THURSDAY, JUNE 19, 1873

JEREMIAH HORROX*

II.

IT is now time to pass to the particular incident which has immortalised the name of Horrox, his observation of the transit of Venus over the sun's disc on November 24, 1639 (O.S.) It would have been sufficient for his renown to have been the first witness of the phenomenon, but he had in addition the honour of supplying an omission of Kepler's, who had indeed predicted the transit of 1631, but had failed to point out the occurrence of another eight years subsequently. The transit of 1631 had not been observed owing to its occurrence at night, and that of 1639 had been foreseen by no one save Horrox, and was watched by no one but himself and his friend Crabtree, whom he apprised of the forthcoming event in a letter dated on the October 26 previous.

We borrow Mr. Whatton's account of the observation ("Life of Jeremiah Horrox," pp. 44—46).

"After having deliberated on the best method of making the observation, he determined to admit the sun's image into a dark room, through a telescope properly adjusted for the purpose, instead of receiving it through a hole in the shutter merely, as recommended by Kepler. He considered that by the latter method the delineation would not be so perfect, unless it were taken at a greater distance from the aperture than the narrowness of his apartment would allow; neither was it likely that the diameter of Venus would be so well defined; whereas his telescope, through which he had often observed the solar spots, would enable him to ascertain the diameter of the planet, and to divide the sun's limb with considerable accuracy. Accordingly, having described a circle of about six inches diameter upon a piece of paper, he divided its circumference into 360°, and its diameter into 120 equal parts. . . When the proper time came, he adjusted his apparatus so that the image of the sun should be transmitted perpendicularly to the paper, and exactly fill the circle he had described. From his own calculations he had no reason to expect that the transit would take place, at the earliest, before three o'clock in the afternoon of the 24th, but as it appeared from the tables of others that it might occur somewhat sooner, in order to avoid the chance of disappointment, he began to observe about mid-day on the 23rd. Having continued to watch with unremitting care for upwards of four-and-twenty hours, excepting during certain intervals of the next day when, as he tells us, he was called away by business of the highest importance, which could not with propriety be neglected, he was at length rewarded for his anxiety and trouble by seeing a large dark round spot enter upon the disc of light."

The "business of the highest importance" was undoubtedly divine service, the transit having taken place on a Sunday. Most modern astronomers of Horrox's profession would, no doubt, have considered the claims of science paramount on an occasion like this. Horrox, in accordance with the feeling of his day, judged otherwise, and when all the circumstances of the case are taken into account, his sacrifice on behalf of what he esteemed a higher duty, must be regarded as an act of extraordinary heroism. He had, it is true, almost convinced himself that the transit could not occur until the afternoon, but even this anticipation was a proof of courageous reliance on his own judgment, being founded on his correction of Kepler's Rudolphine tables, according to the data supplied by which it should have occurred at 8.8 A.M. The phenomenon was also observed by Crabtree, but less perfectly, owing to the cloudy state of the atmosphere at Manchester. A letter from Crabtree on the subject to another north-country astronomer, Gascoigne, contains the remarkable expression, "I do believe there are as rare inventions as Galileo's telescope yet undiscovered."

Horrox did not remain at Hoole much above six months after this great achievement. In July, 1640, we find him again at Toxteth, which he never afterwards left. He must, accordingly, have resigned his curacy, on what account is unknown, as is also the precise nature of his subsequent avocations. We only gather from his correspondence that his affairs were in a very unsettled state, that the duration of his stay at Toxteth was uncertain, and that he was continually called from home. From his complaints of the impossibility of prosecuting his astronomical researches, one would almost surmise that his occupation was nocturnal, especially as he found time for the observations on the tides already referred to. His sustained enthusiasm for astronomy, as well as the generosity of his temper, is touchingly shown in a letter congratulating his friend Crabtree on the success of some observations reported by him: "Your letter alone," he says, "has enough and more than enough to transport beyond all bounds a soul more master of itself than mine. My emotion and gladness are such as you will more easily understand than I express." After several postponements, he eventually fixes January 4, 1641, for a visit to Broughton, but the intention was frustrated by his sudden death on the morning of the preceding day. We learn this from an endorsement by Crabtree, who gives no particulars respecting the cause of death, and who himself, according to Dr. Wallis, only survived his friend for an extremely short period.

We are indebted to Crabtree for the preservation of Horrox's extant papers, those only having escaped destruction which were obtained by him after the writer's death. Of the remainder, part were destroyed during the Civil Wars; part carried to Ireland by Horrox's brother Jonas, who appears to have shared his scientific tastes, and there lost; another portion, after having aided in the compilation of Jeremiah Shakerley's astronomical tables, was destroyed in the great fire of 1666. Crabtree's MSS., happily including the autograph of the "Venus in Sole visa," were purchased after his death by Dr. Worthington, of Emmanuel College, subsequently Vicar of Hackney, and a copy of the "Venus," lent by him to the astronomer Hartlib, having found its way into the hands of Hevelius, was published by the latter in 1662. The Royal Society, just instituted in England, immediately took cognizance of the remainder of the MSS., and having obtained these from Dr. Worthington, placed them in the hands of Dr. Wallis, Professor of Geometry at Oxford, whose Latin translation was ultimately published in 1674. By a judicious arrangement of his materials he was enabled to digest these into a perfect treatise, to which he gave the title of "Astronomia Kepleriana Defensa et Promota." To this he added a translation of the scientific portion of

* Continued from p. 117.

Horrox's letters to Crabtree, to which we are indebted for most of our scanty biographical information. An inspection of the originals, should these have been preserved would probably contribute much to clear up doubtful points, and to complete our conception of Horrox's intellectual character. The main outlines of the latter, however, are sufficiently apparent. They comprise a marvellous patience and persistency, combined with wide-reaching activity, a philosophical faculty for generalisation, ambition, enthusiasm, and self-confidence. The versatility of his attainments is attested by the composition of his "Venus" in Latin, by the quotations in his letters from Horace and Juvenal, and by his reference to Raleigh's "History of the World." Of his restless energy and fertility of resource we have proof in the promptitude with which, when debarred from his favourite pursuit, he turns to the investigation of the tides. His grasp of general principles is displayed, among other passages, by a remarkable one in which he speaks of the possibility of illustrating the elliptic orbits of the planets by terrestrial analogies. "To which method of confirmation Kepler is always partial, and most justly, inasmuch as Nature throughout the universe is One, and the general harmony of creation causes the lesser things to be examples of the greater, as the revolution of the moon around the earth is an emblem or imitation of that of the stars around the sun." We have already had occasion to appreciate his enthusiasm; and the self-reliance usually associated with enthusiasm is powerfully evinced in another letter exhorting Crabtree to undertake, in conjunction with him, the preparation of a new set of astronomical tables. From some expressions in this it may be conjectured that he felt hurt at the ignorant comments of his neighbours, and his resentment against his false guide Lansberg, which occasionally transgresses the limits of what would be considered courtesy at the present day, is another indication of a sensitive spirit. When we add to these traits the self-denial manifested on occasion of the transit, and in the temporary renunciation of his astronomical researches in deference to the claims, as seems probable, of his family, we must recognise in Horrox no mere man of science, but a distinct individuality of singular force and attractiveness. His precise place in the scientific world must be left to astronomers to determine; it requires, however, no special knowledge of the science to apprehend that the obscure youth who, under every disadvantage, was able to correct Kepler, might, if only he could have continued at Cambridge, very probably have rivalled him. In him England lost the promise of an astronomer of the first class, which loss, like many a similar one, would have remained absolutely unknown, but for the fortunate conjunction of his name with a phenomenon of regular recurrence and universal interest. If the commemoration of his great achievement cannot be equally universal, it should at least transcend merely local limits. Local patriotism has done its part well; an appropriate memorial has been erected in the church at Hoole, and we are exceedingly indebted to Mr. Whatton for his intelligent memoir and valuable translation of the "Venus in Sole visa." More, however, is demanded, and it would redound to the credit of Horrox's countrymen if, on the December day of 1874, when English watchers scan the skies of another hemisphere for the transit of Venus, Englishmen at home were found dedicating a national monument to the first observer of the phenomenon in this.

JAGOR'S "PHILIPPINE ISLANDS"

Reisen in den Philippinen, von F. Jagor. Mit zahlreichen Abbildungen und einer Karte. (Berlin: Weidmannsche Buchhandlung. 1873.)

THE increasing importance which the Philippines are assuming in both English and American commerce, the comparative insufficiency of the information we possess concerning them, and the beauty and productiveness of nearly the whole region, amply justify the ardour with which the author of this volume has devoted himself to a thorough exploration of the group, and an exhaustive study of every feature of interest appertaining to its component islands and their population. In this very interesting and acceptable work he has given to the world the results of his observation and inquiries, and of these it may be said that, while in point of extent and variety they are sufficiently comprehensive to embrace within their limits every subject of interest or of practical importance to which we should expect to find a place assigned in a book of travels having any pretensions to completeness, they bear the evident impress of the patient, laborious research, and the careful examination and weighing of facts, for which his countrymen are famous.

M. Jagor can hardly be said to be a recent traveller in these islands. His journey through them was made in the years 1859 and 1860, but unforeseen circumstances put a sudden stop to it; and though fully intending to resume it at a later day, that purpose has not yet been accomplished. Although it must be admitted, therefore, that his work does not make its appearance with all that absolute freshness about it to which we are accustomed in these days of ocean steam-navigation, the apparently long interval which has elapsed since his visit has been profitably turned to account by him in the careful study of an immense mass of materials accumulated by himself during his stay, or which he obtained through the Spanish Colonial Minister, or found in the great national libraries of London and Berlin, including a few bulky monkish chronicles, the perusal of which last was a work both long and tedious. In the vast labour incident to the extraction from these various sources of their most important and most interesting details, he has been sustained by a conviction that his subject was worthy of it. He has felt, as he tells us, that few countries in the whole world are so little known or so seldom visited as the Philippines, while none present more agreeable attractions for the traveller, or have been more profusely endowed by the hand of Nature, or contain a larger store of neglected treasure for the natural historian. So strong and so abiding is his faith on this last point, he gravely assures his readers, that even poor travellers would amply cover the cost of their journey by the sale of their collections. Without going so far as to endorse this suggestion in its full and entire significance, it is nevertheless true that the descriptions here given constitute, in the aggregate, a picture of marvellous natural

wealth, of which it is on many accounts desirable that modern enterprise should have full and trustworthy information.

The travels recorded in this volume extended through the greater portion, certainly the most important and interesting, of the Spanish Philippines. Manila was the starting point. The author first made a short excursion northwards, thence into the province of Bulacan, and returning to Manila ascended the river Pasig, at the mouth of which it stands, to the great lake of Bay, crossing which he made several journeys into the province of Laguna. Returning thence to Manila, he crossed its magnificent bay, spacious enough to hold all the navies of the world, and proceeding by sea along the deeply indented southern coast of the great island of Luzon, and traversing the Straits of San Bernardino, landed at Albay, the chief town of the large insular province of the same name. From this point he made an excursion into the extreme southern districts of the island, visiting the great volcano of Balusan on his way, and returning to Albay, started thence in a north-westerly direction on a journey through southern Camarines. On this journey many natural features of the highest interest engaged his attention, and notably the great volcanoes of Mayon and Yriga, the Bateo Lake, and the remarkable siliceous wells near Tibi, with the great flat cones called the "white" and the "red," between which they lie—the whole of this district presenting one of the finest examples of calcareous depositions, in various states of advancement, in the whole world. Returning westwards to his main route, he reached Meroce Caceres, near the confines of northern and southern Camarines, and from this point made a considerable digression eastwards, for the purpose of visiting the vast volcano Ysarog, of which, and of the inhabitants of the region, he has given a full and highly interesting description. Again returning to his main route, he arrived at Cabusao on the Bay of San Miguel, and from this point, partly by land and partly by coasting, he explored about forty miles of the eastern coast of this portion of North Camarines, making occasional journeys inland where the prospect of reward seemed to invite attention. Returning to Albay, he embarked at that place for the next important island in this remarkable archipelago, Samar. There he landed at the north-eastern point, and crossing in a south-westerly direction to its western coast, coasted some twenty or thirty miles southwards to Carthalogan. From this place he traversed the centre of the island, and descending the river Ulut, reached the eastern side. He next coasted to its south-eastern extremity, and thence returned westwards, landing at Tacloban, the chief town of the closely adjacent island of Leyte, on which he made a journey many miles to the south. He then traversed the narrow Straits of San Francisco, which separate Samar and Leyte, visiting the ancient rock sepulchres in which the inhabitants of Bisay and some other localities interred the remains of their heroes and their elders. Continuing his return journey by sea, he again reached Manila, after having visited some minor islands, and obtained interesting information relative to them.

It would be vain to attempt, within the narrow limits of space available for our present purpose, anything like a substantial account of the innumerable matters of interest, with which M. Jagor's book deals. The mere enumeration of them would very considerably extend the proportions of an ordinary review, and there are many, very many, which present attractions of the highest order for the geographer, the geologist, the ethnologist, the naturalist, and others who interest themselves in certain special branches of modern science. All that can be done is to indicate a few of the more striking portions of the work, by which its character and completeness may be judged of, referring to the work itself—which we venture to think would well repay translation—those specially interested in its subject.

In his first chapter, the author makes some remarks on the situations of the group, and describes a few amusing circumstances which resulted from the ignorance of Magellan and his followers, of the difference of time depending upon difference of longitude. Such was the injudicious commercial policy of the Spaniards in those dependencies, that the intercourse between them and the Mother Country "was limited to the conveyance of officials and ecclesiastics, and their ordinary necessaries—provisions, wine, and other beverages (Caldos), and, a few French romances excepted, some very dull books—histories of Saints and other similar matters." As regards the aspect of Manila, despite the glowing descriptions of it given by many travellers, the author experienced considerable disappointment; his first impressions being received at a most unfavourable moment, since he landed towards the close of the dry season. The account he gives of the state of society in Manila and its suburbs is anything but inviting. "Life in the city proper can scarcely be agreeable: pride, envy, place-hunting, caste-hatred, are the order of the day. The Spaniards deem themselves superior to their Creoles, who, in their turn, reproach them with coming to the colony only to eat their fill. The same hatred and the same grudge exist between the whites and the half-castes." It appears that cock-fighting is the great pastime of the population. The social, political, and commercial condition of the colony is fully developed in the first four chapters of the book, and in connection with this part of the subject the author ventures on a few reflections on the future of the Philippines. He says:—"Now that the Eastern shores of the Pacific are at length becoming populated, and with unparalleled rapidity are advancing towards their great future, the Philippines can no longer remain in the exclusion which has hitherto been their lot; because, for the western coast of America, there is certainly no tropical Asiatic country so favourably situated; while as regards Australia, it is only in certain relations that Dutch India can dispute precedence with them. Their trade with China, on the contrary, whose staple-market Manila originally was, as also that with the western countries of Asia lying nearer to the ports of the Atlantic, they must for ever renounce."

The fifth chapter is devoted to a very clear and comprehensive exposition of the geography and the meteorology of the Archipelago, the political divisions of the Islands, their various populations, and the languages spoken in them.

On his first journey into the province of Bulacan, the author was much struck with the fertility of the soil, a subject upon which he has a good deal to say, as also

upon the contrivances used for fishing. There, too, as in other portions of his route, he became familiar with the ways of Spanish priests, and formed his experiences of native hospitality, besides learning something of the system of wholesale plunder which is carried on almost with impunity, on sea and on land, in this as in all other portions of the islands, where it is likely to pay. It appears, from the author's statements, that piracy is frequent on the coast, and that the country is likewise exposed to gangs of lawless marauders, against whom the Government is almost powerless, while the people are generally deprived of firearms, or, when provided with them, don't know how to use them. Occasionally they make descents upon the land, plundering wherever they go, often accompanying their rapacity with deeds of violence, even murder, and constantly carrying away their victims as prisoners.

Of the land and sea journeys of M. Jagor, generally, it may be said that they are full of incident, and that he never allows anything to escape his notice which may appear to him to be likely to have interest in the eyes of Europeans. From volcanic eruptions to the many odd incidents that presented themselves to him on his journey, nothing is unworthy of his attention, nor beyond his graphic power. His style is at once quiet, simple, and effective, and will delight every reader of German, by the ease with which it portrays the grandest or the most simple objects. He is always deeply impressed with the grandeur of the scenery through which his path lies, heightened as it often is by the beauty and luxuriance of tropical vegetation, and the majesty of primæval forests which extend their dense masses to the sea-margin. The natural productions of the country—animal, mineral, and vegetable—are the subject of copious mention ; and in connection with this part of the subject he has been at great pains to examine for himself, and put on record, the industrial and Governmental conditions under which all this mineral and other wealth is, or rather is not, made available for commerce. This is remarkably seen in his chapters on Manila hemp, and on the Government tobacco monopoly.

One of the most curious and interesting portions of the whole book is the twentieth chapter, which describes some remarkable antiquities in the narrow San Francisco strait, a locality whose picturesqueness the author extols, questioning much "whether the ocean anywhere laves a spot of such rich and peculiar beauty." The substance of this chapter, together with a few other portions of the work, has already appeared in Bastian and Hartmann's "Zeitschrift für Ethnologie." The remains referred to are certain ancient sarcophagi found in cavities in a series of marble-like rocks situated near the eastern entrance to the straits, and in a few other remarkable localities. These rocks rise out at sea to a height of a hundred feet. Their summits are dome-shaped, and their bases are much worn by the action of the sea. In these cavities the ancient Pintados, a race of tattooed Indians, and some other natives of the Archipelago, deposited the remains of their wives and elders as before adverted to. They placed them in carefully closed coffins along with the objects which in life they deemed most precious. Slaves were sacrificed at their burial, in order that they might not be without attendants in the next world. These spots were regarded with superstitious awe by the natives, who believed them to be haunted. A young Spanish clergyman led an expedition to some of the caves, and after some religious ceremonies, wrecked the coffins, and turned their contents into the sea. The superstition still lingers about the rocks, although much weakened. The author had some difficulty in finding men resolute enough to accompany him on an expedition having a somewhat different object in view, that of bringing away some of the relics. He succeeded, however, and the trophies were deposited by him in the Zoological Museum of Berlin University.

Profs. Roth and Virchow have contributed to the scientific portion of the book—the former dealing minutely with the geology of the group, the latter with its ancient and its more recent inhabitants. A copious appendix contains articles treating of the Islands under every possible aspect—historical, antiquarian, commercial, and governmental. The book is handsomely got up, and is printed in Roman characters, now getting more and more into use in Germany, and it is enriched with numerous admirably executed engravings, in various styles, from drawings made by the author on the spot, or obtained by him during his journey. A beautifully executed map is added, and the whole volume may be said to be an important and valuable contribution to the literature of its class.

MILLER'S ROMANCE OF ASTRONOMY

The Romance of Astronomy. By R. Kalley Miller, M.A. (Macmillan & Co., 1873.)

IT is in days of strongly marked utilitarianism, when so much is brought into the market that was never intended to go there, and so much of what is there is unfortunately rated at its marketable value only, that corresponding efforts should be made, by those who have the welfare of society at heart, to maintain the due balance of the human intellect by the cultivation of its imaginative faculty. It is here that poetry affords the noblest aid ; and even the profusion of modern fiction may be looked upon by the philanthropist with less regret ; if only moderately sensible and well-guided, it may lend important assistance in obviating that degeneration which would be the sure result of undue and excessive mental development in any one direction.

The work now before us, a curious little book with a curious title, may in this view of things not be without its value. It is a reprint and enlargement of some popular lectures which appeared in the *Light Blue ;* and the author tells us that his object "has not been so much to instruct as to entertain, and possibly in some cases to inspire a taste which might lead to the further prosecution of a most fascinating study ; and this will be his apology for passing over many important parts of the subject, and simply selecting a few points here and there which seem to afford scope for striking or amusing amplification." And in pursuance of this design, he brings before us a series of speculations as to the possible condition of other worlds, where fancy is allowed as full a range as the most romantic of readers can desire. As an amusing instance of his peculiar vein, the following passage may be cited : "The part of the moon which appears bright to us must

have any moisture which it may contain dried up by his (the sun's) vertical beams ; while on the other, or dark side, the ground must be frozen hard to the depth of several feet, the mountains covered with glaciers, and the seas blocked up with icebergs. At the very margin between the two hemispheres there will be a narrow temperate zone, which will of course move round the moon, as the latter turns round its axis and presents its different faces successively to the sun ; and the only way in which we can see that life could be supported with comfort at the moon (supposing the atmospherical difficulty surmounted) would be by moving constantly round it, so as to keep always in this temperate zone. A queer Noah's Ark-like sight it would be to see the whole inhabitants of the moon, side by side, in a huge procession extending from pole to pole, and hurrying quickly round it at the rate of ten miles an hour—some riding, some driving, and some travelling in slow railway trains ; beasts, wild and tame, galloping by their side, and all the birds of heaven flying along over their heads !" The chapter, too, on Astrology, is of a very diverting character, and above all, Zadkiel's horoscope of the heir-apparent to the British throne.

In the face of such an avowal as the author has made, anything like rigidity of criticism would be out of place : but we cannot help expressing regret that his always pleasing and often beautifully written descriptions should occasionally require the support of a more accurate statement of facts. We have so much respect for his ability, and admiration more especially for the high tone of his principle, as to hope that the book may reach a second edition : but in that case we should hope for the removal of several blemishes which it might seem invidious to point out, but which will be obvious to the scientific reader. T. W. W.

OUR BOOK SHELF

Proceedings of the Berwickshire Naturalists' Club, Vol. vi. No. 4.

THIS is, we believe, the oldest field-club in existence, and has all along been one of the most efficient and most prosperous so far as numbers and funds are concerned. Its publications, moreover, are already numerous, and contain much valuable material for the natural history, archæology, and antiquities of Berwickshire. There must be already a vast amount of material shut up in the transactions of the now numerous local societies, of the greatest value in reference to the natural history of this country and to students of biology generally, but almost inaccessible except to the members of the various societies. It is a pity that some means could not be devised for bringing the most important contributions to local natural history, in its widest sense, together in some systematised form, so that they could be readily referred to and made available to students at large. Sir Walter Elliot refers to this point in his able address on Provincial Scientific Societies, and it is to be hoped that the Committee appointed by the British Association will give it their consideration. Prefixed to the Proceedings before us is the President's, the Rev. F. R. Simpson's, address, which is wholly occupied with an interesting account of the various meetings of the club during the summer of 1872. For this society is purely a field club, meeting only during the summer months, to explore some of the rich vales of Berwickshire or stretch their limbs over some of the bonny Cheviot fells, gathering rich stores of varied knowledge, and finding a glorious appetite for the substantial dinner which usually winds up the meetings. One of the longest and most interesting papers is by one of the secretaries, Mr. James Hardy, "On Langleyford Vale and the Cheviots," being a sort of survey of the district between Wooler and the base of Cheviot, and containing a wonderful amount of information on the geology, botany, zoology, and especially the prehistoric antiquities of the district. Mr. Hardy also contributes some valuable entomological lists to this part of the Proceedings, and various antiquarian papers; while Mr. Robert Hislop has a list of the rarer Coleoptera occurring chiefly in the parish of Nenthorn. Sir Walter Elliot contributes a list of the diurnal birds of prey hitherto found within the club's limits. There are many other valuable papers including a memoir of the late Dr. William Baird, F.R.S., one of the founders of this old society, appended to which is a list of his many writings. There are two very well executed plates of flint implements and a sculptured stone, and a fine portrait of the Club's late Secretary, Mr. George Tate.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

Dr. Bastian's Turnip-Cheese Experiments

IN a former communication* I gave an account of a series of experiments by Dr. Bastian, in which it was established that, "by following his directions, infusions can be prepared which are not deprived by an ebullition of from five to ten minutes of the faculty of undergoing those chemical changes which are characterised by the presence of swarms of Bacteria, and that the development of these organisms can proceed with the greatest activity in hermetically sealed glass vessels, from which almost the whole of the air has been expelled by boiling."

In the first paragraph of that paper I adverted to the importance in every experimental inquiry of defining as completely as possible the method by which any given result can be attained. With this consideration in view, I now propose to give an account of additional experiments, made chiefly for the purpose of elucidating the influence of slight variations of temperature on the result. To guard against the possibility of mistake, it may not be unadvisable to remark that, whereas in the experiments previously reported upon, I took no part, excepting as a witness, I am exclusively answerable for those now to be recorded.

Certain particulars in Dr. Bastian's method have been objected to as possible sources of uncertainty. Thus it has been suggested that when a flask, of which the neck has been drawn out to a capillary orifice, is boiled even for ten minutes over a lamp, it is not certain that the whole of the liquid contained in it is heated to the temperature of boiling ; and again, that when the lamp is withdrawn in the act of closing the capillary orifice, germs may enter from without. Although I do not attach much importance to either of these objections, I have modified Dr. Bastian's method, so as to render them inapplicable. The modification, however, applies exclusively to the mode of heating the hermetically sealed flasks. As regards the preparation of the liquid, I have in no respects departed from his instructions.

The liquid is prepared by simmering slices of peeled turnip in a beaker containing about a pint of distilled water. The acid infusion thus obtained, is, if necessary, concentrated by evaporation until it possesses a specific gravity of from 1018 to 1020. It is then filtered and neutralised with sodic carbonate. A little Cheddar cheese is rubbed up with a few drachms of the liquid in a mortar, and the mixture strained through calico. By adding the strained product to the rest of the infusion a turbid liquid is obtained, in every drop of which particles of cheese can be detected by the microscope, although there are scarcely any of a sufficient size to be distinguished by the naked eye.

In the first four sets of experiments retorts were used, in the others flasks. In either case they were charged with the liquid of which the preparation has just been described (their necks having been previously drawn out), boiled over a spirit lamp, and sealed hermetically by directing the flame of the gas blow-

* See NATURE, vol. viii. p. 180.

pipe on the orifice at the same moment that the lamp was withdrawn. The experiments of the first two sets may be regarded merely as more exact repetitions of the former ones. Their results are confirmatory of those previously obtained. In the others the flasks were subjected to the temperature of ebullition under pressures exceeding that of the atmosphere. Although the excess of temperature in no case exceeded two degrees and a half, it will be seen that it exercised a decided influence on the results.

The pressures employed varied from one-tenth of an inch to three inches of mercury. According to * Wüllner's table, founded on those of Régnault and Magnus, an excess of 27 63 mill. over the normal pressure (760 mill.), determines an increase of 1° C. in the temperature of boiling, so that here 0°·924 C. corresponds to one inch of pressure. Similarly we have 0° 88 for the second inch, and 0°·873 for the third inch. In other words 100°·92 C. is the temperature of ebullition at one inch, 101°·81 at two inches, 102°·68 at three inches. In describing the experiments I use the expression "turnip-cheese" liquid to denote the neutral infusion of turnip with cheese of which the preparation has been given above; and in recording the results the words barren and pregnant are employed to express the absence or presence of living Bacteria. In any liquid which has been kept five days at the temperature of fermentation there is no difficulty in determining in which of these two conditions it is, for if Bacteria are present at all they are present in such numbers that every field is crowded with them. Bodies which appear to be dead Bacteria are met with here and there in every specimen. They are as numerous in liquids examined immediately after prolonged boiling as in others. They are probably derived from the cheese.

The retorts or flasks were examined after periods varying from three to six days, during which they were kept in the warm chamber at 32° C. Each was tested by observing that when the point of the blow-pipe flame was directed on the neck of the flask the softened part was first drawn in and then gave way with a loud crack.

With these preliminary observations I proceed to give an account of the experiments.

March 1.—Two retorts were charged with turnip-cheese liquid of which the specific gravity was 1017·2, each retort receiving 25 c.c. One was immersed in boiling water in a saucepan for an hour and then placed in the warm chamber: the other was placed in the chamber at once, *i.e.* immediately after it was boiled and closed hermetically. Both were examined on the 4th. The first was barren, the second pregnant.

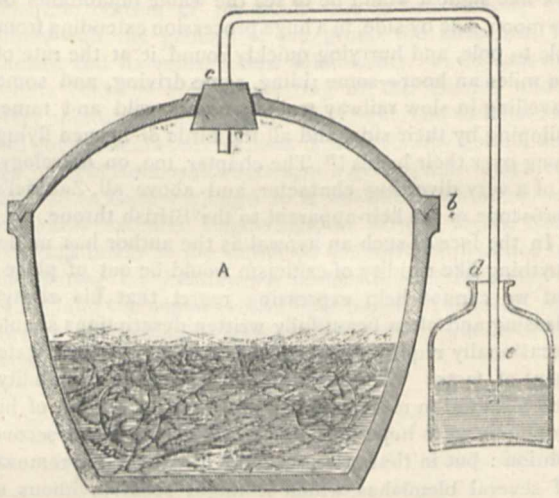
March 4.—Nine retorts were charged with cheese-turnip liquid, sp. gr. 1020. Each contained 35 c.c. After having been boiled and closed hermetically, eight of the retorts were successively subjected in couples to the temperature of boiling water in a digester.

The construction of the digester was such that during the ebullition, which in each case was continued for 15 minutes, steam escaped through various narrow openings. The heating of the retorts was accomplished in four processes, each couple of retorts being heated separately and the valve differently weighted in different cases. Thus in three ebullitions the weights employed were severally 2 lbs., 4 lbs., and 6 lbs., while in the fourth, no weight was added to that of the valve itself. The experiment was planned in this way in order that the influence of pressure might be observed, but in carrying out, it was at once observed that with this view the method was a futile one, for steam escaped so readily in each experiment through the valve that there could be no doubt that all the retorts were in reality subjected to the same temperature, *i.e.* to the ordinary temperature of ebullition. The ninth retort was treated in the same way as the others with this exception, that the ebullition was continued for an hour, the valve remaining open.

The liquids were examined March 10. Of the eight which were immersed in boiling water for 15 minutes, all were pregnant. The ninth retort was barren.

March 13.—Six retorts were charged with turnip-cheese liquid, sp. gr. 1018, after which they were boiled and closed hermetically as before. The retorts were immersed in boiling water as previously, but the experiment was so planned that the pressure under which ebullition took place could be increased at will. The arrangement of the apparatus will be best understood from the diagram. A is a strong iron pot (or digester), the lid of which fits it by a grooved joint *b*. To render the joint air-tight, the groove is filled with white lead before fitting on the lid, which is then tightly wedged into its place. The valve having been removed, the orifice of the digester is stopped by a vulcanite plug, *c*, through which the long tube passes. This forms a perfect joint, for the greater the internal pressure, the more tightly it fits. The end of the tube dips into mercury contained in a large bottle, *e*, and is retained in its place by a holder at *d*, not shown in the diagram. The pot is half filled with water containing a quantity of hay, among which the flasks are arranged. It is supported on a triangle and heated by a Bunsen's burner, the mercury bottle being raised on blocks until the end of the tube dips to about the right depth under the surface of the metal. A more exact adjustment is attained by means of the holder already mentioned.

In this apparatus the six retorts were subjected to the temperature of ebullition under various pressures, viz., two under a pressure of three inches, two under a pressure of four inches,



and two under a pressure of two inches. The period of heating in each case was fifteen minutes. All of the flasks were placed, after heating, in the warm chamber at 32° C., and were examined March 18. All were barren.

March 22.—Four retorts were charged with turnip-cheese liquid, sp. gr. 1019, each receiving 50 c.c. Of these two were heated in the apparatus at the temperature of ebullition under a pressure of one inch, the other two under a pressure of half an inch. Of each couple one was accidentally broken. Both the remaining ones were examined March 27, and found to be barren.

May 7.—Nine flasks were charged with turnip-cheese liquid, sp. gr. 1019, each flask containing 50 c.c. Of these, four were subjected to the temperature of water boiling under pressure of one inch of mercury for thirty minutes, and four for the same period to the temperature of ebullition under one-tenth of an inch. They were examined May 12. Of each set one contained Bacteria, the rest being barren. The liquid in the other flask, which was simply boiled, and closed while boiling, had an offensive smell, and contained much scum.

May 22.—Thirteen flasks were charged with turnip-cheese liquid, sp. gr. 1019·5. Of these six were subjected to the temperature of ebullition at three inches, and six to the ordinary temparature of boiling water. The remaining flask, after having been closed hermetically in ebullition in the same way as the rest, was placed with them in the warm chamber. All the flasks were examined May 26. All the six flasks of the first set were barren. Of the six flasks of the second set four were barren, the others contained innumerable living Bacteria. The liquid in the other flask was offensive, and contained masses of bacterial scum.

After the examination several of the flasks containing barren liquids, particularly those which had been heated under pressure, were replaced in the warm chamber. Some of them were simply closed hermetically (the liquid having been taken for examination by means of a freshly drawn out capillary tube), others were closed after the introduction of a drop of distilled water. On opening these flasks several days afterwards, it was found that those which had been impregnated by the addition of

* Wüllner, Lehrbuch der Experimentalphysik, B. III., p. 559.

the distilled water were full of Bacteria, the others remaining barren. This was done to show that the liquid, although deprived of its power of germination, is as capable as before of supporting the life of Bacteria.

The results of the preceding experiments may be summed up as follows:—In sixteen experiments the liquids were subjected to the temperature of boiling at the normal pressure; of these, eight were heated for 15 minutes, and all bred Bacteria; six were heated for 30 minutes, of which two bred Bacteria; two for an hour, both of which were barren.

Of ten subjected to the temperature of ebullition at pressures not exceeding one inch, eight were barren. Both the liquids which were found to be pregnant had been heated for 30 minutes, one under a pressure of one-tenth of an inch, the other of one inch.

In the twelve experiments in which the liquids were heated under pressures exceeding one inch, all were barren, although half of them were subjected to that temperature for only 15 minutes.

It is unnecessary for me to draw any inferences from the preceding experiments; it may not, however, be superfluous to point out that, although all the flasks heated above 101° C. remained sterile, this fact affords no ground for concluding that any definite relation exists between that precise temperature and the destruction of the germinating power of the liquid in question. All that has been shown is that the *chance* that such a liquid will breed Bacteria is diminished either by slightly increasing the temperature to which it is heated, or increasing the duration of the heating. Thus it appears to me quite probable that if a sufficiently large number of flasks were heated even to 102° C., some of them would still be found to be pregnant.

University Coll., London, June 7 J. BURDON SANDERSON

Fertilisation of the Pansy.—Ground Ivy

THERE is one further point in the structure of *Viola tricolor* which is not mentioned by Mr. Bennett or by Mr. Hart, but which seems to confirm the theory of the former gentleman that *V. tricolor*, as distinguished from most other Violas, is fertilised by a small insect such as Thrips instead of by the proboscis of larger insects.

Before I saw Mr. Bennett's paper, my attention had been called by Miss Dowson to the fact that whereas in the Sweet and Dog Violets, the circle of anthers presses close to the style all round, there is in *V. tricolor* an opening between the two appendaged stamens. The use of this opening will evidently be to allow the small creature to enter in and crawl down the stamen to the nectary at the end of the appendage. This structure may be also seen in *V. cornuta*, which seems to be fertilised in the same way. In *V. tricolor* the opening is exactly opposite to the black streak, or guide-post, as Mr. Bennett has termed it. In *V. cornuta*, although this black mark is not so evident, there is a distinct triangular mark pointing downwards exposed by the opening of the stamens. On each side of the style are two sets of hairs, looking like "whiskers" to the scull-like crest of the style, on which lots of pollen rest. The small insect on entering the flower can hardly help crawling into the cavity at the top of the stigma, for the entrance to the flower is almost completely blocked up by it. On emerging from it it would crawl over the top, which Mr. Hart mentions as seen in *tricolor*, and which I also find in *cornuta*, be guided through the hole by the triangular mark, and so find his way to the nectary. On emerging, covered with pollen, and entering its next flower, it will again be deluded into the *cul-de-sac* in which the stigmatic surface is, where it will deposit its pollen. The details of the structure of the appendaged stamens, as contrasted with those of other Violas, fully bear out this view.

As regards the English translation for the German *bestäuben*, I would suggest to Mr. Hart that "pollenate" is an impossible word; *pollen, pollinis*, must give the verb to "pollinate," as *fulmen, fulminis* gives *fulminate*. But there is a great advantage in a word which speaks for itself, and, if the word "be-pollen" offends scientific ears (Mr. Hart does not tell us why), would the literal translation of the German "to be-dust" be offensive? If not, I think it would tell its own tale. The word "empollen" seems justified by *embalm*, but the prefix generally means to place in or convert into, as in *enthral, emprison, embed*. Hence it would at least be ambiguous.

The form of Ground Ivy mentioned by your correspondent S.S.D. grows here abundantly in several spots, seeds freely, and is remarkable for having a much shorter style in proportion to the tube of the corolla than the common form in which the style and stigmas protrude from the tube. F. E. KITCHENER

Rugby, June 15

Mr. Kitchener having been kind enough to send me the above letter, I may, perhaps, be allowed to add a few additional notes. Since writing the former paper I have had the opportunity of examining three other species of *Viola*, *V. calcarata*, *elatior*, and *lactea*, all of which present a remarkable contrast to *V. tricolor* in a very curious point of structure. In *V. tricolor* the stigma is brought into close contact with the lowest petal by a very peculiar "knee" in the style, the effect of which is so completely to close up the central cavity of the flower as to render it extremely difficult for any large insect to insert its proboscis into the spur. In all the three species above-named, which I believe to be fertilised by bees, the style is nearly straight, so as to leave a considerable gap between the stigma and lower petal, quite large enough for the insertion of the proboscis of a bee. In none of these is there the least indication of the black triangular streak on the style which I take to serve, in *V. tricolor*, the purpose of guiding the Thrips to the nectary. The ring of anthers is also perfectly closed, as described by Miss Dowson in the case of the Dog and Sweet Violet, there being no opening for the admission of the small insect, as in the pansy. A striking difference in the form of the stigma also favours the same conclusion as to the mode of fertilisation.

ALFRED W. BENNETT

ON THE ORIGIN AND METAMORPHOSES OF INSECTS*

VI.

THE metamorphoses of insects have always seemed to me one of the greatest difficulties of the Darwinian theory. In most cases, the development of the individual reproduces to a certain extent that of the race; but the motionless, imbecile pupa cannot represent a mature form. No one, so far as I know, has yet attempted to explain, in accordance with Mr. Darwin's views, a life history, such as that of a butterfly, in which the mouth is first mandibulate and then suctorial. A clue to the difficulty may, I think, be found in the distinction between developmental and adaptive changes; to which I have called attention in a previous article. The larvæ of insects are by no means mere stages in the development of the perfect animal. On the contrary, they are subject to the influence of natural selection, and undergo changes which have reference entirely to their own requirements and condition. It is evident, then, that while the embryonic development of an animal in the egg may be an epitome of its specific history, this is by no means the case with species in which the immature forms have a separate and independent existence. If an animal when young pursues one mode of life, and lives on one kind of food, which subsequently, either from its own growth in size and strength, or from any change of season, alters its habits or food, however slightly, it immediately becomes subject to the action of new forces: natural selection affects it in two different and, it may be, very distinct manners, gradually leading to differences which may become so great as to involve an intermediate period of change and quiescence.

There are, however, peculiar difficulties in those cases in which, as among the Lepidoptera, the same species is mandibulate as a larva, and suctorial as an imago. From this point of view *Campodea* and the Collembola (*Podura*, &c.) are peculiarly interesting. There are among insects three principal types of mouth—first, the mandibulate; secondly, the suctorial; and thirdly, that of *Campodea* and the Collembola generally, in which the mandibles and maxillæ are retracted, but, though far from strong, have some freedom of motion, and can be used for biting and chewing soft substances. This type is intermediate between the other two. Assuming that certain representatives of such a type found themselves in circumstances

* Continued from p. 109.

which made a suctorial mouth advantageous, those individuals would be favoured by natural selection in which the mandibles and maxillæ were best calculated to pierce or prick, and their power of lateral motion would tend to fall into abeyance; while, on the other hand, if powerful masticatory jaws were an advantage, the opposite process would take place.

There is yet a third possibility—namely, that during the first portion of life, the power of mastication should be an advantage, and during the second that of suction, or *vice versâ*. A certain kind of food might abound at one season and fail at another, might be suitable for the animal at one age and not at another: now in such cases we should have two forces acting successively on each individual, and tending to modify the organisation of the mouth in different directions. It will not be denied that the ten thousand variations in the mouth-parts of insects have special reference to the mode of life, and are of some advantage to the species in which they occur. Hence no believer in natural selection can doubt the possibility of the three cases above suggested, the last of which seems to explain the possible origin of species which are mandibulate in one period of life and not in another. The change from the one condition to the other would no doubt take place contemporaneously with a change of skin. At such times we know that, even when there is no change to form, the temporary softness of the organs precludes the insect from feeding for a time, as, for instance, is the case with the silkworm. When, however, any considerable change was involved, this period of fasting would be prolonged, and would lead to the existence of a third condition, that of the pupa, intermediate between the other two. Since other changes are more conspicuous than those relating to the mouth, we are apt to associate the existence of a pupa-state with the acquisition of wings: but the case of the Orthoptera (grasshoppers, &c.) is sufficient proof that the development of wings is perfectly compatible with continuous activity; so that in reality the necessity for rest is much more intimately connected with the change in the constitution of the mouth, although in many cases no doubt the result is accompanied by changes in the legs, and in the internal organisation. An originally mandibulate mouth, however, like that of a beetle, could not, I think, be modified into a suctorial organ like that of a bug or a gnat, because the intermediate stages would necessarily be injurious. Neither, on the other hand, for the same reasons, could the mouth of the Hemiptera be modified into a mandibulate type like that of the Coleoptera. But in *Campodea* and the Collembola we have a type of animal closely resembling certain larvæ which occur both in the mandibulate and suctorial series of insects, and possessing a mouth neither distinctly mandibulate, nor distinctly suctorial, but constituted on a peculiar type capable of modification in either direction by gradual change, without loss of utility.

In discussing this subject it is necessary also to take into consideration the nature and origin of wings. Whence are they derived? why are there normally two pairs? and why are they attached to the meso- and metathorax? These questions are not less difficult than interesting. It has been suggested, and I think with justice, that the wings of insects originally served for aquatic and respiratory purposes. From the various modes by which respiration is effected among the different groups of aquatic insects, there are strong reasons for concluding that the original insect stock was, like *Campodea* (Pl 3, Fig. 5), a land animal. But in aquatic insects there is a tendency to effect the purification of the air through the delicate membraneous covering of more or less leaf-like expansions of the skin. In the larva of *Chloëon* (Pl. 4, Fig. 1), for instance, that singularly resembles *Campodea* (Pl. 3, Fig. 5), several of the segments are provided with such foliaceous expansions; which, moreover, are in constant agitation, the muscles of which, in several remarkable points, resemble those of the true wings. It is true that in *Chloëon* the vibration of the so-called branchiæ is scarcely, if at all, utilised for the purpose of locomotion; the branchiæ are, in fact, placed too far back to act efficiently. The situation of these branchiæ differs in different groups; indeed, it seems probable that originally there were a pair on each segment. In such a case, those branchiæ, situated near the centre of the body, neither too much in front nor too far back, would serve the most efficiently as propellers. The same causes which determined the position of the legs would affect the wings also. Thus a division of labour would be effected; the branchiæ on the posterior segments of the thorax would be devoted to locomotion; those on the abdomen to respiration. This would tend to increase the development of the thoracic segments, already somewhat enlarged to receive the muscles of the legs.

That wings may be of use to insects under water is proved by the very interesting case of *Polynema natans*, which I discovered in 1862, and which uses its wings to swim with. This, however, is a rare case; and it is possible that the principal use of the wings was, primordially, to enable the mature forms to pass from pond to pond, thus securing fresh habitats and avoiding in-and-in breeding. If so, the development of wings would tend to be relegated to a late period of life; and by the tendency to the inheritance of characters at corresponding ages, to which Mr. Darwin has called attention,* the development of wings would be associated with the maturity of the insect. Thus the late acquisition of wings in the Insecta generally, seems to be itself an indication of their descent from a stock which was at one period aquatic in its habits, and which probably resembled the present larvæ of *Chloëon* in form, but had thoracic as well as abdominal branchiæ.

If these views are correct, the genus *Campodea* must be regarded as a form of remarkable interest, since it is the living representative of a primæval type from which not only the Collembola and Thysanura, but the other great orders of insects have all derived their origin.

Finally, from the subject of metamorphoses we pass naturally to that most remarkable phenomenon which is known as the "Alternation of Generations:" for the first systematic view of which we are indebted to my eminent friend Prof. Steenstrup.

I have always felt it very difficult to understand why any species should have been created in this double character; nor, so far as I am aware, has any explanation of the fact yet been attempted. Yet insects offer, in the metamorphoses which they go through, a phenomenon not altogether dissimilar, and give a clue to the manner in which alternation of generations may have originated.

The caterpillar owes its difference from the butterfly to the early stage at which it leaves the egg; but its actual form is mainly due to the influence of the conditions in which it lives. If the caterpillar, instead of changing into one butterfly, produced several butterflies, we should have an instance of alternation of generations. Until lately, however, we knew of no such case; each larva produced one imago, and that not by generation but by development. It has long been known, indeed, that there are some species in which certain individuals remain always apterous, while others acquire wings. Many entomologists, however, regard these abnormal individuals as perfect, though wingless insects; and therefore, though these cases appear to me to deserve more attention than they have yet received, I shall not found any argument on them.

Recently, however, Prof. Wagner of Kazan, has discovered that, among certain small gnats, the larvæ do not themselves directly produce the perfect insect, but give rise to other larvæ, which undergo metamorphoses of

* Origin of Species, 4th ed. pp. 14 and 97.

the usual character, and eventually become gnats. His observations have been confirmed, as regards this main fact, by other naturalists; and there can, I think, be no doubt that they are, in the main, correct.

Here, then, we have a distinct case of alternation of generations, as characterised by Steenstrup. Probably other cases will be discovered in which insects undeniably in the larval state will be found to be fertile. Nay, it seems to me possible, if not probable, that some larvæ which do not now breed, in the course of ages may come to do so.

If this idea is correct, it shows how the remarkable phenomenon known as alternation of generations may have originated. At any rate, we find among insects every mode of development; from simple growth on the one hand, to well-marked alternation on the other. In the wingless species of Orthoptera there is little difference, excepting in size, between the young larva and the perfect insect. The growth is as simple and gradual as in any other animal; and the creature goes through nothing which would, in ordinary language, be called a metamorphosis. In the majority of Orthoptera the presence of wings produces a marked difference between the larva and the imago. The habits, however, are nearly the same throughout life, and consequently the action of external circumstances affects the larva in the same manner as the perfect insect.

This is not the case with the Ephemeridæ. The larvæ do not live under the same conditions as the perfect insects; external forces accordingly affect them in a different manner; and we have seen that they pass through some changes which bear no reference to the form of the perfect insect: these changes, however, are for the most part very gradual. The caterpillars of Lepidoptera have even more extensive changes to undergo; the mouth of the larva, for instance, is remarkably unlike that of the perfect insect. A change in this organ, however, could hardly take place while the insect was still growing fast, and consequently feeding voraciously. Nor, even if the change could be thus effected, would the mouth, in its intermediate stages, be in any way fitted for biting and chewing leaves. The same reasoning applies also to the digestive organs. Hence the caterpillar undergoes little, if any, change, except in size, and the metamorphosis is concentrated, so to say, into the last two moults. The changes then become so rapid and extensive, that the intermediate period is necessarily one of quiescence.

Owing to the fact that the organs connected with the reproduction of the species come to maturity at a late period, larvæ are generally incapable of breeding. There are, however, some flies which have viviparous larvæ, and thus offer a typical case of alternation of generations, owing to the early period of leaving the egg, and the action in many cases of external circumstances on the larva different from those which affect the mature form.

Thus, then, we find among insects every gradation, from the case of simple growth to that of alternation of generations; and we see how from the single fact of the early period at which certain animals quit the egg, we can account for their metamorphoses and for the still more remarkable phenomenon that, among many of the lower animals, the species is represented by two very different forms. We may even, from the same considerations, see reason to conclude that this phenomenon may in the course of ages become still more common than it is at present. As long, however, as the external organs arrive at their mature form before the internal generative organs are fully developed, we have cases of metamorphosis; but if the reverse is the case, then alternation of generations often results.

The same considerations throw much light on the remarkable fact, that in alternation of generations the reproduction is, as a general rule, agamic in the one form. This results from the fact that reproduction by distinct sexes requires the perfection both of the external and internal organs; and if the phenomenon arise, as has just been suggested, from the fact that the internal organs arrive at maturity before the external ones, reproduction will result in those species only which have the power of agamic multiplication.

Moreover it is evident that we have in the animal kingdom two kinds of dimorphism.

This term has usually been applied to those cases in which animals or plants present themselves at maturity under two different forms. The different forms of ants and bees afford us familiar instances among animals; and among plants the remarkable case of the genus *Primula* has recently been worked out with his usual ability by Mr. Darwin. Even more recently he has made known to us the still more remarkable phenomenon afforded by the genus *Linum*, in which there are three distinct forms, and which therefore offers an instance of polymorphism.*

The other kind of dimorphism or polymorphism differs from the first in resulting from the differentiating action of external circumstances, not on the mature, but on the young individual. The different forms, therefore, stand towards one another in a relation of succession. In the first case the chain of being divides at the extremity; in the other it is composed of dissimilar links. Many cases of dimorphism under this second form have been described under the name of alternation of generations.

The term, however, has met with much opposition, and is clearly inapplicable to the differences exhibited by insects in different periods of their life. Strictly speaking the phenomena are very frequently not alternate, and, in the opinion of many eminent naturalists, they are not cases of generation at all.†

In order, then, to have some name for these remarkable phenomena, and to distinguish them from those cases in which the *mature* animal or plant is represented by two or more different forms, I think it would be convenient to retain for these latter exclusively the terms dimorphism and polymorphism; and those cases in which animals or plants pass through a succession of different forms might be distinguished by the name of dieidism or polyeidism.

The conclusions, then, which I think we may draw from the preceding and other considerations are:—

1. That the occurrence of metamorphoses arises from the immaturity of the condition in which some animals quit the egg.

2. That the form of the insect larva whenever it departs from the original vermiform type, depends in great measure on the conditions in which it lives. The external forces acting upon it are different from those which affect the mature form; and thus changes are produced in the young which have reference to its immediate wants, rather than to its final form.

3. That metamorphoses may therefore be divided into two kinds, developmental and adaptational.

4. The apparent abruptness of the changes which insects undergo arises in great measure from the hardness of their skin, which admits no gradual alteration of form, and which is itself necessary in order to afford sufficient support to the muscles.

5. The immobility of the pupa or chrysalis depends on the rapidity of the changes going on in it.

6. Although the majority of insects go through three well-marked stages after leaving the egg, still a large number arrive at maturity through a somewhat indefinite number of slight changes.

* Of course all animals in which the sexes are distinct are in one sense dimorphic.

† "There is no such thing as a true case of 'alternation of generations in the animal kingdom; there is only an alternation of true generation with the totally distinct process of gemmation or fission."—*Huxley on Animal Individuality*, Ann. and Mag. of Nat. Hist., June 1852.

7. When the external organs arrive at this final form before the organs of reproduction are matured, these changes are known as metamorphoses; when, on the contrary, the organs of reproduction are functionally perfect before the external organs, or when the creature has the power of budding, then the phenomenon is known as alternation of generations.

8. Thus, then, it appears probable that these remarkable phenomena may have arisen from the simple circumstance that certain animals leave the egg at a very early stage of development, and that the external forces acting on the young are different from those which affect the mature animal.

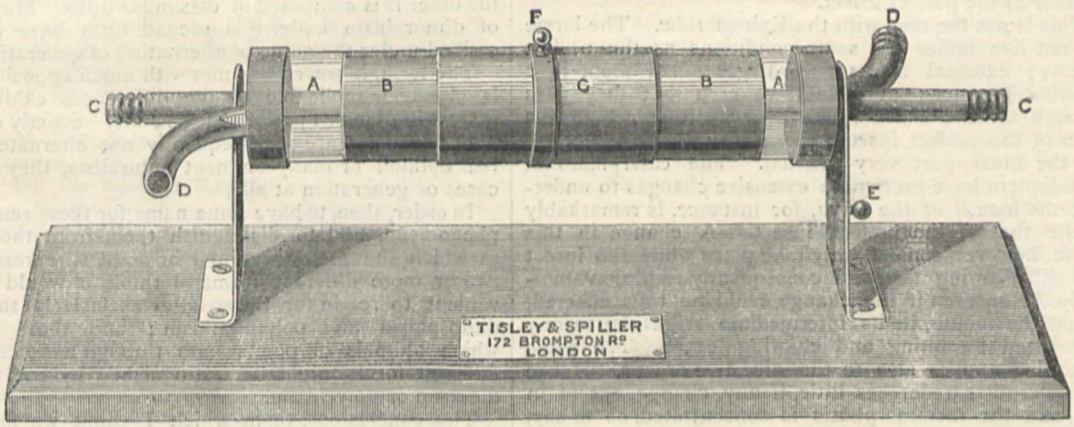
JOHN LUBBOCK

(*To be continued.*)

ON AN IMPROVED FORM OF OZONE GENERATOR

A SHORT description of an improved form of ozone generator, exhibited at the last meeting of the Chemical Society, may perhaps be interesting to the readers of NATURE.

Probably no apparatus hitherto introduced, for the production of ozone by electric induction, has in its working during the time it was in use was successfully neutralised. Such an apparatus works exceedingly well but requires delicate handling, and is not perhaps very well adapted for having other pieces of apparatus attached to it.



New Ozone Generator.

This new instrument is an improved modification of the above, but permits of a continuous stream of water of any required temperature being maintained through it; and further, the annular space which in the case of glass tubes is often very irregular, causing thereby an unequal electrical discharge, is made as true as possible, and the result is a more uniform conversion of the gas into ozone. The apparatus as at present made will be better understood by the following description referring to the accompanying diagram:—A A is a piece of glass tube of a little more than one inch in diameter, and of as uniform a bore as can be obtained. On each end of this tube is placed a brass cap, bored with two holes, and coated internally with shellac; in the interior of this glass tube and of a diameter scarcely less than that of the tube itself, but not quite so long, is placed a thin hollow brass box, B B, with its surface made as true as possible by turning in a lathe; this brass box is placed concentrically with the outer tube and is completely coated on its exterior surface with tin, the tin being acted upon to the smallest extent by the ozone. This hollow box communicates with the exterior of the apparatus by means of the tubes C C passing through the centre of the caps. It is intended that a current of water shall be kept circulating through the interior of this box, the water being brought into direct contact with its sides by means of a small spiral placed within it, the box being of a slightly less diameter than the glass tube, a small annular space will remain between the two, and through this space the gas to be ozonised is passed by means of the tubes D D; the box itself is made one of the electrified surfaces, and a strip of tin foil G, fixed to the outside of the glass tube, forms the other; two binding screws, E and F, serve to make the necessary connections with an induction coil.

The production of ozone by this apparatus is exceedingly regular and constant. No quantitative estimations with iodide of potassium and sulphurous acid have as yet been made with regard to the amount of ozone obtained, but an approximate experiment upon the quantity of indigo bleached in a given time, seems to indicate that this amount is quite equal to, if not rather in excess of, that obtained when the ordinary apparatus is used. This instrument possesses also some minor advantages; it is not so easily broken, other pieces of apparatus are very readily attached to it, and at the same time its cost is less. There appears to be no reason why larger forms should not be manufactured upon the same principle. These instruments are made by Messrs. Tisley and Spiller of Brompton.

THOS. WILLS

THE LAW OF STORMS DEVELOPED*

II.

IT has been asserted lately that the Gulf Stream has no influence upon storms; that they have no tendency to run toward it or to run upon it; and that what geographers and seamen have always said about the Gulf Stream as a "weather-breeder" and "storm-king" is absurd. I think it can be demonstrated that this well-known popular belief is not absurd.

It is an observation as old as Aristotle, that the storms of the middle latitudes in the Northern Hemisphere advance from west to east. This is obviously partly due to the fact that the winds on their eastern sides are southerly, that they come from the equatorial regions, and hence are highly charged with aqueous vapour. This vapour is absolutely essential to the sustenance of the storm. Moreover, the law of storms requires that the southerly winds should enter the storm-vortex on the eastern side, and as this is the side on which the greatest quantity of vapour is found, and the side of greatest condensation, of the greatest evolution of latent heat, hence of the greatest aërial rarefaction and barometric fall, to this side the heavier air from the west will push as into a great hollow. Thus do we actually find that all storms, formed west of the Gulf Stream, are actually propagated toward it. It may be argued from the above facts that the anti-trade winds are thus maintained by storms incessantly making the circuit of the globe within the temperate zone. But in reality, instead of being the effect of storm influence, the anti-trades are originated by independent solar agency, as are the trades, and they are potential and causal in producing the eastward progression of all cyclones. It must be conceded that the pressure of vast aërial currents does serve to force the meteor along with them as the river-eddy is carried down stream with the water-current; otherwise it is impossible to explain the westward progression of tropical hurricanes. While yet in the band of easterly trade-winds the storm will invariably work its way or be propagated toward *the most humid region*, unless mechanically borne in another direction by the great atmospheric current in which it is often embedded as an eddy in a river. The cyclone-tracks over all the oceans lie in the central bands of the great ocean-currents of high temperature and great evaporation, and the band of cyclonic violence is often beautifully coterminous with the sharply-marked blue-tinted edge of the Gulf Stream. Thus, in the Pacific, the Loochoo Islands lie just in the path of the Kuro Siwo, the great Pacific Gulf Stream of the Japanese, and are visited by the most fearful typhoons; but the Bonin Islands, in the same parallel, but on the extreme margin of the Kuro Siwo, have very mild and moderate storms.* "If a storm commences anywhere in the vicinity of the Gulf Stream, it naturally tends towards that stream, because," as Loomis says, "here is the greatest amount of vapour to be precipitated, and when a storm has once encountered the Gulf Stream, it continues to follow that stream in its progress eastward." Vessels and Japanese junks, dismasted in gales off the Asiatic coast, have been drifted for many days in the current of the Kuro Siwo, to the coast of California, just as West-Indian beans, cocoa-nuts, and vegetables, have been drifted to Iceland, Greenland, and Spitzbergen, on the extension of the Gulf Stream. According to all meteorological observations of the tracks of storms, we are warranted in believing that cyclones and hurricanes do, as a matter of fact and of atmospheric law, run on the hot currents of the sea as naturally as the watercourse clings to its bed. Practical seamen, though unable to

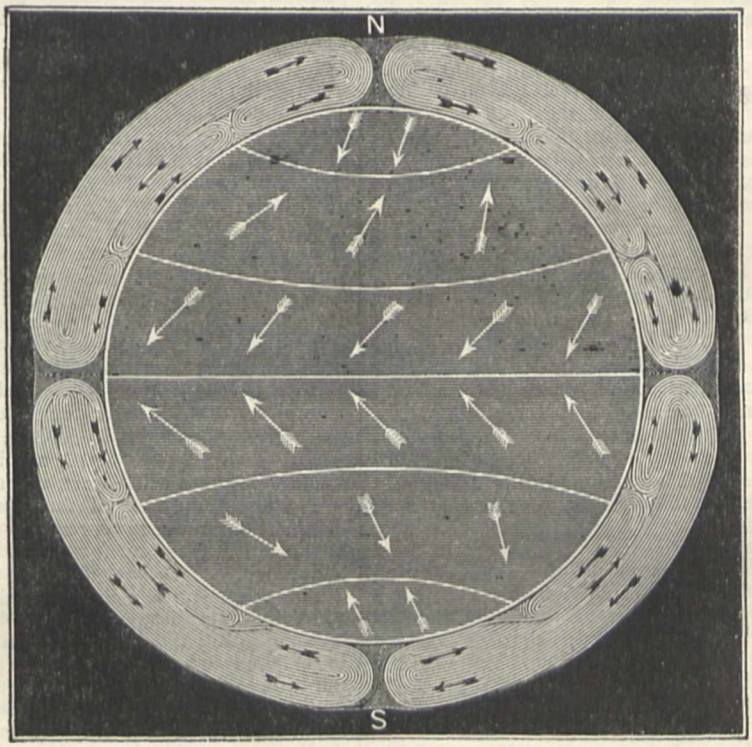


FIG. 3.—The Atmospheric Movements.

* Continued from p. 124.

* See Redfield's Report on Pacific Cyclones.

explain the fact, are always on the look-out for these furious gales when sailing on the axial lines of the Gulf Stream, on the hot Mozambique current (the Gulf Stream of the Indian Ocean), and on the dark superheated waters of the Kuro Siwo of the Pacific.

So dangerous and disastrous are the storms which course along the Gulf Stream that sailors avoid it, and the American Sailing Directions and those of the British Admiralty advise all vessels, sailing from the West Indies to New York or Liverpool, to beware of taking advantage of its current, although it would help them along from three to four miles an hour. Close observation has traced these storms continuously from the Florida coast to New York, through Redfield's labours, and thence to England, through the records of the Cunard steamships, and thousands of detached observations.

We have now reached a point where we can properly and intelligently consider a question that has always baffled meteorologists—the origin of cyclones. The diagnosis of the phenomenon necessarily precedes its explanation. This subject has engrossed many minds, and various have been the ingenious devices for unravelling its mystery. Mr. Redfield—the father of storm physics—in his modesty and diffidence, so distrusted himself and in his day so keenly felt the need of a more enlarged induction of facts, that he has scarcely left us his opinion. The theories of other writers have all long since been abandoned by themselves or suffered to drop from the notice of the scientific world as evidently incapable of explaining the phenomena of cyclones. This has been the fate of them all, unless possibly we except the theory advanced by the great meteorologist, M. Dové, of Berlin. Briefly stated, the latter hypothesis is this (at least in its application to West Indian hurricanes), viz., that "they owe their origin to the intrusion of the upper counter trade-wind into the lower trade-wind current" (Dové's "Law of Storms," p. 264).

Without pausing here to examine this theory upon its merits and upon the facts, we hasten to mention a different hypothesis advanced, nearly two years ago, as a substitute for that of M. Dové, and as affording an entirely original and satisfactory explanation of the origin of cyclones.

The hypothesis was likewise based upon the agency of the trade-winds, but in a manner wholly different from that elaborated by the German meteorologist. In the original paper in which my views were published, the following statement was made :—"It can be demonstrated that the origin of cyclones is found in the tendency of the south-east trade-winds to invade the territory of the north-east trades, by sweeping over the equator into our hemisphere."

The hypothesis advanced, in lieu of another seemingly less satisfactory, claimed to rest upon observations conducted in the very region most notorious for the generation of cyclones.

To test this, we need only to examine the Atlantic trade winds.

Theoretically, physical geography has generally represented the motions of the atmosphere somewhat as is represented in the accompanying diagram (Fig. 3) of the winds, as projected by Prof. William Ferrel, of Cambridge. The elaborate pages of Prof. Coffin, in his invaluable volume on the "Winds of the Northern Hemisphere," as deduced from myriads of observations, show that the graphic illustration furnished by the diagram is approximately correct.

The region of the trade winds, it will be seen, more than covers the torrid zone of the earth, and at all the seasons of the year overlaps both the northern and southern tropics. While this is theoretically true, and is usually put forth as a fact, it must be accompanied with one or two important qualifications and additions.

Let us see what these are. The well-known oscillation or swinging of the belts of winds to and fro on the meridians, which is kept up in never-ceasing response to the apparent annual motion of the sun as he crosses and recrosses the equator, must ever underlie the conception we form of the trade winds and be perpetually present to the mind's eye. This oscillation has never yet received the popular attention it needs. The sun traverses (apparently) an arc of 23½° on either side of the line; and we might, *a priori*, suppose that the thermal or meteorological equator, the thermal or meteorological Tropics of Cancer and Capricorn, and all those phenomena which lie between them and beyond them, move over an arc of as many degrees as they traverse. Such an inference, however, is not borne out by observation, and we propose to confine ourselves strictly to what may be proved by observation. It is clear that the trade-wind belt does traverse or vibrate over a wider zone than any physicist has yet assigned to it, which is not more than ten degrees of latitude north and south respectively of the Tropic of Cancer and that of Capricorn. These winds, when first experienced by Spanish sailors, gave, to that portion of the Atlantic over which they blew, the name *el Golfo de las Damas* (the Ladies' Sea) because they rendered navigation so easy that a girl might take the helm. But, "gentle" as they are, they have a wide sweep, and, in the summer of the Northern Hemisphere, extend far beyond the Tropic of Cancer. They have often been distinctly felt at Madeira and the Azores (near the 40th parallel) in summer, and it is highly reasonable to suppose that they then fully reach the latitude of 40° N. The equatorial side of the north-east trade-wind belt, of course, vibrates with the sun. In summer it stretches along between the 10th and 12th parallels of north latitude, verging in August on the 13th parallel, and, according to one writer, occasionally the north-east trades at that season do not extend south of the 15th parallel of north latitude. Dampier, "the prince of navigation," as the English call him, gives the direction of the wind in the summer months, between the equator and 12° north, as south-south-east, south-south-west, and south-west.

The equatorial side of the north-east trade-wind belt in winter approaches very nearly to the equator, and may be located in January at least as far south as the latitude of 2° north.

The freshest trade-winds in the North Atlantic are generally found between the parallels of 10° and 25°, and by long protracted experiment in seamanship they have been found to have an average propelling power, when the wind is taken just abaft the beam, of about six knots an hour. But, of course, the northern boundary of the south-east trade-wind likewise varies and vibrates with the seasons. So also, and under the same condition, does the southern boundary of this trade vary and vibrate with the seasons. Its normal and mean position is a little south of the parallel of 25° south, but in the winter of our hemisphere it is pushed much farther south, and in the vicinity of 35° south latitude. The charts of Captain Wilkes give easterly winds for the east coast of Australia, and also for the south coast of Africa. Sir John Herschel, speaking from knowledge gained by his long residence at the Cape of Good Hope, tells us that there "the south-easterly winds which sweep over the Southern Ocean, infringing upon the long range of rocks which terminates in the Table Mountain, is thrown up by them, makes a clean sweep over the flat table-land which forms the summit of that mountain (about 3,850 ft. high), and thence plunges down with the violence of a cataract" ("Meteorology," p. 96).

From these high southern latitudes, we must conceive the motion of the south-east trades, extending northward in summer to the neighbourhood of the parallel of 10°.

T. B. MAURY

(To be continued.)

THE CORONAL ATMOSPHERE OF THE SUN*

II.

WHEN the subject is a phenomenon so complex as that of the corona, it is necessary to bring to bear upon it various methods of study. This is why I have thought it indispensable to consider the corona from the triple standpoint of its aspect, the analysis of its light, and its polariscopic manifestations. Let us discuss these varied observations.

Let us first of all see what can be learned from an examination of the corona during the first instants of totality. We have seen that the general structure of the corona persisted throughout the duration of totality. We cannot, then, admit here any effect of diffraction engendered at the surface of the lunar screen by the rays grazing the edges of that screen Let us revert to the geometric circumstances of a total eclipse. At the moment when totality is produced, the disc of the moon is tangent, at one point, to that of the sun, and edges off gradually more and more to the opposite point. Diffraction will be produced, then, under physical conditions the most different, at various points of the lunar limb, and an aureole due to that cause will reveal, by its dissymmetry, such a diversity of conditions. Moreover, an aureole of this kind will present a continually varying aspect during the various phases of totality. Unsymmetrical at the outset, it will be modified with the movement of the moon, and will tend to assume the same form all round our satellite, when the disc of the latter is equidistant from that of the sun. Finally, from that point this aureole will pass through the same phases inversely until the reappearance of the sun.

However, nothing like this was produced at Shoolor. The general structure of the corona remained the same throughout the continuance of totality.†

It is unnecessary to dwell on the hypothesis of an aureole produced by a lunar atmosphere. We know now that if a gaseous layer exists on the surface of our satellite, it must be of so small extent that the grand phenomenon of a corona could not be produced by it.

Our own atmosphere cannot be adduced as the cause of the phenomenon, though it is evident that it plays an important part in the particular aspects which the corona may present at different stations, according to the state of the sky at these stations. It acts as a modifying, but not as a producing cause.

Let us pass, meanwhile, to the spectroscopic observations. The corona presents the hydrogen lines throughout all its visible extent; in certain parts as far as to 12′ or 15′ in height. This observation is certain. The precision of the spectroscopic scales, the experience we have had in such determinations, and the care which was taken in the last observation to compare the lines of the corona with those of a protuberance, of which they are only a prolongation, leaves no doubt as to this point.

But if the corona presents the hydrogen lines, we must ask this testing question—Is this light emitted or reflected? The constitution of the coronal spectrum will afford us an answer.

If the light of the corona is reflected, this light can only have a solar origin. It proceeds from the photosphere and the chromosphere, and its spectrum ought to be that of the sun, that is, a luminous ground with obscure lines. But such is not the constitution of the coronal spectrum; that presents to us the hydrogen lines standing in strong relief on the ground; after the green line (1474) this is the most striking manifestation in the phenomenon. We must conclude that the coronal medium is self-lighted, in great part at least, and that it contains incandescent hydrogen. This first point is conclusively established. But is it to be inferred from this that the whole of the light of the corona is emitted light? Evidently not; and on this point a delicate observation in spectrum analysis and polarisation may inform us. In fact, the spectrum of the corona presented to me, besides these bright lines, many obscure lines of the solar spectrum, the line D, and some in the green. This fact proves the presence of reflected solar light. We may ask why the principal Fraünhofer lines are reduced to the line D. It should be remarked that the coronal spectrum, not being very luminous, is especially perceptible in its central part, and that, in this part, the lines C, F, &c., are replaced by the bright lines. In these conditions the line D alone remains important; thus it is on it I have directed all my attention. As to the finer lines, they were much more difficult to discern, a fact very easily explained by the very large opening I was obliged to give to the slit of the spectroscope.

The proof of the existence of the Fraünhofer lines in the spectrum of the corona is a work of delicacy; it was not obtained by the other observers. This fact is explained partly by the great purity of the sky at Shoolor, partly by the power of my instrument. I have no doubt that the observation will be confirmed by astronomers who work under conditions equally favourable.

The presence of reflected solar light in the spectrum of the corona is of great importance; it shows the double origin of this coronal light; it explains observations of polarisation which appeared irreconcilable;* but above all, it enables us to understand how the solar light forming in some sort the ground of the spectrum of the corona, this spectrum may be considered continuous; and we know that hitherto this circumstance has been the great obstacle which prevented the corona from being regarded as entirely gaseous. The phenomena of polarisation presented by the corona are for the most part those of radial polarisation, which shows that reflection takes place chiefly in the corona, and that that which may be produced in our atmosphere is only secondary. Polarisation then agrees here with my observation of the Fraünhofer lines; but in order that the agreement may be complete, it is necessary that the polariscopic analysis, like the spectral analysis, should show that the light of the corona is only partially reflected. This is precisely what happened. We have seen, in fact, that near the limb of the moon, where the coronal light is brightest, polarisation appears less pronounced than at a certain distance. The reason is, that in the inferior regions emission is so strong that it conceals reflection, and the latter appears, with its peculiar characteristics, only in the layers where it is able to assume a certain relative importance.

Thus the two analyses, spectral and polariscopic, fairly interpreted, agree as to the double origin of the coronal light, and all the observations unite in demonstrating the existence of this circumsolar medium. This medium is distinguished both by its temperature and by its density from the chromosphere, of which the limit, moreover, is perfectly distinct, as is shown in all the drawings of the protuberances and of the chromosphere. There is thus a necessity for giving it a name: I propose that of "coronal envelope" or "coronal atmosphere," to remind us that the luminous phenomena of the corona owe to it their origin.

The density of the coronal atmosphere must be excessively rare. In fact, it is known that the spectrum of the chromosphere in its superior parts is that of a hydrogen medium successively rarified; but as the coronal medium, according to the indications of the spectrum, ought to be even infinitely less dense, we see how rare this medium

* Continued from p. 127.

† It is quite evident that this constancy of aspect only agrees with points of general structure sufficiently distant from the sun not to be influenced by variations of light resulting from the displacement of the moon, relatively to the low and very luminous regions of the chromosphere.

* If we consult the history of eclipses we shall see that observers have often obtained contrary results, which has been the means of casting a kind of discredit on this kind of observation. But if these observations are considered in view of the double nature of the light of the corona, and of the effects of our atmosphere, we shall be able to remove most of the difficulties.

must be. This conclusion is further corroborated by astronomical observations. Science has recorded the passage of comets as only some minutes' distance from the surface of the sun; these bodies must have traversed the coronal atmosphere, and yet, notwithstanding the lightness of their mass, they did not fall into the sun.

I shall add here, as to the constitution of the coronal atmosphere, a few ideas which do not rigorously flow from my observations, but which appear to me very probable, but upon which the future must pronounce.

I said, *à propos* of the observations in the telescope, that the corona was shown at Shoolor with a form almost square, and that it was distinguished by gigantic dahlia-like petals. It is a fact that in each eclipse the figure of the corona has often varied; it has exhibited the most eccentric appearances. I have no hesitation in saying that this medium, now incontestably recognised, and which I propose to name the "coronal atmosphere," very probably does not represent the whole of the aureole which is seen during total eclipses. It is quite credible that portions of the rings or trains of the cosmical matter then become visible and thus tend to complicate the figure of the corona. It belongs to future eclipses to instruct us on this point. But with regard to the coronal medium itself, there is no doubt that it presents singular forms, which convey but little idea of an atmosphere in equilibrium. Moreover, I am inclined to admit that these appearances are produced by trains of very luminous and dense matter from the superior layers ploughing this troubled medium. The protuberant jets, which carry the hydrogen to such great heights, must have a peculiar influence upon this coronal medium, whose density is quite comparable to that of the cometary media.

It is, then, very probable that the coronal atmosphere, like the chromosphere, is very much agitated, and that it changes its shape very rapidly, which will explain how it presents different appearances every time it has been observed.

To repeat: I have been able to establish at Shoolor, by trustworthy and consistent observations, that the solar corona presents the optical characteristics of incandescent hydrogen gas, that this very rare medium extends to very variable distances from the sun, from half a radius of the sun to about double that at certain points; but I give these figures only as results of an observation, not as definitive. It is quite certain, moreover, that the height of the corona must be necessarily variable.

This result seems to be a considerable advance in the general problem of the corona. If our foreign rivals have not obtained a result so decisive* as those of the French mission, I believe it must be attributed to the altogether exceptional purity of the sky in the station which I chose with such pains, and also to the combined optical arrangements which gave to the luminous phenomena which it was the object to catch, an exceptional power.† JANSSEN

CHRONOMETER TESTS

THE following, which has been sent us by the Scientific Editor of *Harper's Weekly*, shows with what minuteness the scientific work of this country is studied in America, and what a critical audience we have on the other side of the water:—One of the most important services that astronomy has rendered to mankind consists in the contributions it has made to the progress of navigation, and the increased security of life and property. In this field England has always taken the lead, and the efforts of Mr. Hartnup at Liverpool are a worthy continuation of the labours of Flamstead, Bradley, and Airy. While the Greenwich Observatory has caused a great improvement in the general standard of the chronometers bought for the use of the Government vessels, Mr. Hartnup has sought to effect a similar reform for the mercantile marine. He has insisted on the vital importance to ship-masters, as well as to owners and insurance companies, of the careful determination of the rates of their chronometers as affected by temperature. The makers of these instruments and the astronomers who use them carefully have always known that which captains of vessels have been very slow to profit by—*i.e.* that the chronometers are, when made, so adjusted that they keep perfect time at two temperatures, such as 55° and 85° F., while between these limits they gain, and beyond them they lose, on the true time. It is rare that this variation in the chronometer rate can be safely overlooked by a careful navigator, though it is frequently done by those whose vessels do not carry a precious burden of 1,000 or 2,000 souls. The only excuse for this neglect is the positive assurance of the maker that the chronometer is perfectly reliable—an assurance that is often fortified by very deceitful figures. The difficulty and expense of a searching investigation into the errors to which every chronometer is liable have long been supposed by the trade to stand in the way of the introduction of such chronometers only as were of approved reliability. In order to obviate the difficulty as far as possible, the Liverpool Observatory has been constructed by Mr. Hartnup specially for the purpose of studying the rates of the chronometers that may be sent thither by captains sailing from that port. The expense of the examination given to such chronometers is comparatively trifling; and the number of chronometers submitted to him has annually increased, until by reason of the recent regulations at that port the number of examinations has amounted to between 1,000 and 2,000 annually, the same instruments having been repeatedly submitted to him. The process pursued by Mr. Hartnup consists in exposing each chronometer for a week to a uniform temperature of 55°, and determining its rate each day; it is then for another week exposed to a temperature of 70°, and then to one of 85°; the next week it is returned to the temperature of 70°, and the last or fifth week it is exposed to the temperature of 55°, as at first. By means of general laws regulating the rates of chronometers it is now possible to determine what the rate will be at other temperatures than the three above mentioned, and knowing these, the navigator is able to apply the proper correction to his time-keeper so exactly that he need never mistake his position upon the ocean.

The records of the Liverpool Observatory for the past year show—1. That the rates of about 10 per cent. of the chronometers tested (those of the mercantile marine very generally have the ordinary compensation balance) are so irregular as to render the instruments entirely unfit for nautical purposes. 2. The error of adjustment for temperature of the remaining 90 per cent. is often so erroneous as to produce a change of daily rate of many seconds, when the temperature varies but little from either of the two standard points of 55° and 85°, or thereabouts. 3. That the best made and most carefully adjusted instruments gain, on the average, daily six-tenths of a second more at a temperature of 70° than at 55° or 85°. 4. That those that have the same rate at 55° and 70°, or at 70° and 85°, lose when exposed to temperatures beyond these limits at the rate of 1·5 seconds daily for a change of 15° in temperature. 5. That when the connection between temperature and daily rate has been well determined, it will remain constant in good instruments for a

* M. Respighi, at Poodookotah, made observations purely spectroscopic which confirm mine; only he found the height of the corona much less, which appears to me to be due to the more feeble luminous power of his instrument.

† This paper contains only an analysis of my observations: I have not been able to refer in detail to those of other observers. I may cite, however, the important remarks of Mr. Lockyer on the structure of the corona, the photographs of Colonel Tennant, the polariscopic observations made at Jafna, those of Capt. Fyers, M. Oudemans, and others.

long time, which need in general to be examined only once in one, two, or three years.

The vital importance of this subject to the interests of safe, speedy navigation, will be impressed upon everyone by the disaster that befell the *Atlantic*, consequent upon being some twenty miles (or ninety seconds of time) out in her reckoning.

NOTES

LAST Thursday the gentlemen already named by us were elected Fellows of the Royal Society.

THE Baly Medal for physiological research has been awarded to Dr. Sharpey.

A PORTION of the collection made by the naturalist D'Albertis in New Guinea, and referred to in our Notes last week, has already arrived in England, and at the meeting of the Zoological Society, on Tuesday, June 17, Mr. Sclater, F.R.S., announced that among other valuable species, it contained both male and female specimens of a previously unknown Bird of Paradise of the Epimachine division, with a peculiarly long and curved beak, which he proposed to name *Drepanephorus albertisi*, after its discoverer.

A PROJECT has been set on foot by Colonel Grant, so well known from his African travels, to form a loan exhibition of skulls and horns of hollow-horned animals, in order that by observation and comparison of a large number of characteristic specimens, facts may be obtained regarding the form, sexual characters, and locality of each particular species. It is proposed to have as many as from twenty to fifty specimens of each species, so as to be able to form groups representing every stage in the life of each, as also to show the varieties of species in different localities. When from three to five thousand specimens of the one hundred and fifty existing species has been promised, means will be taken to secure the most suitable place in London for their exhibition.

ARRANGEMENTS have been made, under the sanction of Dr. Whewell's friends and executors, for the publication of a life of the late Master of Trinity, with selections from his correspondence and remains. The literary and scientific remains and correspondence will be edited by Mr. Todhunter, Lecturer, and ormerly Fellow of St. John's College, Cambridge. The account of Dr. Whewell's college and university career will be written by Mr. W. G. Clark, Senior Fellow of Trinity College, Cambridge. Some of the most distinguished of Dr. Whewell's friends, to whom application has been privately made, have kindly placed their papers at the disposal of the editors, and expressed their approbation of the proposed work. The editors now ask in a more public manner for the loan of letters or other materials which will assist them in their labours. Mr. J. L. Hammond, Fellow of Trinity, as the surviving executor under Dr. Whewell's will, has undertaken to receive, on behalf of the editors, any documents that may be intrusted to them, all of which will be catalogued and carefully preserved, and returned within such limits of time as may be prescribed.

A CONFERENCE took place on Saturday, in promotion of a project to which we have already alluded as the "Trades Guild of Learning," for extending the advantages of university education to the working and middle classes of this country. It is proposed that local organisations shall be formed in various towns, and put into communication with a central guild, for the purpose of defraying the cost of the attendance of duly authorised lecturers sent from the Universities of Oxford and Cambridge, to conduct classes and deliver lectures on subjects, such, for example, as Political Economy, English Literature, Force and Motion, Astronomy, Physical Geography, &c. Technical education is to form a leading department of the scheme, and it appears that Nottingham, Derby, and Leicester have already made arrangements and fixed dates for receiving the lectures, and that the authorities of both Universities, but that of Cambridge especially, have given cordial encouragement to the idea. Saturday's conference was very fairly attended by representative working men in the capacity of delegates from societies more or less numerous and powerful, and the whole day from eleven in the morning until seven in the evening was occupied in the discussion of the project. Mr. Samuel Morley, M.P., presided for the first few hours, and was succeeded in the chair by Mr. Mundella, M.P. With them were the Rev. H. Solly, Mr. James Stuart, M.A., Hon. Sec. to the Syndicate, who is actively engaged in furthering the scheme in connection with the Universities, Mr. Webster, Q.C., and other gentlemen, and a few ladies. It was agreed that women should not be excluded from the advantages of the guild.

ON June 7 a meeting was held of the Druitt Testimonial Committee, at which it was reported that a handsome silver cup, along with 1215*l.*, was to be presented to Dr. Druitt, who is still in India.

THE subscribers to the Children's Hospital, Bristol, have resolved to admit female practitioners to the medical staff of the hospital.

THE following, in alphabetical order, have passed first-class in Natural Science at St. John's College, Cambridge:—Clough, Jukes-Browne, Koch, Marshall, Sollas. Of the above, Marshall has been elected to a Foundation Scholarship, Clough, Jukes-Browne, Koch, Sollas (scholar 1872) have been awarded exhibitions.

IN the last issued Part of the *Birds of Europe*, which has just appeared, the name of Mr. Sharpe is no longer associated with that of Mr. Dresser as co-editor. The former of these two gentlemen has been compelled, on account of his many duties at the British Museum, to retire from his connection with the work which he was so instrumental in organising, and Mr. Dresser is now sole editor. The Viscount Walden, F.R.S., President of the Zoological Society, has relieved him of part of his considerable task, by undertaking to write most of the synonyms of the future parts, which will be sufficient guarantee for its accuracy and exhaustiveness.

THE concluding Part of Dr. W. L. Buller's *Birds of New Zealand* has just been issued. The genus *Apteryx*, the last discussed, and most interesting in the avifauna of these islands, is divided into four species at least, of which *A. haasti* closely resembles *A. owenii*, except in size, being considerably larger. The author also considers that the evidence, as far as it goes, is in favour of *A. haasti* differing from *A. maxima* of M. Jules Verreaux, which he thinks represents another species as large as a full-grown turkey. The Introduction contains several interesting supplementary notes; further facts are given in favour of the Quail Hawk (*Hieracidea novæ-Zealandiæ*) being distinct from the Sparrow Hawk (*H. brunnea*); the validity of *Platycercus alpinus*, as a species, is established; the Huia bird (*Heteralocha acutirostris*) is placed among the Starlings, close to *Creadion* instead of with the *Upupidæ*, and *Tribonyx mortieri* is included in the New Zealand fauna. There are seven excellent plates, and a supplementary series is promised.

THE recent changes which took place in French policy have deprived science of an active and able leader in M. Jules Simon, who was sparing no trouble to promote new inquiries and restore French science to its pristine activity. His imme-

diate successor has had no time to make any show of his intentions. M. Batbie seems to feel inclined to accept the inheritance of M. Jules Simon, as far as it relates to the *Facultés* (the equivalent of the several English Universities). It is supposed on good grounds that all the schemes of M. Jules Simon for building a new Faculté of Sciences on the back part of the Luxembourg will not be interfered with by the sudden presidential change. It remains to be ascertained what will be the working of the new system on the courses of lectures delivered by unofficial men of science.

M. LEVERRIER has entered on his new office of Director of the French National Observatory. The Observatory Board has decided on his formal proposition that they shall co-operate with the Bureau des Longitudes for taking a new measure of the French arc from Dunkerque to Oran *vid* Spain. Commander Perrier will be the chief geodesist for that most important survey.

M. WOLF has taken a series ot magnificent photographs with Leon Foucault's siderostat during the last partial eclipse. He was then testing the photographic process which he intends using in Japan on the next Transit of Venus. The Japan Embassy was present at the operations and exhibited a great deal of truly scientific curiosity.

M. THIERS is now busy studying geology for the purpose of writing an essay on the destiny of mankind. He will take an anti-Darwinian view of the question. M. Daubree is his teacher for geology. He was taught in astronomy ten years ago by M. Leverrier, and in Natural Philosophy by M. Mascart, lecturer at the Collége de France.

M. BARTHELEMY SAINT-HILAIRE has already resumed his work of translating Aristotle and commenting upon it. The volumes now in hand relate to scientific subjects.

MESSRS. MACMILLAN & Co. will shortly publish the "Elements of Embryology," by Michael Foster, F.R.S., Prelector in Physiology at Trinity Coll. Cambridge, and F. M. Balfour, Scholar of Trinity College, Cambridge.

THE French Academy has named a commission to prepare a list of candidates for the place of Foreign Associate, vacant by the death of Baron Liebig. The commission is composed of MM. de Quatrefages, Liouville, Morin, Becquerel, Dumas, Chevreul, and Milne-Edwards.

TURIN possesses an Industrial Museum, which, though it has been established only a few years, is, according to *L'Institut*, one of the most complete in Europe, second only to the Conservatoire des Arts et Métiers de Paris. The value of this establishment has just been increased by the publication of a monthly periodical entitled *Annals of the Italian Industrial Museum*. The Director of the Museum is M. Codazra, and the Conservator, Mr. W. T. Jervis.

M. PAUL BROCA contributes to the *Revue Scientifique* an account of some researches he made about twelve years ago for the purpose of ascertaining the influence of education on the development of the brain. He took as his subject 20 attendants and 18 pupils of the hospital of Bicêtre, the average age of the former being 39½ years, and the average height 1·643 metre; the average age of the latter 26½ years, and the average height 1·689 metre. Notwithstanding the great advantage of the former in the matter of age—for it has been ascertained that the mean weight of the brain increases up to 40 years—the measurements made by M. Broca were very considerably in favour of the pupils, who had undergone a long training before being admitted to the hospital, and some of whom have since had a distinguished career. We can only here give the differences between the various measurements of the two groups of heads, the + denoting the excess (in millimetres) in favour of the hospital pupils. Antero-posterior diameter—Maximum + 4·89, inial + 5·87; transverse diameter + 2·91; cephalic cephalometric index − ·55; inio-frontal curve—total + 9·90, anterior part + 9·25, posterior part + 0·65: horizontal curve—total + 16·06, anterior part + 10·90, posterior part + 5·16; transverse curve—bi-auricular + 13·90, supra-auricular 11·70. M. Broca thinks that the results of the measurements prove, in the first place, that mental culture and intellectual work increase the volume of the brain, and in the second place that the increase takes place principally in the frontal lobes, which are the seat of the highest faculties of intelligence. Very important conclusions in favour of the spread of the higher education may be drawn from these statistics.

WE are glad to see, from a pamphlet by Mr. Ellery (just elected F.R.S.), "Notes on the Climate of Victoria," that a beginning has been made to put into shape the multitude of statistics which have already been accumulated as to the climate of that country. With regard to the rainfall, we quote the following paragraph:—By selecting Melbourne as the locality in which the most extended series of observations have been obtained, we remark that in the years 1848, 1849, and in 1863, the rainfall was far above the average; in 1864, 1865, 1866, and 1870 it fell below the average, especially 1865, when it only reached 15·9 inches. In 1848 and 1849 extensive and destructive floods occurred, and again in 1863; in 1865 and 1866 the country suffered from a severe drought; and the year 1851, following the heavy rains of 1849, was also a dry one, although the amount of rainfall, if ever observed, cannot yet be ascertained. An opinion has often been expressed that there is a periodicity in the excessive rainfalls and droughts in Australia generally; but although the above results may give some slight grounds for this supposition, a far greater number of years' observations will be necessary from which to deduce any law of this kind.

THE United States Signal Corps has recently extended its series of observations in the form of a daily record of the surface and bottom temperature of the rivers and harbours upon which the several stations are situated. This, while of much interest in a meteorological point of view, is also of practical importance in connection with the subject of introducing useful food fishes into the rivers and lakes of the United States, as lately provided for by Congressional enactment. It is well known that the possibility of introducing salmon into any given stream will depend upon the relationship of its temperature during the summer and autumn to the particular species; some kinds, as the true salmon of the North Atlantic (*Salmo salar*), requiring a summer minimum of at least sixty to sixty-five degrees, while others will bear a higher temperature.

AN institution has been founded in Vienna by M. Anton M. Pallac, which he calls a Rudolfinum, or Students' Home—a college of technical science for students of any nationality. It is now announced that this gentleman has arranged with the officers of the Rudolfinum to furnish free lodgings in that building to three hundred professors and teachers, of all nations and countries, who intend visiting the exhibition of 1873. The offer is made for the months of July, August, and September, and applies alike to the professors of royal academies and the teachers of any kind of public schools. Early application is to be made, giving in each instance the name, address, and teaching position of the applicant, locality of school or institution in which he is engaged, with the date and length of time of his desired occupancy of these free lodgings. The application is to be addressed to the administration of the Rudolfinum, 4, Moierhofgrasse, Vienna.

THE principal paper in the last number (Vol. ii. No. 4) of the

"Proceedings of the Bath Natural History Society," is a long address by the president, the Rev. Leonard Blomefield, F.L.S., F.G.S., on "Local Biology," containing many valuable hints as to the objects which members of such societies ought to have in view, illustrated by many interesting facts and recent observations in natural history. He shows how valuable the field work of local scientific societies might be made when intelligently and judiciously conducted, not only in collecting facts as to local biology, but in helping to solve many of the most important problems which are at present occupying the attention of biologists. The main qualification for efficient work of this kind is an intelligent and sharp look-out. Mr. Blomefield concludes his paper by some remarks on the faunas of Bath and Somerset. We are glad to see the address has been printed separately, and we would recommend it to the attention of all local scientific societies. The two other scientific papers in this number are on "Devonian Fossils from the Sandstones on the N.E. of the Quantocks," by the Rev. H. H. Winwood, F.G.S., and "The Geographical Position of the Carboniferous Formation in Somersetshire, with Notes on possible Coal Areas in adjoining Districts in the South of England," by J. McMurtrie, F.G.S., the latter illustrated by a well-constructed map.

We have received a wonderfully cheap pennyworth in the shape of a "Descriptive Guide to the Fossil Collection" of the Museum of the Leeds Philosophical and Literary Society. The pamphlet is interestingly written and well arranged, and contains a long and valuable list of useful books of reference on Palæontology.

The Third Annual Report of the Devon and Exeter Albert Memorial Museum, Schools of Science and Art, and Free Library, is altogether a very satisfactory one. Great facilities are offered for scientific study and laboratory practice, and these appear to be largely taken advantage of. The number of individual students during the current session is 89, and the subjects at present taught in the school are Mathematics, Theoretical Mechanics, Physical Geography, Geology, Acoustics, Light and Heat, Vegetable Anatomy and Physiology, Systematic and Economic Botany, Magnetism and Electricity, and Inorganic Chemistry with laboratory practice. According to the library statistics, a very large increase during the past year has taken place in the number of scientific books sought for, both in the consulting and lending libraries.

The following is the ephemeris of Tempel's Comet for the days named as, calculated by Mr. Hind for Greenwich midnight:—

1873	True R.A. h. m. s.	True N.P.D. ° ′ ″	Log Δ
June 20	16 14 50·1	111 18 19	9·91982
22	14 23·7	111 38 44	9·92529
24	14 4·9	111 58 53	9·93106
26	13 53·9	112 18 45	9·93711
28	13 51 1	112 38 19	9·94342
30	13 56·7	112 57 34	9·94996
July 2	14 10·8	113 16 31	9·95671
4	14 33·6	113 35 10	9·96365
6	16 15 5·3	113 53 30	9·97077

The additions to the Zoological Society's Gardens during the past week include a black Iguana (*Metopoceros cornutus*) from San Domingo, presented by Mr. John Dutton; two golden Tench (*Tinca vulgaris*), presented by Lord Herbrand Russell; two black Kites (*Milvus migrans*), presented by Mr. H. F. Blissett; two starred Tortoises (*Testudo stellata*) from India, presented by Capt. C. S. Sturt; a smooth-headed Capuchin (*Cebus monachus*) from Brazil, presented by Mr. J. A. Horsford; a Rhesus Monkey (*Macacus erythræus*) from India, presented by Mr. G. Cork; an Entellus Monkey (*Semnopithecus entellus*) from India; four Sturgeon (*Accipenser sturio*); two American Rice-birds (*Dolichonyx oryzivora*); five horned Lizards (*Phrynosoma cornutum*) from Texas, purchased; a Lion (*Felis leo*) from Africa; a Collared Mangabey (*Cercocebus collaris*), a Diana Monkey (*Cercopithecus diana*), and a Moustache Monkey (*C. cephus*) from W. Africa, on approval.

SCIENTIFIC SERIALS

The *Journal of Botany* for May commences with a critical investigation, illustrated by a plate, by the editor, of the very common but badly understood Dock, *Rumex obtusifolius*, which is followed by two papers on the distribution of plants, Additions to the British lichen flora, by Rev. M. Crombie, and Additions to the flora of Berkshire, by James Britten. In this number is also the very useful annual list of the new species of phanerogamous plants described in periodicals published in Great Britain during the year 1872. The plate which now accompanies every number is a great addition to the value of this magazine.

In the June number the illustrated article is by Mr. W. P. Hiern, on *Physotrichia*, a new genus of Umbelliferous plants from Angola, from the Welwitschian collection. Mr. F. Townsend contributes a paper on a much controverted subject, some points relating to the morphology of *Carex* and other Monocotyledons. The short notes and queries are, as usual, not the least interesting portion of these two numbers.

Poggendorff's Annalen der Physik und Chemie, Supplement vol. vi., part. I. This number contains the first instalment of a series of researches on the volume constitution of solid substances; a lengthy paper in three parts, the first being introductory and theoretical, the second describing methods, and the third detailing results in the case of chlorides, bromides, and iodides.—Prof. Schwedoff of Odessa follows with an interesting paper, in which he establishes a correspondence between the propagation of electrical currents in thin conducting insulated plates and that of light rays in transparent media. A "ray of electricity" is represented by the line drawn from a pole to any given point of the body, and means simply the direction in which electrical "masses" (in the plate) are attracted to the pole or repelled from it. He shows that the intensity of such rays is inversionally proportional to distance from the pole; that they are reflected (it may be oftener than once), from the edges, the angles of reflection and incidence being equal; that they do not lose intensity by reflection, nor suffer change of sign. His theory and mode of experiment are illustrated by figures.—An article by Dr. Heinrich Schneebeli on bar-magnetism, contains a full and thorough investigation of magnetic moment in permanent bar-magnets, and more especially of the position of the magnetic pole; this is determined by two different methods which do not suppose a knowledge of the law of distribution of the magnetic fluid, and the results (closely agreeing), are applied in correction of the tangent galvanometer.—Carl Pape contributes a determination of the optical constants of blue vitriol, and Alexander Müller the first part of studies on chloride of iron solutions without change of aggregate state.—Among the extracted matter may be noted an article by Kohlrausch on the reduction of the Siemens unit of galvanic resistance to absolute measure, and one by Edlund on the nature of electricity, which has already appeared in English form.

The *Monthly Microscopical Journal* commences with an article by Dr. R. L. Maddox on an Entozoon with ova, found encysted in the muscles of a sheep, which he calls *Cysticercus oviparicns*. Then comes a very valuable paper on the development of the face in the sturgeon, by Mr. Parker, F.R.S., which, if followed by the description of a few more type-forms, will render the development of that complicated portion of the body, the head, one of the most easily understood sections of the vertebrate body. Mr. Joseph Needham gives a concise *résumé* of the methods employed for cutting sections of animal tissues for microscopical examination, in which he strongly advocates the method of freezing as "the simplest and most elegant mode" of obtaining sections of yielding tissues. Assistant-Surgeon Woodward describes how that a $\frac{1}{10}$th objective, sent to him by Mr. Tolles to test, gave a balsam angle of less than 80°, whilst a second, a $\frac{1}{8}$th of peculiar construction, having four combinations instead of three, gave the high angle of more than 100° when fully closed, and so exceeding the extreme limit assigned as attainable by Mr. Wenham. Mr. H. Davis gives further facts in support of the originality of his theory respecting the survival of Rotifera after desiccation.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 8.—"Researches in Spectrum Analysis in connection with the Spectrum of the Sun."—No. II. By J. Norman Lockyer., F.R.S.

The observations in this paper are a continuation of those referred to in the previous communication bearing the same title. They deal (1) with the spectrum of chemical compounds, and (2) with the spectra of mechanical mixtures.

I. *Chemical Compounds.*

Several series of Salts were observed; these series may be divided into two :—1st, those in which the atomic weights varied in each series; 2nd, those in which the associated elements varied in each series. The following salts were mapped :—

$Pb\ F_2$, $Pb\ Cl_2$, $Pb\ Br_2$, $Pb\ I_2$; $Sr\ F_2$, $Sr\ Cl_2$, $Sr\ Br_2$, $Sr\ I_2$; $Ba\ F_2$, $Ba\ Cl_2$, $Ba\ Br_2$, $Ba\ I_2$; $Mg\ F_2$, $Mg\ Cl_2$, $Mg\ Br_2$ $Mg\ I_2$; Na F, Na Cl, Na Br, Na I.

The conditions of the experiments are described, the same aluminium cups, described in the first paper, were used, and the poles were arranged in such a manner that they could at will be surrounded with any gas or vapour. Hydrogen was used in some of these experiments; it was purified in the usual manner by drying, and freeing from traces of sulphuretted hydrogen, it was then passed over clean cut pieces of sodium, and admitted to the poles. An induction-spark from 5 one-pint Grove cells was used, the *circuit being without the Leyden jar.*

The lead compounds behaved (in air) as follows :—

The fluoride gave the eleven longest lines of the metal, but four were very faint.

The chloride gave nine lines; one of these is very short.

The bromide gave six lines, but one is a mere dot on the pole.

The iodide gave four lines distinctly and two as dots, one of which is scarcely visible.

It is pointed out that the decrease in length and number of lines follows the increase in the atomic weight of the non-metallic element, the lines dying out in the order of their length.

Barium was next experimented on, the same series of salts being used. A marked departure from the results obtained in the case of the lead compounds was observed especially in the case of the fluoride, its spectrum being much the simplest; in fact it consisted of only four lines. Strontium behaved like barium, and so did magnesium fluoride. This anomalous behaviour was found to be most probably due to the exceedingly refractory nature of these fluorides, all of them being quite infusible, and non-volatile in any spark that was used.

Sodic fluoride, sodic chloride, sodic bromide, and sodic iodide exhibited a behaviour exactly the reverse of that of lead, *i.e.* the iodide showed most of the metallic spectrum.

The difference between flame-spectra and those produced by a weak electric discharge are then discussed. Beads of the chlorides, &c., were heated in a Bunsen-gas flame; BaI_2 gave a "structure" spectrum (since proved to be due to the oxide) and the line 5534·5, by very far the longest metallic line of barium; the bead fused. The bromide behaved like the iodide, and so did the chloride, except that its spectrum was more brilliant. Baric fluoride gave scarcely a trace of a spectrum, the oxide structure being scarcely visible, and 5534·5 very faint indeed. The strontium salts follow those of barium, 4607·5, the longest strontium line appearing in conjunction with an oxide spectrum. The strontic fluoride, however, refused to give any spectrum whatever. These results are compared with those obtained with the weak spark, and it is shown that the difference is one of degree; *e.g.* baric bromide gives 25 lines in the spark; these are the longest lines. In the flame it gives but one line; but this is the longest of all the barium lines, and indeed very far exceeds all the others in length. When the flame-spectra are compared with those produced by the low tension spark, the spectra of the metals in the combination are in the former case invariably more simple than in the latter, *so that only the very longest line or lines are left.*

Some experiments made by Mr. R. J. Friswell to determine the cause of the similarity of the spectra of the various salts of the same metal observed in air are then given, the conclusion being that the spectrum observed is really that of the oxide.

Kirchhoff and Bunsen's, Mitscherlich's, and Clifton and Roscoe's prior conclusions on the points investigated are stated at length; and it is shown that the observations recorded, taken in conjunction with the determination of the long and short lines of metallic vapours, are in favour of the views advanced by Mitscherlich, Clifton, and Roscoe. For while the spectra of the iodides, bromides, &c. of any element in air are the same as stated by Kirchhoff and Bunsen, the fact that this is *not* the spectra of the metal is established by the other *fact, that only the very longest lines of the metal are present, increased dissociation bringing in the other metallic lines in order of their length.*

The spectra have been mapped with the salt in hydrogen; here the spectra are different, as stated by Mitscherlich, and *the metallic lines are represented according to the volatility of the compound, onry the very longest lines being visible in the case of the least volatile one.*

The following are the conclusions arrived at :—

1. A compound body has as definite a spectrum as a simple one; but while the spectrum of the latter consists of lines, the number and thickness of some of which increase with molecular approach, the spectrum of a compound consists in the main of channelled spaces and bands which increase in like manner. In short, the molecules of a simple body and of a compound one are affected in the same manner by their approach or recess, in so far as their spectra are concerned; *in other words, both spectra have their long and short lines,* the lines in the spectrum of the element being represented by bands or channelled lines in the spectrum of the compound; and in each case the greatest simplicity of the spectrum depends upon the greatest separation of molecules, and the greatest complexity (a continuous spectrum) upon their nearest approach.

2. The heat required to act upon a compound, so as to render its spectrum visible, dissociates the compound according to its volatility; the number of true metallic lines which thus appear is a measure of the dissociation, and doubtless as the metal lines increase in number the compound bands thin out.

Mitscherlich's obvervations, that the metalloids show the same structural spectra as the compound bodies is then referred to, and the question is asked whether the molecules of a metalloid do not in structure lie between those of elements on the one hand and compounds on the other.

These considerations are applied to solar and stellar spectra; the general appearance of the solar spectrum shows that in all probability there are no compounds in the sun.

Secchi's maps of a large number of stellar spectra are referred to as now indicating beyond all doubt the existence of compound vapours in the atmosphere of some stars; and it is suggested that the phenomena of variable stars may be due to a delicate state of equilibrium in the temperature of a star which now produces the great absorption of the compound and now that of the elemental molecules.

The second part of the paper deals with the mechanical mixtures. Maps of the spectra of alloys of the following percentages are given :—

Sn and Cd	percentages of Cd	10·0, 5·0, 1·0, 0·15.
Pb and Zn	,, ,, Zn	10·0, 5·0, 1·0, 0·1.
Pb and Mg.....	Mg	10·0, 1·0, 0·1, 0·01.

It is pointed out that the lines die out in the order of their length as the percentage becomes less, the shortest lines disappearing first; and that although we have here the germs of a quantitative spectrum analysis, the method is a rough one only, but that further researches on a method which promises much greater accuracy are in progress.

The bearing of these results on our knowledge of the reversing layer of the sun's atmospheres is then discussed.

Mathematical Society, June 12.—Dr. Hirst, F.R.S., president, in the chair.—The following papers were read :—"Some general theorems relating to Vibrations," Hon. J. W. Strutt; "Invariant conditions of multiple concurrence of three conics," Mr. J. J. Walker; "On a new form of Biquaternion, being the ratio of two systems of forces," Prof. Clifford; "A further note on geodesic lines," Prof. Cayley.—A paper by Prof. Wolstenholme, "The locus of the point of concourse of tangents to an epicycloid, inclined to each other at a constant angle," was, in the author's absence, taken as read.—A conversation ensued on the subject of Prof. Clifford's paper, in which the president, Prof. Cayley, and Mr. S. Roberts took part.

Geological Society, May 28.—Prof. Ramsay, F.R.S., vice-president, in the chair. The following communications were read :—"The Glaciation of the northern part of the Lake-district," by J. Clifton Ward. The author stated the leading questions to be settled by his investigation of the northern part of the Lake-district as follows :—The fact of the glaciation of the district being granted, and of this he adduced abundant evidence, the questions that arose were whether the glaciating agent worked from north to south, whether it came from within or from without the district, and finally, whether the agent was floating ice, a system of local glaciers, or an unbroken ice-cap. As the result of his investigation he maintained that there is no evidence that a great ice-cap from the north ever swept over this district. The ice-scratches trending along the

principal valleys, but sometimes crossing watersheds, indicate a great confluent glacier-sheet, at one time almost covering a great part of the district, the movement of which was determined by the principal water-shed of the Lake-district. In the part of the Lake-district under consideration the ice, during its increase, carried forward, from south to north, a great quantity of rocky material. There are no signs in the district of the occurrence of mild periods during the epoch of primary glaciation, but the author thought that the climate had probably become moderate before the great submergence of the land commenced. The author noticed the effect of the submergence upon the results of previous glacial action, and maintained that when the land had sunk 800 or 900 ft. there was a recurrence of cold, and boulders were transported by floating ice. Until the submergence reached 1,500 ft. there was no direct communication between the northern and southern halves of the Lake-district except by the straits of Dunmail Raise. From the directions which would be taken by the currents in the sea at this period, it would appear that boulders may then have been transported by floating ice in some of the same directions as they had previously been carried by glacier-ice. The extreme of submergence appeared to have been about 2,000 ft. The author further maintained that on the re-elevation of the district there was a second land-glaciation, affecting the higher valleys and clearing them of marine drift.—"Alluvial and Lacustrine Deposits and Alluvial Records of the Upper Indus Basin," by Frederic Drew. The author said that he felt the necessity for a careful classification of the phenomena of alluvial deposits, for the want of recognition of the different kinds was likely to lead to incorrect deductions; the classification he proposed was the following:—I. *Loosened material*, which consisted of disjointed rocks or loose angular stones, sometimes mixed up with mud, which had been separated and disintegrated, but since that had remained *unmoved*. II. *Taluses*, the substance of which had fallen by its own weight, and not been transported by streams. These were the great heaps of angular matter that were found at the foot of cliffs, with a slope generally of near 35°. A special form was the fan-talus, which occurred where the falling matter had either originated from, or collected to, one spot, from which again it spread, and made a partial cone of the same slope as the ordinary taluses. III. *Alluvial Fans*.—These were the fan-shaped extensions of alluvial or torrential matter that spread out from the mouths of gorges, where these debouched into a more open valley. They were in form cones of a low angle, commonly 5° or so; they had accumulated by layer after layer on a cone-shaped surface, as shown by the radial sections exhibiting layers of a straight slope, and the chord sections showing curves, which were by the theory hyperbolas. Many complicated phenomena were produced by the denudation of these fans, and the production of secondary ones, some of which were illustrated by diagrams. IV. *Alluvium*, which was defined as a deposit which sloped down the direction of the valley of the stream which had made it, and did not appreciably slope or curve over in a direction at right angles to that. With regard to the country in question, there was evidence of a succession of three states:—1st, The cutting of the valleys. 2nd, The accumulation of alluvial matter. 3rd, The cutting down of the streams through that alluvial matter. Accumulation denotes an excess of supply of material from the rocks (by disintegration) over what can be carried away by the streams. Denudation, or the cutting down of the streams through their alluvium (the lowering of their beds), denotes a deficiency of supply of material from the rocks as compared with the transporting power of the streams. Hence the author inferred that the period of great accumulation of these alluvial deposits was one of great disintegration of rocks, one of intense frost; in other words, it was the Glacial period, and that the denudation occurred when the cold lessened, and there came to be a smaller supply of disintegrated material. The connection of various glacial phenomena with the alluvium, such as the one described above, was taken to corroborate the inference that the greater deposits were made during the Glacial epoch.

Geologists' Association, June 6.—Mr. Robert Etheridge, F.R.S., vice-president, in the chair.—"On Ammonite Zones in the Upper Chalk of Margate, Kent," by Mr. F. A. Bedwell. The author described, and showed by sections, the exact positions in the cliffs to the east and west of Margate, of fifteen large Ammonites, twelve of which lie between the Flagstaff and the Cliftonville Hotel, a space of about half a mile, and some of them exceed three feet in diameter. All these twelve are in a bed closely approximating to an exact parallel with a faint line of nodular flints which undulates over this part of the cliff and are at a constant distance of eight feet below that line. These facts indicate the following (1) The presence of an Ammonite zone, and of (2) a true sea floor. (3) The parallelism of this with the horizontal flints, and (4) that all the horizontal bands of flint must be assumed to have been aggregated before the chalk moved. Particulars were also given of three other beds of Ammonites, one to the west of Margate, another forty feet below that first mentioned, and a fourth at Pegwell Bay, at the top of the cliff near the landing-stage. The first and second were conjectured to be identical, and also the third and fourth. Specimens from the first and second beds were respectively identified by Mr. Etheridge as *A. leptophyllus* and *A. Lewesiensis*. Similar beds elsewhere were referred to, but details could only be given of one. This is to be seen at low water near the Black Rock at Brighton. A remarkable bed of continuous solid flint, three or four inches thick, occurs round and under the Isle of Thanet. Between the Foreland and Pegwell Bay it is in the upper part of the cliff, sinks below the shore at Pegwell Bay and Kingsgate, rises again to the west at the back of Margate Harbour but disappears immediately, appears again to the south, as pointed out by Mr. Whitaker in his Geology of the London Basin, at Cap Point near Walmer, and again at Shepherd's Well Station, 10 miles inland, where it is surmounted by the soft almost flintless chalk of Margate, and finally it was known throughout the island by the well diggers. This positive testimony of coincident and uniform flint aggregation over so large an area appeared to be an important fact in its bearing on the origin of flint. Mr. Bedwell stated that he had found the ammonites entirely by trusting to the zone of life theory insisted on by Mr. Caleb Evans in his paper on the Chalk (Geol. Assoc. 1870), and had failed to find them until he had selected the faint line of flints as a datum line and worked from that. He advised all young students of the chalk to examine a cliff in true horizons and not in a mere indiscriminate effort to make a large bag of specimens, to record carefully the exact chronological order of each fossil extracted by referring it to a datum line as suggested by Mr. Caleb Evans, to keep in mind the time which may have separated the life history of two fossils though only distant a few feet from each other, and to try to correlate two sections of chalk rather by the succession of zones of life in each cliff than by a mere comparison of indiscriminately collected fossils. The author in conclusion urged the importance of allowing Nature to teach her own independent lessons at the cliff side, of supplementing Nature by books rather than books by Nature, and pointed out how easy it was for those with little knowledge of details to be of service to science by simple observation and following to its end one single thread and one only, and then laying the results before scientific men, leaving them to estimate the value of the information.

Royal Horticultural Society, June 4.—Scientific Committee.—A. Smee, F.R.S., in the chair.—A fruit of *Anona reticulata* was sent produced in the gardens of Sir Walter Trevelyan at Wallington.—A letter was read from Prof. Westwood, stating that some grubs which had been submitted to him as having completely destroyed some bulbs, proved to belong to *Merodon clavipes*, a very rare insect in England, and in this case probably introduced.—A Pelargonium of the variety Cleopatra was exhibited from the Chiswick Garden. It had produced trusses of flowers of its proper pink as well as others of its ancestral scarlet.—Dr. Gilbert made some remarks on the proposed use of chalk mixed with coal in furnaces for horticultural purposes. He said it was quite certain the chalk could not supply any heat; on the contrary, its conversion into lime involved a considerable loss of heat in order to effect the change. What the chalk did was to absorb the heat and radiate it out again, and pieces of broken fire brick would probably answer the purpose equally well. The mixture of these substances simply, so to speak, diluted the coal.—A fine specimen of fasciated asparagus was shown from Mr. Macmillan. It has been produced two years running apparently from the same plant.

General Meeting.—Viscount Bury, M.P., president, in the chair.—The Rev. M. J. Berkeley stated that he had recently seen in Denbighshire nectarine trees, the flowers of which usually produced five carpels instead of one. He commented on the effects of the late frost on the potatoes at Chiswick. Some were very much injured, while others had escaped altogether, and in some instances of two stems to one root, one had been killed back and the other not touched.

PHILADELPHIA

Academy of Natural Sciences, March 4.—Mr. Vaux, vice-president, in the chair.—Mr. Thomas Meehan exhibited a flower of *Bletia Tankervillia* (*Phaius grandiflora* of some authors), in which the dorsal sepal (or, as some authors contend, petal), had united with the column, and had been much retarded in its development accordingly. He said that he had several dozen of flowers produced in this way this winter, all, however, confined to separate spikes from those which bore the perfect flowers. It was usual to pass over these appearances as "monstrosities," but in truth the whole Orchid structure was little less than a monstrosity. He did not think as much had been made out of the changes of structure in orchids in the study of evolution, as might be, in consequence of the impression that these abnormal forms, as they were termed, were monstrosities, or the results of cultivation. There had been already on record accounts of changes in wild orchids more remarkable than many much dwelt on by many modern writers on development. He further remarked that, in examining closely the flowers of *Bletia Tankervillia* early in the morning, he found on the outside, at the base of the three exterior petals, a liquid exudation from a small gland. It was highly probable that these glands were rudimentary spurs, and that, if the course of nutrition which sustained the cohering power of an orchid could in any way be diverted before the final direction of form, each of these outer petals might take on some of the labellate character with its attendant spur, which gave such a peculiar appearance to so many orchidaceous plants.

March 18.—The president, Dr. Ruschenberger, in the chair.—"On the Occurrence of an Extinct Hog in America."—Prof. Leidy exhibited the fragment of a lower jaw of a pig which Prof. Hayden had picked up, together with many remains of extinct mammals, in the pliocene sands of the Niobrara River, Nebraska. The specimen he viewed as of recent character, and not as a true indigenous fossil. Prof. Leidy remarked that he had never seen any remains of the hog which he could confidently view as true American fossils.—Prof. Cope stated that Dr. Hayden handed to him for determination some bones on a fragment of the Green River shale of the Eocene of Wyoming. They indicated a species of Anourous Batrachian, but as the individuals were not fully developed, he was not prepared to identify the genus. They constituted the first indication of this order in time; those previously known from Europe and India being all of Miocene age.

PARIS

Academy of Sciences, June 9.—M. de Quatrefages, president, in the chair.—M. Dupuy de Lome presented to the Academy, in the name of the Minister of Marine, the first number of the "Memorial of Marine Artillery" and its appendix, "The Artillery Remembrancer." These are published for the use of French naval officers, and contain an immense amount of information on the armament of foreign ships of war. Great space is devoted to English naval matters, and the Memorial is well worthy of the attention of our own naval authorities.—The following papers were read:—Researches on new propyl derivatives, No. 2, by M. A. Cahours. The glucinum, silicon, and boron compounds of propyl were described.—On normal and abnormal speech, by M. Bouillaud.—On the intervention of atmospheric nitrogen in the phenomena of vegetation, by M. P. P. Dehérain. The author described some experiments which showed that, in the presence of ammonia, glucose absorbs nitrogen from the air.—On the multiple causes which provoke the fall of lightning, by M. W. de Fonvielle.—On the theory of the spots and the dark nucleus of the sun, by M. E. Vicaire. The author replied to M. Faye's recent answer to him; he thinks that Respighi's observations quoted by M. Faye tend to support his views rather than those of that astronomer, *i.e.* that the absence of the chromosphere over the spots is due to a cessation of the emission of the gases of which it is composed, and not to their being swallowed up by a cyclone.—Researches in spectrum analysis in relation to the spectrum of the sun, by Mr. J. N. Lockyer. This was a letter to M. Dumas giving an account of the author's late paper read before the Royal Society.—An answer to M. Raynaud's late note on the resistance-maxima of magnetic coils, by M. Th. du Moncel.—On the relation between electric and capillary phenomena, by M. G. Lippmann.—On the boiling points and molecular volumes of the chlorinated isomers of the ethylic series, by M. G. Hinrichs.—On ethylacetylene formed by synthesis, and on its identity with crotonylene, by M. L. Prunier. The author has synthesised this body by passing equal volumes of ethylene and acetylene through a porcelain tube heated to dull redness.—On the synthesis of phenyl-allyl, by M. Chojnacki. The author obtained this body by acting on a mixture of equal weights of benzine and iodide, or bromide of allyl, with $\frac{1}{3}$th of its weight of powdered zinc.—On the combinations of titanic chloride with the ethers, by M. Demarçay.—On phenyl-cyanine, by Mr. T. L. Phipson.—Note on M. Mène's paper on the preparation of ammonic sulphate from nitrogenous waste, by M. L'Hote.—On the estimation of phosphoric acid in manures, coprolites, and fossil phosphates, by M. Ch. Mène.—Mineralogical note on the dibasic plumbic sulphate of l'Ariége, by M. E. Jannettaz.—On the affinities of *Etheostomata* (Agassiz), by M. L. Vaillant.—Magnetic observations, by M. Diamilla-Muller.—Spectroscopic researches on the fumerolles of the eruption of Vesuvius of April 1872, and on the actual state of that volcano, by M. L. Palmieri. This was a very short extract from a letter, the only points being that thallium and boric acid are found in the sublimates from these vents, and that since the eruption the mountain has exhibited a state of abnormal quietude.

DIARY

THURSDAY, JUNE 19.

ROYAL SOCIETY, at 8.30.—On the Fossil Mammals of Australia, Part IX. Family Macropodidae: Prof. Owen, C.B.—On the Nature and Physiological Action of the Poison of Naja Tripudicans, and other Indian Venomous Snakes: Dr. Fayrer and Dr. Brunton.—Researches in Circular Solar Spectra Applied to Test Residuary Aberration in Microscopes and Telescopes: Dr. Royston-Pigott.—On the Structure and Development of the Skull in the Pig (*sus scrofa*): W. K. Parker.—Results of the Comparisons of the Standards of Length of England, Austria, Spain, United States, Cape of Good Hope, &c.: Lieut.-Col. Clarke.—On Comparative Vegetable Chromatology: H. C. Sorby.

SOCIETY OF ANTIQUARIES, at 8.30.—On Further Excavations at Silchester: Rev. J. G. Joyce.

LINNEAN SOCIETY, at 8.

CHEMICAL SOCIETY, at 8.—On the Influence of Pressure upon Fermentation, Part II.: Horace Brown.—Researches on the Action of the Copper-Zinc Couple on Organic Bodies, III., and on Normal and Iso-Propyl Iodides: Dr. J. H. Gladstone and A. Tribe.—On Cymenes from different sources optically considered: Dr. J. H. Gladstone.—On the Action of Bromine on Alizarine: W. H. Perkin.—On some Decompositions and Oxidation Products of Morphine and Codeine Derivatives: E. L. Mayer and Dr. C. R. A. Wright.—On the Decomposition of Tricalcic Phosphate by Water: R. Warrington.—On a new Tellurium Mineral, with Notes on a Systematic Mineralogical Nomenclature: J. B. Hannay.—Communications from the Laboratory of the London Institution, No. XII;—On New Derivatives of Cresol: Dr. H. E. Armstrong and C. L. Field.

NUMISMATIC SOCIETY, at 7.—Anniversary.

FRIDAY, JUNE 20.

MEDICAL MICROSCOPICAL SOCIETY, at 8.—The Pathological Relations of Diptheria and Croup: Jabez Hogg.

MONDAY, JUNE 23.

GEOGRAPHICAL SOCIETY, at 8.30.

WEDNESDAY, JUNE 25.

SOCIETY OF ARTS, at 4.—Anniversary.

GEOLOGICAL SOCIETY, at 8.—On Six Lake-basins in Argyllshire: His Grace the Duke of Argyll, K.T., F.R.S., President.—Description of the Skull of a Dentigerous Bird (*Odontopteryx toliapicus*, Owen), from the London Clay of Sheppey: Prof. Richard Owen, F.R.S.—Contribution to the Anatomy of *Hypsilophodon Foxii*, Huxley: J. W. Hulke, F.R.S.—On the Glacial Phenomena of the Long Island, or Outer Hebrides: James Geikie.—On Fossil Corals from the Eocene Formation of the West Indies: Prof. P. Martin Duncan, F.R.S.—Note on the Lignite-deposit of Lal-Lal, Victoria, Australia: R. Etheridge, Jun.

THURSDAY, JUNE 26.

SOCIETY OF ANTIQUARIES, at 8.30.

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