THURSDAY, DECEMBER 29, 1892.

GORE'S "VISIBLE UNIVERSE."

The Visible Universe. By J. Ellard Gore, F.R.A.S. (London: Crosby Lockwood and Son, 1893.)

THE object of this book is "not to propound any new hypothesis, but simply to explain and discuss theories which have been supported by well-known astronomers and other men of science" as to the "evolution of the Solar System," and to give a popular account of the "construction of the Universe *as we see it*, and its probable development from pre-existent matter."

Mr. Gore has already acquired considerable success as a popular writer on astronomical subjects, and the scheme of the present volume is, as we might expect, a very good one. The first three chapters are devoted to a popular account of the hypotheses of Kant and Laplace, the principal objections that have been urged against them, and the modifications and additions suggested by recent research. In subsequent chapters such subjects as the fuel of the sun, the luminiferous ether, the constitution of matter, celestial chemistry, and the meteoritic hypothesis are dealt with. Mr. Gore then reaches the purely descriptive portion of his subject, and gives excellent chapters on the Milky Way, and on "the latest results respecting the distribution of stars and nebulæ and their relative motions." Various theories of the construction of the Universe are then discussed, and in a final chapter the idea of infinite space and a finite universe is developed.

Although the general scheme of the book is excellent, the execution falls in many places far short of its promise and our expectations. When Mr. Gore confines himself to the historical and descriptive his work is, on the whole, well done, but in discussing theories he has in several cases obviously ventured out of his depth, and has consequently spoiled what would otherwise have been a valuable addition to popular astronomical literature.

For his chapters on the Nebular Hypothesis and Faye's theory of the formation of the solar system Mr. Gore has largely availed himself of M. Wolf's "Les Hypothèses Cosmogoniques." He has also introduced extensive quotations from "the late Mr. Jacob Ennis," but in considering Ennis as an authority, Mr. Gore is probably alone. Mr. Ennis was, on his own admission, not a mathematician, and certainly did not by "his own discoveries," place the nebular hypothesis on a firm mathematical basis. He proved Mars could not have satellites; that the heat of the sun was entirely due to chemical combination; that Sirius has twelve planetary attendants; and made several other equally important discoveries. *His* mathematical demonstration of the truth of the nebular hypothesis is about as sound as the well-known proofs that the earth's surface is flat. Mr. Gore would have done well to have omitted the quotations from Ennis, and to have filled the space with a fuller account of the recent mathematical investigations of the nebular hypothesis, especially those of Prof. G. H. Darwin.

Quoting freely from Young and Sir William Thomson, Mr. Gore is fairly safe in his chapter on the fuel of the sun, but he is in error in stating that "the meteoric theory of the sun's heat must be abandoned." It is true that the larger portion of the solar heat is believed to be due to shrinkage, but it is generally conceded that a considerable fraction has its origin in falls of meteoric matter into the sun. A glaring case of the misuse of a scientific term occurs in this chapter (p. 52), where Mr. Gore is responsible for the statement that "the theory generally held by astronomers ascribes the heat of the sun to shrinkage of its *mass* caused by gravitation." Mr. Gore surely meant volume.

The chapter on celestial chemistry is meagre and unsatisfactory. It seems incredible that the application of photography to spectroscopic work is not even mentioned, and that no allusion is made to the Draper catalogue of photographic stellar spectra, to Rowland's photographic map of the solar spectrum, or to any of the recent photographic work. Mr. Gore is also in error in this chapter when he states (p. 79) that although the great nebula in Andromeda "has never been resolved into stars the evidence of the spectroscope shows it is not gaseous." Bright bands have been seen in the spectrum by Backhouse Fowler, and myself, and these have been identified as probably due to carbon radiation.

The Meteoritic Hypothesis is dealt with in considerable detail, and here Mr. Gore is most seriously in error. He gives what is professedly "a review of the principal facts and arguments advanced by Lockyer," and carefully enumerates all the objections that have been urged by "his opponents," ending the account with the opinion that "on the whole, therefore, we seem bound to conclude that the weight of evidence is against the truth of the Meteoritic Hypothesis." The chapter bears internal evidence that Mr. Gore began his consideration of this hypothesis with the opinion which he enunciates as his final judgment, already formed.

The summary of Prof. Lockyer's book has not been made with the care that should have been bestowed upon it. There are at least two misquotations; on p. 91, the substitution of "periastron" for "perihelion" makes nonsense of what is otherwise an important paragraph, and on p. 113 the omission of the word "other" considerably modifies the meaning of the passage quoted.

There are several errors due to hasty compilation, observations and theories being attributed to Prof. Lockyer in cases where he only quotes the observations and adopts the theories. On p. 92 Mr Gore says "he (Lockyer) also finds line absorption in Comet Wells and the great September comet of 1882." This is misleading, the observations of absorption having been made by Copeland, Maunder, and Vogel. On p. 93 we find the "theory that the light of comets is due to collisions between the component meteorites" attributed to Prof. Lockyer. The theory is due to Reichenbach, Tait, and Sir William Thomson; Prof. Lockyer's contribution being the demonstration that spectroscopic observations lead to and support the hypothesis. The results of Tait's calculations given on pp. 227–229 of the "Meteoritic Hypothesis" are also attributed to Lockyer on p. 93 of Mr. Gore's book. On p. 95 we read, "the spectra of the true nebulæ consist of a very faint continuous spectrum crossed by one, two, three, or four bright lines" Lockyer gives seventeen bright lines in his table. Mr. Gore's footnote that "the complete hydrogen series of lines were photographed by Dr. Huggins in 1890," in the great nebula in Orion is also a mistake.

Mr. Gore has evidently failed to appreciate the importance of several portions of Prof. Lockyer's book, and has consequently omitted to mention them in his summary. Thus the observations of meteoritic glows recorded on pp. 49-51 of the "Meteoritic Hypothesis" are entirely passed over. In these experiments it was found that on slowly warming meteorites in a vacuum tube through which electric discharges were passing, the spectrum of hydrogen was first developed, then carbon was added, and the first line due to any metal was the 500 line which is the characteristic nebular line. Further heating gave the 495 line and then the B magnesium lines. These experiments, omitted in Mr. Gore's summary, are an effective answer to the objections of Messrs. Liveing and Dewar given on p. 116 of this book, for we have here the 500 line developed in presence of hydrogen, and at a lower temperature than the B lines.

Mr. Gore believes that "one of the crucial tests of the meteoritic hypothesis" is the question of the identity of the 500 nebular line with the magnesium fluting at this wave-length. He says (p. 86) that "it is on the identity of this fluting (or rather its brightest edge) with the chief line in the spectrum of the nebulæ that the meteoritic hypothesis mainly depends," and from pp. 118-121 it is obvious that he thinks the evidence conclusively against the hypothesis on this point.

In the first case the identity of the 500 nebular line with magnesium is not essential to the meteoritic hypothesis, although the latest observations have strongly supported the case for the identity. The main point is whether the 500 nebular line is due to high or to low temperature, and whether nebulæ are high or low temperature phenomena. Previous to the publication of Prof. Lockyer's book all cosmical bodies were believed to be cooling. The nebulæ were considered to be the hottest of all bodies, and on losing heat were supposed to pass into stars of the Sirian type. Further loss of heat converted them into stars of the solar type, and by still further loss they became red stars with banded spectra before reaching final extinction. This hypothesis was supplemented by Dr. Croll, who suggested that nebulæ were formed by the complete and almost instantaneous volatilisation of these dark bodies on collision, the heat generated by impact being sufficient for the purpose. Lockyer's hypothesis supposes nebulæ to be loose swarms of colliding meteorites. Condensation of these swarms by gravitation increases the number of collisions, and as the temperature rises we get *stars* with bright lines in their spectra. Further increase of temperature gives red stars of Secchi's III. class, which pass with still rising temperature into stars with fine absorption lines in their spectra, and so on until the Sirian type is reached, in which we have the highest temperature. Collisions have now ceased and the process of cooling begins, the stars passing into the solar type, then into red stars of Secchi's IV. class, and to final extinction.

The lines in the spectra of nebulæ and bright line stars according to this theory may be due to three causes. (*a*) Radiating vapours filling the interspaces between the meteorites; the lines of hydrogen and the bands of carbon being due to these. (*b*) *Low temperature* lines of metals, due to grazing collisions of meteorites. (*c*) High temperature lines of metals, due to direct collisions. It is essential to the theory that low temperature lines o metals should be found in nebulæ spectra, and the low temperature origin of the 500 line seems clearly established. Its chemical origin is of quite secondary importance. That it is due to low temperature is shown by the experiments on meteoritic glows which Mr. Gore omits; by its presence in comets away from the sun, as observed by Huggins in 1866 and 1867 (this being the only line present), by Vogel in Coggia's comet, and Konkoly in the great September comet of 1882; and also by the fact that it persists in all temporary stars as the temperature falls and is the last line to disappear. Until these facts are explained away the foundation of the meteoritic hypothesis remains unshaken. Mr. Gore seems unaware that this main point is now generally admitted, for although the low temperature origin of nebulæ was denied by Dr. Huggins as late as 1889, it was adopted in his Address to the British Association at Cardiff in 1892.

There is early evidence in the book that Mr. Gore has entirely failed to grasp this essential point of the hypothesis. On p. 41, discussing Croll's impact theory of the formation of nebulæ, he says, "according to Prof. Lockyer the temperature of the original solar nebula was as high as that of the sun at present." Mr. Gore would have done well to have noted that on p. 528 of his book Prof. Lockyer explicitly states that "the temperature of the most prominent radiating vapours in nebulæ is about that of the Bunsen burner."

Mr. Gore's misconception of the theory and the spirit in which he approached its discussion are also shown on p. 101, where he says, "All these conclusions rest, of course, on the supposed coincidence of certain lines in the spectra of comets, nebulæ, and stars, with bright lines and flutings, a coincidence which has been disputed by other observers. Relying, however, on the accuracy of his experiments, Lockyer proposes a new grouping of cosmical bodies. He supposes some of these bodies to be increasing in temperature, while others—like our own sun—are cooling." To this he adds a footnote, "Lockyer's curve rests on this assumption, but it should be stated that some astronomers doubt that the sun is really cooling." We should be glad to know who these "astronomers" are. Mr. Gore himself is evidently not of their number, for he distinctly recognizes the sun as a cooling body in his chapter on the fuel of the sun, and specially mentions it as such on pp. 42 and 53. It is possible that Mr. Gore has misunderstood the apparently paradoxical fact that a body, in changing from a gas to a liquid, may rise in temperature while losing heat, but that will not justify the loose style which leaves it to be understood by the general reader that Lockyer's curve rests solely on his experiments, and the "assumption" that the sun is cooling, and that this fact is doubted by some astronomers. We are quite aware that Mr. Gore's expression will bear other interpretations, but this is the idea conveyed to several readers to whom we have shown the book.

Returning to the question of the coincidence of the 500 nebular line with magnesium, the evidence recorded by Mr. Gore is in favour of, rather than against, the identity.

His facts are:—Huggins finds the wave-length in the Orion nebula as 5004·75, the magnesium fluting being 5006·5, a difference of 1·75. At the same time, Huggins finds very little, if any, sensible motion in the line of sight. Mr. Keeler finds as a mean from 10 nebulæ 5005·68, magnesium being, according to his measurement, 5006·36, a difference of ·68. These latter observations completely invalidate Huggins's evidence on this point, especially as Mr. Keeler recognizes a motion of recession for the Orion nebula of 10·7 miles per second.

Mr. Gore ought to have recorded the fact that in Keeler's observations the comparisons for different nebulæ gave the magnesium sometimes more refrangible and sometimes less refrangible than the nebular line. Later observations of Keeler, "corrected for the earth's orbital motion and the sun's motion," give the nebular line a wave-length of 5005·93, *i.e.* only ·43 from the magnesium. Assuming Keeler's latest results as perfectly correct, and placing his position at Charing Cross, while representing the position found for this line by Dr. Huggins in 1868 at St. Paul's Cathedral, we find Dr. Huggins's limiting positions in 1889 as the extreme east and extreme west ends of Green Park, his 1890 position in the middle of Green Park, while the magnesium fluting will be at Cecil Street. When we consider that a motion in the line of sight of less than twenty miles per second will make the nebular line and the magnesium fluting absolutely coincident, that the rate of the sun's motion in space is estimated but not absolutely known, that these measurements are probably the most difficult of all astronomical observations, and that every increase of power and accuracy has brought the lines closer together, we are certainly *not* justified in stating that the "weight of evidence" is "against the truth of the hypothesis." The differences in recorded wave-lengths of well-known solar lines by experienced observers are in many cases greater than the difference in question here.

Mr. Gore regards the dispersion used by Prof. Lockyer as insufficient, and yet he records that sixteen prisms were used by Lockyer in some of his observations of the coincidence of the nebular line with magnesium, so that his dispersion was actually greater than that used by Dr. Huggins, and two-thirds that of Mr. Keeler, whose dispersion equalled twenty-four prisms.

The objections to that portion of the meteoritic hypothesis which deals with the meteoritic origin of the lines in the auroral spectrum do not in any way affect the main hypothesis. That this subject is unimportant is distinctly recognized by Prof. Lockyer, "Meteoritic Hypothesis," p. 97, where he claims that "certainly the coincidence is such as to justify us in regarding meteoritic dust as the origin of the spectrum *until a better and more probable origin is demonstrated.*"

We are told (p. 122) that Mr. Monck objects to Lockyer's hypothesis, because it contains no explanation of "why all the planets and asteroids and the great majority of the satellites revolve in the same direction, why the orbits of the larger bodies of the system deviate so little from the circle and why they are so nearly in the same plane." This was asked in 1890; and yet Prof. G. H. Darwin had in 1888 shown that a swarm of meteorites which, on the meteoritic hypothesis would form a nebula, may be considered as a gas, and therefore any answer that the nebular hypothesis can give to these questions will also apply to the meteoritic hypothesis.

Such puerile suggestions as that the meteorites used by Prof. Lockyer "*may have been*" of terrestrial origin: "that meteor clouds dense enough to produce the requisite amount of light by their collisions would also be dense enough to intercept *a great part of it* again on its way to the earth" (the italics are ours); and objections based on Mr. Monck's interpretation of Prof. Newton's calculations, and on opinions to which Mr. Monck "*inclines*" as to the origin of certain comets, are evidence that Mr. Gore has not hesitated to avail himself of anything that in any way seems to disagree with the meteoritic hypothesis. The whole of the "objections" of the "opponents" of Prof. Lockyer recorded by Mr. Gore are on matters of secondary importance, and have been insisted upon by him owing to his complete misconception of the theory. As a guide to the meteoritic hypothesis his chapter is misleading, and utterly valueless either as exposition or as criticism.

After his account of the meteoritic hypothesis Mr. Gore abruptly turns to a comparison of the various drawings that have been made of the Milky Way, and gives an interesting and valuable summary of the present state of our knowledge as to star distribution and movement and the construction of the Universe. For this portion of the book we have nothing but praise. It is carefully written and copiously illustrated. Mr. Gore has evidently taken the word "visible" in its widest possible sense, for he includes not only things visible to the retina of the eye, but those visible to the retina of the camera; and six excellent reproductions of photographs of nebulæ and stars clearly demonstrate the superiority of the latter for astronomical purposes. It is probable that the use of photography in the preparation of complete charts of the Milky Way will throw much new light upon many of the points discussed in this portion of the book, and may profoundly modify many of the views at present held; but in presenting a clear and concise account of the present state of our knowledge Mr. Gore has made a valuable addition to the literature of the subject. An appendix, in which are given various calculations and tables involved in the discussion of several points raised in the book, and a useful index, complete the volume.

A. TAYLOR.

THE IRON MANUFACTURE IN AMERICA.

On the American Iron Trade and its Progress during Sixteen Years. By Sir Lowthian Bell, F.R.S. (Edinburgh and London: Ballantyne, Hanson, and Co.)

IT is impossible, in the limited space at our disposal, adequately to review this remarkable book, in which no branch of a very comprehensive subject appears to have escaped the author's close attention.

So full of detail and so exhaustive of the subject-matter are the various sections into which the work is divided, that we can do little more than glance at the numerous subdivisions.

The first section, dealing with international trade, discusses at length the American policy of protection. Comparison is made of American exports as affected by British free trade. Then follows a series of short articles on various subjects—the Anglo-American, imports of tinplates from this country, imports and exports of both countries, America as consumer and as exporter, and other important matters. By way of illustration copious tables are adduced with the author's deductions therefrom, and these will well reward the closest attention.

Section 2 deals with the relative cost of the necessaries of life in various mining and metallurgical localities :—

"In the United States the manufacturers are enriched at the expense of the agriculturist and of other consumers. Some time before the abolition of protective duties in the United Kingdom years of scanty harvests entailed a great amount of misery among the labouring population of these islands, and at all times the landed interest by the protection granted to it by law, imposed a burthen upon industry generally. This relation between land and industry is now, as we have seen, reversed in the United States, by which, according to our views, the manufacturers are enriched at the expense of the agriculturists and of other consumers.

"Circumstances have greatly changed since the repeal of the corn laws, and the general introduction of free trade in the British Isles, for we have a people, the largest food importers in the world, obtaining their supplies 3000 miles from where they are grown, frequently at prices as favourable as those charged in the cities of America itself."

Sir Lowthian Bell appears to grasp fully a difficult situation, and gives a fair summary of the relative economic position of the two countries, and though his views will hardly be endorsed in their entirety by Americans, the present statement of them cannot fail to strengthen the movement now in progress towards a modification of the existing fiscal policy.

It is somewhat out of our province here to comment upon the protective policy so ardently advocated in America, but we are of opinion that had iron manufacturers in the States adopted, even partially, our policy of free competition, they and their *employés* would now have been in a stronger position, and would have had a better prospect of successfully competing with us. It is possible that the very natural desire to foster the home industry has carried them a little too far.

In the next section the assemblage of materials on American is compared with that on British railways in an exhaustive manner.

Section 5 treats of the iron ores of the States, and is fully illustrated with maps, topographic and geological, together with the coal fields. The quantities raised at different periods are given, and show that in ten years the production of ore has been fully doubled. This is followed by a detailed account of the mines and costs of working. Pages 96-104 contain some interesting speculative matter on the genesis of iron ores; the cost of raising ore, together with chemical analyses, is compared with that of Great Britain and other countries. The importance of having iron free from phosphorus is shown. It is noted that iron ore suitable for the Bessemer acid process has been imported. In 1880 only 27·35 per cent. of native ore was deemed suitable and raised for this purpose.

Treating of raw material in the States, the writer gives a vivid picture of the boundless wealth of both ore and fuel existing within a limited area. In the great Lake district there is a wide strip of country over 1000 miles long, where ore is found, and this is insignificant when compared with the immense resources of fuel. The origin of natural gas, petroleum, and its uses receive attention —"natural gas is not a suitable form of fuel for the blast furnace."

Section 9, on the manufacture of coke, is interesting. At the outset coke is defined and compared with its analogues—anthracite or native coke. The losses necessarily entailed in the manufacture of coke are discussed, together with modes of minimizing them. It is shown that it is impossible to utilise the gases evolved in coking or heating coal in the blast furnace, and how slowly this was realized in early practice.

Here the author's ripe experience comes into play. The *rationale* of coking is tersely put, together with the methods dealing with the utilization and recovery of the ammonia, tar, &c., the products of the destructive distillation of coal, "or coking," with special appliances adapted for this purpose. The comparative merits of hard and soft coke in the blast furnace are discussed. Commercial details are appended, which speak for themselves, and which appear accurate.

From the section on the manufacture of pig iron it may be gathered that the gigantic methods of procedure, and the enormous energy diplayed in the business of the American iron manufacture, leave the average cautious Englishman in the rear. There is, however, the reverse side for consideration : it is questionable whether even the magnificent results before us have not been purchased at too great a cost. Enormous quantities of iron have without doubt been turned out, such as would never have been dreamt of here ; but it would seem that authorities are not yet in agreement as to the relative merit of English and American practice. So far our American cousins appear satisfied, pointing triumphantly to the saving of both time and material accruing from their present practice. At the Edgar Thompson Works (page 170) one of the furnaces ran 2462 tons of iron in one week, and showed an average make of 2813 tons per week with an expenditure of only 16·80 cwts. of coke per ton of iron. One needs, however, only to take Sir L. Bell's elaborate demonstration of the laws which govern the consumption of fuel in the blast furnace, and its utilization for the reduction of the ore, to see clearly that the above production is scarcely in the domain of practical work, carried out under ordinary conditions with average ores and fuel. Also (p. 162) he remarks, if Great Britain fails to offer striking examples such as are described by Mr. Potter and Mr. Gayley, yet, all things considered, a more uniform as well as loftier pitch of excellence in British furnace work can be proved.

Our space does not admit of a complete statement of Sir L. Bell's proofs ; shortly, he first tabulates the work done at Middlesbrough with that of the Pittsburg blast furnace, and absolutely demonstrates that the large makes are not altogether due to superior practice. A perusal of the tabular statement given satisfactorily accounts for the larger consumption of fuel in the English furnace.

The poorer ore of Cleveland consumes 3·48 cwt. of coke, as against only 1·42 cwt. in the richer ore used at Pittsburg for the future of the slag.

The quantity of slag determines the fuel required for its consumption, and here is the chief difference in the amount of fuel required, amounting to 2·06 cwts. The Clarence furnace consumed 19·99 cwt. of coke per ton of iron; the Pittsburg furnace consumed 16·80, difference 3·19, and deducting 2·06 from 19·99 cwt. = 17·93, showing an excess of 1·13 against the English furnace. This is practically the only margin we have for economy in the other sources of waste tabulated in Sir L. Bell's comparison of heat distribution.

A positive saving is effected of only 1·13 cwt., and reasons are given showing that, all things considered, this may be counterbalanced by the increased expenses incurred in American practice. As instance pp. 172–174 there are now four furnaces in action at the Clarence works performing duty well after 17½ years' service, as against the hard-driven furnaces in America with lining worn out, and useless in one-sixth of the period.

The limitation is well-defined in the following words, pp. 182–183:—

"As one who has been fifty years at blast furnaces, I am greatly impressed with the pitch of excellence to which the Americans have brought this useful invention.

"While saying so much I have not in my mind the enormous makes.

"In respect to this we must remember that neither in materials nor in labour can we look for any economy in this country.

"On the subject of large makes I must admit that I failed to shake the belief of my friend, Mr. E. C. Patter, that there is a great advantage in tasking the endurance of the furnace to the extent of reducing it to a wreck about every three years.

"I cannot say I am quite a convert to his creed, but recent experience, and the unswerving conviction of my American friends, have raised in my mind the disposition to make a trial of Cleveland ironstone, on what I have thought a questionable mode of action."

The question of heat intensity, or actual temperature, which must vary with the rate at which the fuel or coke is consumed, has not been mooted, and we admit there is no positive reason why it should.

Yet it is evident that a certain fuel—coke, for instance—may be so burnt as only to give a heat intensity barely sufficing for the fusion of lead. On the other hand, it may be so manipulated, *i.e.* rapidly consumed by a quick draught or forced blast "as to attain a heat intensity (temperature) sufficing for the fusion of pig iron."

Working with high pressure blast and driving in a large volume of air (87·15 cwts. Clarence, as against 71·20 cwts. Pittsburg, see p. 172), the heat intensity must be greater in the latter instance, and must, "according to the law of heat exchanges," result in the more rapid economic fusion of iron in the hearth, also intensifying the usual chemical reactions. This seems worth consideration; temperature is an important factor—in saying this it must not be inferred that the estimation of the calorics which a given fuel evolves, and their distribution, must be set aside; on the contrary, they remain the fundamental basis of any study bearing on the economic uses of fuel. Finally, one gathers on the whole that American practice is not universally superior to ours, and competent authorities are as a rule inclined to a compromise. In other words we might graft or partially adapt their practice to ours, so reaping the benefits of both; for something may be urged in favour of either system.

JOHN PARRY.

A COUNTY FAUNA.

The Fauna and Flora of Gloucestershire. By Charles A. Witchell and W. Bishop Strugnell. (Stroud: James, 1892.)

IT would really be almost difficult to discuss this book serious spirit were it not that the publication of so ambitious a work as the Natural History of a County must always be regarded as a serious undertaking. The reader who has struggled through the volume will lay it down with a sigh—not of regret at leaving it, but at the thought that time has been wasted in its compilation.

A glance at the index is almost enough to condemn the book, without making any attempt at further acquaintance. Among nearly a score of errors in spelling, *subuteo*, *oesalon*, *tinninculus*, occur as three consecutive words. Nor is this carelessness by any means confined to the index. Such blemishes disfigure the book from beginning to end; and when, among a host of errors, we find such mistakes as *haliotidæ* and *helliborus*, we can hardly ascribe all the blame to the printer. The compilers usually give us "Cotteswold," but in the introduction the name is spelt "Cotswold," and there are pages on which both forms occur—in one case only a line apart.

A more serious fault is the want of balance in the work. The space allotted to birds occupies eighty-two pages, while the chapter on ants takes up nearly twenty, and that on wasps and bees close upon fifty pages. We may say at once that the two latter are so good, and stand out in such marked contrast to the rest of the work that, in spite of their disproportionate length, we hardly grudge a line of the room they occupy. Perhaps, however, it is the length of these papers which makes one of the writers on mosses omit "many other interesting species," for want of space. Another contributor calls his list of fungi "short and very imperfect." If the list is as complete as it is possible to make it, no one can fairly complain of its shortness; but surely it is scarcely worth while to print an avowedly imperfect list in what professes to be a County Flora.

The fauna opens with a brief account of the bats, a mere list of names, among which we look in vain for any evidence of observation. The notices of the quadrupeds contain some interesting particulars, but they present little that is new. In the article on the badger a good deal of information is given on the authority of a gentleman who appears to think no observations but his own are worthy of credence. One of his own observations is thus worded: "Any one who has caught badgers at night knows only too well that it is certain death to a dog which is good enough to hold it in the open to follow it into an open drain large enough for the dog to reach it." Other people who have hunted badgers have found that an extremely small terrier is quite able to turn a badger from its earth; and that although the dog may be hurt, even seriously, by its formidable antagonist, the contest does not by any means mean "certain death" to it.

The chapter on birds bears evidence of having been put together in the most casual manner. Various contributors have sent in notes as to whether, in their experience, birds were rare or not, and these appear to have been printed without any attempt at summarizing. The result is that the whinchat is described in one line as "common," and in the next as "occasionally seen." The marsh-tit is "rare," and also "generally distributed." The cirl bunting is in one line called "rare" and "by no means rare." The coot is "rare" (!) and "frequently met with." The woodcock, according to one observer, "has been seen." If it were clear that such remarks applied to different parts of the county, there might be some sense in printing them. As they stand, they are useless and bewildering. One contributor is surprised at the occurrence of the gannet just outside the limits of the county, because "they generally inhabit the Bass Rock"! They certainly do, and "there's milestones on the Dover road." But perhaps there is nothing in the whole chapter which quite comes up to what we read about two starlings that one of the contributors watched "fighting furiously . . . each bird . . . trying to force its bill into that of the other. *He was informed that the purpose of each bird was by this means to render the opponent insensible; so as to be more easily destroyed.*"

In the article on reptiles occur these remarkable words:—"The slowworm is habitually 'slow,' but we know of no reptile or quadruped which, in proportion to its size, can move more rapidly."

There are several errors in spelling in the list of land and fresh-water shells, and it is rather misleading to give "Downs, under stones," for the habitat of the species here called *Bacutus*, without adding "near the sea."

Helianthemum polifolium is given as a Gloucestershire plant. It would be interesting to know if this is correct. The localities usually given are in Somerset and Devon.

Among the illustrations are some interesting figures of famous trees; but it seems hardly worth while to have inserted such a very ordinary-looking plate as that of the common crayfish.

Allusion has already been made to two chapters the excellence of which is all the more marked by contrast with the grandiloquent flights and the trivial details of much of this unfortunate volume. Rev. W. F. White's paper on ants contains, as might be expected, accounts of many interesting and original observations. Mr. Vincent Perkins's excellent chapter on wasps and bees, again, is extremely good, though the writer deals only with the neighbourhood of Wotton-under-Edge. That so imperfect, and, as far as much of its contents goes, we are afraid we must say untrustworthy, a book should ever have been published is matter for regret. The real "Fauna and Flora of the County of Gloucester" yet remains to be written.

OUR BOOK SHELF.

The Chemistry of Life and Health. "University Extension Manuals." By C. W. Kimmins, M.A., D.Sc., Staff Lecturer in Chemistry, Cambridge University Extension Scheme. (London: Methuen and Co., 1892.)

THIS little book is well adapted to secure the aim of the author, which is "to give sufficient information on the particular portions of the sciences involved to enable readers . . . . to appreciate fully the fundamental principles of hygiene." There can be no doubt of the importance, one might truly say, the national importance, of the spread of sound knowledge regarding the laws of health. Such sound knowledge cannot be attained except it be built upon a well-laid foundation of chemistry and physiology. To lay the foundation, and rear the structure, in a little book of 160 pages is almost impossible. Dr. Kimmins has, wisely, omitted much; but what he retains is of fundamental importance; his facts are clearly enunciated and systematically arranged. A careful study of this book, especially when it is supplemented, as it is meant to be, by a course of lectures, cannot fail to be most useful. The book is written for ordinary people, not for professional students; the teaching is sound and clear. The first chapter, on the principles of chemistry, is the least satisfactory in the book; but in this chapter the author has attempted, what is surely unattainable, to give an elementary knowledge of the features of chemical action, the use of chemical symbols, and the molecular and atomic theory, in sixteen small pages. As an introduction to the study of the application of chemical facts and principles to the conditions of healthy life, the book is to be thoroughly recommended.

Naked-Eye Botany, with Illustrations and Floral Problems. By F. E. Kitchener, M.A. Pp. 182 and fifty-two woodcuts in the text. (London: Percival and Co., 1892.)

ON turning over the pages of this book one wonders why "Naked-Eye Botany" was chosen for the title, because, although a small book, it has some reference at least to a great many things that cannot be seen with the naked eye. It is something in the way of Prof. D. Oliver's "Lessons in Elementary Botany," but one misses the Professor in it. On p. 7 we are introduced to stomata, and physiological processes are described in some detail. Nevertheless it contains much useful matter, and with a little revision and better selections would make a very good first book. For example, the chickweed is chosen for the first lesson. But the flowers of this plant are so small and the number of parts in the various floral whorls is so variable that it is not a good subject to begin with. The "problems," or questions, also at the end of each chapter are too wide-reaching. Referring to *Aspidium Filix-mas*, we are told that the "production of the fertilized seed, more correctly called oosphere, from the prothallus, can scarcely be made out with the naked eye." Saying nothing about the name given to the fertilized body, we must protest that "scarcely" is not the word to qualify the observation.

Perhaps it is too much to ask that the headmaster of a "high school" should be acquainted with even remotely recent discoveries in physiological botany; but it would not be unreasonable to ask him to use the text-books of specialists. It is now some years since the reproduction of *Lycopodium* was fully described, yet Mr. Kitchener still teaches that the spores are of two sorts.

The Great World's Farm: some account of Nature's Crops and how they are Grown. By Selina Gaye. (London: Seeley, 1893.)

THIS is a delightful book, pleasantly written, full of information, and on the whole remarkably free from those errors, generally the results of misunderstanding, which are the sins that do so easily beset writers on popular science. The volume, which contains some excellent illustrations, deals with "pioneer labourers," "soil-makers," "soil-carriers," "soil-binders," "field-labourers," "guests welcome and unwelcome," "nature's militia," and so forth. We do not propose to tell who or what the labourers, the guests, or the militia are. We advise those of our readers who are interested in the transactions of the Great World's Farm to get the volume and ascertain for themselves.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Measurement of Distances of Binary Stars.

SOME years ago I communicated to a few astronomers a plan for measuring the distance which separates us from some of the binary stars, believing, as I did, that by using the diameters of their paths as a basis, determinations of distance could be made which are impossible with the means at present in use.

This basis could, I hoped, be calculated by first ascertaining the velocities with which the stars are moving in their paths, in a somewhat similar manner to that employed for measuring the motions of stars with the spectroscope, except that instead of making a comparison with a hydrogen flame, the spectra of the two stars should be compared by photographing them together. The width of any double lines, which may show themselves (the one line belonging to the spectrum of the receding star, and the other to the advancing one) would be a measure of their velocities expressed in miles. Applying this information to the known period of revolution of the system, its diameter can also be expressed in miles, and this would enable one to estimate the distance from the earth if the angle between the two stars were known. This suggestion has already borne fruit, the relative velocity of some rapid, but as yet inseparable, binaries having recently been determined.

The answers received to my suggestions were discouraging, but since then instruments have been improved, and I trust that you will think the matter of sufficient importance to be brought before the notice of your numerous astronomical readers. Should any of them be able to make the necessary determination, a foundation-stone will have been laid, not only for obtaining a true idea of perhaps undreamt of stellar distances, but also of the masses of binary stars, and possibly a connection may ultimately be traced between them and the adjoining ones.

The two most brilliant binary stars are α Centauri and α Geminorum, and as in both these cases the paths are elongated ellipses, and the stars near their extremities, efforts should be directed towards determining their distances as suggested above. C. E. STROMEYER.

Strawberry Hill, November 16.

Remarkable Weapons of Defence.

THE following extract from a letter from such a careful observer as Mr. E. E. Green is of such general and special interest as to require publication.

Mr. R. J. Pocock informs me that the Acaroid is almost certainly *Holothyrus coccinella*, Gerv., a species that appears to be common in Mauritius, and that in the lateral membranous area between the carapace and the cephalothoracic limbs is a distinct orifice which was regarded by Dr. Thorell as of respiratory import, but in connection with Mr. Green's interesting discovery of the existence of offensive glands in this animal it is necessary to bear in mind the possibility of its being the outlet of these organs.

The mite has such a hard integument, that being taken into the mouths of the lizards and birds that would probably prey upon it in the situations it frequents, would probably do it little or no damage if it were speedily rejected. G. F. HAMPSON.

THE accompanying insects—apparently Orobatid mites—were found by me in the district of Tallawakelle, Ceylon (alt. 4600 ft.), under stones and rocks in damp, shady situations. It was only by accident that I became aware of their remarkable weapons of defence—an exceedingly pungent secretion.

About five hours after handling one of these insects I accidentally touched my tongue with my finger. Immediately an extraordinarily pungent, galvanic sensation or taste commenced rapidly to spread over my mouth, quickly reaching my throat. Rinsing my mouth and gargling with hot water failed to arrest the progress of the sensation, which was accompanied with excessive salivation. The unpleasantness lasted for several hours, and then died away without any further consequences. I also unconsciously rubbed my face, at the angle of the eye, with the same finger; after which a rather pleasant warmth spread over that part of my face, and was distinctly perceptible the following morning.

I could not for some time trace the cause of this effect. I at first put it down to the agency of a fungus that I had been carrying, but a further experiment negatived this idea. I afterwards tested the insect, and found it to be the real agent. The experiment was repeated at my suggestion, by a medical friend—Dr. R. J. Drummond—who can testify to the result. He described the sensation as somewhat like that produced by the strongest menthol. We both noticed that it had a numbing effect upon the mucous membrane of the mouth.

It is evident that this property must be a very efficient protection to the insect. The rapidity with which the secretion acts would cause it to be very quickly ejected if picked up by either a bird or a lizard—the only enemies that would be likely to attack it. E. ERNEST GREEN.

Eton, Pundulorja, November.

A Suggestion.

As very shortly now NATURE will reach its jubilee volume, I hope you will permit me, as an uninterrupted subscriber for nearly twenty years, to offer a suggestion with regard to that occasion.

As the volumes of NATURE contain original contributions, observations, and notes in all branches of science, more varied and valuable than are to be found in any other scientific periodical publication in existence, there is not a worker, in whatever branch he may be engaged, that does not find it necessary to be continually referring to its pages; but, unfortunately, through lack of a general handy index, he discovers what he wants only after the expenditure of a very great deal of time and worry.

I write, therefore, not only in my own name, but (by request in a private way) in that of a large number of fellow-workers in the subjects in which I am myself specially interested—biology, palæontology, anthropology, geography—to suggest that you should celebrate the jubilee of NATURE by conferring on your readers the immense boon of a classified index to its contents.

During some investigations I was making in 1876-7 I so felt the need of a collected index that I went to the trouble of compiling for myself one, up to that date, classified according to sciences, subdivided again according to the sections of each, which in subsequent work saved me weeks of time and trouble. To my regret, this MS. got lost or destroyed, and there is nothing in connection with NATURE that I, and I am certain every other worker, would now hail with greater satisfaction than the announcement that the means of reaching with expedition and precision the treasures at present so deeply buried in your (nearly) fifty priceless volumes, will be ced within our reach with its jubilee volume. OLD SUBSCRIBER.

Superstitions of the Shuswaps of British Columbia.

REFERRING to the above, as recorded by Dr. George Dawson, F.R.S., in the Transactions of the Royal Society of Canada, and included in your Notes of last issue, in which attention is called to the belief among the Shuswaps and some other North American races, that small lizards enter the bodies of men, pursuing them, and devouring their hearts, I was at once struck with the almost exact resemblance of this belief to one very generally prevailing in Ireland, as regards common water Newts, which go by the name of Man-eaters (pronounced Man-aters). This I can testify to from personal knowledge; but it has been accidentally confirmed by an experiment which I hope I may be pardoned for referring to. Where I reside are three Irish servants, to whom I caused to be shown a drawing of the Water Newt, and with the request that I might be told its name, and anything they knew about it One of these, a Galway woman, speaking Irish better than English, gave me the name in her language (which I won't attempt to transcribe, for it was a very long one), and also said that the animals were well known to jump down people's throats to their certain destruction. C. BUSHE.

Athenæum, December 24.

The Great Ice Age.

THERE is in the Astronomical theory of the Ice Age a point of some importance, not mentioned by Sir Robert Ball in his interesting work on this subject, to which I invite the reader's attention. I mean *the slowness with which the difference between the length of summer and that of winter is varying in the neighbourhood of its maximum.*

To compute this difference and its mean value, we put

a = the mean distance of the earth from the sun,
e = the eccentricity of the earth's orbit,
ω = the longitude of the perihelion of the earth's orbit,
T = the length of the year in mean solar days,
Δ = the difference between the lengths of the two seasons in mean solar days,
η = the mean value of this difference during the interval between the two dates, corresponding to $\omega = \omega_1$ and $\omega = \omega_2 > \omega_1$.

Then, the eccentricity remaining always extremely small, the difference between the areas of the two segments in which the line of the equinoxes divides the earth's orbit, may be put—and with sufficient accuracy,

$$= 2ae \cdot 2a \sin \omega = 4a^2 e \sin \omega.$$

Hence, we find, by Kepler's first law,

$$\frac{\Delta}{T} = \frac{4a^2 e \sin \omega}{\pi a^2 \sqrt{(1 - e^2)}},$$

and consequently, by neglecting the third and higher powers of e,

$$\Delta = \frac{4Te \sin \omega}{\pi}.$$

Observing that the eccentricity remains sensibly constant for a period of time, which is doubtless to be reckoned by many tens of thousands of years, we obtain, by means of the formula just found,

$$\eta = \frac{4Te}{\pi} \int_{\omega_1}^{\omega_2} \sin \omega d\omega : \int_{\omega_1}^{\omega_2} d\omega$$

$$= \frac{4Te}{\pi} \cdot \frac{\cos \omega_1 - \cos \omega_2}{\omega_2 - \omega_1}.$$

Finally, by substituting the numerical values of our constants, we shall have the following formulæ for computing Δ and η:—

$$\Delta = 465e \sin \omega,$$

$$\eta = \frac{465e (\cos \omega_1 - \cos \omega_2)}{\omega_2 - \omega_1},$$

positive values designating that in the Northern Hemisphere and negative values that in the Southern Hemisphere the summer exceeds the winter.

From the first formula we deduce that, for a given eccentricity, the disparity in the lengths of the seasons shall be as great as possible when the line of the equinoxes is perpendicular to the axis major of the orbit. Now, putting e = 0, 071, the maximum eccentricity, the values of Δ and η for a few values of ω are as follows:—

ω °	Δ	$\omega_2 - \omega_1$ °	η
90	33		
85 or 95	33	95 − 85	33
80 or 100	32½	100 − 80	33
75 or 105	32	105 − 75	32½
70 or 110	31	110 − 70	32
65 or 115	30	115 − 65	32
60 or 120	28½	120 − 60	31½
55 or 125	27	125 − 55	31
50 or 130	25	130 − 50	30
45 or 135	23	135 − 45	29½

If we remember that the longitude of the perihelion increases in about twenty-one thousand years from 0° to 360°, then, it will be seen by inspecting these results that, for example, during the interval between the two dates corresponding to $\omega = 65°$ and $\omega = 115°$, *i.e.* during a period of nearly three thousand years, the mean difference between summer and winter will be thirty-two days, and that during this period the difference itself will never sink below thirty days. N. L. W. A. GRAVELAAR.

Deventer, Netherlands, December 17.

Aggressive Mimicry.

IN his last letter Mr. Poulton observes that I am one of "four recent writers" who have made use of the collections in the Natural History Museum and the Museum of the Royal College of Surgeons, for the purpose of illustrating the phenomena of mimicry between *Volucella* and *Bombex.* This is the case, but I should like to add that the species which I have depicted are not *V. bombylans* and *B. muscorum* (the questionable resemblance of which in nature, and the erroneous labelling of which in the "show cases," constitute the grounds of Mr. Bateson's somewhat "aggressive" criticism on other "recent writers"), but *V. bombylans* and *B. lapidarius*, where the fact of resemblance can admit of no doubt ("Darwin and After Darwin," p. 329). Indeed, Mr. Bateson fully recognizes the close similarity in appearance between these two species; and, as I refrained from giving the hypothetical explanation of it to which he objects, I avoided all the issues which have since been raised in the NATURE correspondence.

Madeira, December 15. GEORGE J. ROMANES.

Artificially Incubated Eggs.

I HAVE been repeatedly informed by poultry-growers and market-men that hens raised from artificially incubated eggs were much less fertile than those produced in the natural way. My information has been derived from persons who did not even know each other. It occurs to me that if true it is a curious matter and worthy of some attention.

W. WHITMAN BAILEY.

Brown University Herbarium, Providence, R.I. December 10.

THE PROPOSED UNIVERSITY FOR LONDON.

A GENERAL meeting of the Association for Promoting a Professorial University for London was held on Wednesday, December 21, when a report, which we print below, was presented by the Executive Committee. We would call the attention of our readers to the penultimate paragraph of this report, which indicates the existence of an agreement, on matters of principle between the Senate of the University of London and the Association.

The last general meeting of members of the Association was held on June 14, 1892, when the Executive Committee presented for approval a series of proposals for the organization of a University in London. These proposals were adopted as the formal expression of the objects of the Association.

Since that meeting the efforts of the Committee have been directed to the furtherance of the principles embodied in the above-mentioned proposals—by endeavouring to obtain the adhesion of literary and scientific men, and of other persons interested in the matter; by organizing a body of evidence to be presented to the Gresham University Commission, and by such other means as have suggested themselves from time to time.

Immediately after the last general meeting, Prof. Huxley became a member of the Association, and consented to accept the office of president. Sir Henry Roscoe and the Master of University College, Oxford, consented to become vice presidents; and the first of these gentlemen has since been an active member of the Executive Committee.

The number of members of the Association is now one hundred and fifty.

Evidence in support of the principles of the Association has been given before the Gresham University Commission by the following gentlemen:—Prof. Ayrton, Mr. F. V. Dickins, Prof. G. C. Foster, Principal Heath, Prof.

Henrici, Prof. Huxley, Prof. Ray Lankester, Prof. Henry Nettleship, Prof. Pearson, Sir H. Roscoe, Prof. Rücker, Dr. Russell, Prof. T. E. Thorpe, Prof. Unwin, Dr. Waller, Dr. Windle, Prof. Weldon.

During the month of November the Committee were informed that a Committee of the Senate of London University had drawn up a series of resolutions, to be submitted to the Royal Commission. Your Committee therefore requested the Vice-Chancellor to allow its members to address the Committee of the University Senate in support of the proposals of the Association. The Vice-Chancellor replied by inviting the Executive Committee of the Association to attend a meeting of the University Committee on Wednesday, December 7. At this meeting the objects of the Association were explained by the President, Sir Henry Roscoe, and Prof. Weldon, and the Vice-Chancellor in reply made an important statement, to the effect that the resolutions which were put forward by the Committee of the Senate were intended to be understood in such a manner as to render them perfectly consistent with the programme of the Association. The resolutions proposed by the University Committee, and since adopted by the whole Senate, are as follows:—

The Senate having reason to believe that a distinct expression of opinion may be useful to the Commissioners at the present stage of the inquiry, desire to recall to their attention the fact that during last year the Senate approved a Scheme for a Reconstitution of the University which provided for the constitution of Faculties consisting of teachers and of Boards of Studies in each Faculty, and for the election of members of the Senate by the Faculties; and that the Scheme further proposed to confer on the University power to hold real property and to accept grants, gifts, devises, and legacies for the purposes of the University, including the establishment of Professorships and Scholarships, whether attached or not to any particular College, and the furtherance of regular liberal education and of original research.

The Senate now desire to state that, if in accordance with the decision of the Commissioners, the Senate is prepared, in order to promote the efficiency of the University, and with a view to its reorganization as a Teaching University in and for London, without curtailment of the functions which it now discharges—

(*a*) To establish and incorporate with the University Faculties in Arts, Science, Laws, and Medicine, and Boards of Studies acting thereunder.

(*b*) To provide for the incorporation with the University of Teaching Institutions of the higher rank.

(*c*) To utilize, with their consent, existing organizations for higher culture, and subject to such utilization to institute and maintain Professorships and Lectureships, whether for academical or other purposes, and generally to assume such functions as may be required for the furtherance and superintendence of a regular liberal education, and for the promotion of original research.

(*d*) To accept and administer fees and such other funds, public or private, as may be necessary, and may be granted or given for the purposes of the reorganized University.

(*e*) To provide for the adequate representation of the Professoriate on the Senate.

The Committee regret that Prof. Pearson, whose energy and enthusiasm have been of such essential service to the Association, has felt obliged to retire from the office of Secretary. His place has been taken by Prof. Weldon.

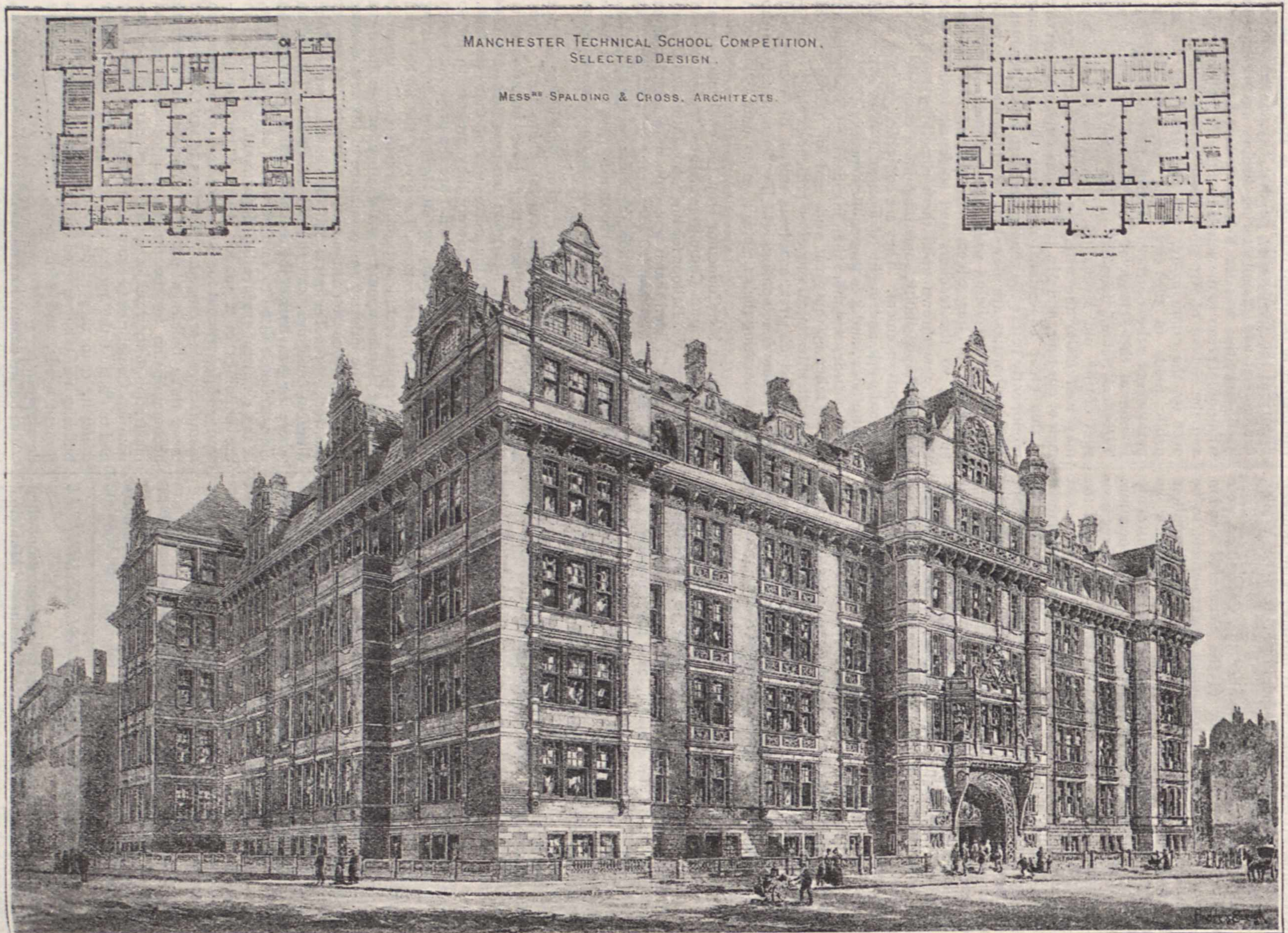
THE MANCHESTER MUNICIPAL TECHNICAL SCHOOL.

IN his interesting address on technical education, when distributing the prizes of the Manchester Municipal Technical School, on the 19th inst., Mr. Balfour pointed out that the occasion was an important one, not only in the history of technical instruction in Manchester, in the history of the Corporation of that city, but also in the commercial and manufacturing history of Manchester itself, since this was the first public occasion of the distribution of prizes to the scholars of the Technical School and the School of Art since these schools were taken over by the municipality, and supported out of the public funds of the city. The fact that the Corporation of the northern metropolis has taken possession of the School of Art and of the flourishing Technical School, founded a few years ago on the site of the old Mechanics' Institution, is one which may well claim the attention of the leading statesmen of our time, and Mr. Balfour has done good service to this great educational movement by thus placing prominently before the country the part which our municipal authorities are now playing in the matter. Fully alive to the revolution which these changes are bringing about in our educational system, Mr. Balfour, speaking to the teachers and students, insisted that there is now thrown upon them something more than personal responsibility, something more than the desire for self-advancement. They are concerned, he said, in a national work, and ought to look at it from a national point of view, and it is this public aspect of the question which justifies and more than justifies the Corporation for having taken up this great work and for having created the greatest technical school at present existing in England, but which, great as it is, is still in its infancy, and will yet show developments which will astonish those who are now devoting their time to it in so public-spirited a fashion.

Then spoke Mr. Councillor Hoy, the chairman of the Technical Education Committee of the Corporation, and in thanking Mr. Balfour for his "thoughtful and charming address" added that it was only nine months since these schools were handed over to the Corporation, that they had to master the whole machinery of the education, to arrange all the details of the transfer, but that in addition they had plunged right away into the necessary steps for erecting a new and enlarged school.

So it is evident that the men of Manchester do not allow the grass to grow under their feet. They know that the business they have undertaken is a big one, and they, like good business men, are prepared boldly to meet the necessities of their position. How boldly and how completely they propose to do so will be seen when we learn what are the proposals which they have made for carrying on their work, for making the necessary preparations, for giving the highest and most complete technical training which can be given in all those matters upon the satisfactory accomplishment of which, the industry and commerce of the vast district of which Manchester is the centre depends. At present the work of the Technical School is carried on in three different buildings, one the old Mechanics Institution where the great bulk of the teaching is done, another in an old warehouse fitted to suit the wants, as far as may be, of the electrical engineering department, and a third in the buildings of a school where a very completely-equipped department for the scientific study of the cotton manufacture is arranged. Needless to say that none of these three buildings provide sufficient or adequate accommodation for the proper practical teaching and illustration of their subjects, and no sooner had the Corporation Committee become acquainted with what they had to do, and the means placed at their disposal for doing it, than they made up their minds that a new building must be erected fully representative of the present needs, and with room, if possible, for future developments.

But before committing themselves to plans or estimates, this committee wisely determined to see with their own


Manchester Technical School Competition.
Selected Design.
Messrs Spalding & Cross. Architects.

eyes what was doing and had been done elsewhere. They visited the English schools, such as they are, and, more important, they went abroad and inspected the well-known technical schools on the continent, and on their return they issued an interesting report containing not only an account of what they saw and learnt, but the conclusions they drew as to how far their Manchester school should be modelled on foreign lines. This journey of inspection gave the members of the committee a new and enlarged view of their duties, and they returned home with the determination that if they could not approach the size of such buildings as the Zurich Polytechnicum or the Technical High School of Charlottenburg, at any rate they would put up a school which should be as complete in its parts as any similar institution abroad and capable of doing for their centre work equally useful and of exerting an equally beneficial influence on their population as any of the foreign schools. Some captious critics were loud in their condemnation of such a way of spending public money as that of sending a number of Manchester men on an educational tour abroad. In fact, no money could be or has been more judiciously or more economically spent. Without a knowledge from personal observation of what is doing elsewhere, these gentlemen could not possibly have carried out their business to a successful issue ; with such a knowledge they can and will do it.

Fortunately for Manchester, the necessity for technical training of the people was long ago preached by one of her most distinguished sons, the late Sir Joseph Whitworth, and his legatees, knowing his views, presented a site for the school of 5000 square yards, situated in the centre of the city, and well placed as regards light and air. On this site the Corporation have decided to build a spacious, not to say magnificent, school, a perspective view of which is found on the opposite page. The whole of the site, including 770 yards in addition given by the Corporation, is to be covered by buildings, and in it ample accommodation will be found for the work carried on in the present temporary premises. This will include engineering, mechanical, electrical, civil and sanitary, the chemical industries, the cotton manufacture, spinning and weaving, the building trades, dyeing and calico printing, metallurgy, letterpress and lithographic printing, and other minor industries; industrial art and design, and the subjects classed under the heads of commercial and economical instruction. And in addition to these proper accommodation for the teaching of the pure sciences, mathematics, foreign languages, to say nothing of manual instruction and gymnastics. All these matters require means of giving practical instruction, not only lecture rooms, but laboratories, workshops, and museums, so the problem of satisfying all their needs is a complicated one, but one which the committee are determined to do their best to carry out. The size of the proposed building called forth a large number of competing designs from some of the first architects of the day, and the first premium was awarded by the Committee, assisted by Mr. Waterhouse, R.A., to Messrs. Spalding and Cross, of London. Their design is in Renaissance style of the early French period, and the internal arrangements are made with the view of giving as much light as possible. The material is red brick with terra cotta facings ; it is roofed with green Whitland Abbey slates. The building will be fireproof throughout, and the flooring covered with wood blocks, except in the case of the dyehouse and laboratories, where impervious paving is needed. One great desideratum in such a building is proper ventilation ; this will be arranged on the plenum or plus pressure system, the air being pumped throughout the building by fans worked by electricity, and the lighting will also be electrical. The building is six stories high, none of the rooms will be lower than 15 feet clear, and averaging from 25 to 30 feet in depth. The class rooms, lecture theatres, drawing and designing offices, laboratories, library, workshops and administrative department, as well as the students' and lecturers' rooms, are all lighted from the face of the building with wide continuous corridors all round each floor, lit from internal areas, and each department will be as far as possible separate and self-contained. The total available floor-space exceeds 150,000 square feet exclusive of the corridors. The main entrance hall is 85 by 50 feet, and it is to be utilized as an industrial museum ; on the first floor is a public lecture hall 30 feet high, and of the above dimensions. On the third floor is the chemical laboratory arranged for 80 working benches. Two independent staircases, as well as a spacious passenger lift give access to the different floors, and extra exits are provided in case of fire. The basement, which is only seven feet below the ground line, is to be fitted with heavy machinery and other apparatus used in industrial operations on a considerable scale. Here we find the electrical and mechanical workshops and testing machinery ; rooms for purposes in which stability is necessary; experimental steam engine, dynamo, and secondary battery rooms ; spinning and weaving machinery for cotton and silk ; rooms for bleaching, dyeing, and finishing ; plumbers', bricksetters', and masons' workshops ; shops for repairs, and construction of new apparatus, &c. The upper stories contain the laboratories, general and special, lecture rooms, drawing offices, gymnasium, library, and students' reading and common rooms.

The following is the space allotted on the various floors for the several departments :—

		Sq. feet.
1.	Administration, Museum, Lecture Hall, Library, Reading Room, Gymnasium, and other offices	26,837
2.	Mechanical Engineering	18,266
3.	Applied Physics and Electrical Engineering	13,666
4.	Textile Trades	19,211
5.	Applied Chemistry, Dyeing, &c., Metallurgy	29,232
6.	Building Trades	10,922
7.	Letterpress and Lithographic Printing ...	2,798
8.	Industrial Design	13,453
9.	Commercial Subjects	11,844
10.	Domestic Economy Subjects	6,461
	Total	152,690

As if to indicate the determination to make the utmost of their building, the Committee have asked Sir Howard Grubb to design a small astronomical and meteorological observatory on the roof! This in the centre of smoky Manchester; but experts say that even here much useful work can be done.

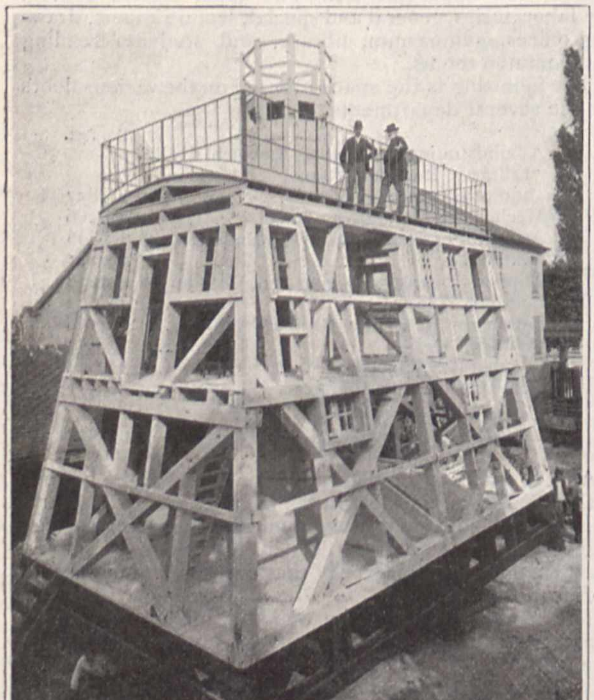
The estimated cost of the building, including fittings, apparatus, and machinery is about £125.000 ; towards this sum the Committee have available £14,000 balance of profit from the Jubilee Exhibition ; £5000 promised by the Whitworth trustees ; and the property belonging to the old schools estimated at £31,000. The remainder of the sum, about £75,000, the Corporation will borrow for a period of thirty years on the security of the 1d. rate. This great school will be governed by a Committee of thirty-six persons, twenty-four of whom are members of the City Council, twelve being chosen from the public interested in the progress of Industrial and Commercial Education.

Enough has been said to give the reader an idea of the scale and completeness of the proposed Municipal School. To work this properly will cost nearly £10,000 per annum. The fees will be low, but nevertheless will bring in a goodly sum, and the funds available from the Local Taxation (Customs and Excise) Act of 1890—commonly termed the beer money—will provide the remainder. Such a school, holding as it will do an intermediate position, between the Board Schools on the one hand, and highest University Education as given in the Owens

College on the other, cannot fail to exert a most important influence on the future development of trade and manufactures in Lancashire. What Manchester is doing in this magnificent way, other towns, notably Birmingham, Salford, Stockport, Oldham, Bolton, and others, are also doing, it is true on a smaller scale, but still in a manner sufficient for their needs. How long will it be before London moves? H. E. ROSCOE.

THE MONT BLANC OBSERVATORY.[1]

THE project of establishing a meteorological and astronomical observatory on the summit of Mont Blanc has, under the care of M. J. Janssen, of the Meudon Observatory, made considerable progress during this year's summer months. It has been decided to use the snow itself as a foundation on which to rest the building. That this can be done with security was shown by some experiments carried out at Meudon last winter. A miniature mountain was made of snow pressed to the same density as that which is found on Mont Blanc at a depth of one or two metres below the surface. This being



made level at the top, discs of lead 35 cm. in diameter, and weighing each about 30 kgr., were placed on the snow, one upon the other. After twelve of these had been piled up, with an aggregate weight of 360 kgr., they were removed and the depth of the impression measured. It was not more then 7 or 8 mm. Thus a structure measuring 10 m. by 5 m. might safely weigh 187,000 kgr. without sinking into the snow more than a few centimetres.

The summit of Mont Blanc is formed by a very narrow edge of rock 100 m. long, running from west to east, and covered by snow which is thicker on the French than on the Italian side. The level of this snow has not shown any important oscillations throughout a number of years. To obviate the disturbing effects of the storms which frequently rage round the summit, the building is constructed in the shape of a truncated pyramid, the lower floor being sunk into the snow. The rectangular base measures 10 m. by 5 m. The upper floor, which will be devoted to the observations, is covered with a flat roof, towards which ascent is made by a spiral staircase leading from the basement upwards through the whole building, and above the flat roof to a small platform destined for meteorological observations.

The whole observatory has double walls to protect the observers against the cold. The windows and doors are also double, and provided on the outside with shutters closing hermetically. The floor is made of double planks, and furnished with trap-doors giving access to the snow supporting the observatory, and to the screw-jacks placed in position for adjusting the level of the building in case the snow should yield. The building will be provided with heating apparatus and all the furniture necessary to make habitation at such an altitude possible.

Up to the present the observatory has been transported in parts to Chamounix. On the Grands-Mulets a cottage has been erected for the use of the workmen and for storing the things destined for the observatory.

On the Grand Rocher Rouge another cottage has been built, only 300 m. below the summit, in which the workers and observers can, if necessary, take refuge. Three-quarters of the materials for the observatory have been transported to the Grands-Mulets (3000 m.) and the rest to the Rocher Rouge (4500 m.).

Next year the erection on the summit will be carried out. An astronomical dome, which is to complete the observatory, will also be taken in hand. The work done up to now has been carried out under great difficulties, owing to the fact that everything had to be carried by hand. But no accident has, so far, marred the success.

Dr. Capus, who accompanied M. Bonvalot in his well-known expedition to the Pamir, has promised his assistance for certain observations. But the observatory will be international, and open to all observers who wish to work there. E. E. F. d'A.

[1] Janssen, *Comptes rendus*, November 28.

M. PASTEUR'S SEVENTIETH BIRTHDAY.

FRENCHMEN may be cordially congratulated on the enthusiasm with which the seventieth birthday of M. Pasteur was celebrated on Tuesday. It afforded a most striking illustration of the way in which they appreciate the services rendered by men of science. But the celebration was not, of course, one in which only the countrymen of M. Pasteur were interested; representatives of science from many different parts of the world were present to do honour to the illustrious investigator.

The ceremony took place in the great amphitheatre of the Sorbonne, which was crowded by a brilliant assembly including many of the foremost men of the day, not merely in science but in politics and literature. M. Carnot was present, and among those who supported him was M. Dupuy, the Minister of Public Instruction. M. Pasteur entered the amphitheatre leaning upon the arm of his son and upon that of the President of the Republic. All who were present rose to their feet and greeted the hero of the day with loud cheers. M. Pasteur, who was much affected by this reception, took his place beside his colleagues of the Institute and a row of Ambassadors and Ministers.

The proceedings were opened by M. Bertrand, perpetual secretary of the Academy of Science, who acted as chairman. At his request an address was delivered by the Minister of Public Instruction, who spoke eloquently of the great qualities displayed by M. Pasteur during his splendid career, and of the benefits conferred on mankind by his labours. After the Minister came M. d'Abbadie, the President of the Academy, who, expressing the congratulations of the Institute, presented to M. Pasteur the large gold medal which had been struck in commemoration of the day. The medal bears on the obverse a likeness of M. Pasteur, while on the reverse is the following inscription : "To Pasteur, on his seventieth birthday, from grateful science and humanity, Dec. 27, 1892." M. Bertrand also spoke, and both his speech and that of M. d'Abbadie were cordially applauded. Sir Joseph Lister, one of the delegates sent by the Royal Society, was warmly greeted. He read in French the following address :—

"M. Pasteur, the great honour has been accorded me of offering you the homage of medicine and surgery. There is certainly not in the entire world a single person to whom medical science is more indebted than to you. Your researches on fermentation have thrown a flood of light which has illuminated the gloomy shadows of surgery, and changed the treatment of wounds from a matter of doubtful and too often disastrous empiricism into a scientific art, certain and beneficent. Owing to you, surgery has undergone a complete revolution. It has been stripped of its terrors, and its efficiency has been almost unlimitedly enlarged. But medicine owes as much to your profound and philosophic studies as does surgery. You have raised the veil which had for centuries covered infectious diseases. You have discovered and proved their microbic nature, and, thanks to your initiative, and in many cases to your own special labour, there are already a host of these destructive disorders of which we now completely know the causes. 'Felix qui potuit rerum cognoscere causas.' This knowledge has already perfected in a surprising way the diagnosis of certain plagues of the human race, and has marked out the course which must be followed in their prophylactic and curative treatment. In this way your fine discoveries of the attenuation and reinforcement of virus and of preventive inoculations serve, and will serve as a lode-star. As a brilliant illustration, I may note your studies of rabies. Their originality was so striking that, with the exception of certain ignorant people, everybody now recognizes the greatness of that which you have accomplished against this terrible malady. You have furnished a diagnosis which immediately dispels the anguish of uncertainty which formerly haunted him who had been bitten by a dog mistakenly supposed to be suffering from rabies. If this were your only claim on humanity, you would deserve its eternal gratitude. But, by your marvellous system of inoculation against rabies, you have discovered how to follow the poison after its entry into the system, and to conquer it there. M. Pasteur, infectious maladies constitute, as you know, the great majority of the maladies which afflict the human race. You can therefore understand that medicine and surgery are eager on this great occasion to offer you the profound homage of their admiration and of their gratitude."

Among other addresses was a striking speech by the Mayor of Dôle, M. Pasteur's birthplace. After the presentation of gifts by foreign delegates, M. Pasteur rose and spoke a few words, which, according to the Paris correspondent of the *Times*, were "broken by sobs." A speech was then read for him by his son. In this speech, as reported in the *Times*, M. Pasteur said, after referring to M. Carnot's presence :—"In the midst of this brilliant scene my first thought turns with melancholy to the recollection of so many scientific men who have known nothing but trials. In the past they had to struggle against the prejudices which stifled their ideas. These prejudices overcome, they encountered obstacles and difficulties of all kinds. Even a few years ago, before the public authorities and the Municipal Council had provided science with splendid buildings, a man whom I loved and admired, Claude Bernard, had for a laboratory, a few steps from here, nothing but a low, damp cellar. Perhaps it was there he was struck by the malady which carried him off. When I heard of the reception intended for me, his memory rose first of all to my mind. I hail that great memory. It seems that you have desired by an ingenious and delicate idea to make my entire life pass before my eyes. One of my Jura countrymen, the Mayor of Dôle, has brought me a photograph of the humble house where my father and mother lived under such difficulties. The presence of all the pupils of the Polytechnic School reminds me of the glowing enthusiasm with which I first entered on the pursuit of science. The representatives of the Faculty of Lille recall for me my first studies on crystallography and fermentations, which opened quite a new world to me. What hopes filled me when I discovered that there were laws behind so many obscure phenomena ! You have witnessed, my dear colleagues, by what a series of deductions I have been enabled as a disciple of the experimental method to arrive at physiological results. If I have sometimes disturbed our academies by somewhat livelier discussions, it is because I was passionately defending truth.

"You, lastly, delegates of foreign nations, who have come so far to give France a proof of sympathy, you afford me the most profound gratification which can be experienced by a man who invincibly believes that science and peace will triumph over ignorance and war ; that peoples come to an agreement not to destroy, but to build up, and that the future will belong to those who have done most for suffering humanity. I appeal to you, my dear Lister, and to you all, illustrious representatives of science, medicine, and surgery. Young men, trust those certain and powerful methods, only the first secrets of which we yet know. And all of you, whatever your career, do not allow yourselves to be infected by vilifying and barren scepticism ; do not allow yourselves to be discouraged by the gloom of certain hours which pass over a nation. Live in the serene peace of laboratories and libraries. Consider first of all, 'What have I done for my education ?' and then, as you advance, 'What have I done for my country ?' until the moment when you will perhaps have the immense happiness of thinking that you have contributed in some way to the progress and welfare of mankind. But whether your efforts are more or less favoured in life you must, on nearing the grand goal, be entitled to say, 'I have done what I could.' I express to you my profound emotion and warm gratitude. Just as, on the back of this medal, the great artist Roty has concealed under roses the date of birth which weighs so heavily on my life, so you have desired, my dear colleagues, to give my old age the spectacle which could most delight it—that of these eager and loving young men."

This closed the ceremony. M. Carnot, before quitting the building, walked over to M. Pasteur and embraced him. The celebration was one of which France has good reason to be proud ; and Englishmen may well regret that such a demonstration, common to governors and governed, would in this country be impossible.

NOTES.

THIS week the American Society of Naturalists has been holding at Princeton, N.J., its eleventh annual meeting, the chair being occupied by Prof. Henry F. Osborn, Columbia College, New York. On Tuesday a lecture was to be delivered by Dr. C. Hart Merriam on the Diak Valley Expedition (illustrated). On Wednesday, after the transaction of general business, the following reports on marine biological laboratories were to be read:—The Sea Isle Laboratory, by Prof. J. A. Rider, University of Pennsylvania ; a marine station in Jamaica, by

Prof. E. A. Andrews, Johns Hopkins University; the marine laboratories of Europe, by Dr. D. Bashford Dean, Columbia College; and the outlook for a marine observatory at Woods Holl, by Prof. C. O. Whitman, University of Chicago. In the evening the annual dinner of the society was to be held, and the president's address was to be delivered. The following are the principal arrangements for to-day (Thursday):—A paper is to be read by Dr. C. W. Stiles, Agricultural Bureau, Washington, on the endowment of the American table at Naples; and reports are to be read on botanical explorations in Florida, by Prof. W. P. Wilson, University of Pennsylvania; the summer work of the U. S. Fish-Commission Schooner *Grampus*, by Prof. William Libbey, Junr., Princeton College; and expeditions of the American Museum of Natural History into New Mexico, Wyoming, and Dakota, by Dr. J. L. Wortman, American Museum Natural History. Then will come the annual discussion, the subject being, What were the former areas and relations of the American Continent, as determined by faunal and floral distribution? The following papers will be read:—Introduction, and evidences from past and present distribution of mammals, by Prof. W. B. Scott, Princeton College; evidence from past and present distribution of reptiles, by Dr. George Baur, University of Chicago; evidence from the distribution of birds, by Prof. J. A. Allen, American Museum of Natural History; and evidence from the distribution of plants, by Dr. N. L. Britton, Columbia College. Special meetings have been held by the American Societies of Anatomists, Morphologists, and Physiologists.

WE learn, from the *Oesterreichische Botanische Zeitschrift*, of the death, at Vienna, of the veteran palæontologist, Dr. D. Stur, Director of the Imperial Geological Institute in that city, and author of several finely illustrated works on palæo-phytology.

DR. VOLKENS, Privatdocent at the University of Berlin, and Dr. Lent are about to start for East Africa, where they propose to carry on scientific investigations. The former has received a grant from the Prussian Academy of Sciences, and will devote himself especially to botanical study. Dr. Lent has received aid from the German Colonial Society, and will give especial attention to geology.

DR. F. BUCHANAN WHITE has presented his fine collection of lepidoptera to the Museum of the Perthshire Society of Natural Science, which is in process of being greatly enlarged. The collection contains twelve thousand specimens, which have been collected by Dr. White in many parts of Europe, though mainly in Great Britain and largely in Perthshire. Many are type specimens, which have been described and figured by the collector in his numerous descriptive papers, and several represent species that have now become extinct.

DURING the latter part of last week an area of low pressure lay to the south-westward of our islands, causing south-easterly gales on our western coasts. This disturbance, however, although it advanced from off the Atlantic, remained comparatively stationary for two or three days, during which time the weather continued fine and dry over England. At the close of the week the low pressure area gave place to an area of high barometer readings, which gradually spread over the United Kingdom from the continent, bringing dry weather and severe frost, with fog in many places. The thermometer in the shade fell to 9° in Leicestershire, and to 17° in London in the night of the 26th, and in many places the day temperature continued much below the freezing point during both Monday and Tuesday. At this time the anticyclone had become thoroughly established, and the area of cold was increasing both in size and intensity, although the conditions in the extreme north indicated a possible change. The *Weekly Weather Report* for the period ending the 24th inst. shows that temperature was above the mean in all districts, being as much as 5° or 6° over Ireland. During the early part of the week the night minima were very high for the time of year. Rainfall was less than the mean in all districts, the deficiency being most considerable in Scotland and in the south-west of England. Bright sunshine was also very deficient; in Scotland and Ireland there was only from 2 to 3 per cent. of the possible amount.

THE Weather Bureau of the U.S. Department of Agriculture has published some valuable "Observations and Experiments on the Fluctuations in the Level and Rate of Movement of Ground-water on the Wisconsin Agricultural Experiment Station Farm, and at Whitewater, Wisconsin," by Franklin H. King. The author holds that a careful and detailed study of the movements of ground-water ought to supply very important knowledge bearing upon the contamination of drinking waters and the spreading of certain classes of contagious diseases, and thus help to place the water-supply for both urban and rural purposes under better sanitary conditions. Every advance which is made towards the increase of yield per acre necessarily means an increased demand for water, so that market gardeners even in Wisconsin and Illinois, where both the annual and summer rainfall is relatively large, are turning their attention, Mr. King says, to the question as to the best means for providing irrigation. A rapid and economical advance in this direction demands, he thinks, a much more thorough knowledge of the movements of underground water than we at present possess. He also urges that in the utilization of natural sub-irrigation, and in the reclaiming of swamp lands for agricultural purposes, there is imminent need for new knowledge in the same direction. Mr. King does not overrate the importance of his own researches. He regards them simply as preliminary studies.

H. HABENICHT, of Gotha, has contributed a paper to *Ausland* (No. 49) on the frequency of icebergs in the Gulf Stream and variations of climate, based upon the reports of icebergs published since 1883 in the pilot charts of the North Atlantic Ocean. He gives a table showing the number of bergs reported in each year in the Gulf Stream, with a summary of the temperature conditions experienced in Europe during each of the four seasons. The number of icebergs varied considerably in different years, from ten in the year 1888 to 674 in the year 1890. The table shows some unmistakable coincidences between the frequency of the bergs and the character of subsequent weather about six months afterwards. The extremely low minimum of iceberg frequency in 1888 was followed by the warmest year of the series; all the seasons of 1889 were warm over Europe. There was another less marked minimum of icebergs in 1889, and this was followed by a relatively warm year in 1890. The remarkable maximum of bergs in 1890 was followed in 1891 by the coldest winter that had occurred for twenty years, and the cold winter was followed by an abnormally cold spring and summer. The table also shows that the coincidences are more marked with iceberg maxima than with minima. Two of the latter in two successive years were followed by only one warm summer, while in the case of the maxima the decrease of temperature occurred in the next year.

MR. D. T. MACDOUGAL contributes to *Science*, December 2, an interesting account of some explorations recently made by a botanical expedition in Idaho. The work of the expedition was planned by Dr. G. Z. Vasey, chief botanist of the U.S. Department of Agriculture. The results are summarized thus:—The basins of Lakes Coeur d'Alene and Pend d'Oreille and of the Clearwater and Palouse rivers were explored; the botanically unknown area in Central Idaho now being limited on the south by the Snake River basin, on the west by the Snake River and the basin explored. About 25,000 specimens of dried plants were collected, representing nearly 1000 species, many of them undescribed forms. Valuable facts concerning general distribution of plants were obtained, since the area explored is one where the Rocky Mountain flora meets and intermingles with the Pacific coast flora in a very interesting manner, while the opportunity afforded by numerous mountain slopes for the furthering of some problems of vertical distribution was not neglected.

AN important paper on fossil mammals of the Wahsatch and Wind River Beds, by H. F. Osborn and J. L. Wortman, has been issued as a bulletin by the American Museum of Natural History, and has also been published separately. It includes a plate and eighteen figures in the text, and is devoted principally to a description of a collection made by Dr. Wortman during the summer of 1891. The authors claim that many new facts of great interest are brought out by the material in the collection. In a preliminary note it is stated that the department of mammalian palæontology in the American Museum of Natural History was established in May, 1891, and that the purpose of the trustees is to procure a representative collection of the American fossil mammals from the successive geological horizons of the West for purposes of exhibition, study and publication. The staff consists of Prof. H. F. Osborn, of Columbia College, Curator, and of Dr. J. L. Wortman, assistant in Palæontology. Mr. Charles Earle and Mr. O. A. Peterson are also engaged as assistants, and Mr. Rudolph Weber as draughtsman. The collections are to be made readily accessible to students, and exhibited as rapidly as they can be put together and mounted. A list of such duplicate specimens as are available for purposes of exchange is to be prepared. A series of casts of the best preserved types is also in preparation for exchange.

LAST week we printed an account of the ceremonies connected with the Tercentenary of Galileo at Padua. In addition to what was then stated we may say that after Prof. Favaro's oration the delegates were invited to present the addresses of which they were the bearers; whereupon, the English delegation having by lot been placed first in order of precedence, at the request of his colleagues, Profs. Darwin and Stone of Cambridge and Oxford, Sir Joseph Fayrer spoke first, on presenting the addresses of the Royal College of Physicians of London and the University of Edinburgh, with which he was entrusted. He spoke in Italian to the following effect :—

"Profondamente commosso all'onore accordatomi dal Reale Collegio dei Medici di Londra, ed anche dall Università di Edinburgo, nel nominarmi il loro delegato, io mi presento davanti a questa insegne adunanza, per far onore alla memoria di uno dei più grandi uomini e dei più illustri sapienti del mondo, e per render omaggio da parte del detto Collegio, così bene come dell' illustre centro di scienza e di filosofia in Scozia, all' inclito scienzato, nonche a felicitare di cuore colla massima riverenza, questo antico seggio di scienza e di filosofia in così lieta e fausta occasione, nella quale si commemorano le scoperte gloriose del celebre e rinomato filosofo, col nome del quale è intimamente collegata la sua storia passata ed anche la sua rinomanza attuale. La scienza di tutto il mondo è senza dubbio in questo luogo ora rappresentata. Da ogni parte sono venuti messaggi di simpatia, ma da nessuno forse, con maggiore premura e zelo che dei compatrioti di Harvey e Newton. Questi, impugnando la facciola caduta dalla mano morta di Galileo, la innalzò e la sostenne per illuminare le tenebre e rischiarare di vera luce i luoghi finallora oscuri anche al gran filosofo stesso; l'altro avendo terminato i suoi studi ed essendo laureato in questa università, divenne dipoi, come socio del Collegio di Londra, famoso per le sue scoperte sulla circolazione del sangue. I suoi studi anatomici che fece a Padova svilupparono in lui quel genio al quale il mondo intero è debitore. Signori miei, non è solo allo scopritore del termometro, e, come si può dire, all' inventore del telescopio ; non è neppure all' astronomo famoso che ha stabilito il sistema eliocentrico, ed ha quasi anticipato le scoperte di Kepler, e che ha dimostrato i satelliti di Giove, le fasi del pianeta Venere, i movimenti diurni e mensili della luna e le macchie solari ; non è infine all' autore del 'Saggiatore,' del 'Sidereus Nuncius' e del 'Dialogo dei due Massimi sistemi del Mondo,'—ma è piuttosto al fondatore della filosofia sperimentale che noi rendiamo adesso omaggio ed onore. Egli, osando, pensare ed investigari da se stesso, rigettando gli assiomi degli antichi sistemi di filosofia, anche quello di Aristotile stesso, e rifiutando gl' insegnamenti della teologia dogmatica, stabilì il sistema del libero esame, affermando che la scoperta della verità dev' essere il primo motivo, e che si deve cercarla per via di sperimenti e non sull' altrui autorità, e che la verità è unica, tanto in respetto alle scienze divine come alle umane. Ardisco dire che nessun migliore tributo si può fare al gran maestro adesso commemorato, che questa riconoscenza festiva dopo trecento anni, dell' assiduo e instancabile lavoro che ha rovesciato non soltanto il sistema Tolomaico, ma ha dato un nuovo impulso vitale ad ogni ricerca scientifica e filosofica. Signori, con queste poche parole ho tentato d'esprimere i sentimenti dell' illustre Collegio e dell' inclita Università dei quali io sono il modesto interprete, e ho l'onore di sommettere queste indirizzi, e con esse, i voti più sinceri dei miei colleghi per la prosperità futura di questa venerabile Università, la quale, molto avanti a Galileo è stata un primo centro della vita intellettuale in Europa, e che anche adesso è famosa per la sua propria eccellenza e pei suoi rapporti col gran savio di cui si può dire, come ha detto Dante di Aristotile : 'Tutti l'ammiron, tutti onor gli fanno.'"

PROF. DARWIN of Cambridge followed Sir Joseph Fayrer with an interesting and eloquent address, also in Italian. He was succeeded by other delegates. We may note that every attention was shown to the foreign delegates, and the great success of the commemoration was courteously assigned by the University authorities in large measure to the sympathy and interest evinced by other nations. It is satisfactory that no inconsiderable share of this was attributed to the English ; their addresses being delivered in Italian evidently afforded much pleasure.

THE *Mediterranean Naturalist*, noting the fact that new and spacious buildings are about to take the place of the old biological station at Cette, expresses regret that no institution of this kind has yet been established in connection with the Maltese Islands. It points out that the marine fauna and flora of Maltese waters offer themselves as a rich and practically untouched field of research, the careful working out of which would be attended with scientific and economic results of the greatest importance.

THE same journal mentions that a petition is to be presented to the Governor of Malta praying that the Maltese fisheries may be more efficiently protected. At present considerable latitude is allowed both as regards the methods practised and as regards the times at which the fishing is carried on. "This," says our contemporary, "is not as it should be. No other food supply can take the place of fish, and the fisheries of the islands under adequate protection and judicious management will always be an unfailing and increasing source of wealth."

THE Department of Public Instruction in New South Wales has published in its Technical Education Series (No. 10) the first part of what promises to be a most valuable "Bibliography of Australian Economic Botany," by J. H. Maiden, curator of the Technological Museum, Sydney. Much information on the properties and uses of Australian plants, and on the products obtained from them is embodied in books of travel, in exhibition literature, pamphlets, proceedings of learned societies, professional journals, and newspapers. It is the author's object to render this scattered information convenient for reference.

A GERMAN translation, by Count Goertz-Wrisberg, of Dr. W. Fream's "Elements of Agriculture," has been published by

Paul Parey, of Berlin, under the title of "Landwirtschaft in England."

THE current number of Wundt's *Philosophische Studien* contains two experimental articles—both dealing with problems of psychological optics. The first (A. Kirschmann, "Beitraege zur Kenntniss der Farbenblindheit") gives an account of a number of interesting cases of colour-blindness, together with criticisms of existing theories. A unique case is that of an inherited, unilateral (left) blindness to the qualities violet, green and yellow. In the second (E. B. Titchener, "Ueber binoculare Wirkungen monocularer Reize") an attempt is made to show that stimulation of one retina is followed by an excitation-process in the other. The psychophysical results are supported by recent physiological discovery.

THE following are the arrangements at the Royal Institution for the Friday evening meetings before Easter, 1893:—Friday, January 20, Prof. Dewar, F.R.S., liquid atmospheric air; Friday, January 27, Francis Galton, F.R.S., the just-perceptible difference; Friday, February 3, Alexander Siemens theory and practice in electrical science (with experimental illustrations); Friday, February 10, Prof. Charles Stewart, some associated organisms; Friday, February 17, Prof. A. H. Church, F.R.S., turacin, a remarkable animal pigment containing copper; Friday, February 24, Edward Hopkinson, electrical railways; Friday, March 3, George Simonds, sculpture considered apart from archæology; Friday, March 10, Sir Herbert Maxwell, early myth and late romance; and Friday, March 17, William James Russell, F.R.S., ancient Egyptian pigments. On Friday, March 24, a discourse will be delivered by Lord Rayleigh. On March 31 and April 7 (the Fridays in Passion and Easter Weeks) there will be no evening meetings.

THE following are the arrangements for lectures at the Royal Victoria Hall in January:—January 3, Mr. Charles E. Reade on a trip through India, with anecdotes of the mutiny; January 10, Mr. A. Hilliard Atteridge on some old Belgian towns; January 17, Prof. Carlton Lambert on the romance of the stars; January 24, Dr. Dallinger on spiders, their work and their wisdom.

THE fermentative changes which the leaves of the tobacco plant are made to undergo before they are worked up and finally handed over to the public, are of the greatest importance in determining the quality of any particular tobacco. It was formerly supposed that the alteration in its condition thus brought about was due to purely chemical changes induced by the process of "sweating" which the leaf undergoes, but some interesting experiments made recently go to show that these important results are effected by special micro-organisms. In a paper read before the German Botanical Society, Suchsland gives an account of some investigations which he has been conducting on the bacteria found in different kinds of tobacco. He has examined fermented tobacco from all parts of the world, and found large numbers of micro-organisms, although but few varieties, mostly only two or three different species in any particular brand and but rarely micrococcus forms. But what is of especial interest is the discovery that pure cultures of bacteria obtained from one kind of tobacco and inoculated on to another kind, generated in the latter a taste and aroma recalling the taste and aroma of the original tobacco from which the pure cultures had been in the first instance procured. Thus it may be possible in the future to raise the quality of German tobacco, not, as heretofore, so much by careful culture and judicious selection of varieties, which has so far proved unsuccessful, but by inoculating pure cultures of bacteria found in some of the fine foreign tobaccos on to our own raw material, whereby similar fermentative changes may be induced and the quality correspondingly improved. The further results promised by Suchsland will be looked for with much interest. In connection with the above experiments on the "transplantation," so to speak, of micro-organisms, it is interesting to note some results obtained lately by Nathan (*Die Bedeutung der Hefenreinzucht für die Obstweinbereitung*). The amount of alcohol present in such wines as cider, currant wine, etc., is generally from 3 to 4 per cent. This small proportion is possibly in part due to the necessarily large dilution of the fruit with water, which considerably reduces the nitrogenous constituents of the "must," and also to the fact that the yeast, according to Hansen mostly present on sweet fruits is the *Saccharomyces apiculatus*, which only possesses a feeble fermentative power. Experiments were made to see whether, by increasing the nitrogenous constituents of the "must," and introducing a pure cultivation of a vigorous wine-yeast, the yield of alcohol would be greater. It was found that by adding a small amount of nitrogenous material, such as 0·15 gram. ammonium chloride, and 5 cubic centimetres of wine-yeast per litre to the "apple-must" (which was the fruit selected) 2 per cent. more alcohol was obtained, and not only was this the case, but this cider possessed a finer and more vinous taste than that untreated, or which had only received an additional supply of ammonium chloride without the wine-yeast. Kosutany in a paper published in the *Landw. Versuchsstationen*, 1892, has recorded the results of his investigations on the behaviour of certain species of wine-yeast. He states that not only is the percentage of alcohol yielded very different with particular yeasts, but that also the taste, smell, and bouquet of the wine inoculated with special cultures were distinctly different according to the variety of yeast employed. It is hoped that, as in the case of tobacco so with wine, it may be possible to raise the quality by the judicious transplanting of bacteria obtained from finer brands.

THE additions to the Zoological Society's Gardens during the past week include a —— Squirrel (*Sciurus* ——) from China, presented by Mr. Julius Neumann; a Crowned Hawk Eagle (*Spizaetus coronatus*) from South Africa, presented by Mr. T. H. Mills; a Macaque Monkey (*Macacus cynomolgus* ♀) from India, deposited; three Sulphury Tyrants (*Pitangus sulphuratus*) from South America, six common Widgeons (*Mareca penelope*, 3 ♂, 3 ♀), four common Pintails (*Dafila acuta*, 2 ♂, 2 ♀), two Pintailed Sand Grouse (*Pterocles alchata*, ♂ ♀) European, purchased.

OUR ASTRONOMICAL COLUMN.

JUPITER'S FIFTH SATELLITE.—Mr. A. A. Common, in a letter to the *Times* for December 28, writes with respect to the fifth satellite of Jupiter:—

"This extremely difficult telescopic object discovered by Prof. Barnard last September at the Lick Observatory has been looked for with the 5ft. reflector on several occasions. On October 18 and on December 13 it was pretty certainly seen, by me on the first occasion, and by Mr. Albert Taylor on the second. The last two evenings (Sunday and Monday) have been very fine, and on each, between five and six o'clock, the satellite has been seen with certainty by Mr. Taylor and in glimpses by me.

"The brightness seems less than that assigned to it by Prof. Barnard, but this may be due to the very much better sky they enjoy at Mount Hamilton; the glare from Jupiter would be with them very much less, so that they would have the planet on a much darker background, and it would appear brighter than it does here.

"I have not heard of any other observations having been made out of America."

COMET BROOKS (NOVEMBER 20, 1892).—*Edinburgh Circular*, No. 36, gives the ephemeris of this comet, from which the following extract is made. This comet, according to Ber-

berich's computations, will soon commence to decrease in brightness.

Berlin, Midnight.

1892–93.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Br.
Dec. 30	15 57 15	58 31·0			
31	16 16 30	60 21·3	0·0820	9·8589	7·66
Jan. 1	16 38 18	62 1·9			
2	17 2 46	63 29·7	0·0812	9·8530	7·89
3	17 29 49	64 41·7			
4	17 59 0	65 34·5	0·0807	9·8521	7·95
5	18 29 40	66 5·4			

COMET HOLMES (NOVEMBER 6, 1892).—The following is a continuation of the ephemeris of this comet for the present week :—

Berlin, Midnight.

1892–3.	R.A. (app.). h. m. s.	Decl. (app.). ° ′	Log *r*.	Log Δ.
Dec. 30	1 2 22	+33 59·5		
31	3 24	57·2		
Jan. 1	4 27	55·1	0·4096	0·3284
2	5 31	53·1		
3	6 36	51·3		
4	7 42	49·6		
5	1 8 50	33 47·9	0·4119	0·3400

THE MARKINGS ON MARS.—In No. 25 of the Publications of the Astronomical Society of the Pacific, Mr. Schaeberle has a preliminary note on the question as to whether the darker and the brighter areas on Mars are water and land or *vice versâ*. Having observed the planet from June 11 up to the present time he has been led to the conclusion opposite to that of Schiaparelli, Flammarion, and other observers, and considers that after all the dark portions should be considered as land and the bright as water. In raising such a question as this Mr. Schaeberle has been very reserved, for should his opinion receive due attention, as of course it should do, and be corroborated, the planet's surface will be looked upon in quite a different light than formerly. In this note he sets forth a few of his reasons for coming to such a conclusion, and it may interest many of our readers if we state some of them briefly. If the dark markings be taken as land, would not the irregular gradations of shade be more naturally expected than if we consider them as fixed surface features? "Light reflected from a spherical surface of water in a slight state of agitation would vary uniformly in intensity. At opposition, the centre of the planet would, for a water surface, appear brightest. Observations show that within a certain distance from the edge of Mars there is a gradual increase in the steady lustre of the brighter areas towards the centre of the planet." Assuming these dark areas to be water, then they should thus be least dark near the centre, which is somewhat contrary to observation. With reference to the "canals," he says that they on this hypothesis "correspond to the ridges of mountains which are almost wholly immersed in water," while with regard to their observed doubling he remarks that they can be explained as "representing parallel ridges of which our own earth furnishes examples." As a concluding argument he takes an observed terrestrial observation, the view of the lower end of San Francisco Bay from Mount Hamilton, San Francisco being fifty miles away. At all hours of the day, he says, "the surface of San Francisco Bay (as seen from the top of Mount Hamilton) is much *brighter* than the neighbouring valley and mountains at the same distance." He further adds that the line of sight makes an angle of more than 87° with the normal to the surface of the bay, while the observer's position "varies all the way from being nearly in a direct line between the bay and the sun to the position in which the sun is nearly in the direction of the bay."

THE LICK OBSERVATORY.—Miss Milicent W. Shinn is the writer of a very interesting pamphlet on the history of the Lick Astronomical Department of the University of California. In these few pages she brings together much with regard to the early events connected with the founding of the giant refractor that is not generally known. For instance, it is curious to read how Mr. Lick wished to be immortalized by leaving bequests for costly statues of himself and his family, and when urging that such statues would be preserved for all time, was answered by Mr. Staples that "more likely we shall get into a war with Russia or somebody, and they will come round here with warships and smash the statues to pieces in bombarding the city." Mr. Lick was so struck by this, that he asked, "What shall I do with the money, then?" How this question was answered is now well known, and astronomical science was presented with the finest object-glass that was ever made.

Mr. Lick's deed prescribed that the Observatory should be "made useful in promoting science," and up to the present these words have been carried out to the letter. The big telescope has not been preserved for one side of astronomical science, but has dived into all branches, as every astronomer is aware. Not only have minute double stars been observed and measured, but the spectroscope has been employed, from which excellent results have been published, while lunar photographs, equalling, if not excelling, those that had been previously obtained, have brought to light much to set us thinking about. Jupiter's fifth moon is perhaps the latest arrival of which we have heard, and this, following just 300 years after Galileo's discovery, would alone render the Observatory famous. That the Lick Astronomical Department, during the few years of its existence, has done an immense amount of good work, especially when one takes into account the comparatively small staff on hand, cannot be denied, and we hope the day will come when the number of such telescopes will be increased, for the ever-opening fields of research point out how necessary they are.

WASHINGTON MAGNETIC OBSERVATIONS.—The United States Naval Observatory has quite recently published their magnetic observations that were made during the past year, prepared on the same plan as that for 1889–90. The observations for 1891, as Mr. Hoogewerff (who was in charge for the greater part of the year) informs us, are better than those of former years, owing to the fact that the reductions took place at no very distant dates from the observations, the experience thus gained helping to correct and guard against conditions which might have tended to give rise to errors. The introduction contains a description of the buildings, methods of observing, together with the personnel during the year, concluding with a description of the tabular results. The tabular results, as usual, show the mean hourly readings for the elements for each month, Table I. containing the mean values for the four years 1888–91.

Simultaneous with this volume was also issued the meteorological observations and results for the year 1888.

GEOGRAPHICAL NOTES.

A SPECIAL number of the *Mouvement Géographique* is devoted to a series of important despatches from M. Alexandre Delcommune, chief of the Lomami expedition of the Katanga Company. Entering the Lomami from the Congo, the party left the river on May 13, 1891, and explored the entirely untraversed territory between its upper valley river and that of the Sankuru as far as 8° S. Thence they turned eastward and reached Lake Kassali on the Lualaba, and struck south through Garenganze's country to Bunkeia. Making a circuit through Katanga and westward, they found the Lualaba near its source, and following it for 200 kilometres, discovered a grand gorge at Nzole, where the river flowed in a succession of wild cataracts between cliffs nearly a thousand feet high, and not more than forty yards apart. From the rapids they returned to Bunkeia, travelled north-eastward over the plateau, crossing the Luapula at its outflow from Lake Moero, and ultimately reached Lake Tanganyika. The difficulties overcome were very great, and the sufferings of the caravan have rarely been surpassed even in the grimmest records of African travel.

AMONGST the English travellers who have recently arrived in London are Mr. Selous, the famous South African hunter, and Mr. Conway, who has probably climbed higher than any other European in the Karakoram range. Both gentlemen will read papers to the Royal Geographical Society early next year

THE arrangements for the Royal Geographical Society's evening meetings after Christmas are unusually varied. Mr. Hose will describe his journey up the Burram river in Sarawak to Mount Dulit, at the first meeting in January. The second meeting will be devoted to the Island of Yezo, when Prof. Milne and Mr. Savage Landor will read papers. Papers by Captain Bower and the American traveller, Mr. Rockhill, on Tibet, will be given later; and Lieutenant Peary will personally describe his experiences in the north of Greenland. In March Prof. Bonny will lecture on the action of ice in producing geographical forms, and there will be other papers dealing with the scientific basis of geography.

The death of Cardinal Lavigerie on November 24 removed one of the most powerful personages who have recently influenced the geography of Africa. It is very largely on account of his labours that the French Roman Catholic missions have played so conspicuous a part in combating the slave trade, and to him also is due the formation of a much-needed Belgian Anti-slavery Society.

The British Government having decided to relieve the East African Company from the responsibility of occupying Uganda, an Imperial commission, under the charge of Sir Gerald Portal, will set out from Mombasa as soon as it can be got ready to take over the administration of the country. Another fact of some interest is the revival by Mr. Cecil Rhodes of the idea of exploring Africa by telegraph. He proposes to lay down a line from the Cape to Uganda, and ultimately to extend it to Egypt. In a few months the South African Company's wires will have reached the mission station of Blantyre north of the Zambesi, and there are no serious physical difficulties in continuing the line to the head-waters of the Nile. The effect on the exploration of Africa will be enormous, not the least important result being the possibility of arriving at the true longitudes of places in the interior of the continent.

DEW AND FROST.

A PAMPHLET recording some interesting "Observations on Dew and Frost," by the Hon. R. Russell, has just been published by Mr. Edward Stanford. We reprint Mr. Russell's "Summary of Results":—

The observations were begun with the object of verifying the commonly received theory of dew, and with a strong feeling that the results obtained by Col. Badgeley, described in the *Proceedings of the Royal Meteorological Society* for April, 1891, opposed as they were in some measure to the accepted teaching on the subject, would not be corroborated. When, after exposing inverted glass tumblers and pans on grass and bare earth in the summer of 1891, dew was often found in surprising amount in the interior, I attributed the deposit to vaporous air which might have entered under the rim and parted with its moisture in the calm of the inclosed space. But when it was found that a tumbler pressed down into dry earth, and other vessels admitting little air from outside, were considerably bedewed in the interior; and when, further, similar vessels inverted on earthenware or metal plates were found to be very slightly or not at all bedewed inside, it became more probable that the vapour condensed in the interior of vessels over grass and garden earth had proceeded from the earth beneath. Next, it was found that china plates, admitting a flow of air between their lower surfaces and the ground, were more heavily bedewed on their lower than on their upper surfaces, and that a cylinder of glass was most bedewed on the lower outer and upper inner surfaces. These observations confirmed the suspicion that the dew on the inside of the hollow vessels was derived from the ground. It was for a long time a matter of doubt and difficulty that vessels inverted over dry, dusty earth and dry turf were found copiously bedewed within on the morning following exposure. On many mornings the amount of dew in the interior increased in some proportion to the precautions taken to exclude free air, and it seemed highly improbable that moist air penetrated, without depositing on its way much of its moisture, either through the dusty earth banked round the edges of the vessel, and exposed to the sky, or else through the dusty covering of earth below the vessel from lower layers.

In December, 1891, during hard frost and very fine weather, with calm or very light airs, the ground being frozen hard, leaves of bushes, ferns, &c., were seen to be frosted both on their upper and lower sides, though much less on the lower sides facing the bare ground than on the upper sides facing the open sky. Where thick fern grew between the observed leaves and the ground, there was no rime on the lower sides of the overhanging ferns or leaves. This seemed to show that the rime on the lower sides of ferns was due to exhalation from the ground, for the interruption of radiant heat from the earth by dry litter would rather favour than reduce the frosting of the under sides. Live leaves on bushes, and dead leaves on the ground, were whitened with frost on their upper sides, and had a thin film or coat of transparent ice on their lower sides. Leaves and sticks on the ground were less frosted on the sides facing the ground than on the top. Thick planks between a few inches and one foot above the ground were about a third as much frosted on the lower as on the upper sides. Considering that the upper side of a plank 1 inch thick would fall to a considerably lower temperature by radiation than the lower side, it may be supposed that the deposition would have been largest on the lower side if they had been at the same temperature. That much frost came from the air independently of the ground, was shown by the white roofs 12 feet above the surface of the earth. On the other hand the grass was much more heavily frosted. Moreover, tumblers inverted and pressed down on dry, hard, bare earth, on sand, and on hard turf, were moderately frosted inside, besides being thickly frosted outside. The indications, on the whole, seemed to resemble those of the previous June, but the vapour condensation attributable to exhalation from the earth bore a much smaller proportion to the total deposit than in the case of dew on interior surfaces observed in summer

Boards, tiles, and stones (sandstone) in heaps were frosted on the top, and especially in cracks and indentations of the top surface, but not in the interstices between the separate pieces. Stones on the ground were sometimes not frosted at all on the top, but much on the parts against the sandy earth, and where bedded in the ground.

Further experiments in May and in the summer months of 1892 gave strong confirmation of the evidence that much dew and frost are caused by exhalation of vapour from the earth, even in dry weather.

The facts that—

(1) A large quantity of dew was invariably found on clear nights in the interior of closed vessels over grass and sand.

(2) Very little or no dew was found in the interior of vessels inverted over plates on the ground.

(3) More dew was found on the lower side of a square, slightly raised, china plate over grass or sand than on the lower side of a similar plate placed upon the first.

(4) The lower sides of stones, slates, and paper on grass or sand, were much more dewed than the upper sides. The flat wooden back of the minimum thermometer on clear evenings when lying on earth, sand, or grass was almost invariably wet before the upper surface.

(5) The lower side of plates of glass, 1 or 2 in. above grass, were as much or more bedewed than the upper sides.

(6) Leaves of bushes, leaves lying on the ground, and blades of grass were about equally bedewed on both sides.

(7) The interior of closed vessels inverted on the grass and covered with two other inverted vessels of badly-conducting substance was thickly bedewed, and the grass in the three circular inclosures also thickly bedewed.

(8) The deposit of dew on the interior of closed vessels inverted over dry garden earth was much less than over sand or turf, although the powdery condition of the earth in the morning showed that no deposit from the air had taken place on its surface during the night.

(9) Usually a greater amount of dew was deposited in the interior of vessels when the earth was moist at a little depth below the surface than when the earth was at its driest.

(10) The temperature of the space under a glass plate or other object suspended near the surface of the ground was higher than that of the upper surface of the object, and, nevertheless, a cloudy film was produced first on the lower surface,—amounted to a proof that a large part of the dew formed is derived from vapour from the earth.

Moreover, the large difference often observed between the quantity of dew deposited in the interior of a vessel inclosing a plant, and the quantity of an empty vessel, proved that much dew may be derived from the earth through plants.

Drinking glasses inverted over grassy turf, and over turf close by, from which the grass was removed, showed a similar excess of deposit on the glasses inclosing grass. More vapour was condensed on plates suspended over grass than over bare earth. In these cases the conditions are somewhat artificial, and the grass, which was covered by a suspended plate or inclosed by a glass, would be warmer than if the exposure to the sky were free, but the disturbance thus caused would tell as much against as in favour of deposition on the interior surface. It may be objected that the air in and above the grass would be colder, owing to the radiating grass, than over the bared spot, and that therefore more dew would be deposited from the air; but this objection would scarcely be valid where a small plant was inclosed on bare earth and the deposition on the interior of the glass compared with that on a glass not inclosing a plant.

Recent investigations have proved the evaporation from plants to be very large, and since evaporation proceeds by night as well as by day, there can be no reason why a moderate proportion of the dew deposited on the surface of blades of grass and on leaves of plants generally should not be derived from the vapour which they exhale. The fact that an equal quantity of dew is deposited on glass, china, painted wood, &c., exposed to the sky to that deposited on grass, may seem to minimize the influence of plant exhalation, but we must remember that the whole of the stratum of air near the ground is rendered more vaporous by these exhalations, and that therefore the dew-point is sooner reached on the surface of any body exposed to the sky in the midst of vegetation than on bare open ground. Moreover, the thickness of the substance prevents earth heat from much affecting the upper surface. The effect of grass in promoting dew formation is owing—(1) To its radiative power cooling its surface below the dew-point. (2) To the consequent cooling of the stratum of air in and over the grass to a point much below that of the air a few feet higher. (3) To the obstruction offered by the grass to any light air or breeze on a nearly calm night, and the consequent settling down, without much disturbance, of a cold heavy stratum. (4) To the prevention by the grassy covering of the drying up process by sun and wind which takes place on bare ground, and to the moist earth which therefore exists under grass near the surface even in dry weather. (5) To the exhalation of vapour from the grass.

The realization of these causes explained what was always, previous to these observations, a difficulty to me, the almost entire absence of dew on heather and dry fern in the summer. Even after heavy dews, heather was invariably found perfectly dry. In fine, calm winter weather, with white frost, heather may be a good deal whitened, and the frost is then derived largely from the open air. Wood, being a good radiator and bad conductor, is heavily bedewed and frosted.

Stones, whether of sandy composition and appearance, or of close grain like flint, pebbles, and slate, are not often visibly bedewed or frosted on the top on clear nights. On their surfaces, touching or very close to the ground, they are heavily bedewed and frosted. A moderate radiative power, their usual situation removed from grass and vegetation, and in the case of the close grained stones, a conductive power greater than that of leaves, grass, and wood, though less than that of metals, prevent the deposition of much atmospheric moisture on their exposed sides. But when air highly charged with vapour impinges on them in a confined space, as on their lower sides, condensation readily takes place, just as it will take place when any substance, even polished metal, is held above the spout of a kettle of boiling water. It is apparent that since stones act as condensors to the vapour constantly arising from the earth, and since the heat of the sun and temperature of the air by day only slightly raise the temperature of the earth immediately beneath a large stone, while the radiation of heat from the stone and low air temperature of the night cause the lower side of the stone to be very cold at night, a rather large amount of moisture must be deposited on its lower surface in every twenty-four hours, and the ground on which it rests must in our climate remain always very moist. The space between the stone and the ground consequently becomes the abode of many insects which live well in damp and darkness.

Occasional observation of the distribution of dew, without careful comparison with the state of the weather, gives an impression of capriciousness which only continuous records comprising various conditions can remove.

Deposition is generally favoured by a humid air, and therefore in this country by southwesterly and westerly winds, which bring over the land the vapour derived from evaporation of the Atlantic Ocean. A smaller fall of temperature by radiation brings about condensation, and there is less tendency in any deposit to evaporate than in a drier air. Radiation may produce a greater fall of temperature in dry air, but the distance from the dew-point is commonly too wide to compensate greater humidity with greater cooling.

Calm is also very favourable to dew-formation. It allows parcels of vapour in the air to remain sufficiently long in contact with cold radiating substances to become greatly cooled, and so to become condensed upon them, and it prevents the dispersion of the stratum of air near the ground, which is continually cooling by contact and radiation. Thus dew goes on forming while the air falls lower and lower beyond its original dew point, and while by a very gentle movement an interchange is kept up between the warmer air touching the ground beneath the grass, and the cold air on the surface of the grass, and between differently cooled layers and portions of air above it. If the air is very humid, a very slight air or breeze is favourable to heavy deposition. On ordinary clear nights, calm and light airs allow the reduction of the lowest stratum of air to the dew-point, and there is no liability to evaporation of the minute deposited particles by portions of air above the dew-point being driven against them. When the air is rather dry, as often happens at night in dry summer weather, and in winter frosts, calm is frequently a necessary condition for the deposit and appearance of dew and white frost. The deposit may be observed to take place on the cessation of wind, and again, the change from calm to wind soon dries off the dew which has already formed. On other occasions, when there is a gentle air or breeze, dew and frost are deposited only in sheltered places, as on the most sheltered slopes of fields, on banks sloping to leeward, on leaves on the lee side of bushes and trees, on the lee side of mole-hills, posts, railings, and other objects. Hollows, depressions, and cracks, in paper, glass, stones, tiles, wood, and leaves, are more bedewed than flat surfaces from the same reason,—the reduction below the dew-point of air less diluted than that which is more free by currents of higher temperature and greater dryness. With a fresh west wind in a clear night, the raised and ribbed parts of leaves, &c., may be thickly bedewed and frosted, but the hollows and folds scarcely if at all less, and the sides of buds, thorns, &c., are more frosted than the points. The wind is, in fact, often sufficiently removed from the dew-point to prevent deposition or continuance of moisture on all parts which are fully exposed to it. Not even free radiation to a clear sky then avails to plant frost-growths upon the object whose temperature is being perpetually supplied by the forcible impact of warmer air.

Free radiation or exposed situation is, on the whole, perhaps the most effectual cause of dew on very many nights in the year. In a level country those parts of a field which are least sheltered by trees and hedges gather most dew and frost on calm nights. Similarly, those parts of any flat substance, such as a sheet of glass or paper, which have the most uninterrupted exposure to the sky are most bedewed. The tops of bushes, posts, railings, inverted drinking glasses, pans, &c., are on calm nights, and sometimes breezy nights, more bedewed than the sides. Greater cold by greater radiation in these cases produces greater deposition from the cooled air which comes in contact with the freely radiating surfaces. It must be remarked, however, that radiation from fine points, such as the tips of sharp thorns, is often not sufficient to counteract in air which is not very humid the effect of the continual impact of air above the dew-point and higher in temperature. Close to the ground the case is different, for there the temperature of the low stratum of air is lower, and usually about the dew-point, there is little movement, and vapour from the ground increases humidity; but even in this situation the points of grasses, &c., are often less bedewed than the sides.

That free radiation is by no means necessary for the formation of heavy dew on grass is proved by the experiments detailed above, made during the summer of 1892. The grass was found heavily bedewed in dry weather within three enclosures of earthenware by which radiation was arrested.

Since grass covered by hollow vessels, and the interior of hollow vessels themselves, are thickly covered with dew, it would seem likely that the grass under overhanging trees would be as thickly bedewed as the exposed grass in a field, and that the under sides of the overhanging leaves would also be wetted. This is not the case. And there are differences in the two situations sufficient to account for the absence of dew under leafy trees. In the first place, on a calm night, the air under a tree is warmer than in the open owing to radiation from the ground being arrested. Secondly, whatever vapour escapes from the earth is unable to condense on the grass which covers it, the grass being but little colder than the air and vapour. Thirdly, and herein lies the chief difference, the air under the tree moves freely and is above the dew-point, since the earth and other objects which it touches are warmer than the grass and air outside. If the air were confined in a small space, the increments of vapour issuing from the earth, and the gradual cooling of the grass under the tree and of the tree itself, might cause deposition, but air which has parted with much of its moisture outside is constantly mixing with a considerable body of air already warmed under the sheltering canopy. Thus all objects under the tree remain above or not much below the dew-point of the air which touches them. Yet, on a calm night, long grass and other substances a little raised above the ground are sometimes heavily bedewed, though largely hindered by overhanging branches from losing their heat by radiation. They often remain nearly dry till the morning hours, and then reach a temperature below the dew-point. The absence of dew under trees and bushes is, within limits, roughly proportional to the area of ground covered. A large surface of dry ground slowly parting with its heat during the night has a powerful effect in preventing condensation. Small bushes on a humid clear night are often much bedewed even on their lower leaves. On the night of October 5, 1892, both sides of the leaves of bushes in all sheltered situations were found thickly bedewed, but where leaves were either exposed to the slight breeze which was blowing, or near the wall of the house on which the sun had shone, they were dry. The warm, dry wall of a house acts a part similar to that of the earth under a tree in radiating warmth to neighbouring objects, and in warming the air by contact. The vapour emerging from earth sheltered by foliage several feet above it has time to mix well with air before coming in contact with solid objects. In the hollow vessels, and even in the space between a raised plate of glass and the earth, the vapour which rises from the earth has no time to become equally distributed in the air before meeting with substances colder than itself; in the closed vessels the initial amount of vapour is augmented so as to produce constant saturation. Objects, such as drinking-glasses, raised several feet above the grass, were seldom much bedewed, and often quite dry.

The increase of pasture-land in England must have a considerable effect in increasing cold by radiation, and in diminishing the amount of vapour in the air at night by deposition on grass. The sensible moisture at night must be increased near the ground, the dew-point being quickly reached on a clear night over grass.

The large quantity of dew found on plates and other objects over sandy ground, dry to a depth of several inches, proves the possibility of a large emanation of noxious vapours from soil containing decaying organic matter below a covering of sand. The ague of parts of East Anglia and of sandy malarious districts may be thus accounted for.

Houses built on sandy ground over a damp subsoil may be considered as scarcely more wholesome than if built on the damp soil itself.

In late summer and early autumn the high temperature of the soil in comparison with the temperature of the surface and of the air near the ground at night, must have a powerful effect in the production of vaporous exhalations. The heavy rains which so often occur in October, the wettest month of the year, must cooperate with a falling air-temperature in driving out air from the pores of the earth.

In nearly all the conclusions of Wells, as stated in his admirable "Essay on Dew," my observations lead me to concur. He found that calm is favourable to the precipitation of dew; that if, in the course of the night, the weather, from being calm and serene, became windy and cloudy, not only did dew cease to form, but that which had formed either disappeared or diminished considerably; that if the clouds were high and the weather calm, dew sometimes formed to no very inconsiderable extent; that dew often forms on shaded grass even several hours before sunset, and continues to form after sunrise; that, if the weather be favourable, more dew forms a little before, and, in shaded places, a little after sunrise, than at any other time; that on substances elevated a few feet above the ground it forms much later in the evening, but continues to form as long after the rising of the sun as upon the ground; that dew is more abundant shortly after rain than during a long tract of dry weather; that dew is always very copious on those clear and calm nights which are followed by misty or foggy mornings, and also on clear mornings after cloudy nights, and generally after hot days; that more dew was formed between midnight and sunrise than between sunset and midnight, owing doubtless "to the cold of the atmosphere being greater in the latter than in the prior part of the night;" that whatever diminishes the view of the sky diminishes the quantity of dew; that a substance placed on a raised board of some extent acquired more dew on a very still night than a similar substance lying on grass; that bright metals attract dew much less powerfully than other bodies, that a metal which has been purposely moistened will often become dry though similarly exposed with bodies which are attracting dew, and that wool laid upon a metal acquires much less dew than an equal quantity laid upon grass in the immediate vicinity; that a metal plate on grass always became moist on the lower side during the night, though the upper side was often very dry, but that if the plate was elevated several feet in the air, the condition of both sides was always the same, whether dry or moist; that wool on a raised board was commonly colder than on the grass on very still nights, and that the leeward side of the board was colder than the windward; that bare gravel and garden mould were very much warmer after sunset than neighbouring grass; that on dewy nights the temperature of the earth half an inch or an inch beneath its surface was much warmer than the grass upon it, and than the air; that metal covering grass was only slightly colder than the grass covered, and this again colder than the earth; that metal thus exposed was warmer than air 4 feet above it, and much warmer than neighbouring grass; that the variety in the quantities of dew, formed upon bodies of the same kind in different situations, was occasioned by the diversity of temperature existing among them; and that on nights favourable to the production of dew, only a very small part of what occurs is owing to vapour rising from the earth.

The last of these conclusions Wells supported by the observation that the dew on the grass increased considerably about sunset, the same time at which dew began to show itself on the raised board, and by the reflection that, "though bodies situated on the ground after they have been made sufficiently cold by radiation to condense the vapour of the atmosphere will be able to retain the moisture which they acquire by condensing the vapour of the earth; yet, before this happens, the rising vapour must have been greatly diminished by the surface of the ground having become much colder." He adduced the fact that substances on the raised board attracted rather more dew throughout the night than substances lying on the grass. He admitted that all the dew on calm, cloudy nights might be attributed to condensation of the earth's vapour, since on such nights the raised board was dry.

But if the grass was moist on these calm, cloudy nights, and the moisture were owing to earth-vapour, it is only reasonable to infer that a very much larger quantity was owing to earth-vapour on clear nights when radiation was comparatively free. Moreover, the fact that substances on the raised board became wetter than substances on the grass may be attributed to the non-conducting wood intercepting the warmth radiated from the ground, and thus allowing a substance on the upper surface of the board to become colder than a substance on the grass. And with regard to the "rising vapour" being greatly diminished by the surface of the ground having become colder, it does not appear that such diminution actually occurs, owing possibly to the influence of the high temperature of the preceding day reaching the moist earth at a little depth below the surface about the same time. I have found the deposition of earth-vapour to proceed at a rapid rate after sunrise over grass.

Wells explains with much ingenuity the reason why leaves of trees often remain dry throughout the night, while those of grass are covered with dew. But he does not, I think, attach sufficient weight to the fact which he mentions among others, that the air near the ground is near one of its sources of moisture, while the tops of trees are removed from that source. The air is both damper and colder near the ground; a stratum of cooled air rests upon warm earth emitting vapour. The tops of trees are pervaded by air which is drier and warmer, and the leaves do not allow air to rest long enough on their cooled surfaces to part with sufficient heat in order that condensation may ensue.

I have found that when the air is clear and not humid, radiation into space is often not sufficient to cause visible dew or frost except in sheltered calm places, and in the same condition of air deposition takes place more on broad surfaces than on thin shoots, threads, and points, and more on the faces than on the edges of leaves. It appears necessary that a certain stability of temperature below that of the air, and a certain protection from re-absorption by the drier portions of air which pass over, should be attained in order that dew and frost may accumulate. When, on the other hand, the air is very moist, with a tendency to mist or fog, a very large condensation takes place on exposed objects, and especially on those which are at some height above the ground, such as the branches and twigs of trees. Points, thorns, spiders' webs, and other thin filaments are then heavily bedewed. Mist or fog often follows.

When some mist has formed on such a night, there is a heavy precipitation on trees, &c., which is increased by wind, and large drops of rain on to the ground beneath them. This condition seems best explained by Aitken's discoveries showing the possibility of a super-saturation of air when the number of dust-particles is unusually small in a mass of air which is humid and cooled to saturation. The dust-particles from their minuteness, and from their inability to fall below the temperature of the air owing to the cloud canopy above, do not condense much of the vapour, and consequently any solid object of the same or slightly lower temperature brings about precipitation from the passing air, which may possibly be super-saturated. A slight fall of temperature in the air, or sometimes an increase of dust-particles, then produces fog. A dry fog may thus result from cold causing condensation on a very large number of dust-particles which are radiating heat rather freely, and a damp mist from partial condensation from super-saturated air on a comparatively small number of dust particles not radiating freely owing to a clouded sky.

These considerations explain why a dry fog is densest in London and a wet mist densest in the country. A dry fog is the work of cold radiating particles, a wet mist is the work of cold air mixing with warm. "In a fog," says Angus Rankin,[1] "the watery vapour in condensing has more particles to condense on, and consequently the particles of fog are smaller, and on meeting with an object with a higher temperature, instead of wetting it, the object dries them up by parting with some of its heat. On the other hand, in a mist, the particles of dust, being few, have more water condensed on each, and so are larger and do not readily evaporate with small increments of heat." Yet in a damp mist the addition of a large number of dust-particles, as in a town by day, scarcely increases the density of the mist. In fact, the wet mist is less dense in London than in the country, owing to the higher temperature and lower humidity of the air. Dry or radiation fogs, which cling to the ground, are the most dense in smoky places.

In fogs with frost in winter, such as have occurred several times in the last few years, I have always found the windward side of objects to be much more heavily frosted than the leeward, and the rime to attach itself most to points and edges. Trees have thus become laden with rime, even so as to break down branches; iron points of railings, splinters of wood, wires, and blades of grass have borne spikes and fern-like growths an inch or more long, and heather and fern in hollows have been whitened as if with a fall of snow. In weather of this kind it is difficult to say what is dew or frost proper, and what is deposited moisture from super-saturated air and from fog. On the same night a white frost may present the characteristics of fog-deposition in a valley and of clear condensation on a neighbouring hill.

Dew and frost are in fine the result of many causes which inter-operate in a complex manner. The importance of the laws of gases of the multitude of fine adaptations in the relations of vapour, air, water, earth, and plants; the importance, too, of the thermal receptivity of boundless space, gives an interest to this branch of meteorology which is second only to its beauty.

[1] *Journal of the Scottish Meteorological Society*. Third Series. No. viii

ARBORESCENT FROST PATTERNS.

PROF. MELDOLA'S account of Arborescent Frost Patterns has excited a good deal of interest, and we have received many letters on the subject, some of which we have already published. To-day we give reproductions of photographs we have received from Mr. J. Maclear, Cranleigh. Fig. 1 represents a photograph of a facsimile tracing of a "Nature print" of an ice crystallite taken by Mr. A. Anderson on a still and sunny early morning in January 1887, after a not very severe frost. The sunshine had just dried the rest of the frost off the flagstone, and left this mud and ice-crystallization, which he promptly secured on soft paper by means of a soft pad-pressure, and thus got a perfect Nature printed impression. The original (now unfortunately lost) showed an appearance of vegetable (moss) growth, even more strikingly than in this tracing from it.

With regard to Fig. 2 Mr. Maclear writes:—"The melting ice under the dabbing pad formed a natural pigment with the mud on the flagstone, the rest of the flagstones being perfectly dry already by the early morning sunshine."

Prof. Meldola sends us the following interesting letter which he has received from Corbridge-on-Tyne:—

"I was much interested by your note in NATURE the other day, anent the frost markings of a vegetable pattern. I have seen just the same forms several times in the north, but it is I think the least common of the patterns usually met with. I write, however, to call your attention to Figs. 1 and 7 of Plate

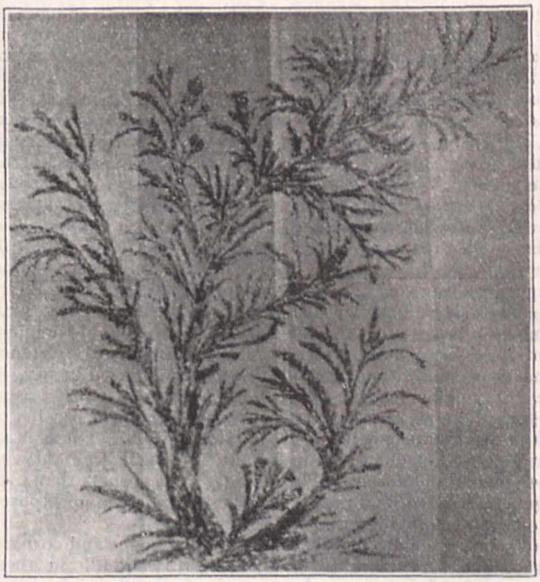


FIG. 1.—Ice crystallite, "Nature printed" by A Anderson, January 1887. Facsimile tracing by J. Maclear, January 1887. Size of crystal 14⅞ inches × 13⅜ inches.

vii, illustrating the article on Meteorology in the "Encyclopædia Metropolitana" (1845, vol. i. of plates, vol. v. of text). These figures are very like yours and some of the others given with them are also very interesting. I have often shown my students when out in the fields in cold weather how exactly the mud-

FIG 2.—Photograph from the original "Nature print," made Mr. A Anderson, of an ice crystallite, January 1887. Size of crystal, 10⅝ inches × 7 inches.

cum-frost markings of the common feathery volute type imitate the so-called *Cauda-galli* fossil fucoid (?) which is one of the most abundant objects on the surface of the carboniferous limestone courses about here. As far as form goes they are identical, and there is no structure to be discovered in the fossil markings.

"Corbridge-on-Tyne, December 16. G. A. LEBOUR."

PROF. SOLLAS writes to us:—The correspondence on this subject that has lately appeared in your columns (particularly Prof. Bonney's reference), leads me to anticipate a communication I hope shortly to present to the Royal Dublin Society on the growth of crystals. The arborescent forms assumed by ice are merely a special case of a very general problem—that of the forms assumed by crystals under different conditions. Petrologists have long been familiar with the tendency of crystals developing in a viscid medium to excessive growth in one or more directions. Felspar is a familiar instance, the lath-like forms which it frequently assumes being due to elongation along one axis (x), the length of prisms measured along this axis often exceeding by ten times that along the axis y or z. The cause of this need not now be discussed; it will be sufficient to add that the phenomenon is not special to felspar, but is of quite general occurrence. With this tendency is connected the origin of curvilinear forms. We may consider the molecules forming the growing face of a long prism; the spheres of influence of these lie half within and half without the substance of the crystal. Considering this influence as attractive (directly or indirectly), we may say that the attraction of the molecules leading to further deposition is one-half their total attraction. If now from the face we pass to the edge between two faces at right angles, only one-quarter of the sphere will be immersed, and the attraction may be spoken of as three-quarters of the whole; while if from the edge we pass to a corner, only one-eighth is immersed, and the attraction becomes seven-eighths. From this it follows that growth should be more rapid at the edges than over the surface of the face, and still more rapid at the corners. In accordance with this we find young growing prisms in a viscid medium increasing so rapidly at the edges as to leave a space in and about the axis filled with the medium in a non-crystalline state. Indeed, a viscid medium is not necessary; hollow prisms are of common occurrence whenever crystallization takes place with rapidity. Further, in quite embryonic crystallites, Vogelsang figures elongated prism-like forms, in which the four corners are produced parallel to the long axis into processes resembling spines. There is an additional reason pointed out to me by Prof. Fitzgerald why growth should be more rapid at the edges and corners than over the general surface, and that is that these parts are more exposed to molecular bombardment.

If crystals are more readily built up along edges and corners, we should expect them to be more readily unbuilt in these regions, and this is in accordance with observation; the zonal felspars of igneous rocks, in the formation of which intervals of solution have alternated with periods of growth, usually present, in the outlines of each resulting envelope, rounded corners.

The influence of corners is well seen in some glassy rocks where small prisms of felspar (andesite) may be observed, with five or six slenderer but longer prisms springing from a corner in radiate divergence.

From this it is but a step to curvilinear growth. Let a prism tend to rapid rectilinear growth, and any check immediately in front will lead to a forward growth from a corner in a slightly different direction; even the competition of molecules for this centre of attraction may by overcrowding bring about this result, and thus both branching and curvilinear forms may arise. This is beautifully exemplified in the spherulites of many igneous rocks, where we find in the centre of a radiately crystallized sphere a long prism of felspar serving as a nucleus, and from the *ends* of this slender, almost linear, prisms diverge towards a spherical surface which by repeated branching and associated curving they everywhere reach, leaving about the sides of the nucleus a spherical space almost devoid of crystal structure. The whole arrangement in median longitudinal section presents a remarkable resemblance to the lines of force as shown by iron-filings about a bar magnet.

Evidently in rapid crystallization with a tendency to linear growth, divergence may be repeated at such frequent intervals as to produce forms which to the unaided eye appear to be continuous curves.

SOCIETIES AND ACADEMIES.

LONDON.

Mathematical Society, December 8.—Mr. A. B. Kempe, F.R.S., President, in the chair.—The following communications were made:—On a theorem in differentiation, and its application to spherical harmonics, by Dr. Hobson.—On Cauchy's condensation test for the convergency of series, by Prof. M. J. M. Hill. Cauchy's condensation test for the convergency of series is as follows:—If $f(n)$ be positive for all values of n, and constantly decrease as n increases, then the series $\Sigma f(n)$ and $\Sigma a^n f(a^n)$ are both convergent or both divergent, where a is any positive integer not less than 2. There is a clear reason why a cannot be unity, for then $\Sigma a^n f(a^n) = \Sigma f(1)$, which is always infinite. It is proved in Chrystal's "Algebra" that the theorem is also true if a have any positive fractional value not less than 2, see part 2, chapter xxvi., § 6, cor. 1. The proof there given when a lies between the consecutive positive integers p and $p+1$ is based on Cauchy's proof for the two cases $a = p$ and $a = p + 1$. But this proof will not apply when $1 < a < 2$, because Cauchy's proof will not apply when $a = 1$. Yet it does not seem possible to assign a reason for excluding values of a between 1 and 2, for Cauchy's method appears to depend on this—viz. that for increasing values of n the expression $f(a^n)$ occupies more and more advanced positions amongst the terms of the series $\Sigma f(n)$; but this is possible if $1<a<2$, as well as when $a>2$. If $a \leqq 1$, then this is no longer true. The problem then considered in this paper is so to recast the proof for fractional values of a as not to exclude the case $1<a<2$. The complete theorem will then stand thus:—If $f(n)$ be positive for all values of n, and constantly decrease as n increases, then the series $\Sigma f(n)$ and $\Sigma a^n f(a^n)$ are both convergent or both divergent if $a > 1$. The demonstration depends on the following theorems.

I. If $\Sigma a^n f(a^n)$ be convergent, then—

$$\sum_{n=1}^{n=\infty} f(n) < f(1) + \ldots + f(t_s)$$

$$+ (a - 1 + a^{-s}) \left[\sum_{n=1}^{n=\infty} a^n f(a^n) - \sum_{n=1}^{n=s-1} a^n f(a^n) \right]$$

where s is any integer so large that

$$a^{s+1} - a^s > 1,$$

and t_s is the greatest integer in a^s, a being greater than 1.

II (A). If $\Sigma a^n f(a^n)$ be divergent, and if $a^n f(a^n)$ diminish as n increases beyond a certain value, then

$$\sum_{n=1}^{n=\infty} f(n) > f(1) + \ldots + f(t_s)$$

$$+ (1 - a^{-1} - a^{-s-1}) \left[\sum_{n=1}^{n=\infty} a^n f(a^n) - \sum_{n=1}^{n=s} a^n f(a^n) \right]$$

II (B.) If $\Sigma a^n f(a^n)$ be divergent, and if $a^n f(a^n)$ do not diminish as n increases beyond a certain value, then—

$$\sum_{n=1}^{n=\infty} f(n) > \sum_{n=1}^{n=s} f(n) + \sum_{n=s+1}^{n=\infty} An^{-1},$$

where s is an integer taken large enough, and A is some finite quantity.—Additional note on secondary Tucker circles, by Mr. J. Griffiths.—Notes on determinants, by Mr. J. E. Campbell. In accordance with the late Prof. Smith's notation, a determinant of the p^{th} class may be written

$$| aijk \cdot \cdot \cdot |$$

The fact that a determinant of the second class (an ordinary determinant) is not altered if the vertical columns be written horizontally is expressed by the identity

$$| aij | = | aji |$$

For determinants of higher class it is known that any of the suffixes can be interchanged, except the first: and if the class be even, the first suffix can also be interchanged with any other, but for determinants of odd class this is not true. By considering a cubic determinant as an ordinary determinant in alternate numbers, the author tries to explain this essential distinction between determinants of odd and even classes. If the element $a_{pqr\ldots} = -a_{qpr\ldots}$, and $a_{ppr} = 0$, the determinant is called skew symmetrical. It is easily seen that skew symmetrical determinants of even class and odd degree vanish identically. This is analogous to the well-known theorem in ordinary determinants; but there is no corresponding analogue to the theorem that skew symmetrical determinants of the second class and even degree are perfect squares. The reasoning which establishes these propositions does not apply to skew symmetrical determinants of odd class. By a different method it is shown that they vanish identically whether the class be even or odd. It is next shown that if we form any determinant of even class $2p$ from $2p$ ordinary determinants, in a manner analogous to that in the rule for the multiplication of two ordinary determinants, the determinant so formed is the product of the $2p$ determinants; and if any determinant of odd class $2p + 1$ is formed from $2p + 1$ ordinary determinants, the determinant so formed is the product of the last $2p$ of these ordinary determinants into the first taken, with all its signs positive. A somewhat similar result is shown to hold for determinants of alternate numbers. As an application, let

$$z = \frac{a_1}{(x - \alpha_1)(y - \beta_1)} + \ldots + \frac{a_n}{(x - \alpha_n)(y - \beta_n)},$$

and let (p, q) denote

$$\frac{d^{p+q}z}{\underline{|p}\,\underline{|q}\,dx^p dy^q}.$$

By multiplying the arrays

$$\left\| \begin{matrix} \frac{a_1}{x - \alpha_1} \cdot \cdot \cdot \cdot \cdot \cdot \cdot \cdot \\ \frac{a_1}{(x - \alpha_1)^2} \cdot \cdot \cdot \cdot \cdot \cdot \cdot \end{matrix} \right\| \quad \left\| \begin{matrix} \frac{1}{y - \beta_1} \cdot \cdot \cdot \cdot \cdot \cdot \cdot \\ \frac{1}{(y - \beta_1)^2} \cdot \cdot \cdot \cdot \cdot \cdot \end{matrix} \right\|$$

we get

$$\begin{vmatrix} (0, 0), & (0, 1) \\ (1, 0), & (1, 1) \end{vmatrix} = \Sigma \frac{a_p a_q (\alpha_p - \alpha_q)(\beta_p - \beta_q)}{(x - \alpha_p)^2 (x - \beta_p)^2 (x - \alpha_q)^2 (x - \beta_q)^2}.$$

Suppose, now, $n = 1$, we get that the primitive of

$$\begin{vmatrix} (00), & (01) \\ (10), & (11) \end{vmatrix} \text{ is } z = \frac{a_1}{(x - \alpha_1)(y - \beta_1)}.$$

Similarly, by multiplying,

$$\left\| \begin{matrix} \frac{a_1}{(x - \alpha_1)} \cdot \cdot \cdot \cdot \cdot \cdot \\ \frac{a_1}{(x - \alpha_1)^2} \cdot \cdot \cdot \cdot \cdot \cdot \\ \frac{a_1}{(x - \alpha_1)^3} \cdot \cdot \cdot \cdot \cdot \cdot \end{matrix} \right\| \quad \left\| \begin{matrix} \frac{1}{y - \beta_1} \cdot \cdot \cdot \cdot \cdot \cdot \\ \frac{1}{(y - \beta_1)^2} \cdot \cdot \cdot \cdot \cdot \\ \frac{1}{(y - \beta_1)^3} \cdot \cdot \cdot \cdot \cdot \cdot \end{matrix} \right\|$$

we get that the primitive of

$$\begin{vmatrix} (00), & (01), & (02) \\ (10), & (11), & (12) \\ (20), & (21), & (22) \end{vmatrix} = 0,$$

is

$$z = \frac{a_1}{(x - \alpha_1)(y - \beta_1)} + \frac{a_2}{(x - \alpha_2)(y - \beta_2)}.$$

Similar primitives are obtained for differential equations, which are in the form of determinants of higher class. A further application is obtained by taking powers of different invariantive symbols, of which (123) is the simplest for the ternary quantic. The resulting invariants are seen to be determinants of some even class.—A geometrical note, by Mr. R. Tucker.—The President (Major MacMahon, F.R.S., in the chair) made an impromptu communication of a problem, the solution of which he thought would be subsidiary to the sought-for solution of the "stamp folding" problem.

Linnean Society, December 15.—Prof. Stewart, President, in the chair.—The President announced the recent death of Mr. H. T. Stainton, a Fellow and former Vice-President of the Society, and of European reputation amongst entomologists, by whom his loss would be widely felt.—Mr. D. Morris exhibited a series of botanical photographs from the west coast of Africa, and gave some interesting details about the appearance and mode of growth of some of the more remarkable forest trees and plants of that region.—The Secretary exhibited a large collection of photographs of Lichens, very neatly mounted and labelled, which had been recently presented to the Society by Prof. Arnold, of Munich.—On behalf of Mr. George Swainson, of St. Annes-on-Sea, Lancashire, Mr. A. R. Hammond exhibited an aquatic dipterous larva, belonging probably to the genus *Dixa*, of which by means of the oxyhydrogen lantern, with microscopic attachment, a good figure was projected on the screen. He referred to the different views which prevailed concerning the dorsal and ventral aspects of this larva, and pointed out that the tail-plates possessed features which in allied forms were characteristic not so much of the larval as of the pupal stage.—A paper was then read by Dr. Maxwell T. Masters, F.R.S., on the classification and geographical distribution of the *Taxaceæ* and *Coniferæ*, his remarks being illustrated by a specially prepared map, lent by Mr. C. B. Clarke, and by specimens of the fruit and leaves of some of the more notable forms.—Mr. George Brook followed with a paper on the affinities of *Madrepora*, and here again, by means of the oxyhydrogen lantern, an excellent series of coral sections was projected, which illustrated very clearly the author's remarks on comparative structure.—A short note on the abnormal form of the lens in the eyes of an albino rat, by Prof. R. J. Anderson, was read on his behalf by the Secretary. The meeting then adjourned to January 19, 1893.

Zoological Society, December 6.—Dr. St. George Mivart, F.R.S., Vice-president, in the chair.—The Secretary read a report on the additions that had been made to the Society's menagerie during the month of November 1892.—Dr. Hickson read a paper entitled "A Revision of the Genera of the *Alcyonaria Stolonifera*, with a description of one new genus and several new species." The author commenced by stating the grounds upon which it might be considered desirable to retain the suborder Stolonifera, and criticized the views of those who place these Alcyonarians in the suborder Alcyonida. Of the genera that had already been proposed only four could now be retained, namely, *Tubipora, Clavularia, Cornularia*, and *Sympodium*, and the author proposed to add one more, namely, *Stereosoma*. The genera *Sarcodictyon, Rhizoxenia, Cornularieila, Anthelia*, and *Gymnosarca* must be abandoned, and the species incorporated in the other genera. A description was then given of the new genus *Stereosoma*, a form found on the coast of North Celebes, distinguished from all other Stolonifera by certain characters of its tentacles and by the absolute non-retractability of its polypes. Several new species of *Clavularia* were then described from North Celebes, Diego Garcia, and Australia. This was followed by a summary of all the species of the genus known to science.—Mr. F. E. Beddard, F.R.S., read a description of the convolutions of the celebral hemispheres in certain rodents. The paper referred chiefly to *Dasyprocta Cœlogenys, Lagostomus, Hydrochœrus*, and *Dolichotis*, being the genera of rodents in which the brains show the greatest development of convolutions.—A communication was read from Prof. Collett, containing a description of a new monkey from S.E. Sumatra, for which he proposed the name *Semnopithecus thomasi*.—Mr. H. J. Elwes read the second portion of an account of the butterflies collected by Mr. W. Doherty in the Naga and Karen Hills and in Perak.

PARIS.

Academy of Sciences, December 19.—Annual Public Meeting.—The President, M. d'Abbadie, gave a brief survey of the life and work of those lost to the Academy by death during the year. Among these were the following members: M. D. D. A. Richet, distinguished for his medical discoveries; M. de Quatrefages de Bréau, the naturalist; M. Jurien de la Gravière, Vice-Admiral under the Empire; M. Pierre Ossian Bonnet, geometrician; Admiral Mouchez, late Director of the Paris Observatory. Foreign Associate: Sir G. B. Airy. *Académicien libre:* M. Lalanne. Correspondents: MM. Gilbert, Abria and Adams. The prizes were awarded as follows: The Grand Prize of the mathematical sciences to M. Hadamard for his solution of the problem of determining the number of primary numbers inferior to a given quantity. One Prix Bordin to M. Gabriel Koenigs for his solution of a problem concerning geodesic lines; another to M. Humbert for his work on hyperelliptic surfaces. The Prix Poncelet to the builders of the Forth Bridge, Sir John Fowler, and Sir Benjamin Baker; the Extra Prize of 6000 francs to M. Hédouin for his work on the Channel currents; the Prix Montyon to M. N. J. Raffard, civil engineer; the Prix Plumez to M. Augustin Normand, for his geometry of ships. In Astronomy, the Prix Lalande was doubled, and awarded to Mr. Barnard and Mr. Max Wolf; the Prix Damoiseau to M. Radau for his work on lunar inequalities of long period caused by planets; the Prix Valz to M. Puiseux for his researches on the *equatorial coudé* and other instruments; the Prix Janssen to M. Tacchini for his solar work. Statistics: The Prix Montyon to MM. M.

Bastié and J. Dardignac for works on the population of France and hygienic statistics respectively. Chemistry: The Prix Jecker to M. Bouchardat for his researches on the terebene carbon compounds. Mineralogy: The Prix Vaillant to M. Lacroix for his work on the application of optical characters to the determination of rocks and mineral species. Botany: The Prix Desmazières to M. Pierre Viala for his "Maladies de la Vigne"; the Prix Montagne—1000 francs to M. l'Abbé Hue, and 500 francs to Dr. F. Xavier Gillot for their mycological researches; the Prix de la Fons Mélicocq to M. Masclef for his "Botanic Geography of Northern France." Medicine and Surgery: Prix Montyon—one to MM. Farabœuf and Varnier for work on obstetric medicine, another to M. Javal for ophthalmometry, a third to M. Lucas Championnière for his work on hernia; the Prix Barbier was shared between M. Laborde ("Death by Chloroform") and MM. Cadéac and Albin Meunier ("Alcoholism," &c.); the Prix Bellion to Dr. Theodore Cotel for his work on "The Education of the Senses"; the Prix Lallemand was shared between M. Binet ("Les Altérations de la Personnalité") and M. Durand ("Les Origines Animales de l'Homme"). Physiology: the Prix Montyon to M. Hédon (diabetes) and M. Cornevin (breeding of domestic animals); the Prix Pourat to M. H. Roger for his researches on the inhibitory power of the nervous shock. Physical Geography: the Prix Gay to M. Moureaux (distribution of magnetic elements in France). General Prizes: Prix Montyon, for improvements in unhealthy industries, to M. L. Guéroult (crystal cutting); the Prix Delalande Guérineau, to M. Georges Rolland for his work on the Algerian Sahara; the Prix Jérôme Ponti, to M. Le Chatelier for his researches on dissociation and chemical equilibrium; the Prix Leconte (50,000 frcs.), to M. Villemin for his demonstration of the specific nature and the transmissibility of tuberculosis. The *Comptes rendus* contains a complete list of the prizes to be awarded in the next few years.

BERLIN.

Physical Society, November 18.—Prof. Du Bois Reymond, President, in the chair.—Prof. Neesen gave an account of experiments made with a view to the photographic recording of the oscillation of projectiles. He employed hollow projectiles in whose interior was placed a sensitive plate, illuminated by sunlight through a small opening. During its rotatory flight the ray of light described curves on the plate, from whose position, taken in conjunction with that of the sun, the oscillation of the axis and point of the projectile would be calculated. The results obtained showed that both the axis and point perform oscillatory movements during the flight which are very different from those usually believed to take place. In order to study these more accurately, Prof. Neesen is busy with the construction of some arrangement which may admit of the introduction into the projectiles of sensitive plates which shall not participate in the rotatory motion.

December 2.—Prof. Du Bois Reymond, President, in the chair.—Dr. Du Bois gave an account of experiments made by Mr. Shea in Berlin on the refraction of light in metals, and in connection with this referred to a theoretical treatise which he had recently published on the same subject in conjunction with Dr. Rubens.

Physiological Society, November 25.—Prof. Du Bois Reymond, President, in the chair.—Dr. Treitel gave an account of observations he had made on two snails enclosed in air-tight glass vessels. Dr. Ad. Baginski gave an account of a very fatal epidemic among rabbits in the same hutch, in which a post-mortem examination of the dead animals showed a serious affection of the liver and intestinal mucous membrane. The liver was filled with cysts of various sizes, in which, together with coccidiæ, some very remarkable growths were found, which led to very marked changes of the epithelial cells.—Dr. Rawitz made a short preliminary statement of observations on Annulata made during his stay at the biological station of Rovigno, on the coast of the Adriatic. While one species was found to be extremely sensitive to light, and to draw in its tentacles at once when shaded, another closely related species was quite unresponsive, while, on the other hand, it reacted immediately to the slightest touch. The first species was much less sensitive to touch.

AMSTERDAM.

Royal Academy of Sciences, October 29.—Prof. van de Sande Bakhuysen in the chair.—Prof. Engelmann spoke (1) on the influence of central and reflected irritation of the nervus opticus on the movement of the cones of the retina; and (2) on the theory of the contraction of muscles.—Prof. Schoute proved the following theorem:—If $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ is the equation of a given ellipse, E, and $f(x_1y)$ contains the terms of the nth order of the equation of a curve C^n with reference to the same axes. The sum A of the eccentric anomalies a_k of the 2_n points S_k common to E and C^n is determined by the relation

$$e^{iA}=\frac{f(a,\,ib)}{f(a,\,-ib)}.$$

He indicated several peculiar cases of this general theorem.—Prof. Kamerlingh Onnes communicated some measurements, by Mr. Leeman, relating to Kerr's phenomenon when reflection takes place at the pole of a cobalt-magnet. The constancy of the difference of phase S, discovered by Dr. Sissingh was confirmed. The measurements agree with the theory of Goldhammer, contrary to that of Drude. Mr. Leeman finds a magneto-optic dispersion in S.

November 26.—Prof. van de Sande Bakhuysen in the chair.—Prof. Schoute continued his communication of October 29, on a general theorem in the theory of plane curves, and corrects a theorem of Laguerre.—Prof. Lorentz dealt with the relative motion of the earth and the luminiferous aether.—Prof. Kamerlingh Onnes spoke of measures on the relation of spark length and difference of potential made by Dr. Borgesius at Groningen with a double bifilar electrometer of his own construction. The differences hitherto found are explained by a correction for pressure and temperature having been omitted. Discharge between two concentric cylinders depends, as Gaugain stated, on the density of the inner one only. Provoking glow discharge on the inner one of two concentric cylinders proves successful in maintaining constant high potentials.

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