"The peculiar and distinctive character of the Royal Society Relief Fund is, that although relief has invariably been granted with the greatest promptitude, the claims have nevertheless been most carefully examined by those whose pursuits in life enable them to form the most correct conclusion as to the character of the claimant. The Committee can most conscientiously state that, in no instance, has any applicant having the slightest claim on the Fund been refused assistance. Sometimes the payments to recipients have been the first information they have received of such a fund being in existence; the Committee may have on some occasions regretted that it had not a larger sum at command, but the relief, whatever its amount, has always been received with gratitude for the substantial aid it afforded, and with pleasure as a recognition on the part of the Council of the Royal Society of good service rendered to science.

"The Committee is naturally desirous to retain sufficient funds in hand to meet any sudden emergency that may arise; at this time there appears a balance somewhat larger than usual, but this arises from there having been only two applicants this year instead of five, as in 1863. It is very probable that if the *existence* of such a fund were more generally known, especially among the members of the Chartered Scientific Societies, further subscriptions would be tendered."

(Signed) W. A. Miller.
W. B. Carpenter.
J. J. Sylvester.
T. H. Huxley.
J. P. Gassiot.

Burlington House,
24th November, 1864.

On the motion of Mr. Busk, seconded by Dr. Gray, the thanks of the Society were voted to Mr. Gassiot for his services in originating and conducting the Scientific Relief Fund.

The President then addressed the Society as follows:—

Gentlemen,

When I had the honour of addressing you at the Anniversary Meeting in 1862, I informed you of the steps which had been taken by the Council towards the formation of an Index to the Scientific Periodical Literature of the Nineteenth Century, or, more precisely, a Catalogue of the Titles of Scientific Memoirs contained in the Scientific Periodicals, in all languages, from the commencement of the present century to the year 1860. The preparation of this work has progressed steadily; and, so far as regards a Manuscript Catalogue to be kept in our own library for the use of the Fellows generally, it may be considered to be very nearly complete. The limit in point of time to which the entries of the Titles should be restricted has been extended to 1863 inclusive. A circular which has been addressed by the Foreign Secretary to seventy

Academies with which the Royal Society is more or less in communication, as well as to several other institutions and individuals, to ascertain whether they possessed any works suitable for cataloguing which were not in our library (enclosing at the same time a list of the works already indexed), has been largely replied to; and we have thus been enabled to considerably extend our Catalogue. The number of titles which it at present includes exceeds 180,000, entered in manuscript volumes, available for reference in our library. Our communications have been responded to in several instances with offers of assistance, and in general with strong expressions of interest in the progress of the work, and of anticipated advantage from its publication.

After a full consideration of the different modes in which such a publication might be effected, the Council decided that the manuscript should in the first instance be offered to Her Majesty's Government, to be printed at the public charge, at Her Majesty's Stationery Office or otherwise, as might be deemed expedient; and that a certain number of copies should be presented to Scientific Institutions at home and abroad, in the name of the British Government and of the Royal Society; the remainder of the impression being offered for sale at the cost of paper and printing only, and the proceeds applied towards the discharge of the expense incurred in the printing, no pecuniary return being looked for on the part of the Society.

The Council have availed themselves of the good offices of a valued Fellow of the Society, Sir Henry Holland, who had been a member of the Council whilst the Catalogue was in progress, to bring the subject of the publication under the consideration of Her Majesty's Government, whose favourable reply has been this morning received.

From the best judgment which the Council can form, there is reason to believe that by the time the Government may be ready to commence the printing, the Catalogue will have been completed with all the titles that can be obtained. The manuscript, as at present prepared, contains the Titles in the order in which they stand in each of the periodical works indexed; but for publication it will be arranged according to authors' names, and be followed by an Alphabetical Index according to subjects. The expense hitherto incurred by the Society in its preparation amounts to about £1400; and possibly £300 or £400 more will be required in the preparation of the Index of Subjects, and in the general revision of the press.

It is with great satisfaction that we see the value and importance of the Philosophical Transactions recognized increasingly from year to year both at home and abroad. Besides the contributions from our own members and countrymen in the past year, to some of which I may briefly advert in the sequel, we have received a very valuable paper from Professor George Forchhammer, of Copenhagen, to a brief

notice of which, as being presented to us from abroad, I will give the first place.

This communication forms a valuable contribution to a great subject —the history of the Sea. It contains a full and compendious inquiry into the constituents of the water of the ocean, divided into seventeen geographical regions, each of which is studied separately from samples taken both at the surface and at various depths. An accurate view is thus gained for the first time of the sea as a whole, and conclusions of great generality are obtained. The minute analytical processes followed in several hundred analyses were so conducted as, in the opinion of competent judges, to inspire entire confidence. They confirm the presence in sea-water of the twenty-five elements already reported by other chemists, and add two others, boron and aluminium, to the number. But it is chiefly by the application of the data thus obtained to the elucidation of various geographical problems of great and general interest that we are led to recognize the full importance of this memoir. I may permit myself to notice one or two of the most remarkable of the conclusions established by it.

In the Atlantic the saline ingredients in the sea-water (the samples being taken at proper distances from the land) decrease with increasing depth. This is found to hold good even to extreme depths. The existence of a Polar current in the depths of the Atlantic is hence inferred, since it is a well-established fact that the equatorial seas are richer, and the polar seas poorer, in saline ingredients.

The large amount of saline contents found by analysis of the water of the well-known current flowing from north-east to south-west, between Iceland and the east coast of Greenland, shows it to be, not as heretofore supposed, a polar current, but one of equatorial origin. The inference is, that it is a returning branch of the great Gulf-stream which we have recently had reason to recognize as extending to the shores of Nova Zembla and to the north coasts of Spitzbergen, carrying to Nova Zembla the floats of the Norwegian fishermen, and to Spitzbergen the same floats, mingled with wood from Siberia. May it not be possible that the "iceless sea, teeming with animal life," described by the adventurous American explorer Dr. Kane as viewed from the promontory which formed the northern limit of his research, is, as he himself surmised, but an extension of the same equatorial stream which produces correspondingly abnormal effects at Spitzbergen, as well as at every other point to which its course has been traced?

When physical researches shall be resumed within the circle which surrounds the Pole, this perhaps will be one of the earliest problems to receive solution—a solution rendered now so simple by the method of inquiry which Professor Forchhammer has made known to us.

In Astronomy the most important results in the year are Sir John

Herschel's Catalogue of *Nebulæ*, which forms Part I. of the Transactions for 1864; and Mr. Huggins's application of the spectroscope to study those mysterious forms, and to examine the chemical constitution of stars and planets. The nebulæ are so widely different from the other heavenly bodies, that ever since their first discovery they have been objects of wonder and speculation. For a long time only three or four of them were known, till about a century ago Messier added about 100 more. His labours, however, were completely eclipsed by the elder Herschel, who gave unprecedented power to the telescope, and used it with skill and sagacity which have never been surpassed. He was rewarded by discovering 2500 of these objects, and finding in them varieties of figure of the most unexpected character.

After such a harvest it might have been thought that little was left to be gleaned in this field; but his accomplished son was not less successful in the northern hemisphere; and when his zeal and energy led him to the Cape of Good Hope, he found in that almost unexplored sky the opportunity of even surpassing his father, and connecting more than 1000 other nebulæ with his own name. Since then the great Achromatics of Poulkova and Harvard, and the gigantic reflectors of Rosse and Lassell have revealed many strange arrangements in them, some of which are scarcely reconcileable with ordinary dynamics; and it is evident that the study of their nature is likely to occupy much of the attention of astronomers for years to come.

At such a crisis no more acceptable gift could be made to Nebular Astronomy than a work which should embody in a practical manual the sum of our actual knowledge of this department, and do for it what the Catalogue of the British Association and others are performing for the stellar branch. And none was so fit for this task as Sir John Herschel himself. Besides his own unequalled familiarity with the subject, and thorough cognizance of the labours of others, he had an advantage in his acquaintance with his father's manuscripts and the labours of his aunt, a person not less an honour to her name, such as none other could possess. And yet more, he had an interest in this pursuit such as can be expected in very few, but without which the labour that must have been expended on this catalogue would have been insupportable. It contains, arranged in Right Ascension, the places of 5079 nebulæ for 1860 with the precessions so chosen that they will be available for at least sixty years to come. Each nebula has its discoverer indicated, the number of observations, and a description of its form and character, composed of a very few letters, but to any one who will learn their symbolic meaning, of marvellous fullness and precision. Copious notes and references, and an introduction which gives full historical information, complete all that can be required by observers.

And that observers will be numerous as soon as Mr. Huggins's researches become generally known, must be anticipated. At our last

Anniversary I noticed briefly that he and Dr. Miller were examining the spectra of the fixed stars; their results have appeared in our Transactions for this year, and can scarcely be estimated too highly. Before them Fraunhofer, and recently Donati, Secchi and some others had examined a few stellar spectra with more or less success; but with inferior apparatus, and far less extensively. Their superiority is mainly due to their referring the spectral lines to no mere instrumental scale (which, from the inevitable variations of the spectroscope-prisms, must be liable to error), but to standard spectra of known elements which are formed in juxtaposition with that to be examined, and to which its lines can be compared with extreme precision. As the stars are but points in a good telescope, it is necessary to expand these images into lines that the details of their spectra may be perceptible. This weakens their light, already feeble; and therefore the telescope to which the spectroscope is applied must be of considerable power; in this instance it has 8 inches aperture. They have examined more than fifty stars, and find all to have a constitution analogous to that of our own sun, and like it to show the presence of several terrestrial elements.

The lines due to sodium seem universal; so also those of magnesium and iron. Hydrogen is also frequent; in two stars it is wanting. The absence of nitrogen from all is very singular, unless it be present under conditions which alter its relation to light. It is to be regretted that the spectra were not compared with nickel, chromium, and the other elements that have been found in aërolites; this, however, we hope will be done for those elements, and indeed for all the other terrestrial ones. The explanation given of the different colours of the stars is doubtless the true one; it arises from the existence of different bands of absorption in particular parts of the spectrum. Thus in the beautiful star β Cygni, these bands are crowded in the blue end of the spectrum of the orange star, and in the red end of that of the blue star. Possibly further investigation of elements may enable us to conjecture why in dichromic double stars the small one is always blue or green. In the planets a closer conformity to the spectrum of the sun, by whose light they shine, might be expected—and is found. In the moon there are no lines whatever due to an atmosphere, nor in Venus. In Jupiter and Saturn, besides the solar lines, there are some identical with those produced by our own atmosphere, and one which must be due to the presence of some peculiar gas or vapour. Mars is still more peculiar; but the appearances give no countenance to the notion that his red colour is due to the chemical composition of his soil. Mr. Huggins has gone yet further and attacked the nebulæ, though their extreme faintness might seem to elude all the power of the spectroscope. The result is at once a strong proof of the soundness of Bacon's precept in doubtful cases, "*Fiat experimentum*," and a demolition of more than one accepted hypothesis. The notion of the elder Herschel,

that these strange bodies were masses of vapour, gradually condensing by radiation of heat and the action of gravity, and that (according to Laplace) in condensing they threw off rings which shrunk up into planets, satellites, and comets, was long in favour with Cosmogonists. Lord Rosse's discovery, that many of them which were cited as evidences of this, were in truth mere clusters of stars; that many more, though not totally resolvable, were yet dotted over with lucid points, produced a reaction which led to doubt the existence of any but stellar materials in the remote heavens. But here we have a totally different view opened. Mr. Huggins began with the planetary nebulæ, so called from presenting well-defined luminous disks (which, however, Lord Rosse has found in all that he examined to be complicated ring and spiral formations). To Mr. Huggins's great surprise he found them to be totally different from the stars; instead of continuous spectra interrupted by a multitude of dark lines, he found (which made it possible to observe them at all) that their light consisted entirely of three bright lines; the faintest indicating the presence of hydrogen, the next some unknown element, and the third a line which coincides with the brightest of nitrogen, but which he hesitates to refer to that body because no others of its bright lines are present. In some of them a very faint star-spectrum is also visible, due of course to the small stars which are found in many nebulæ, often in such numbers that their presence can scarcely be merely optical. Some nebulæ, and all the clusters which in ordinary telescopes look like them, do not show the distinctive three lines, but merely star-spectra. The importance of this new view, this new "Explorator Abyssi," to borrow a phrase of Hooke, cannot be rated too highly; and you will I am sure join me in expressing our hopes that these gentlemen will press onward in the bright path which they have opened, and perhaps with even higher instrumental powers.

One who has not taken part in this kind of observation must speak with reserve; but I cannot refrain from expressing a wish that their telescope were of much greater aperture—as two or three feet. The object of the telescope is in this case mere concentration of light, and it will probably be attained without anything of that perfect finish which is required for exact definition. If so, a mirror of silvered glass, or even copper, and of comparatively short focus, or one of Fresnel's Light-house lenses, might be a powerful auxiliary.

The remarks which I ventured to make in my Address at the last Anniversary, on the expediency of combining Pendulum Experiments with the Astronomical and Geodesical operations of the Great Indian Arc, have given occasion to a correspondence between Colonel Walker, the Superintendent of the Indian Trigonometrical Survey, and myself, which has been subsequently augmented by letters from several Fellows of the Royal Society conversant with such subjects, written in reply to

a Circular which, with the concurrence of the Council, I addressed to them. This correspondence having been submitted in a printed form through the proper channel to the Secretary of State for India, the proceedings proposed by Colonel Walker for carrying out the experiments have been officially sanctioned. An application to the Royal Society for a loan of two of the pendulums which had been previously employed in similar experiments, with their attendant clock, has been acceded to; and a Vacuum Apparatus convenient for transport, in which the pendulums may be vibrated at the Indian stations, has been constructed at the Kew Observatory. Captain Basevi, of the Royal Engineers, appointed to conduct the experiments in India, has resided for some weeks at Kew for the purpose of making himself practically acquainted with the instruments, and the mode of experimenting with them. Circumstances having obliged Captain Basevi to proceed to India before the base observations could be made at Kew, these have been undertaken by the Kew Observing Staff, and will be carried on in an apartment arranged for the purpose, which will be hereafter available for the verification of the same pendulums on their return from India at the close of the operations; and will, moreover, supply a convenient locality for future occasions of a similar kind, as well as for the comparison of the pendulums of other countries. We may not unreasonably anticipate that such experiments may henceforward be regarded as an appropriate accompaniment to the measurement of arcs in all parts of the globe.

I am glad to be able to add that Colonel Walker has also directed that the Indian Survey should be provided with instruments for determining the absolute values of the three magnetic elements at the Indian stations. We may thus hope to obtain a further investigation of the (apparent) systematic anomaly in the direction of the lines of magnetic force in the central parts of India, which is so remarkable a feature in the admirable magnetic survey of that portion of the British dominions executed by the Messrs. de Schlagintweit.

Whilst on the subject of terrestrial magnetism, I may be permitted to notice that, in a paper presented in the last session, I have called the attention of the Society to a very remarkable feature, made known by the comparison of the disturbances of the magnetic declination in England, and at stations nearly in the same latitude in the eastern parts of Asia. The days in which such phenomena occur are almost without exception the same in both localities; the hours (of absolute time) at which the maxima and minima of disturbances characterized by a common type take place are, within very small limits, also the same; but the *direction* in which the magnet is at the same moment deflected in these otherwise most accordant phenomena is systematically *opposite* in England and in eastern Siberia. I attach of course far more importance to the fact itself than to the hypothesis which guided me to its anticipation, and thence to its discovery; still, an hypothesis which has

led to the knowledge of a fact of so much theoretical importance entitles itself to some consideration; whilst no one can doubt that a knowledge of the fact itself strengthens the desire for the multiplication of stations in distant parts of the globe, at which these phenomena are systematically observed; and in this view the Society will hear with pleasure that, by intelligence very recently received, we learn that the authorities in the colonies of Mauritius and Victoria have decided on the establishment of magnetical observatories supported by colonial funds, to be equipped with similar instruments to those at Kew, and to be conducted on the system which is there exemplified. We are led in these two instances to recognize the advantage which a colony derives from having a Governor whose education has fitted him to appreciate the importance of cultivating the physical sciences.

We have learnt with satisfaction from Stockholm that the Swedish Expedition to Spitzbergen has returned from the second year of a survey preliminary to the measurement of an arc of the meridian; and that the result has been that no doubt is entertained of the practicability of the measurement of an arc of at least 3°, with a possibility of further extension. The report of the completion of the preliminary survey is be published in the early part of the winter; and the summer of 1865 is looked forward to for the commencement of the arc itself.

In Meteorology, we have, in the 2nd Part of the Philosophical Transactions for 1863, the first of a series of papers by Dr. Hermann de Schlagintweit on the "Numerical Elements of Indian Meteorology," based on observations made chiefly by officers in the late East India Company's Service at 207 stations, the original records of which were placed by the Indian Government in the author's hands for reduction and coordination. The present paper discusses the temperatures and the isothermal lines over India, both for the entire year and for each of the meteorological seasons. The differences between the forms of the isothermals in the different seasons are excessive, and full of instruction to climatologists who will study their causes. For the full elucidation of the subject, however, we must await a similar coordination of the barometric and hygrometric relations; there is probably no portion of the globe where the connexion of the periodic variations of the barometer, thermometer, and hygrometer manifests itself so clearly and so instructively as in Hindostan. There the "Trades" become "Monsoons": the aërial pressure describes from winter to summer a regularly inflected hollow curve; whilst the aqueous vapour inversely increases its tension; and the temperature attains its maximum before the sun has reached its greatest altitude*.

* See in illustration the annual variations in the plate of the "Report on the Meteorology of Bombay" in the British Association volume for 1845.

I proceed to announce the awards which the Council has made of the Medals in the present year; and to state the grounds on which those awards have been made.

The Copley Medal has been awarded to Charles Darwin, Esq., F.R.S., for his important researches in Geology, Zoology, and Botanical Physiology.

In 1832 Captain FitzRoy, commissioned by the Admiralty to proceed in command of the 'Beagle,' on a Voyage of Survey to the Southern Hemisphere, liberally offered, in the interest of science, to give up half his cabin to any qualified naturalist who would volunteer to serve on the Expedition, no remuneration being attached to the duty. Mr. Charles Darwin, then a ripe student at Cambridge, ardently devoted to the study of natural history, having heard of the offer, like Sir Joseph Banks, in the earlier of Cook's Voyages, eagerly came forward as a volunteer. The voyage of the 'Beagle' extended over the consecutive years from 1832 to 1836, and embraced regions presenting such fertile fields for research in the Volcanic, Coral, and other Islands of the Atlantic and Pacific Oceans, that the results of his observations actively occupied, after his return, ten years of Mr. Darwin's time in publication; and have since mainly suggested and determined the most prominent of his latest labours. His scientific works and memoirs have included a very wide range of subjects, which may be classified under the heads of Geology, Zoology, Physiological Botany, Physical Geography, and Genetic Biology, each of which he has enriched with important original contributions. The award of the Copley Medal has been founded on Mr. Darwin's researches in the three first-named branches of science.

Geology.—Mr. Darwin has been preeminently successful in the solution of a great problem in physical geography, and in applying it to the explanation of geological phenomena, by his important work on the Structure and Distribution of Coral Reefs, which appeared in 1842. The successive voyages of many eminent navigators had shown that vast tracts in the deepest parts of the Pacific and Indian Oceans were studded with circular groups of Coral Islets enclosing lagoons; and that long detached reefs of the same formation flanked lines of coast in a nearly unbroken stretch of about 1000 miles. The reefs and islands have been carefully mapped and surveyed; and the different forms exhibited by them had been accurately classified under the names of "Atoll Islands," "Encircling Reefs," "Barrier Reefs," and "Fringing or Shore Reefs." Eminent naturalists had observed the habits and mode of growth of the Zoophytes in the most favourable localities; and the comparatively shallow depths at which the reef-building species live had been determined. But no satisfactory explanation of the phenomena was arrived at—why Atolls assumed their peculiar form, and why Barrier Reefs included broad lagoon channels between them and the

contiguous coasts. Some explanations were indeed propounded, but were manifestly inadequate to meet all the conditions.

The subject was in this state when Mr. Darwin took it up. Combining careful observation upon Coral Reefs and Atolls with reflections upon the range and distribution of Volcanic Islands, he divided the area of the Pacific and Indian Oceans into tracts of elevation and depression. All the Coral Phenomena of Atolls, Encircling Reefs, and Barrier Reefs were accounted for upon the supposition of a long-protracted but gradual subsidence under the ocean of large areas of land, admitting the Coral Formation to grow up whilst its foundation sunk down; while Fringing Reefs were explained as appertaining to areas of elevation where the land had risen up or was progressively rising. On this view the apparently discordant facts ranged themselves in perfect harmony. Fringing Reefs were thus converted into Barrier Reefs, and Encircling Reefs into Atolls, "the instant the last particle of land sinks beneath the ocean." Representing on a map the two classes of facts by different colours, it was shown that active volcanos are absent in the region of Atolls and Barrier Reefs, while they abound in areas of Coral Fringes and of elevation.

Mr. Darwin's researches were received by naturalists with lively satisfaction as fixing an era in the history of the investigation, and as contributing one of the most important illustrations which geology had received since it had been shaped into a science. A flood of light was thus thrown upon the ancient calcareous formations which enter so largely into the composition of the superficial crust of the earth; and something like a definite idea was arrived at respecting areas of depression and elevation.

In addition to his researches upon coral reefs, Mr. Darwin has made numerous contributions to Geology, both in the descriptive and theoretical divisions of the science. As belonging to the former class may be cited his admirable 'Journal of Researches,' containing observations on the Geology of the various countries visited during the voyage of the 'Beagle'; notes during a survey of the east and west coasts of South America, with a transverse section of the Cordilleras between Valparaiso and Mendoza; Geological observations on South America, published as a separate work in 1846; Geological observations on the Volcanic Islands visited during the voyage of the 'Beagle,' with brief notices of the Geology of Australia, New Zealand, and the Cape of Good Hope, also published as a separate work; on a remarkable Bar of Sandstone off Pernambuco; on the Deposits containing extinct Mammalia in the neighbourhood of the Plata; on the Geology of the Falkland Isles; on the Distribution of Erratic Blocks in South America.

In theoretical or speculative geology may be cited his memoir on the connexion of certain Volcanic Phenomena in South America, and

on the Formation of Mountain Chains and Volcanos as the effect of Continental Elevations; his memoirs on the Parallel Roads in Glenroy; on the Effects produced by the ancient Glaciers of Carmarthenshire; on the Transport of Erratic Boulders from a lower to a higher level; and on the Origin of Saliferous deposits. From the Ossiferous Superficial deposits in the neighbourhood of the Plata Mr. Darwin brought home an important collection of fossil mammalian remains, which formed the subject of a separate volume by Professor Owen. In his memoir 'On the Formation of Mould,' as the result of the digestive process of the common earthworm, he furnished a fresh and instructive illustration of the large effects which are produced in the organic kingdom by the continued agency of apparently insignificant instruments.

The present occasion admits of little more than a bare enumeration of these labours, which are stamped throughout with the impress of the closest attention to minute details and accuracy of observation, combined with large powers of generalization. The Geological Society of London signalized its estimate of their importance by the award of a Wollaston Medal.

Zoology.—In zoological science Mr. Darwin's eminent merits were to some extent acknowledged ten years ago by the award of a Royal Medal. On that occasion the zoological work that was most particularly distinguished was his Monograph on the Cirripeds, a class of animals whose life, history, structure, and classification had previously been involved in the greatest obscurity and confusion. Notwithstanding the difficulties attending the study of these animals, and the extraordinary anomalies presented in their structure, habits, and affinities, Mr. Darwin was successful, as the result of unwearied labour and patience, and of the exercise of the most acute and accurate observation, in clearing up all that was obscure, and in disclosing for the first time numerous facts of the utmost interest and importance. But since the principal points contained in this monograph have been already detailed in the Proceedings of the Royal Society on the occasion referred to, it is needless here to recapitulate them. It will be sufficient to remark that the justness of the estimation then placed upon Mr. Darwin's labours has since been completely confirmed by the concurrent voice of all Zoologists, and that the Monograph on the Cirripeds is universally acknowledged to be a model of what such a work should be, and as fully entitling its author to a place in the foremost rank of zoological observers and authors. His labours in the same department were completed by the publication, about the same time, of two monographs on the Fossil Cirripeds of Great Britain, published by the Palæontological Society. This subject, which had before received scarcely any attention, and was left in the greatest obscurity, is in these monographs treated in the most complete and exhaustive manner; and all its difficulties were removed for future observers by the lucid and admirable definition of the various

parts, and the light thrown upon the structure and relations of the animals.

In other departments of zoology Mr. Darwin's labours, though not given in the same complete form as in the Monographs, have been numerous and important. They are distinguished by the same extent and variety of knowledge, the same scrupulous fidelity, accuracy, and minuteness of observation, and by the sagacity with which the most important generalizations have been drawn. Amongst these contributions should more especially be noticed the observations on the distribution and habits of the animals described in the 'Zoology of the Voyage of the Beagle,' and in the 'Journal of Researches' in the course of that voyage, in which most interesting and justly popular work we find first distinctly enunciated the important "law of the succession of Types," or the law that existing animals have a close relation with the extinct species found in the same regions. Nor, amongst the many other weighty and interesting remarks contained in this volume, should notice be omitted of those which have reference to the common assumption that the presence of the remains of large animals necessarily implies that the country inhabited by them must have possessed a luxuriant vegetation. The fallacy of this assumption is plainly shown by Mr. Darwin, and the importance of his correction of a prevalent error of this kind can hardly be overrated.

In his most recent work 'On the Origin of Species,' although opinions may be divided or undecided with respect to its merits in some respects, all will allow that it contains a mass of observation bearing upon the habits, structure, affinities, and distribution of animals, perhaps unrivalled for interest, minuteness, and patience of observation. Some amongst us may perhaps incline to accept the theory indicated by the title of this work, while others may perhaps incline to refuse, or at least to remit it to a future time, when increased knowledge shall afford stronger grounds for its ultimate acceptance or rejection. Speaking generally and collectively, we have not included it in our award. This on the one hand; on the other hand, I believe that, both collectively and individually, we agree in regarding every real *bonâ fide* inquiry into the truths of nature as in itself essentially legitimate; and we also know that in the history of science it has happened more than once that hypotheses or theories, which have afterwards been found true or untrue, being entertained by men of powerful minds, have stimulated them to explore new paths of research, from which, to whatever issue they may ultimately have conducted, the explorer has meanwhile brought back rich and fresh spoils of knowledge.

Botanical Physiology.—Mr. Darwin's first botanical work, 'On the various contrivances by which British or Foreign Orchids are fertilized by Insects, and on the effects of Intercrossing,' marks an epoch in the history of physiological botany, and taken in all its bearings, is perhaps

the most masterly treatise on any branch of vegetable physiology that has ever appeared. The objects which the author had in view in entering on a comprehensive study of the sexual system of Orchideæ, were to show that the contrivances by which they are fertilized are as varied and almost as perfect as any of the most beautiful adaptations of the animal kingdom, and that these contrivances have for their main object the fertilization of one flower by the pollen of another. In pursuance of this object Mr. Darwin set himself to investigate, first, the structure and development of the flower of living specimens of nearly every British species; secondly, to observe how impregnation was naturally effected in each; thirdly, to make a similar structural investigation of the principal exotic forms; and, fourthly, to ascertain by experiment the method by which these also are in all probability fertilized. To these investigations Mr. Darwin brought all the resources of a most skilful microscopic dissector, of an unwearied and exact observer, of a sagacious experimentalist fertile in resources, of an entomologist versed in the structure and habits of insects, and of an excellent judgment in interpreting obscure phenomena, and drawing from them correct conclusions.

The result is a work no less remarkable for the novelty of its facts, and for the importance of their bearing, than for its being the first which correlates the structure with the functions of the floral organs of one of the largest and most conspicuous of the families of plants. It would not be difficult to justify this strong encomium by examples of great interest taken from the work itself, but it would be incompatible with the limits of this Address; suffice it therefore to say, that the general conclusion to which Mr. Darwin arrives is, that all the forms, even the most grotesque, which the floral organs of Orchids possess, are directly and obviously of use, and that every structural and physiological modification, however minute, tends, with scarcely an exception, to ensure the fertilization of the ovules of one plant by the pollen of another.

Mr. Darwin's next contribution to physiological botany is entitled "On the two forms, or dimorphic condition, in the species of *Primula*, and on their remarkable sexual relations." The phenomenon of there being two distinct forms of flower in the genus *Primula* has long been familiar to naturalists, but the real nature of the difference between them, and of their respective functions, had not occurred to anyone. Mr. Darwin first suspected that the relations between the forms might be sexual, and he has since, with consummate skill, incontrovertibly proved this to be the case. By a most searching examination of a vast number of specimens of each form, in cultivated varieties as well as in species, he found that, in all, the two forms presented in their stigmatic surfaces, ovules, and pollen, *constant* differences, unbroken by a single instance of transition between the distinct forms. By experiments continued for several years, he proved that in this genus complete fer-

tility is only obtained by impregnating one form by the pollen of the other, each species of *Primula* being divided into two sets or bodies, which cannot be called distinct sexes, for both are hermaphrodite; yet they are so in a certain sense, for they require reciprocal union to effect perfect fertility. This remarkable fact has as yet no known parallel. The cross impregnation is effected by insects, the structure of insect and flower being such that one form cannot by this means be impregnated either by its own pollen or by that of a flower of its own form.

In a subsequent paper Mr. Darwin has shown that in a species of the genus *Linum*, which is also dimorphic, whilst the pollen in the two forms is absolutely undistinguishable microscopically, and the stigmas differ but slightly and not in any apparently important respect, the pollen of one form is ineffectual when placed on the stigma of its own flower, but acts immediately upon that of the other form. The generally received idea that the impregnation of plants may be effected indifferently by wind or by insects, is shown to be fallacious; plants being structurally adapted for the one or the other, and not indifferently for either.

He has similarly investigated a still more complicated case in the common *Lythrum salicaria* of our ditches, which, as regards its flowers, is trimorphous, there being three instead of two sexual forms, differing in the relative lengths of their two series of stamens and of their styles. In estimating the novelty and value of Mr. Darwin's botanical discoveries, we should not overlook that they have all been obtained by the study of some of the most familiar and conspicuous of our native plants, and some of the best-known and easily procured cultivated exotics.

Mr. Busk,

I will request you to present this Medal in the name of the Society to your friend Mr. Darwin, and with it the expression of our deep regret that the state of his health prevents the gratification which it would have been to us all to have welcomed him here on this day.

And you will be able to tell him, from your own observation, the hearty satisfaction with which the Society regards the bestowal of this, its highest mark of esteem, in evidence of its appreciation of labours almost incessantly pursued for now between thirty and forty years.

The Council has awarded a Royal Medal to Warren De la Rue, Esq., F.R.S., for his observations on the Total Eclipse of the Sun in 1860, and for his improvements in Astronomical Photography.

The advantages which photography affords in the delineation of celestial objects and phenomena are now generally recognized. This art has been already successfully applied to depict the infinitely diversified surface of the moon; the sun with its spots and faculæ, and those mysterious appendages which are only to be seen during a total eclipse;

as well as the markings on the surfaces of some of the principal planets. It has also been employed to measure the apparent distances and angles of position of double stars, and to record the time of the sun's passage over the wires of a transit instrument with much greater accuracy than could be done by an actual observer; and it is probable that the number of the useful applications of the art to astronomy has by no means reached its limit.

Among those who have successfully cultivated this comparatively new department of astronomy, it may perhaps be fairly said that Mr. De la Rue stands preeminent. It is not that he claims any priority in making this application of the photographic art. Several astronomers have made experiments in celestial photography, and some of these earlier than Mr. De la Rue, but no one, I believe, has devoted himself so systematically and assiduously to overcome the many difficulties which are met with in the process, and no one has been so successful in the results which he has obtained, particularly in regard to the sun and moon, his photographic pictures of which bodies are sufficiently delicate in their details to admit of the most precise measurement. No one who has not seen Mr. De la Rue's pictures of the moon can form an idea of their exquisite sharpness and beauty of definition. No doubt part of the superiority of these pictures is due to his employment of a *reflecting* telescope of exquisite defining power, the large mirror of which was figured by his own hands, and by peculiar machinery of his own contrivance. Thus he entirely avoided those imperfections of the actinic image which arise from outstanding chromatic dispersion in the very best refractors, especially when, as usual, they are achromatized for the luminous and not for the chemical rays of the spectrum.

The late Professor Bond, of Cambridge, in the United States, with the assistance of Messrs. Whipple and Black, of Boston, was the first to make a photographic picture of any heavenly body. In the year 1845 he obtained good pictures of α Lyræ and of Castor, and in 1850, by means of the great reflector of the Harvard Observatory, he obtained a daguerreotype of the moon, which was placed in the Exhibition of 1851. It was the sight of this which first gave the impulse to Mr. De la Rue's labours in this direction.

At the latter end of 1852, Mr. De la Rue took some successful positive lunar photographs on collodion by means of an equatorially mounted reflecting telescope of 13 inches aperture, made by himself; and he was probably the first to employ in celestial photography the then recently discovered collodion process, which is that now exclusively adopted. At that period he had not applied any driving motion to the telescope, and was therefore obliged to follow the apparent motion of the moon by means of a sliding frame fixed in the eyepiece holder, and moveable by the hand; but in 1857 he applied a driving clock to the telescope, the rate of which could be adapted to

follow the moon in right ascension, and thus of course a much greater approach to perfection was attainable.

In the department of solar photography, Mr. De la Rue stands almost alone. Assisted by the suggestions of the late Mr. John Welsh, he devised the Kew photoheliograph, which is now regarded as a model instrument for taking instantaneous sun-pictures. This instrument was taken to Spain by Mr. De la Rue in 1860 in order to observe the total solar eclipse, and the undertaking was perfectly successful. Numerous photographs were taken during the partial phase, and two during the totality, that showed the forms and positions of the red protuberances much more perfectly than had ever been done before. The experience gained respecting the photographic energy of the light of the prominences is also very valuable; for it is shown that a much shorter time of exposure than Mr. De la Rue ventured upon would have been sufficient to obtain good pictures, so that it may be expected that in future eclipses astronomers will be able to get a greater number of photographs during the totality, while the photographs themselves will be sharper and better defined. The photographs obtained in the solar eclipse of 1860 have been discussed by Mr. De la Rue in a most elaborate paper in the Philosophical Transactions for 1862, forming the Bakerian Lecture. In this memoir, and in his reports on the progress of Celestial Photography in the volumes of the British Association for 1859 and 1861, Mr. De la Rue has fully described his processes and instruments, and has thus deepened the feelings of obligation to him, by giving others the benefit of his long experience in the art, though even with this guidance no one can hope to attain to great proficiency in its practice without time, patience, and perseverance.

Mr. De la Rue,

I have the gratification of presenting you with this Medal, which the Council has awarded to you for your most valuable labours in the application of Photography to Astronomy.

You, Sir, are in the enjoyment of the fullest health and strength, and may, we hope, look forward to many years of active and useful occupation in departments which you may be said to have created for yourself.

You may be well assured, Sir, that the sympathy and interest of the Royal Society will continue to attend you in this work, while it will count on many valuable contributions from you to its Transactions in future years.

The Council has awarded a Royal Medal to Jacob Lockhart Clarke, Esq., F.R.S., for his researches on the intimate structure of the Spinal Cord and Brain, and on the development of the Spinal Cord, published in five memoirs in the Philosophical Transactions, and in other writings.

On the occasion of conferring on one of our Fellows a well-earned

reward for his enlightened and persevering labour in investigating the structure of the central organs of the nervous system, we may not inappropriately recal to mind that one of those who, in former times, most signally advanced this department of anatomical knowledge was an early Fellow of this Society, Dr. Thomas Willis, and that his celebrated treatise on the Anatomy of the Brain was illustrated by drawings from the pencil of no less eminent an associate than Sir Christopher Wren, also a Fellow, and afterwards President of the Society. But in that day, and down to a recent period, the investigation was carried on with the naked eye, and accordingly the more intimate structure and organization were hidden from view until brought to light in our own time by the aid of the microscope. It is true that the tissue of the brain and nerves did not escape the notice of the earlier microscopic observers; of this, indeed, there is well-known evidence in the early volumes of our own Transactions; still their inquiries were almost entirely confined to the microscopic characters of the fibres and other constructive elements of the cerebral and nervous tissues, whereas the application of the microscope, in tracing the arrangement of these elements, and their combination into an organized structure, dates little further back than the last twenty years.

In this field of inquiry Mr. Clarke has been one of the most able and successful workers. No sooner had he entered upon it than he introduced an important improvement into the method of investigation. The observations had previously been made on opaque sections of the parts examined, on which only the coarser features of the structure could be discerned; but Mr. Clarke devised a process for rendering them transparent, whereby it became possible to trace the finer and more intimate arrangement; and this method has not only, in his own hands, proved fruitful in valuable results, but, having been adopted by his fellow-labourers in the same pursuit, has been most influential on the general progress of the inquiry.

The investigation itself, even with every available aid, is singularly difficult and laborious. Section after section of the spinal cord throughout its whole length, and of its complex cranial prolongation, must be carefully scrutinized, thoughtfully compared, and, for the most part, minutely delineated; and sometimes many different specimens must be prepared and examined in order to make out a single point. In this exhausting work Mr. Clarke has long and meritoriously persevered amid the calls of an active professional life. The results of his labours are made known in his various papers, published chiefly in the Philosophical Transactions, and in the elaborate delineations with which they are illustrated. And it is pleasing to know that, in all essential points, his observations have been confirmed by the most accurate and trustworthy of his contemporaries.

After what has been said of the difficulties of the inquiry, it will be

readily conceived that Mr. Clarke's investigations, successful though they have been, have left not a few intricacies of structure still to be unravelled; and, in speaking of the advances actually made, it will be sufficient here to indicate the chief points which have either been made known for the first time, or more exactly determined and placed in a clearer light through Mr. Clarke's labours.

One of the principal subjects of investigation was the grey substance which forms the interior part of the spinal cord. The figure which this part assumes in different regions of the cord has been more exactly described and delineated, and the nature and arrangement of its constituent elements more fully examined and more clearly exposed than heretofore. Two columns or tracts, composed of nerve-cells, and previously undescribed, have been shown to exist in the grey substance through nearly the whole length of the cord, and two others in a shorter extent. Moreover Mr. Clarke was, as we believe, the first to point out that the central canal of the spinal cord is lined with epithelium, and he certainly first explained the true nature of the tissue immediately surrounding the canal, which had previously been mistaken for nervous substance.

The course and connexions of the fibres of the nerve-roots after they enter the substance of the spinal cord have, as yet, been by no means fully made out; but Mr. Clarke's investigations have shed considerable light on that obscure point of anatomy, and, amongst other observations of moment, he has shown that a part of the posterior or sentient roots take, in the first instance, a downward direction—an unlooked-for anatomical fact, which was afterwards strikingly shown by Brown-Sequard to be in harmony with physiological experiment.

The structure of the medulla oblongata, and the relation of its several tracts or divisions to the columns of the spinal cord, as well as the intimate nature of the grey masses which are there superadded, and their connexion with special sets of fibres and nerve-roots, are questions which have long tried the skill and patience of anatomists, and which have received fresh elucidation from the keen scrutiny and sagacious interpretation of Mr. Clarke; and in this branch of his inquiry he has arrived at new facts, and has been able to correct serious errors which had been introduced on respected authority.

But the researches of Mr. Clarke on the spinal cord have not been confined to its perfected structure; he has investigated the mode of its development in the fœtus; and one of his papers in the Philosophical Transactions contains a minute account of the changes observable in the form and structure of both the white and grey substance at successive stages of development, in man, mammalia, and birds; also, a description of the intimate structure of the intervertebral ganglia, and of the mode of development of the cells and fibres which enter into the formation of these different parts.

Finally, although it must be confessed that the knowledge acquired of the intimate structure of the nervous centres has as yet afforded but little direct insight into their functional mechanism, it cannot be doubted that approved and trustworthy investigations of structure tend powerfully to promote physiological truth, by enabling us to distinguish between true and false anatomical data when used as a basis of physiological reasoning, and by sweeping away the imaginary groundwork of much vain speculation and erroneous doctrine.

Mr. Clarke,

I beg leave to present you with this Medal, which has been awarded to you, on the recommendation of those in the Council most competent to judge of the subjects on which you are engaged, as a well-earned reward of your persevering labours, which the Council is well aware have demanded from you the devotion of all the leisure remaining to you amidst the duties of an active professional career. I need scarcely add that the Council hopes that this mark of approbation of services already performed will also be an incitement to further labours in the same or in kindred fields of research.

The Council has awarded the Rumford Medal to Professor John Tyndall, F.R.S., for his researches on the Absorption and Radiation of Heat by Gases and Vapours.

Previously to the researches of Professor Tyndall, hardly anything had been done in the way of an experimental determination of the absorption of radiant heat by gases and vapours. Melloni had inferred from his experiments that atmospheric air is sensibly diathermanous in a length such as that of an ordinary room, while Dr. Franz came to the conclusion that a column of air only 3 feet long absorbed more than $3\frac{1}{2}$ per cent. of the heat-rays from an argand lamp. The discrepancy of these results gives some view of the difficulty of the experiments; but it is only by the perusal of the earlier part of Professor Tyndall's first memoir on the subject, that the skill and patience can be appreciated with which the various sources of error were one by one detected and eliminated by him.

In his first memoir he shows that the elementary gases, hydrogen, oxygen, nitrogen, as well as air freed from moisture and carbonic acid, when examined in a length of about 4 feet, exert on the heat radiated from lampblack at 212°, an absorption not exceeding about $3\frac{1}{2}$ per cent., and liable to be altered by the slightest impurity present in the gases. The results obtained with compound gases and with vapours, on the other hand, were very different,—olefiant gas, for instance, in the same length absorbing 81 per cent. of the incident heat. About twenty gases and vapours were examined, and that not only at atmospheric pressure (or, in the case of vapours, in a state of saturation), but also at a variety

of inferior pressures. Among these substances may particularly be mentioned, as being constituents of our atmosphere, carbonic acid and aqueous vapour, both of which, but more especially the latter, were found to exert a considerable absorptive action, so that Professor Tyndall concludes that it is to its aqueous vapour that the absorption of radiant heat by our atmosphere is mainly due. He also shows that the gases operated on when heated, radiate heat in an order corresponding to that of their absorption.

In his second memoir, besides continuing the same subject, he has struck out a new and remarkable method of determining the absorption and radiation of heat by gases and vapours, depending on what he calls *dynamic* radiation and absorption. In this method the results are arrived at without the use of any extraneous source of heat or cold whatsoever, but simply by the heat or cold produced by the condensation or rarefaction of the gas itself, or of a mixture of the vapour with air or a diathermanous gas.

It may serve to show the difficulties which beset the inquiry, arising from the interference of disturbing causes, to state that two such experienced physicists as Professor Tyndall and Professor Magnus of Berlin should have arrived at, and long maintained, opposite conclusions respecting the absorption of radiant heat by air, and the influence of aqueous vapour. This led Professor Tyndall in a third memoir to consider more especially the case of aqueous vapour, which he had already treated in his two former papers. The result is that his conclusions have been so confirmed by a system of checks and counterchecks, and by the complete harmony which they present with what we know to be true in other cases, that it seems impossible to doubt their correctness.

The conclusion that the chief absorbing action of the atmosphere on non-luminous heat is due to the aqueous vapour which it contains, has numerous and important bearings on meteorology, and has been applied by Professor Tyndall to the explanation of some phenomena which appear hitherto to have been imperfectly understood.

In his fourth memoir, besides various other subjects of investigation, he compares the absorption of heat by vapours with that produced by the same substances in the liquid state, and concludes that for non-luminous radiant heat (in accordance with what we know for light) the general character of the absorption is the same, in whichever of the two states the substance may be found.

In a fifth memoir, just published, he examines among other things the penetrative power of the heat radiated from various flames, and shows that such heat is absorbed with especial facility by the gases which result from the combustion.

Professor Tyndall concludes from his researches that, as a general rule, the opacity of a substance with respect to radiant heat from a source of comparatively low temperature increases with the chemical

complexity of its molecule; and he has given some remarkable instances in which the law is found to be true. Whatever may be thought of our ability to explain the law in the present state of our knowledge respecting the molecular constitution of bodies, the law itself is in any case highly remarkable.

Professor Tyndall,

In presenting you with this Medal I will acknowledge that I am more embarrassed in the choice of the expressions which should accompany it than in the three preceding instances, arising from the warm feelings of personal regard and admiration which I have felt for you, I may permit myself to say, from the very commencement of your scientific career in this country. It has been your fate, Sir, that each last achievement may almost be said to have dimmed the lustre of those which preceded it. I will only add the expression of my heartfelt hope that your health, so valuable to us all, and which ought not therefore to be lightly compromised, will be preserved to enable you to accomplish fresh labours which shall still surpass those which have gone before.

On the motion of Sir Henry Holland, seconded by the Master of the Mint, it was resolved—"That the thanks of the Society be returned to the President for his Address, and that he be requested to allow it to be printed."

The Statutes for the election of Council and Officers having been read, and Mr. John Hogg and Professor Huxley having been, with the consent of the Society, nominated Scrutators, the votes of the Fellows present were collected, and the following were declared duly elected as Council and Officers for the ensuing year:—

President.—Major-General Edward Sabine, R.A., D.C.L., LL.D.

Treasurer.—William Allen Miller, M.D., LL.D.

Secretaries.—{ William Sharpey, M.D., LL.D.
George Gabriel Stokes, Esq., M.A., D.C.L.

Foreign Secretary.—Professor William Hallows Miller, M.A.

Other Members of the Council.—Professor John Couch Adams, M.A.; James Alderson, M.D.; George Busk, Esq., Sec. L.S.; Colonel Sir George Everest, C.B.; Hugh Falconer, M.A., M.D.; John Peter Gassiot, Esq.; John Edward Gray, Ph.D.; Thomas Archer Hirst, Ph.D.; Sir Henry Holland, Bart., M.D., D.C.L.; Henry Bence Jones, M.A., M.D.; Sir Roderick Impey Murchison, K.C.B.; William Odling, M.B.; Professor William Pole, C.E.; Rev. Bartholomew Price, M.A.; Sir John Rennie, Knt.; The Lord Stanley.

On the motion of Mr. Arnott, seconded by Mr. Bowman, the thanks of the Society were voted to the Scrutators. The Society then adjourned.