (*Meles taxus*), British, presented by Mr. Geo. M. Margon-Wilson; a Silver-backed Fox (*Canis chama*) from South Africa, presented by Mr. C. R. Rennie; two Black Rats (*Mus rattus*, var.), British, presented by Mr. W. J. Smith; a Purple-faced Monkey (*Semnopithecus cephalopterus*, ♀) from Ceylon; a Common Camel (*Camelus dromedarius*, ♂) from Arabia, deposited; two Black-headed Buntings (*Emberiza melanocephala*), a Puffin (*Fratercula arctica*), European; two Canada Geese (*Bernicla canadensis*) from North America; fourteen Golden Carp (*Carassius auratus*) from China, purchased.

OUR ASTRONOMICAL COLUMN.

TUTTLE'S COMET (1899 *b*).—The following positions are given by Herr J. Rahts in *Ast. Nach.* (Bd. 149, No. 3555):—

Ephemeris for 12*h. Berlin Mean Time.*

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br.
April 20	... 4 8 26·6	... +16 37 42	... 1·80
21	... 11 58·1	... 16 11 14	...
22	... 15 28·9	... 15 44 31	... 1·82
23	... 18 59·0	... 15 17 34	...
24	... 22 28·5	... 14 50 24	...
25	... 25 57·4	... 14 23 1	...
26	... 29 25·7	... 13 55 24	... 1·86
27	... 4 32 53·4	... +13 27 35	...

The comet should be looked for immediately after sunset; it travels during the week from between γ and δ Tauri to a position about 2° south of α Tauri (Aldebaran).

TEMPEL'S COMET (1873 II.).—M. L. Schulhof, of the Paris Observatory, gives, in a communication to *Ast. Nach.* (Bd. 149, No. 3554) the calculated elements and ephemeris of this comet, which will arrive at perihelion about the middle of June next.

Elements.

T = 1899, June 18·0 Paris Mean Time.

$$
\left.
\begin{array}{rl}
M = & 352^\circ\ 26'\ 22''\cdot 9 \\
\pi = & 306\ 33\ 51\cdot 5 \\
\Omega = & 120\ 57\ 57\cdot 0 \\
i = & 12\ 38\ 56\cdot 2 \\
\phi = & 32\ 49\ 41\cdot 2 \\
\mu = & 671''\cdot 8846 \\
\log a = & 0\cdot 481808
\end{array}
\right.
$$

(π, Ω, i: 1899·0)

Ephemeris for 12*h. Paris Mean Time.*

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br.
April 20	... 18 24 29·3 ...	− 5 36 9	... 0·285
21	... 26 16·0 ...	5 31 27	...
22	... 28 2·4 ...	5 36 44	... 0·317
23	... 29 48·5 ...	5 32 2	...
24	... 31 34·4 ...	5 27 20	...
25	... 33 20·0 ...	5 22 39	...
26	... 35 5·4 ...	5 18 0	... 0·358
27	... 18 36 50·4 ...	− 5 13 22	...

The brightness in 1878 was 0·113, while during the apparition of 1894 it was 0·190, so that the present return should be much easier of observation. The comet will be travelling from the south-eastern border of Ophiuchus, through Scutum Sobieski, into Aquila, and search should be made in the early morning.

VARIABLE STAR NOTES.—The fourth pamphlet issued from the Rousdon Observatory of Sir C. E. Peek, at Lyme Regis, South Devon, contains the individual observations of the variables R and χ Cygni, extending over the period 1887 January 20 to 1896 December 23. The resulting estimates of magnitude are also plotted out at the end of the pamphlet showing the light-curves, from an examination of which it appears that the period of χ Cygni is something over 14 months, and that of R Cygni about 12·5 months.

SPECTRUM OF SATURN'S RINGS.—Prof. Vogel many years ago stated that he had observed a strong absorption band in the red region of the spectrum of Saturn, at λ 6183, which was extremely faint or absent in the spectrum of the rings. Prof. Keeler in 1889 could detect no trace of it in the ring spectrum, using the 36-inch Lick refractor. During the evening of August 18, 1898, Mr. Ellerman, of the Yerkes Observatory, photographed the spectrum of Saturn on an isochromatic plate very sensitive to the red region, using the 40-inch telescope. The spectroscope used had one flint prism of 60° angle, the collimator and camera lenses being 1·4 inches aperture and 19 inches and 10½ inches focus respectively. The planet being far south the exposure had to be short, so the slit had to be used fairly wide. A reproduction of an enlargement (7·5 times) from this negative is given in *Astrophysical Journal* for March (vol. ix. p. 186). The absorption band referred to is very readily seen in the spectrum of the ball of the planet, but no trace of it is at all visible in the ring spectra. The conclusion drawn by Prof. Hale from this fact is that the rings possess little or no atmosphere, thus confirming the result formerly obtained from visual observations.

THE SUN'S MEAN TEMPERATURE.—In our last issue we called attention to a criticism of Dr. See's article on "The Sun's Heat," by Dr. A. S. Chessin, in the *Astronomical Journal*, No. 456. In the current issue, No. 458, there are some further remarks by Prof. S. Newcomb and Dr. Chessin, which we give below.

Prof. Newcomb writes: "Dr. Chessin's remark in *A. J.*, 456, does not seem to me well founded. The problem is this: The parts of a spherical gaseous mass A are kept in equilibrium between the force of their mutual gravitation, and of their elasticity due to temperature. To preserve this equilibrium let there be an absolute temperature T_0, which may increase from the surface to the centre. Now, by the radiation of heat, let the radius of the mass A contract from R_0 to R. What is the temperature T necessary to maintain the equilibrium of the mass after contraction? The formula given by See,

$$T = \frac{R_0 T_0}{R},$$

does not seem open to doubt. I do not see how hydrodynamic laws enter into the question."

Dr. Chessin writes: "With regard to Prof. Newcomb's remark, I beg to observe that I did not raise the question as to whether the law which Dr. See calls *his* (and which, more correctly, should be called Ritter's, who expressed it in 1881, as Dr. See states himself), was at all plausible or not. I simply objected to Dr. See's *derivation*, in the course of which, as I have stated before, he assumes that which he wants to prove.

"As to neglecting the principles of hydrodynamics, it suffices to point out, for example, the inadmissible assumption of uniform density throughout a gaseous body in dynamical condition (v.l. contraction and radiation)."

SOURCES OF IMPORTANT MINERALS.

A VALUABLE Blue Book by Prof. C. Le Neve Foster, F.R.S., containing statistics relating to persons employed in mining, the output of minerals, and the number of accidents occurring in mines and quarries in the British Colonies and in foreign countries, has just been published by the Home Office. The tables are not complete, but the information given in them presents many points of interest. The part of the introduction referring to output is printed below, and the two accompanying diagrams, reproduced from plates in Prof. Foster's report, illustrate graphically the variations in the production of coal and iron ore in several countries during the past twenty years.

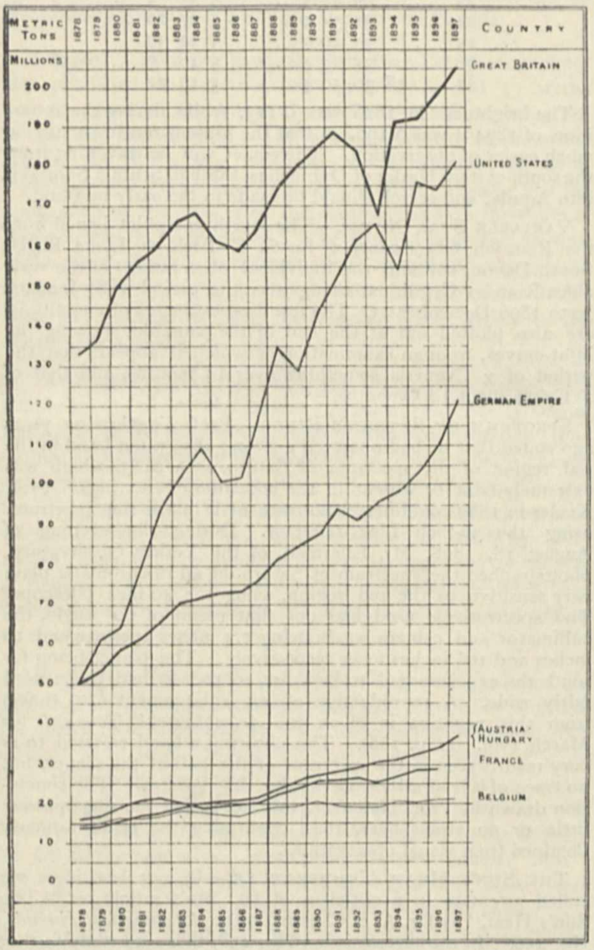

Fig. 1.—Diagram showing the output of coal in six the principal coal-producing countries during the past twenty years.

Coal.—The United Kingdom is at present the most important producer of coal, but the rapid growth of coal mining in various parts of the United States, as apparent from the curve in diagram (Fig. 1), and the knowledge of its enormous resources, lead to the belief that the mother country will eventually have to yield its position to the younger branch of the Anglo-Saxon race. The British Empire, as a whole, produces more than two-fifths of all the coal raised in the world.

Copper.—Figures do not furnish a proper basis for comparison of output, because some countries state their output as ore, and others as metallic copper. The United States, with the enormous output of 223,000 tons of metal, produce more than half the copper of the world, and Spain and Portugal together about one-eighth.

Gold.—In the race of the gold-producing countries the South African Republic has been rapidly gaining upon the United States, and, though a little behind in 1897, will take the first place for the current year. In 1897 it may be said approximately that these two countries and Australasia each produced more than one-fifth of the world's supply. The only other country needing mention is Russia, with nearly one-tenth of the total.

Iron.—Tables which merely show tons of ore without stating the average percentages of metal must be read with caution; but, whether judged by the gross weight of the ore or by the actual amount of metal present, the United States take the lead among the iron-yielding countries. Great Britain comes next as a producer of iron, and is followed by Germany with its 10

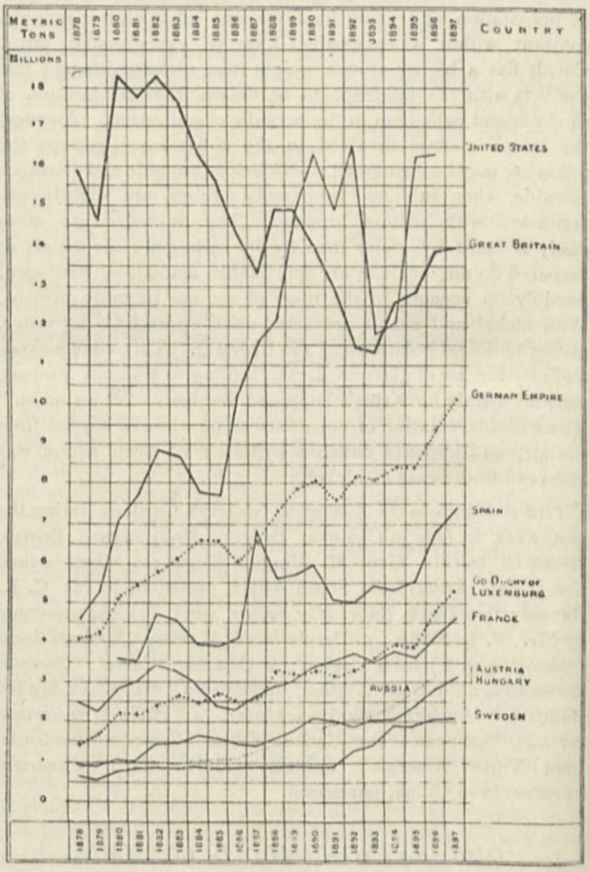

Fig. 2.—Diagram showing the output of iron ore in the principal iron-producing countries during the past twenty years.

million tons of ore derived mainly from the poorer but easily wrought deposits of Alsace-Lorraine. Spain ranks fourth with a production of 7 million tons of ore; but in comparing its position with that of Germany, the higher percentage of metal in the Spanish ores should be borne in mind. In the same way the low percentage of iron in the ore produced in Luxemburg must be considered in comparing its output of 5 million tons with that of France, Russia and Austria-Hungary.

The production of iron ores in the principal countries during the past twenty years is illustrated by a diagram (Fig. 2).

Lead.—Spain is the greatest lead-producing country in the world; it is followed at no great distance by the United States. Germany produces little more than half the total output of Spain.

Petroleum.—Russia and the United States are the two great petroleum producers. In the British Empire, Canada and Burma are the only oil regions deserving mention at the present time, though their output is, comparatively speaking, small.

Salt.—The United States and the United Kingdom produce about 2 million tons of salt each, Russia $1\frac{1}{2}$ million, Germany $1\frac{1}{4}$ million, India about 1 million.

Silver.—Here again the United States are the largest producers, followed closely by Mexico. Australasia furnishes an output nearly equal to one-third of that of the United States, and Bolivia and Germany approximately the same amount.

Tin.—The Malay Peninsula is *facile princeps* as regards the production of tin, probably yielding nearly two-thirds of the world's supply; and when aided by other British Possessions fully three-quarters.

Zinc.—The mines of Upper Silicia alone would suffice to make the German Empire *par excellence* the zinc-producing country of the whole world. The United States, after a long interval, take the second place in the list.

It must be carefully remembered that many valuable minerals are not mentioned: for instance, Cape Colony produces diamonds to the value of $4\frac{1}{2}$ millions yearly; Italy has no equal for its sulphur, Chili for its nitrate of soda, Germany for its potassium salts, Spain for its quicksilver, and the United States for their phosphates.

ON THE ORIGIN OF MAGNETO-OPTIC ROTATION.[1]

IT is known (*Phil. Mag.*, December 1897) that when in a material molecule there exists an independently vibrating group of ions or electrons, for all of which the ratio e/m of electric charge to inertia is the same, then the influence of a magnetic field H on the motions of this group is precisely the same as that of a rotation with angular velocity ω, equal to $\frac{1}{2}e\text{H}/mc^2$, imposed on the group around the axis of the field, on the hypothesis that the extraneous forces acting on the ions are symmetrical with respect to this axis. This result involves the main features of the Zeeman effect; it requires that the separations of the doublets representing the spectral lines arising from such a group must all be equal when measured in differences of frequency, or be inversely as the square of the wave-length in vacuum when measured in differences of wave-length, a relation which Preston has recently found to obtain for the natural series of lines in ordinary spectra.

The object of this note is to point out that it is possible to deduce the Faraday effect from the Zeeman effect by general reasoning, as regards any medium in which the optical dispersion is mainly controlled by a series of absorption bands for which the Zeeman effect obeys the above law, without its being necessary to introduce any special dynamical hypothesis. For this law ensures that the effect of the magnetic field on the periods of the corresponding free vibrations of the molecules is the same as that of a bodily rotation, say with angular velocity ω, round its axis;[2] while the complete circular polarisations of the Zeeman doublets, viewed in the direction of the axis, show that their states of vibration are symmetrical with respect to that axis. Thus, Ω being the angular velocity of the displacement vector in a train of circularly polarised waves traversing the medium along the axis, the state of synchronous vibration which it excites in the molecules will have exactly the same formal relation to this train when the magnetic field is off as it would have to a train with very slightly different angular velocity $\Omega \pm \omega$ when the magnetic field is on, the sign being different according as the train is right-handed or left-handed. Now, change of this angular velocity Ω means change of period of the light: thus the propagation of a circularly polarised wave-train when the field is on is identical with that of the same wave-train when the period is altered by its being carried round with angular velocity $\pm \omega$ and there is no influencing magnetic field.

This last result has been employed by H. Becquerel as a single hypothesis (suggested by Maxwell's notion of a magnetic field in this connection as a vortex in the medium) from which to deduce quantitatively both the Zeeman effect and the Faraday effect, and thus correlate them ("Sur une interprétation applicable au phénomène de Faraday et au phénomène et Zeeman"—*Comptes rendus*, November 8, 1897). He shows, employing chiefly the quantitative results of his own previous experimental investigations, that the hypothesis is capable of providing a satisfactory general view of the whole range of the phenomena, and in particular that it leads immediately to a simple law of dispersion for the Faraday effect, namely rotatory power proportional to $\lambda dn/d\lambda$ where n is the refractive index corresponding to wave-length λ measured in vacuum, a law which is in good agreement with Verdet's results for carbon disulphide and creosote.

The preceding argument provides a general dynamical justification of this hypothesis, for the case of all media in which the ordinary gradient of dispersion is mainly controlled by one or more powerful absorption bands beyond the visible spectrum, for all of which the Zeeman constants are the same: it also shows that Becquerel's hypothesis has an approximate validity when these constants are nearly the same for all the effective bands. In the immediate neighbourhood of any single band the dispersion is anomalous, and is controlled practically by that band alone; the application will then be exact, and in Becquerel's hands it has given a complete account of the excessive and anomalous rotation first observed by Macaluso and Corbino in sodium vapour for light adjacent to the D lines. As was to be anticipated, these simple general conclusions are consistent with the results of the more special dynamical investigations of FitzGerald and Voigt.

[1] Communication to the Cambridge Philosophical Society, March 6, by J. Larmor, F.R.S.

[2] The circumstance that the mean of the two disturbed periods is equal to that of the undisturbed line shows that no effect of constitutive type is involved in addition.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. ROBERT MUIR, at present professor of pathology in the University of St. Andrews, has been appointed to the chair of Pathology in the University of Glasgow.

BY the will of the late Miss Elizabeth Brown, who died on March 5, the British Astronomical Association will receive her observatory at Further Burton, with the astronomical instruments in it, and the sum of 1000*l*.

Science states that Mr. John D. Rockefeller has offered 100,000 dollars to Denison University, Granville, O., if the friends of the institution will, within the next year, raise the sum of 150,000 dollars.

THE British Child-Study Association has issued the first number of a magazine entitled *The Paidologist*, which is to be published three times a year, and will be concerned with the physical and psychical aspects of child-life. The aims of the Association are both scientific and educational; and the new magazine is intended as a medium in which the results of research on child psychology shall be recorded, and practical suggestions which will assist in the evolutionary progress of the race shall be described.

WITH reference to the Board of Education Bill, the Council of the Association of Technical Institutions has unanimously adopted the following resolutions: (1) In reference to Section 2 of Clause 3, "That, inasmuch as in some counties and in most county boroughs the funds available are already fully appropriated for the purposes of technical education it is not, in the opinion of this Council, desirable that these funds should be applied to the payment of the expenses of inspecting schools under this Section." (2) "That, in the opinion of this Council, having regard to the fact that the funds assigned under the provisions of the Technical Instruction Acts are not more than adequate for the maintenance and development of technical education, it is essential that for the further purposes of secondary education additional funds be provided." It has also decided to take steps to endeavour to secure that the interests of technical education shall be adequately represented on the consultative committee named in Clause 4 of the Bill.

THE Commissioners appointed under the University of London Act, 1898, have given notice that they are now prepared to consider applications from duly qualified teachers and lecturers giving instruction of the University type in public educational institutions situate within a radius of thirty miles from the University buildings, who desire to be recognised as teachers of the University. By a "public educational institution" the Commissioners understand to be meant an institution for general education or for any special kind of education, which is not carried on for private gain or profit. Applications stating the applicants' qualifications should be addressed to the Secretary, Mr. T. Bailey Saunders, at the office of the Commission, 32 Abingdon Street, Westminster, S.W., on or before Saturday, May 13, 1899. It will, it is added, be convenient if teachers and lecturers in physics, chemistry, or other subjects, effective instruction in which requires laboratories and expensive apparatus, would state what resources of that character they have at their disposal. Teachers or lecturers on whose behalf applications have already been made by their colleges or schools need not repeat them.

At a meeting held in University College, Bristol, on Thursday last, the Bishop of Hereford, President of the College, being in the chair, it was decided to found a University College Colston Society, holding an annual dinner in the same manner as the Grateful Dolphin, and Anchor Societies, but with a distinctly educational aim. It was pointed out by the Bishop of Bristol that not only were the Colston benefactions to education larger than to all other objects combined, but that the sums devoted to this object in Bristol by Edward Colston were larger than those which have given origin to the existing annuities and doles. It is hoped that a Colston endowment fund may thus be raised, and scholarships instituted to enable girls and boys who have shown promise to pass on to the College from schools and other institutions in the city. The University College has recently fallen heir to a legacy of 5000*l*. bequeathed by the late Mr. Stuckey Lean. This will probably be devoted to a much-needed extension of buildings. Both the Bishop of Hereford and the Bishop of Bristol expressed opinions favourable to the establishment in the near future of that University for the West of England, centred in Bristol, which Sir Norman Lockyer foreshadowed when the British Association recently met in that city. We cannot but believe that the citizens of Bristol will speedily follow the lead set them by the citizens of Birmingham, and take active steps to enable those who have the cause of higher education in the West of England at heart to realise the ideal thus placed before them.

On Saturday last, in opening a new county school established at Presteign under the Welsh Intermediate Education Act, the Duke of Devonshire referred to the part he played in educational affairs. He remarked that he had on previous occasions had to protest against the assumption which seemed to have been made that he was, or professed to be in any degree, an educational expert. That was not the least the case. An educational expert should be a person who had himself received a very large and extensive education, and who had, in addition, devoted himself to the study of education, which was in itself a science and a profession. To neither of these could he lay the smallest claim. If, without the slightest pretension on his part, he had assumed to be in any sense an education advocate, it was because he had been for some considerable period deeply impressed with the national importance of the better training of the people in one branch, and that a very limited branch, of education—that was to say, in the teaching of science and of art as applied to our industries and to our commercial position. He had seen in many ways the close connection which existed between the discoveries and teaching of science and the efficiency and prosperity of our industries. He had seen how other countries appeared to be more alive to the existence of this close connection than we were ourselves, how in other countries the imparting of this kind of instruction had been made more the business of the State, and how they had been able to induce their people more fully to take advantage of the opportunities for this kind of education than we had hitherto succeeded in doing. But to see the necessity for this kind of technical training of the people, and to suggest the means by which it was to be provided, were two very different matters; and, although he had done his best to impress the views which he had formed on this subject on his fellow-countrymen, he had never professed, and he did not profess, to be an expert adviser as to the manner in which this technical training should be applied to our people.

Referring to the Board of Education Bill, the Duke of Devonshire said it had been his duty to bring in a Bill the object of which was the better organisation of education, and especially of secondary education. He thought the interests of the measure, which he believed to be an important one, might suffer if it were to be supposed that he, in the conduct of it, spoke as an educational expert with theories and ideas on education of his own, instead of being, as he was, merely a politician and an administrator charged with the duty of attempting to improve the organisation of our education with the assistance of experts who were much better qualified to advise and to give counsel than he was himself. This might be a good system or not a good system, but it was our system of government. We did not put a great strategist at the head of the War Department, or a skilful sailor, or a great shipbuilder at the head of the Admiralty. We selected ordinary statesmen or politicians to control these two great departments, requiring, as they did, the highest technical skill in the shape of skilled professional advisers. In his opinion, it would be a very great mistake indeed if we were to commit the charge of the Education Department to a professor, a schoolmaster, or an educational expert, however great might be the range of his studies, and however much he might have devoted himself to the study of the science of education.

SCIENTIFIC SERIALS.

Wiedemann's Annalen der Physik und Chemie, No. 2.—Propagation of electrodynamic waves along a wire, by A. Sommerfeld. To approximate to practical conditions, the author admits a finite thickness for the wire, and supposes it to be single, straight, and infinite. He shows that when the frequency is high and the wire thick, propagation takes place with nearly the velocity of light; but when that is not the case, the rate may be only three-quarters of that. All the occurrences are confined to a surface layer of the wire not more than 0·1 mm. thick.—Polarisation and hysteresis in dielectric media, by W. Schaufelberger. The loss of energy by hysteresis in a paraffin ellipsoid oscillating in an electrostatic field is proportional to the square of the electric force. Ebonite is, in comparison, a very imperfect dielectric.—Proportionality of emission and absorption, by W. Voigt. The author attempts to provide a theoretical foundation for Kirchhoff's law. He is obliged to assume the coexistence of irregular and heterogeneous waves, since regular wave-trains would not obey the law.—Canal rays, by A. Wehnelt. A mica cross introduced into the dark kathode space casts a shadow upon the kathode itself, thus proving that rays proceed from the anode to the kathode. Further, it is extremely probable that no kathode rays are given out except where anode rays impinge upon the kathode. When they penetrate the kathode, we have Goldstein's "canal rays."—A new method of detecting electric waves, by A. Neugschwender. A slit is cut in the silver surface of a mirror, and the latter is placed in circuit with a cell and galvanometer. No current is indicated until the mirror is breathed upon. But the deflection that is then shown is immediately annulled by the impact of electric waves upon the mirror. Conductivity is restored when the waves cease, provided there is a source of moisture, say a wet sponge, near the galvanometer.—Isolation of long heat rays by quartz prisms, by H. Rubens and E. Aschkinass. The extremely long heat rays obtained by successive reflections at surfaces of rocksalt and sylvine are transmitted by quartz, and their refractive index is thus easily determined. It is extremely high, being 2·19 for waves 56 μ long.—Continuity of the electric discharge in rarefied air, by Mr. Cantor. The author employs the coherer to test the continuity of the vacuum discharge under conditions where Hertz pronounced them to be absolutely continuous. In every case waves were given out by the tubes. But it is still possible that part of the discharge may have been continuous.

SOCIETIES AND ACADEMIES.

London.

Entomological Society, April 5.—Mr. G. H. Verrall, President, in the chair.—Mr. Blandford exhibited insects of different orders collected by Dr. Albert L. Bennett in West Africa, and read some notes by Dr. Bennett on the habits of the Goliath beetles.—Mr. McLachlan exhibited young larvæ of a "locust," received from Mr. E. A. Floyer, Director-General of Telegraphy in Egypt, and said by him to have caused the *Calotropis* trees in Nubia to be in a moribund condition. The larvæ were identified by Mr. Burr as those of a species of *Poecilocerus*, probably *P. vittatus*, Klug.—Mr. Blandford gave an account of a paper by Dr. A. Ribaga, published in the "Rivista di Patologia Vegetale," v. p. 343, on an asymmetrical structure occurring in the adult female of the common bed-bug, and apparently hitherto overlooked, although it communicated with the exterior by a conspicuous notch in the fourth abdominal segment, midway between the median line and the lateral margin. This structure consisted of a large quasi-glandular mass of unknown nature in which was encapsuled an organ consisting of fibres, the free ends of which terminated in minute chitinous spines in a recess lying under the fourth abdominal segment. The adjacent margin of the fifth segment was thickened and set with strong teeth. The non-glandular part of this singular structure was conjectured by its discoverer to be a stridulating organ; but no evidence of stridulation had been obtained. It was certainly far more complex than most, if not all, other stridulating organs known to exist in insects.—Mr. G. J. Arrow communicated "Notes on the Rutelid genera *Anomala*, *Mimela*, *Popillia*, and *Strigoderma*."

Mathematical Society, April 13.—Lieut.-Colonel Cunningham, R.E., Vice-President, in the chair.—The chairman briefly referred to the loss the Society had sustained by the recent death of its foreign member, Prof. Sophus Lie.—Mr. A. B. Kempe, F.R.S., having taken the chair, Lieut.-Colonel Cunningham read a paper on conformal division. Major MacMahon, F.R.S., Messrs. Lawrence, Western, and the chairman joined in a discussion on the paper.—The following papers were communicated in abstract. On the characteristic invariants of an asymmetric optical system, Mr. T. J. Bromwich. The reduced path from one point to another is expressed in terms of the directions of the ray at those points. It is now found possible to put down eight invariants by inspection (only six are independent). These are expressed in terms of those given by Prof. Sampson (*Proceedings*, vol. xxix.). The remainder of the note consists in bringing the reduced path to two canonical forms and some geometrical interpretations.—Concerning the four known simple linear groups of order 25920, with an introduction to the hyper-Abelian linear groups, Dr. L. E. Dickson. (1) On the direct determination of stress in an elastic solid with application to the theory of plates; (2) on the stress in a rotating lamina; (3) the uniform torsion and flexure of incomplete tores with application to helical springs, Prof. J. H. Michell.—The theorem of residuation, Noether's theorem, and the Riemann-Roch theorem, Dr. F. S. Macaulay.—Impromptu communications were made by Messrs. Hargreaves, Heppel, Roseveare, Western, and the chairman. This last drew attention to the following curious properties of the number 7, viz.:—

$$18^3 \equiv +1, \quad 19^3 \equiv -1 \pmod{7^2 \text{ and } 7^3}$$
$$1353^3 \equiv +1, \quad 1354^3 \equiv -1 \pmod{7^4 \text{ and } 7^5}$$
$$82681^3 \equiv +1, \quad 82682^3 \equiv -1 \pmod{7^6 \text{ and } 7^7}$$

but these properties do not extend to 7^8 and 7^9.

EDINBURGH.

Royal Society, April 3.—Prof. Duns in the chair.—Dr. R. Kennedy read a paper on the restoration of coordinated movements after nerve section, of which the following are some of the main results. The peripheral segment of the divided sciatic nerve was rotated to the extent of a semicircle before reunion to the central segment by means of suture. As a result of this, the nerve fibres of the central segment were brought into apposition with non-corresponding peripheral segments, and the nerve thus placed in the best conditions for the formation of new paths for the nervous impulses. Restoration of coordinated movements commenced on the seventh day after the operation, and was complete from the fourteenth to the twenty-first day. Despite this early restoration of function, the peripheral segment showed the presence of Wallerian degeneration and of complete regeneration of young nerve fibres, showing that early restoration of function was not due to healing by so-called first intention, but, instead, to regeneration of the peripheral segment. In one case in which the two segments of the divided sciatic were united accurately in the old relationship, an exactly parallel course as regards the time taken for restoration of function was exhibited.—A paper was also communicated by Mr. Bellyse Baildon, at present lecturer in English in the University of Vienna, on the rimes in the authentic poems of William Dunbar.

PARIS.

Academy of Sciences, April 10.—M. van Tieghem in the chair.—On the interpretation of a limited number of observations, by M. Hatt. The author discusses the method of dealing with a measurement which deviates considerably from the others when the total number of observations is small, recently proposed by M. Vallier, and shows by means of a particular case that the treatment suggested is not always trustworthy.—On the applications of aluminium, by M. Henri Moissan. A criticism of the recent work of M. Ditte on this subject. M. Moissan points out that the aluminium used by M. Ditte in his researches was not rigorously analysed, and that he attached no importance to the small impurities of the metal, although these latter may well have had a considerable influence upon the results. Aluminium is now produced in a much purer state than was the case five years ago, a series of seven analyses, made in 1893, giving a mean percentage of 93·4, as against 97·8 per cent. for aluminium made four years later. The fact that the aluminium water vessels used in Madagascar were mounted in contact with iron, may also have influenced the rapidity of corrosion by the electrolytic action which would be set up at the expense of the aluminium.—The production of electromotive forces by the displacement of masses of liquid of different conductivities submitted to the magnetic action, by M. R. Blondlot. If a vessel containing two layers of zinc sulphate of different concentrations, into each of which is plunged an electrode of amalgamated zinc, is placed in a strong magnetic field, when the liquids are mixed, differences of electromotive force can be observed between the two electrodes by means of a capillary electrometer. The theory of the results is fully discussed.—The favourable action exercised by the pancreas on alcoholic fermentation, by MM. R. Lépine and Martz.—Application of the *criterium of Tisserand* to the small planets, by M. Jean Mascart.—On a differential linear equation, by M. A. Liapounoff. A discussion of the equation

$$\frac{d^2y}{dx^2} + \mu p(x)y = 0,$$

where $p(x)$ is a given continuous function of a real variable x, having a period ω, and μ an arbitrary parameter.—A new interpretation of the condition necessary for a double integral, taken over a surface, to be independent of the boundary of the surface, by M. Ch. Méray.—On the homography of the theory of beams, by M. Andrade.—On surfaces of plain or spherical lines of curvature, by M. Émile Waelsch.—Three formulæ of great generality relating to curves in space, by M. N. I. Hatzidakis.—On the effect of an increase or decrease of pressure upon the electrolytic interrupter, by M. A. Le Roy. Both a decrease and an increase of the atmospheric pressure interferes with the working of the Wehnelt interrupter.—Some working conditions of the Wehnelt electrolytic interrupter, by M. Paul Bary.—On the variation of the electrical resistance of metals and their alloys, due to torsion, by M. Coloman de Szily. To eliminate the effects of temperature, the alloy constantin was chosen, the coefficient of increase of resistance with temperature of which is extremely small, and the work carried out in a room the temperature of which did not vary 0°·1 C. during the experiments. The resistance was found to increase with the angle of torsion; up to the elastic limit of the material these two quantities were proportional, but for higher angles of torsion the resistance increased more rapidly than this.—Points correlative to the points of Bravais, by M. Pierre Lefebvre.—On a new method of preparing the silicide of iron, FeSi, by M. P. Lebeau. A mixture of iron filings and silicide of copper, the latter being in excess, is heated in the electric furnace. The resulting ingot consists of a mass of crystals of iron silicide, cemented together by silicide of copper, the latter being readily removed by dilute nitric acid.—The preparation and properties of a crystallised sub-phosphate of copper, by M. Georges Maronneau. Copper phosphate and carbon heated together in suitable proportions in the electric furnace, give a crystallised compound of copper and phosphorus of the composition Cu_2P.—On the thermal properties of lime prepared at different temperatures, by M. Henri Gautier. Limes prepared at different temperatures show remarkable differences in the rate of hydration when placed in water, lime fused in the electric furnace being so slowly acted upon that it is possible to accurately determine its density in water. It was thought that these differences might be due to differences in the molecular state of the lime, which would correspond to variations in the heats of solution. This, however, was not borne out by the experiments, samples of lime prepared at 1000°, 1200°, 2000°, and the temperature of the electric furnace all giving the same results in the calorimeter.—Actino-photometer based upon the luminosity of phosphorescent zinc sulphide and the intensity or nature of the exciting sources of light, by M. Charles Henry.—On dextrine considered as a reserve material, by M. Leclerc du Sablon.—On some new anatomical peculiarities in the fatty grains (cotyledons and endosperm), by M. Edouard Heckel.—On an extraordinary halo observed at Paris, April 5, 1899, by M. Joseph Jaubert.

DIARY OF SOCIETIES.

THURSDAY, APRIL 20.

ROYAL SOCIETY, at 4.30.—The Physiological Action of Choline and Neurine: Dr. Mott, F.R.S., and Dr. Halliburton, F.R.S.—Intestinal Absorption, especially on the Absorption of Serum, Peptone, and Glucose: Prof. R. Waymouth Reid, F.R.S.—Studies on the Morphology of Spore-producing Members. No. 4. The Leptosporangiate: Prof. F. O. Bower, F.R.S.—Note on the Fertility of Different Breeds of Sheep, with Remarks on the Prevalence of Abortion and Barrenness therein: W. Heape.—Some further Remarks on Red-water or Texas Fever: A. Edington.
ROYAL INSTITUTION, at 3.—The Atmosphere: Prof. J. Dewar, F.R.S.
LINNEAN SOCIETY, at 8.—The Botany of the Ceylon Patanas: H. W. H. Pearson.—Imitation as a Source of Anomalies: Prof. R. J. Anderson.—List of British and Irish Spiders.—Rev. O. Pickard Cambridge, F.R.S.
CHEMICAL SOCIETY, at 8.—Some Dipyridyl Derivatives from Citrazinic Acid: W. J. Sell and H. Jackson.—On the Interaction of Mercurous and Mercuric Nitrites, with the Nitrites of Silver and Sodium: P. C. Ray.—The Synthesis and Preparation of Terebic and Terpenylic Acids: W. Trevor Lawrence.—The Allotropic Modifications of Phosphorus: D. L. Chapman.—β-Isopropyl Glutaric Acid: F. H. Howles and J. F. Thorpe.—Ethyl Ammoniumsulphite: Edward Divers and Masataka Ogawa.—Ethyl Ammonium Selenite and Non-existence of Amidoselenites (Selenosamates): Edward Divers and Seihachi Hada.
INSTITUTION OF CIVIL ENGINEERS, at 8.—"James Forrest" Lecture: Magnetism: Prof. J. A. Ewing, F.R.S.

FRIDAY, APRIL 21.

ROYAL INSTITUTION, at 9.—Structure of the Brain in Relation to its Functions: Frederick Walker Mott, F.R.S.
PHYSICAL SOCIETY, at 5.—On the Effect of a Solid Conducting Sphere in a Variable Magnetic Field on the Magnetic Induction at a Point Outside: C. S. Whitehead.—Demonstration of Richards's Method of Standardising Thermometers: Dr. R. A. Lehfeldt.
EPIDEMIOLOGICAL SOCIETY, at 8.30.—The Relations of Bacteriology to Epidemiology: Dr. F. R. Blaxall.

SATURDAY, APRIL 22.

GEOLOGISTS' ASSOCIATION.—Excursion to Staines. Director: W. Whitaker, F.R.S. Leave Waterloo at 1.57 p.m.; arrive Staines Junction 2.36 p.m.

MONDAY, APRIL 24.

SOCIETY OF ARTS, at 8.—Leather Manufacture: Prof. Henry R. Procter.
ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Journeys on the Nyasa-Tanganyika Plateau: Captain F. R. F. Boileau, R E., and L. A. Wallace.
SOCIETY OF CHEMICAL INDUSTRY, at 8.30.—The Relations of the Society to Chemical Engineering and to Industrial Research: George Beilby.
INSTITUTE OF ACTUARIES, at 5.30.—On the Requirements of the Life Assurance Companies Act, 1870, in regard to Valuation Returns, with some Notes on the Classification and Valuation of Special Policies: Ralph Todhunter.

TUESDAY, APRIL 25.

ROYAL INSTITUTION, at 3.—Zebras and Zebra Hybrids: Prof. J. Cossar Ewart, F.R.S.
ANTHROPOLOGICAL INSTITUTE, at 8.30.—Ju Ju Laws and Customs of the Niger Delta: Le Comte C. de Cardi. Illustrated by Lantern Slides and a variety of objects from West Africa.—Exhibition of Lantern Slides of Views in the Colony of Sierra Leone and the Protectorate, with Short Descriptive Account: T. J. Alldridge.
INSTITUTION OF CIVIL ENGINEERS, at 8.—Annual General Meeting of Corporate Members.
ROYAL PHOTOGRAPHIC SOCIETY, at 8.—A Demonstration of the Making of Glass Diaphragms: Thomas Bolas.

WEDNESDAY, APRIL 26.

SOCIETY OF ARTS, at 8.—Coal Supplies: T. Forster Brown.
GEOLOGICAL SOCIETY, at 8.—On Limestone-Knolls in the Craven District of Yorkshire and elsewhere: J. E. Marr, F.R.S.—The Limestone-Knolls below Thorpe Fell, between Skipton and Grassington in Craven: J. R. Dakyns.—On Three Species of Lamellibranchs from the Carboniferous Rocks of Great Britain: Dr. Wheelton Hind.

THURSDAY, APRIL 27.

ROYAL SOCIETY, at 4.30.
ROYAL INSTITUTION, at 3.—The Atmosphere: Prof. J. Dewar, F.R.S.
INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Experiments on Alternate Current Arcs by Aid of Oscillographs: W. Duddell and E. W. Marchant. (Conclusion of Discussion.)—Capacity Measurements of Long Submarine Cables: J. Elton Young.
INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—Address by the President, Sir William H. White, K.C.B., F.R.S.

FRIDAY, APRIL 28.

ROYAL INSTITUTION, at 9.—Some Features of the Electric Induction Motor: Prof C. A. Carus Wilson.
INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—Evaporative Condensers: Harry G. V. Oldham.

BOOKS and SERIALS RECEIVED.

BOOKS.—Elementary Physics and Chemistry, First Stage: R. A. Gregory and R. T. Simmons (Macmillan).—Th. Ipané: C. Graham (Unwin).—La Bicyclette, sa Construction et sa Forme: Dr. C. Bourlet (Paris, Gauthier-Villars).—Die Vegetation der Erde, iii.: Dr. G. Radde (Leipzig, Engelmann).—The Hunterian Oration delivered on February 14, 1899; Sir W. MacCormac (Smith, Elder).—Inwood's Tables of Interest and Mortality for the Purchasing of Estates, &c., 25th edition, revised, &c., by W. Schooling (Lockwood).—Lehrbuch der Algebra: Prof. H. Weber, Zweite Auflage, Zweiter Band (Braunschweig, Vieweg).—Geschichte der Physikalischen Experimentierkunst: Profs. Gerland and Traumüller (Leipzig, Engelmann).—The Natural Waters of Harrogate: Dr. F. W. Smith (Dawbarn).

SERIALS.—Zeitschrift für Physikalische Chemie, xxviii. Band, 3 Heft (Leipzig).—National Geographic Magazine, April (Washington).—The Atoll of Funafuti, Part 7 (Sydney).—Monthly Weather Review, December, 1898, and Annual Summary for 1898 (Washington).—Knowledge, April (High Holborn).—The Photo-Miniature, April (Dawbarn).—Transactions of the Astronomical and Physical Society of Toronto for the Year 1898 (Toronto).—American Journal of Science, April (New Haven).—Popular Astronomy, April (Northfield).—Atlantic Monthly, April (Gay).—Morphologisches Jahrbuch, 27 Band, 1 Heft (Leipzig).—Agricultural Gazette of New South Wales, February (Sydney).—Mémoires de la Société de Physique, &c., de Genève, Tome xxxiii. Part 1 (Genève).

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