THURSDAY, AUGUST 16, 1888.

CELTIC HEATHENDOM.

The Origin and Growth of Religion as Illustrated by Celtic Heathendom. The Hibbert Lectures for 1887. By J. Rhŷs. (London: Williams and Norgate, 1888.)

PROF. RHŶS has made an important contribution in this volume, if not to the development of religion in general, at all events to the study of Indo-European mythology. Almost for the first time, the religious legends of the Kelts have been subjected to scientific treatment, and the resources of scientific philology have been called in to explain them. The Keltic languages and mythology have long been a happy hunting-ground for the untrained theorist and charlatan: in the Hibbert Lectures for 1887 we find at last etymologies which can be trusted, and a method of investigation which alone can lead to sound results.

The method employed by Prof. Rhŷs is the comparative method of science. The literature of the Keltic nations does not begin until after the triumph of Christianity; and apart from a few Gaulish inscriptions, and the questionable assertions of Latin or Greek writers, our knowledge of Keltic paganism must be derived from such traces of it as we may detect in a later and hostile literature. These traces consist for the most part of the myths and legends preserved in Irish manuscripts or Welsh romances.

By comparing the Irish and Welsh legends one with another, and analyzing the primitive meaning of the proper names round which they centre, Prof. Rhŷs has attempted to recover their original form and signification, verifying his conclusions not only by an appeal to etymology, but also, wherever it is possible, to the evidence of the Gaulish texts. Without doubt, a considerable number of his conclusions are merely hypothetical, and in some cases his interpretations depend on the exercise of the same Keltic imagination as that which inspired the old story-tellers, but, on the whole, he has laid a broad and solid foundation of fact, which must be the starting-point of all future researches in the same field. He will himself be the first to acknowledge the tentative and theoretical character of much of his work; indeed, the readiness with which he admits in his appendix that he has changed his opinion in regard to certain questions is a witness to his possession of the true scientific spirit, which is always open to conviction.

The lectures appropriately begin with an account of Gaulish religion, so far as it can be gathered from the scanty evidence of the monuments. Then follow chapters on the Zeus of the insular Kelts, as well as on the Culture-hero and on the Sun-hero, the two latter of whom Prof. Rhŷs endeavours to keep apart, though the attempt does not seem to me to be more successful than it has been in the case of other mythologies. The suggestion, indeed, that the Keltic Culture-hero may have been a deified man, like the Norse Woden, the Greek Prometheus, or the Indian Indra, has little in its favour; at all events, if Indra or Prometheus were of human origin, the Sun-god must have been of human origin also. The myths told about "the Culture-hero" are precisely similar in character to those told about "the Sun-hero."

The last lecture is occupied with those figures of Keltic mythology which are not directly connected with either the beginnings of civilization or the adventures of the solar orb. Here Prof. Rhŷs has done important service for the historian by sweeping away the foundations on which the so-called early history of Ireland has been built. The races who have been supposed to have successively effected a settlement in the island belonged to the world of mythology. The Tuatha dé Danann, or "Tribes of the goddess Danu," were long remembered to have been the fairies; the Fomorians, or "submarine" monsters, were supernatural beings whose home was beneath the sea; and a human ancestry is denied even to the Fir-bolgs or "Men of the Bag." I am not sure that Prof. Rhŷs does not sometimes go too far in refusing an historical character to the personages and events recorded in Keltic tradition; the recent revelations of early Greek archæology are a useful warning in this respect, and the Keltic Professor himself is obliged to admit that by the side of the mythical Emrys and Vortigern there were an historical Ambrosius and an historical Vortigern. A story must have a setting in time and place, and the internecine quarrels of the lively Kelt afforded frequent opportunities for attaching an old story to the heroes and circumstances of the day. It is not so many years ago since Atreus and Agamemnon were relegated to the domains of mythology; yet we now know, from archæological exploration, that the legends in which they figured were based on historical fact.

In a book so rich in new ideas and information it is difficult to select anything for special notice. Bearers of the name of Owen, however, will be interested by finding it traced back to the Gaulish agricultural god Esus, whose name is connected by Prof. Rhŷs with the Norse *áss*, "a god," and the Professor is to be congratulated on his discovery of the origin of King Lud, the Lot of the Arthurian romances. Lud is the Welsh Llûdd, in Old Welsh Lodens, who bears the title of Llûdd Llawereint, or "Lud of the Silver Hand." The initial sound of Llûdd, however, is due to that of the epithet so constantly applied to him, the primitive form of the name having been Nûdd, which appears in the Latin inscriptions of Lydney as Nodens or Nudens, a sort of cross between the Roman Mars and Neptune. Nodens, again, was the Irish Sky-god, "Nuada of the Silver Hand," and a myth was current which explained the origin of the title.

Equally worthy of notice is what Prof. Rhŷs has to tell us about "the nine-day week" of the ancient Kelts. He shows that like the Latins they made use of a week of nine nights and eight days, and he points out that traces of a similar mode of reckoning time are to be found in Norse literature. Whether he is right in ascribing the origin of such a week to a habit of counting the fingers of one hand admits of question, and I do not see how the Irish divinity Maine who presided over the day of the week can be the Welsh Menyw, if, as we are told, Maine owes his origin to *secht-main*, itself borrowed from the Latin *septimana* or seven-day week. Prof. Rhŷs believes that he has found a further resemblance between the calendar of the primitive Kelts and Scandinavians, in the fact that the year in both cases began at the end of the autumn. But no argument can be drawn from the fact in favour of the theory which places the primæval seat of the Aryan race within the Arctic Circle, since the civil year of the Jews also began with the ingathering of the harvest at the time of the autumnal equinox, and no one would propose to transfer their forefathers to the distant north.

The points of likeness between the mythologies and religious conceptions of the Kelts and Scandinavians, to which Prof. Rhŷs has drawn attention, are numerous and striking. How many of them go back to an age when the ancestors of the Scandinavians and of the Aryan Kelts still lived together it is impossible to tell, but several of them can most easily be explained as due to borrowing. It is now well established that Norse mythology and religion were influenced not only by Christianity but also by the mythology and religion of the Kelts, with whom the Norsemen came into contact in the Hebrides, in Ireland, and in the Channel Islands, and in a comparison between Keltic and Scandinavian legends this influence must always be allowed for.

I must not part from Prof. Rhŷs's learned and important lectures without exercising the privilege of a reviewer by objecting to certain of his conclusions. These relate to the Keltic allusions to a Deluge, and to the stories of a contest between the gods and the monsters of the lower world. Whatever may be the origin of the Keltic myths which are supposed to refer to such events, they cannot be compared with the Indian legend of the deluge of Manu or with the story of the conflict between the gods of Olympos and the Titans. It has long since been pointed out by Lenormant that the Indian legend was borrowed from Babylonia; and its hero, Manu, has nothing to do with the Kretan Minôs. Apart from the unlikeness of the vowel in the first syllable of the two names, Minôs seems to be a word of Phœnician origin. The conflict between the gods and the Titans, again, has now been traced to Babylonia. Like the twelve labours of Herakles, the Babylonian epics have been recovered in which the story appears in its earliest form, before it was passed on to the Greeks through the hands of the Phœnicians. The Titans and Herakles were alike figures of Semitic, and not of Aryan, mythology.

I have left myself space to do no more than draw attention to two very interesting questions suggested by Prof. Rhŷs's lectures. It is in Scandinavian rather than in Latin mythology that he finds parallels to the myths and legends of the Kelts. Nevertheless, linguistic science teaches us that the Keltic dialects had most affinity to Latin and not to the Scando-Teutonic languages. Was Latin mythology, then, so profoundly modified by some foreign system of faith, such as the Etruscan, as to have lost a considerable part of its original character even before it passed under the influence of the Greeks? Was it, in fact, Etruscanized before it was Hellenized? The other question relates to the causes which have reduced the gods of a former age to the human kings and princes of later Keltic legend. The same transformation characterizes the traditions of ancient Persia, as it also characterizes Semitic tradition. In the case of Persia, such unconscious euhemerism seems to have been brought about by a change of creed. Was this also the reason why in Keltic story the ancient Sky-god became Nuada of the Silver Hand? If so, the old theology would have remained practically unchanged until the conversion of its adherents to Christianity, and the growth of most of the mythology beneath which Prof. Rhŷs has discovered the forms of dishonoured deities would have taken place in the centuries which immediately followed the fall of the Roman Empire. They are the same centuries, be it remembered, which divide the history of Britain into two portions, separated from one another by a veil of myth.

A. H. SAYCE.

HAND-BOOK OF THE AMARYLLIDEÆ.

Hand-book of the Amaryllideæ. By J. G. Baker, F.R.S. 203 pp. (London: George Bell, 1888.)

SINCE Herbert's "Amaryllidaceæ," published in 1837, there has not been any work brought out containing descriptions of all or approximately all the species of Amaryllidaceous plants until the appearance of this little work. Herbert's volume has long been both rare and out of date, and some such book as the present was a desideratum. Neither could anyone be found who has a better or more extensive knowledge of the bulbous plants than Mr. Baker, whose monographs of the Liliaceæ and Iridaceæ are well known to all lovers of these groups. The work before us is the result of twenty-three years' study, and embodies descriptions drawn up not only from herbarium material, but especially from living plants—some grown at Kew Gardens, others from the conservatories and gardens of professional and amateur cultivators. It is intended as a working hand-book for gardeners and botanists, and as such seems suited for its purpose.

The group of Amaryllideæ is one which has suffered in popularity from the modern rage for Orchids. A glance at the volume will show that many species were introduced into cultivation from fifty to a hundred years ago, and are now quite lost from our gardens. In those days Cape bulbs were very popular; and Masson at the close of the last century, and Cooper and others in later years, introduced many beautiful and curious plants now known to us only by their dried specimens and drawings. Of these the curious South African genus Gethyllis is a striking example, six out of the nine species here described being only known from Masson's sketches and specimens, and this in spite of the numerous careful and energetic collectors we have now at the Cape of Good Hope.

One reason for this disappearance of species is the very narrow limits of their distribution in many cases, although it appears that the individuals are often abundant when the right locality is reached. Witness, for example, the little Tapeinanthus of Spain and Morocco, discovered by Cavanilles in 1794, and lost again till two years ago, when it was re-discovered in profusion by Mr. Maw, who has stocked our gardens with it; and very similar are the cases of the strange green-flowered Narcissus of Gibraltar and the Lapiedra, known to Clusius as early as 1574, and still a great rarity even in herbaria at the present day. When it is remembered that these three plants grow in localities close to our own shores, it is not surprising that many of the more distant South African species figured by Jacquin in his sumptuous works, as well as many Andean and Peruvian species, are still absent from our gardens and houses.

Besides the rarity of some of these plants, they have a habit of entirely disappearing after flowering, and indeed in many cases they will only appear at irregular and long intervals, which also conspires to make them difficult to procure, so that collectors are necessarily anxious to know the time of the year at which they should be looked for in flower, and this the author has where possible added to his description.

The volume includes, besides the typical Amaryllideæ, the Alstrœmeriæ and Agaveæ, but the Hypoxideæ and Vellozieæ are omitted on the grounds that they have been elsewhere fully dealt with. This we think a pity, as it would have made the work more complete to have included these groups; but this will hardly affect cultivators, with whom the Hypoxids are rarely found favourites on account of their comparatively insignificant flowers and general similarity, while the Vellozias, though they would be welcome additions to our stoves on account of their beautiful flowers, yet baffle our gardeners on account of their bulkiness and slow growth.

In the Agaveæ it will be noticed that of many species (in fact, nearly one-third) only the foliage is known. For garden purposes perhaps the form and number of the leaves may be sufficient, at least for identification; but it cannot be considered satisfactory to publish as new species, and endow with scientific names, plants of which the inflorescence is unknown. The author, however, has but done his duty in incorporating these species into his work.

One may hope that the publication of this compendium will stimulate our amateur gardeners to turn their attention more carefully to this comparatively neglected group. Already for some time signs have not been wanting to show that they are rising into favour again to some extent. The Narcissi, Hippeastrums, and Crinums are undergoing elaborate cultivation and hybridization by the best of our gardeners with the highest success, and if this hand-book contributes to the study of this group it will have done its work. H. N. R.

OUR BOOK SHELF.

Another World; or, The Fourth Dimension. By A. T. Schofield, M.D. (London: Swan Sonnenschein, 1888.)

THIS work consists of seven chapters. The first four—the land of no dimensions, the land of one dimension, the land of two dimensions, and the land of three dimensions—consist of large extracts from "Flatland," with a running commentary upon them, bringing out their salient facts. Indeed, had not "Flatland" been published, the author admits his own book would not have been written. In Chapter V., the land of four dimensions is mathematically considered, and here we have stated, from analogy, the relations of a being in one dimension with that above him and its inhabitants, *e.g.* one in the third dimension (our world) with the fourth; and in Chapter VI. the land of four dimensions is considered in relation to ours of three. Chapter VII. considers generally the land of four dimensions, with facts and analogies. The fourth dimension is not discussed on the lines of Mr. Hinton's "What is the Fourth Dimension?" but after the mathematical side of the question has been considered, our author "further considers the actual facts around us bearing on the question, and compares the deduced laws of the fourth dimension with some of the claims of Christianity as stated in the Bible." Here we must close our notice—as we cannot go into an examination of these topics in our columns—with saying that there is much of interest in the pages before us, and for some readers the speculations of the later chapters may have as much interest as the mathematical certainties of the earlier chapters have for others.

Euclid's Method, or the Proper Way to Treat on Geometry. By A. H. Blunt. (Shepshed: Freeman, 1888.)

THIS booklet consists of an introduction (pp. 3–10), and the method of treating on geometry (pp. 10–23). We let the writer speak for himself:—"In this small work I have attempted to show the proper way to treat on geometry, and which I conceive was the method of Euclid; for it will be seen that the results are right from the way in which they are arrived at, and that they agree with Euclid's results. It is certain, I think none will deny, that when Euclid composed his 'Geometry,' he did everything in it under the guidance of reason and knowledge of what the true method consists in; but since he has not expressed or shown those reasons (and it would not have been proper, nor would it have been necessary to have done so in his 'Geometry'), they therefore appear to have been known but very little to anyone else since his time, as is evident from the expressions and unjust fault-finding made against him in the writings of modern geometers, which greatly betray their own ignorance of the true method. So long as the true method remains unknown, it is not to be wondered at that men should busy themselves in finding faults with Euclid, his work being so complete and perfect as to leave them but little else to do. Not that I would be understood to mean that his works ought to be accepted in blind submission as everything perfect, or that no faults, if there are any in it, ought to be pointed out"; and so on. *Ex pede Herculem!* The author's remarks are made sincerely, and for a certain order of mind his explanations are likely to clear up many points in the Definitions. It is to these only that he confines his attention in pp. 10–23, and he gives good reasons why Euclid should have taken them in the order he has taken them. This was his object: write, then, Q.E.D., and *Vivat* Euclides!

On the Distribution of Rain over the British Isles during the year 1887. Compiled by G. J. Symons, F.R.S. (London: Edward Stanford, 1888.)

MR. SYMONS'S "British Rainfall" is so well known that we need only say of the present issue that it is in no respect inferior to the preceding volumes of the series. The marked characteristic of 1887 was the prevalence of droughts. According to Mr. Symons, the year has had no equal for widespread deficiency of rainfall since 1788. Naturally, therefore, much space is devoted in this volume to the subject of droughts; and in one chapter—on "Historic Droughts"—he has brought together, from a variety of sources, a large amount of information that ought to be as interesting to historians as to meteorologists. In the preface Mr. Symons calls special attention to important additions which have been made to our knowledge of the rainfall of the Lake District. These have resulted from a grant of £42 7*s.* made by the Royal Society from its own funds in 1886.

LETTERS TO THE EDITOR.

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

The "Tamaron" of the Philippine Islands.

A LETTER, which I have just received from our Corresponding Member, the energetic traveller and naturalist, Prof. J. B. Steere, of Ann Arbor, Michigan, U.S.A., announces that he has made a remarkable zoological discovery in the Philippine Islands. In the interior of the little-known Island of Mindoro he has procured specimens of a strange animal, which, although much talked of in the Philippines, is little, if at all, known elsewhere. This is the *Tamaron* of the natives, a wild species of the family Bovidæ, allied to the Anoa of Celebes, which Prof. Steere proposes to call *Anoa mindorensis*. Its general colour is black, the hairs being short and rather fine. A greyish white stripe runs from near the inner corner of the eye towards the base of the horn. There is also a greyish white spot above the hoof on all the feet, and a greyish white patch on the inside of the lower fore-leg. The height of the male at the shoulder is about 3 feet 6 inches, the length from the nose to the base of the tail about 6 feet 8 inches. The horns are about 14 inches long. Prof. Steere obtained two males and one female of this animal, of which his full description will be read at the first meeting of the next session of the Zoological Society. The discovery is of much interest, as giving an additional instance of the similarity between the faunas of Celebes and the Philippines, which was already evident from other well-known cases of parallelism between the natural products of these two countries.

P. L. SCLATER.

Functionless Organs.

IN reference to the Duke of Argyll's letter, I should wish to say that I am not aware of any reason for regarding the electric organ of any Skate as a "prophetic structure," using that term in the sense given to it by the Duke. And I should be very glad if he, instead of confining himself to a simple assertion that it is so, would explain the reasons which lead him to regard it as being so. It might then be possible to combat those reasons.

Further, I think it is only right to say that my own observation of the progress of the doctrine of evolution during the last quarter of a century leads me to a conclusion diametrically opposed to the Duke's in regard to the balance of evidence in favour of, or opposed to, the doctrine of creative design in variations on the one hand, and that of the non-significance of variations on the other hand.

I do not hesitate to say that what may be called "pure" Darwinism—the doctrine of the origin of species by the natural selection in the struggle for existence of non-significant congenital variations—is everywhere being more completely demonstrated by reasoning and observation as the single and sufficient theory of that origin; to the exclusion of Lamarckism, and still more certainly to the exclusion of any vestige of the doctrine of design.

E. RAY LANKESTER.

45 Grove End Road, N.W., August 4.

WITH a certain class of thinkers, when endeavouring to disparage the labours of Charles Darwin, no argument appears absurd. Does the Duke of Argyll, in his letter which appeared in your last issue (p. 341), mean to imply by his "prophetic germs" that such cases as the mammæ in the male indicate a time when he will be able to take part with the female in suckling the young, and that the coccyx is prophetic of a tail to the human family, or that a time is approaching when the rudimentary covering of hair on the human body will develop into a warm coat similar to that of the bear or the beaver? For myself, I fail to see how a "functionless organ" can build *itself* up. Perhaps the Duke of Argyll will explain.

J. T. HURST.

Raymond Villa, Geraldine Road, Wandsworth, S.W., August 11.

Dr. Romanes's Article in the "Contemporary Review."

ABSENCE from England has hitherto prevented me from seeing Mr. Poulton's letter in your issue of July 26 (p. 295). Having just read it, I am not a little surprised that he should have deemed it necessary to refer me to the titles of two of the most notorious essays in the recent literature of Darwinism. Nor can I fail to wonder that, without a particle of evidence, he should accuse any man of "not making himself acquainted with views which he professes to express."

If I could think it worth while to discuss a somewhat lengthy matter with a critic of this kind, it would be easy enough to justify the incidental remark in my paper to which he has drawn attention. But my only object in noticing his criticism is to observe that, if its tone is due to his supposing that I have not sufficiently appreciated the importance of his own experiments in this connection, he is entirely mistaken. For, although I do not agree with his theoretical interpretation of them, it has always appeared to me that the experiments themselves are among the most valuable which have hitherto been made regarding the causes of variation. But it has also appeared to me that my appreciation of their importance in this respect depends upon what he calls "the Lamarckian conception," *i.e.* a conception which he expressly repudiates. Were it not for the attitude of theory which he thus adopts, of course I should not have alluded to him as a naturalist who concerns himself less with the causes of variation than the other (or Lamarckian) writers whom I had occasion to name. But, as the matter stands, I have merely forestalled the expression of his opinion as stated by himself, where he says in his letter to you, "I agree with Dr. Romanes in the belief that my work does not throw any light upon the causes of variation."

My paper was concerned only with the opinions of others, and I nowhere expressed the "belief" thus attributed to me. In point of fact, "the Lamarckian conception" enables me to hope that work of the kind on which Mr. Poulton is engaged is more calculated than any other to throw light upon the problem in question; and it seems to me a curious corroboration of the remark to which he objects that, on account of his loyalty to the school of Weismann, he is obliged to regard his own experiments as destitute of significance in this respect.

August 9. GEORGE J. ROMANES.

Taxation in China.

NATURE (vol. xxxvii. p. 269), in its review of M. Sîmon's "China: its Social, Political, and Religious Life," represents on that author's authority that in China "taxation is very light—not one-hundredth part of what it is in France," a statement so misleading to publicists, so illusive to economic science, that I take upon myself the task of exposing its fallacy, both as regards direct and indirect taxation.

Taking for illustration the amount of taxation at Ningpo (M. Sîmon was the efficient Consul of his country at that port, where he won golden opinions of foreigners generally, and natives as well), it will be seen that he has been led into egregious errors by incompetent interpreters.

M. Sîmon says that "five francs per *hectare* is the utmost that is paid for the best land."

From municipal archives I tabulate the following relative to the three qualities of rice land:—

Quality of Land.	Relative Quantity.	Taxation per Mou.	Taxation per hectare.	Taxation per acre.
1st	60% ...	$0.35 ...	$5.25 ...	$2.10
2nd	25 ...	0.28 ...	4.20 ...	1.68
3rd	15 ...	0.25 ...	3.75 ...	1.50
Average ...	100	0.29⅓	4.40	1.76

Six mou = one acre. Fifteen mou = one hectare.

Hill land, $0.13 per mou. From the second quality only one crop is obtained.

Instead, therefore, of the *best land* being five francs per *hectare*, it is (according to present rate of exchange) about 21 francs, and for the average about 17 francs per *hectare*.

With regard to indirect taxation, that author affirms that the Chinaman has no excise duties to pay. So far from that being the case, his octrois (*likin*) contribute far more to the State demands than the levies on his land; but from lack of trustworthy data, that is altogether an incomputable quantity.

Nevertheless, with such levies, and the salt gabel and so forth, it may be shown that the Chinese are not overburdened with taxation; albeit to imagine that their taxation is "not one-hundredth part of what it is in France" is sheer economic hallucination.

D. J. MACGOWAN.

Wenchan, June.

Partial Eclipse of August 7.

THE above eclipse was observed at Cambridge, and the times of contact were estimated as follows:—

	h.	m.	s.	
First contact ...	6	44	50	G.M.T.
Last contact ...	7	7	20	,,

At the time of greatest eclipse, 6h. 56m., a photograph was taken which on being measured gives a magnitude of about

0·021, but this is only a rough approximation. The co-ordinates of the Observatory are—

28·6s. E.
52° 12′ 10″ N.

A. C. CROMMELIN.

Trinity College, Cambridge, August 10.

Macclesfield Observations.

MANY years ago, in studying Rigaud's "Bradley," I was impressed by several references to extensive series of observations with transit and quadrant made at the observatory of Shirbourn Castle, some of which Bradley evidently thought worthy of comparison with his own inaccuracy. It has often occurred to me that these observations, if the records still exist, may well be worthy of as thorough a reduction as has been given to those of other early astronomers. Perhaps some of your readers can tell us something about these records of 1739-89.

CLEVELAND ABBE.

Washington, July 30.

A Lunar Rainbow.

WET Mountain Valley in Colorado is situated some 8000 feet above the sea, and is surrounded by mountains, the Sangre de Cristo Range, on the western side, rising to some 14,000 feet in its highest peaks. For the last few days we have had a succession of thunderstorms—dark clouds pouring forth abundant rain—which have mostly swept along the range, leaving the valley clear, and often in sunshine. Last night, at 9 p.m., there passed just such a storm, while the full moon shone brightly from the east, where it had just risen. The result was a lunar rainbow —part only of the arc, a distinct band of light, in which the several colours were hardly to be observed. The phenomenon, which was new to me and must surely be rare, lasted only about a quarter of an hour, when the storm passed on.

West Cliff, Colorado, July 25. T. D. A. COCKERELL.

GLOBULAR STAR CLUSTERS.

PHYSICAL aggregations of stars may be broadly divided into "globular" and "irregular" clusters. Although, as might have been expected, the line of demarcation between the two classes is by no means sharply drawn, each has its own marked peculiarities. We shall limit our attention, in the present article, to the first kind.

The particles of a drop of water are not in more obvious mutual dependence than the components of these objects—"the most magnificent," in the elder Herschel's opinion, "that can be seen in the heavens." Were there only one such collection in the universe, the probability of its separate organization might be reckoned "infinitely infinite"; and no less than one hundred and eleven globular clusters were enumerated by Sir John Herschel in 1864. It does not, however, follow that the systems thus constituted are of a permanent or stable character; the configuration of most of them, in fact, points to an opposite conclusion.

There may, of course, be an indefinite number of arrangements by which the dynamical equilibrium of a "ball of stars" could be secured; there is only one which the present resources of analysis enable us distinctly to conceive. This was adverted to, many years since, by Sir John Herschel. Equal revolving masses, uniformly distributed throughout a spherical space, would, he showed, be acted upon by a force varying *directly* as the distance from the centre. The ellipses described under its influence would then all have an identical period: whatever their eccentricities, in whatever planes they lay, in whatever direction they were traversed, each would remain invariable; and the harmony of a system, in which no perturbations could possibly arise, should remain unbroken for ever: provided only that the size of the circulating bodies, and the range of their immediate and intense attractions, were insignificant compared with the spatial intervals separating them ("Outlines of Astronomy," 9th ed., p. 636).

But this state of nice adjustment is a mere theoretical possibility. There is no sign that it has an actual existence in Nature. The stipulations, upon compliance with which its realization strictly depends, are certainly disregarded in all stellar groups with which we have any close acquaintance. The components of these are neither equal, nor equally distributed. Central compression, more marked than that due simply to the growth in depth inward of the star strata penetrated by the line of sight, is the rule in globular clusters. The beautiful white and rose-tinted one in Toucan shows three distinct stages of condensation; real crowding intensifies the "blaze" in the middle of the superb group between η and ζ Herculis; in other cases, the presence of what might be called a nuclear mass of stars is apparent. Here, then, the "law of inverse squares" must enter into competition with the "direct" law of attraction, producing results of extraordinary intricacy, and giving rise to problems in celestial mechanics with which no calculus yet invented can pretend to grapple.

Sir John Herschel allowed the extreme difficulty of even imagining the "conditions of conservation of such a system as that of ω Centauri or 47 Toucani, &c., without admitting repulsive forces on the one hand, or an interposed medium on the other, to keep the stars asunder" ("Cape Observations," p. 139). The establishment, however, in such aggregations of a "statical equilibrium," by means of this "interposed medium," is assuredly chimerical. The hypothesis of their rotation *en bloc* is countenanced by no circumstance connected with them. It is decisively negatived by their irregularities of figure. These objects are far from possessing the sharp contours of bodies whirling round an axis. Their streaming edges betray a totally different mode of organization.

Globular clusters commonly present a radiated appearance in their exterior parts. They seem to throw abroad feelers into space. Medusa-like, they are covered with tentacular appendages. The great cluster in Hercules is not singular in the display of "hairy-looking, curvilinear" branches. That in Canes Venatici (M 3) has "rays running out on every side" from a central blaze, in which "several small dark holes" were disclosed by Lord Rosse's powerful reflectors (Trans. Roy. Dublin Society, vol. ii. p. 132, 1880); showing pretty plainly that the spiral tendency, visible in the outer regions, penetrates in reality to the very heart of the system. From a well-known cluster in Aquarius (M 2), "streams of stars branch out, taking the direction of tangents" (Lord Rosse, *loc. cit.* p. 162). That in Ophiuchus (M 12) has stragglers in long lines and branches, noticed by the late Lord Rosse to possess a "slightly spiral arrangement." Herschel and Baily described a remarkable group in Coma Berenices (M 53) as "a fine compressed cluster with curved appendages like the short claws of a crab running out from the main body" (Phil. Trans., vol. cxxiii. p. 458).

We find it difficult to conceive the existence of "streams of stars" that are not *flowing;* and accordingly the persistent radial alignment of the components of clusters inevitably suggests the advance of change, whether in the direction of concentration or of diffusion. Either the tide of movement is setting inward, and the "clustering power" (to use Sir William Herschel's phrase) is still exerting itself to collect stars from surrounding space; or else a centrifugal impulse predominates, by which full-grown orbs are driven from the nursery of suns in which they were reared, to seek their separate fortunes, and lead an independent existence elsewhere. It would be a childish waste of time to attempt at present to arrive at any definite conclusion on so recondite a point; but if the appeal to "final causes" be in any degree admissible, it may be pointed out that mere blank destruction and the eventual collapse of the system would seem to be involved in the first supposition, while the second implies the progressive execution of majestic and profound designs.

After the lapse of some centuries, photographic measurements will perhaps help towards a decision as to whether separatist or aggregationist tendencies prevail in clusters. Allowance will, however, have to be made, in estimating their results, for the possible movements of recession or approach of the entire group relatively to the solar system, by which perspective effects of closing up or of opening out would respectively be produced.

Inequalities of brightness, to the extent of three or four magnitudes, are usually perceptible among the lustrous particles constituting these assemblages. Nor are their gradations devoid of regularity and significance. Generally, if not invariably, the smaller stars are gathered together in the middle, while the bright ones surround and overlay them on every side. Thus, the central portion of the magnificent Sagittarius cluster (M 22) accumulates the light of multitudes of excessively minute stars, and is freely sprinkled over with larger stars. The effect, which probably corresponds with the actual fact, is as if a globe of fifteenth magnitude were inclosed in a shell of eleventh magnitude stars, some of these being naturally projected upon the central aggregation. Sir John Herschel remarked of a cluster in the southern constellation of the Altar ("Gen. Cat." 4467): "The stars are of two magnitudes; the larger run out in lines like crooked radii, the smaller are massed together in and around the middle" ("Cape Observations," p. 119). A similar structure was noted by Webb in clusters in Canes Venatici (M 3), in Libra (M 5), and in Coma Berenices (M 53) ("The Student," vol. i. p. 460). Here, again, we seem to catch a glimpse, from a different point of view, of a law connecting growth in mass and light with increase of tangential velocity—consequently, with retreat from the centre of attraction; and the assumption of an outward drift of *completed* suns gains some degree of plausibility.

Irregularities of distribution in clusters take a form, in some instances, so enigmatical as to excite mere unspeculative wonder. At Parsonstown, in 1850, three "dark lanes," meeting at a point considerably removed from the centre, were perceived to interrupt the brilliancy of the stellar assemblage in Hercules. They were afterwards recognized by Buffham and Webb, and are unmistakable in one (at least) of Mr. Roberts's recent photographs of that grand object. The clusters in Ophiuchus, in Canes Venatici, and in Pegasus ("G. C." 4670) are similarly *tunnelled*. Preconceived ideas as to the mechanism of celestial systems are utterly confounded by appearances not easily reconcilable, so far as we can see, with the prosecution of any orderly scheme of circulatory movement. Even if absolutely vacant, the extensive clearings indicated by the phenomenon of dusky rifts, must of course, in globular clusters, be partially obliterated by the interposed light of the surrounding star-layers. They can hence become perceptible only when their development is most fully pronounced; and, in a less marked shape, may exist in many clusters in which they defy detection.

The apparent diameter of the cluster in Hercules, including most of its branches, is 8′; that of its truly spherical portion may be put at 5′. But since the sine of an angle of 5′ is to radius about as 1 : 687, it follows that the real diameter of this globe of stars is 1/687 of its distance from the earth. Assuming this distance to be such as would correspond to a parallax of 1/20 of a second, we find that the more compact part of the cluster measures 558,000,000,000 miles across. Light occupies about thirty-six days in traversing it. The average brightness of its components may be estimated at the twelfth magnitude; for, although the outlying stars are of the tenth and eleventh ranks, the central ones are, there is reason to believe, much fainter. The sum total of their light, if concentrated into one stellar point, would at any rate very little (if at all) exceed that of a third magnitude star. And one third magnitude star is equivalent to just 4000 stars of the twelfth magnitude. Hence we arrive at the conclusion that the stars in the Hercules cluster number about 4000; and that Sir William Herschel, in estimating them at 14,000, erred considerably on the side of excess.

If, then, 4000 stars be supposed uniformly distributed through a sphere 558,000,000,000 miles in diameter, an interval of 28,365,000,000 miles, or more than ten times the distance from Neptune to the sun, separates each from its nearest neighbour.[1] Under these circumstances, each must shine with about one thousand times the lustre that Sirius displays to us. Since, however, five millions of stars even of this amazing brilliancy would be needed to supply the light we receive from the sun, the general illumination of the cluster can only amount to a soft twilight, excluding, it is true, the possibility of real night on any globe situated near its centre.

At the distance conjecturally assigned to this cluster, our sun would appear as a seven and a half magnitude star; it would shine, that is to say, about sixty-three times as brightly as an average one of the grouped objects. Each of these, accordingly, emits 1/63 of the solar light; and if of the same luminosity, relative to mass, as the sun, it exercises just 1/500 of the solar attractive power. The mass of the entire system of 4000 such bodies is thus equal to that of eight suns. This, however, may be regarded as a minimum estimate. The probabilities are in favour of the cluster being vastly more remote than we have here assumed it to be; hence proportionately more massive, and composed of brighter individual bodies than results from our calculation. Differences of distance are alone adequate to account for the variety of *texture* observable in globular clusters. That in Aquarius, for instance, compared by Sir John Herschel to "a heap of golden sand," might very well be the somewhat coarse-grained Hercules group withdrawn as far again into space. At a still further stage of remoteness, the appearance would presumably be reached of a stellar throng in the Dolphin ("G. C." 4585), which, with low powers, might pass for a planetary nebula, but under stronger optical compulsion assumes the granulated aspect of a true cluster. And many such, their genuine nature rendered impenetrable by excessive distance, are doubtless reduced to the featureless semblance of "irresolvable" nebulæ.

But there are real as well as apparent diversities in these objects. Although smaller and more compressed clusters must, on the whole, be more remote than large, looser ones, yet "this argument," Sir William Herschel remarked, "does not extend so far as to exclude a real difference which there may be in different clusters, not only in the size, but also in the number and arrangement of the stars." There may be globular clusters with components of the actual magnitude of Sirius; others, optically indistinguishable from them, may be aggregated out of self-luminous bodies no larger than Mars, or even than Ceres, or Pallas. There is, indeed, a strong likelihood that clusters and nebulæ form an unbroken series—that swarms of meteorites are connected by such interminable gradations with swarms of suns, as to admit of no impassable barrier being set up between them.[2] The rifted structure, for instance, and truncated spectrum of the Hercules cluster bring it into unmistakable relations with the great nebula in Andromeda; yet it is scarcely doubtful that the one object is an assemblage of orbs each of them, quite possibly, the rival of our sun in lustre; and the other, a collection of what we can only describe as cosmical shreds and particles. Further analogies emerge to view through the reproduction in many nebulæ of the "hairy" appendages of globular clusters, and in the spirality of arrangement characteristic of both classes

[1] See J. E. Gore's similar calculation, based, however, on different data from those assumed above, in Journal Liverpool Astr. Soc. vol. v. p. 169.
[2] See Mr. Lockyer's "Bakerian Lecture," p. 29.

of object. These strange and, at present, unaccountable resemblances will probably be developed and possibly be interpreted by future investigations.

A. M. CLERKE.

TIMBER, AND SOME OF ITS DISEASES.[1]

XI.

IT may possibly be objected that the subject of the present paper cannot properly be brought under the title of these articles, since the disease to be discussed is not a disease of timber *in esse* but only of timber *in posse;* nevertheless, while acknowledging the validity of the objection, I submit that in view of the fact that the malady to be described effects such important damage to the young plants of several of our timber-trees, and that it is a type of a somewhat large class of diseases, the slight impropriety in the wording of the general title may be overlooked.

It has long been known to forest nursery-men that, when the seedling beeches first appear above the ground, large numbers of them die off in a peculiar manner—they are frequently said to "damp off" or to "rot off." A large class of diseases of this kind is only too familiar, in its effects, to cultivators in all parts of the world. Every gardener, probably, knows how crowded seedlings suffer, especially if kept a trifle too damp or too shaded, and I have a distinct recollection of the havoc caused by the "damping off" of young and valuable Cinchona seedlings in Ceylon.

In the vast majority of the cases examined, the "damping off" of seedlings is due to the ravages of fungi belonging to several genera of the same family as the one (*Phytophthora infestans*) which causes the dreaded potato disease—*i.e.* to the family of the Peronosporeæ—and since the particular species (*Phytophthora omnivora*) which causes the wholesale destruction of the seedlings of the beech is widely distributed, and brings disaster to many other plants; and since, moreover, it has been thoroughly examined by various observers, including De Bary, Hartig, Cohn, and others, I propose to describe it as a type of the similar forms scattered all over the world.

It should be premised that, when speaking of this disease, it is not intended to include those cases of literal damping off caused by stagnant water in ill-drained seed-beds, or those cases where insufficient light causes the long-drawn, pale seedlings to perish from want of those nutrient substances which it can only obtain, after a certain stage of germination, by means of the normal activity of its own green cotyledons or leaves, properly exposed to light, air, &c. At the same time, it is not to be forgotten that, *as conditions which favour the spread of the disease to be described*, the above factors and others of equal moment have to be taken into account; which is indeed merely part of a more general statement, viz. that, to understand the cause and progress of a disease, we must learn all we can about the conditions to which the organisms are exposed, as well as the structure, &c., of the organisms themselves.

First, a few words as to the general symptoms of the disease in question. In the seed-beds, it is often first noticeable in that patches of seedlings here and there begin to fall over, as if they had been bitten or cut where the young stem and root join, at the surface of the ground: on pulling up one of the injured seedlings, the "collar," or region common to stem and root, will be found to be blackened, and either rotten or shrivelled, according to the dampness or dryness of the surface of the soil. Sometimes the whole of the young root will be rotting off before the first true leaves have emerged from between the cotyledons; in other cases, the "collar" only is rotten, or shrivelled, and the weight of the parts above ground causes them to fall prostrate on the surface of the soil; in yet others, the lower parts of the stem of the older seedling may be blackened, and dark flecks appear on the cotyledons and young leaves, which may also be turning brown and shrivelling up (Fig. 36).

If the weather is moist—*e.g.* during a rainy May or June—the disease may be observed spreading rapidly from a given centre or centres, in ever-widening circles. It has also been noticed that if a moving body passes across a diseased patch into the neighbouring healthy seedlings, the disease in a few hours is observed spreading in its track. It has also been found that if seeds are again sown in the following season in a seed-bed which had previously contained many of the above diseased seedlings, the new seedlings will inevitably be killed by this "damping off." As we shall see shortly, this is because the resting spores of the fungus remain dormant in the soil after the death of the seedlings.

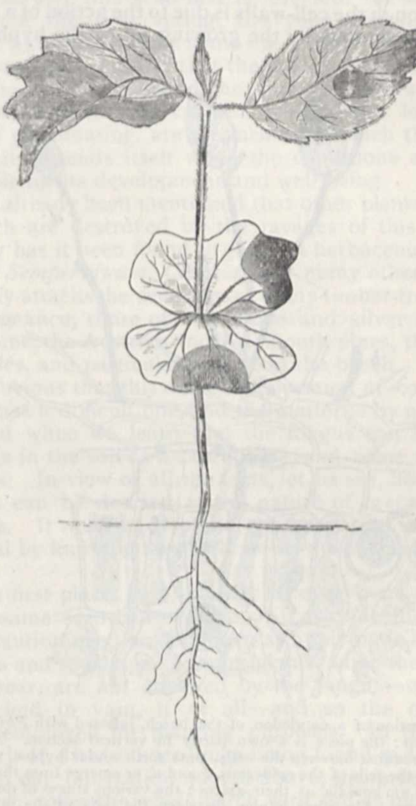

FIG. 36.—A young beech-seedling attacked by *Phytophthora omnivora*: the moribund tissues in the brown and black patches on the young stem, cotyledons, and leaves. are a prey to the fungus, the mycelium of which is spreading from the different centres. The horizontal line denotes the surface of the soil.

In other words, the disease is infectious, and spreads centrifugally from one diseased seedling to another, or from one crop to another: if the weather is moist and warm—"muggy," as it is often termed—such as often occurs in the cloudy days of a wet May or June, the spread of the disease may be so rapid that every plant in the bed is infected in the course of two or three days, and the whole sowing reduced to a putrid mass; in drier seasons and soils, the spread of the infection may be slower, and only a patch here and there die off, the diseased parts shrivelling up rather than rotting.

If a diseased beech seedling is lifted, and thin sections of the injured spots placed under the microscope, it will be found that numerous slender colourless fungus-filaments are running between the cells of the tissues, branching and twisting in all directions. Each of these fungus-fila-

[1] Continued from p. 299.

ments is termed a hypha, and it consists of a sort of fine cylindrical pipe with very thin membranous walls, and filled with watery protoplasm. These hyphæ possess the power of boring their way in and between the cell-walls of the young beech seedling, and of absorbing from the latter certain of the contents of the cells. This is accomplished by the hyphæ putting forth a number of minute organs like suckers into the cells of the seedling, and these suckers take up substances from the latter: this exhaustion process leads to the death of the cells, and it is easy to see how the destruction of the seedling results when thousands of these hyphæ are at work.

At the outer parts of the diseased spots on the cotyledons or leaves of the seedling, the above-named hyphæ are seen to pass to the epidermis, and make their way to the exterior: this they do either by passing out through the openings of the stomata, or by simply boring through the cell-walls (Fig. 37). This process of boring through the cell-walls is due to the action of a solvent substance excreted by the growing tip of the hypha: the

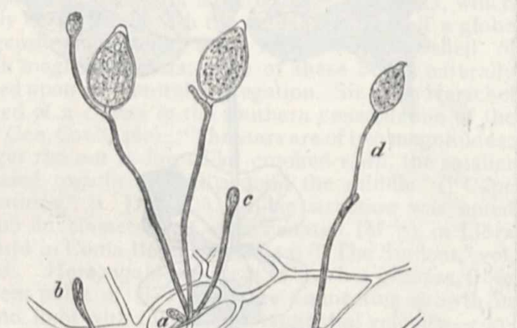

FIG. 37.—Portion of a cotyledon of the beech, infested with *Phytophthora omnivora*: the piece is shown partly in vertical section. The mycelium, spreading between the cells, puts forth aërial hyphæ, which bore between the cells of the epidermis, *b* and *d*, or emerge from the stomata, *a*, and form conidia at their apices: the various stages of development are shown. On other hyphæ, between the cells of the interior, the oospores are formed in oogonia, *c* and *f*. (Highly magnified.)

protoplasm secretes a ferment, which passes out, and enables the tip to corrode or dissolve away the substance of the cell-walls. It is also characteristic of these hyphæ that they make their way in the substance of the cell-walls, in what is known as the "middle lamella": in this, and in what follows, they present many points of resemblance to the potato-disease fungus, which is closely allied to *Phytophthora omnivora*.

The hyphæ which project from the epidermis into the damp air proceed to develop certain spores, known as the *conidia*, which are capable of at once germinating and spreading the disease. These conidia are essentially nothing but the swollen ends of branches of these free hyphæ: the ends swell up and large quantities of protoplasm pass into them, and when they have attained a certain size, the pear-shaped bodies fall off, or are blown or knocked off.

Now the points to be emphasized here are, not so much the details of the spore-formation, as the facts that (1) many thousands of these spores may be formed in the course of a day or two in warm, damp weather; and (2) any spore which is carried by wind, rain, or a passing object to a healthy seedling may infect it (in the way to be described) within a few hours, because the spore is capable of beginning to germinate at once in a drop of rain or dew. A little reflection will show that this explains how it is that the disease is spread in patches from centres, and also why the spread is so rapid in close, damp weather.

When a conidium germinates in a drop of dew for instance, the normal process is as follows. The protoplasm in the interior of the pear-shaped conidium becomes divided up into about twenty or thirty little rounded naked masses, each of which is capable of very rapid swimming movements; then the apex of the conidium bursts, and lets these minute motile zoospores, as they are called, escape (Fig. 38, *a*).

Each zoospore then swims about for from half an hour to several hours in the film of water on the surface of the epidermis, and at length comes to rest somewhere. Let us suppose this to be on a cotyledon, or on the stem or root. In a short time, perhaps half an hour, the little

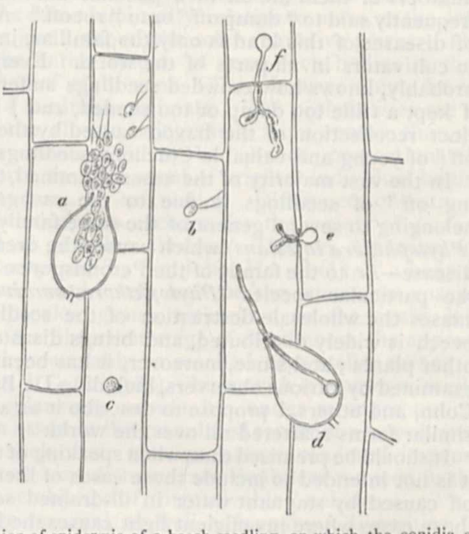

FIG. 38.—Portion of epidermis of a beech-seedling, on which the conidia of the *Phytophthora* have fallen and burst, *a* and *d*, emitting the motile zoospores, *b*, which soon come to rest and germinate, *c*, by putting forth a minute germinal hypha, *c*, *e*, which penetrates between the cells of the epidermis, *e* and *f*, and forms the mycelium in the tissues beneath. At *d* a zoospore has germinated, without escaping from the conidium. (Highly magnified: partly after De Bary and Hartig.)

zoospore begins to grow out at one point—or even at more than one—and the protuberance which grows out simply bores its way directly through the cell-wall of the seedling, and forms a cylindrical hypha inside (Fig. 38, *b*, *c*, *e*, *f*): this hypha then branches, and soon proceeds to destroy the cells and tissues of this seedling. The whole process of germination, and the entrance of the fungus into the tissues, up to the time when it in its turn puts out spore-bearing hyphæ again, only occupies about four days during the moist warm weather in May, June, and early in July.

We are now in a position to make a few remarks which will enable practical people to draw helpful conclusions from what has been stated. Let us suppose a seed-bed several feet long and about three feet wide, and containing some thousands of young beech seedlings: then suppose—by any means whatever—that a single conidium of *Phytophthora omnivora* is carried on to a cotyledon of one of the seedlings. Let us further assume that this occurs one warm evening in May or June. During the night, as the air cools, the cotyledon will be covered with a film or drops of water, and the conidium will germinate, and allow, say, thirty zoospores to escape. Now, the average size of a conidium is about 1/400 of an inch long by about 1/700 of an inch broad, and we may take the zoospore as about 1/2000 of an inch in diameter; thus it is easy to see that the film of moisture on the cotyledon is to a zoospore like a large pond or lake to a minnow, and the tiny zoospores, after flitting about in all directions, come to rest at so many distant points on the cotyledon—or some of them may have travelled abroad along the moist stem, or along a contiguous leaf, &c. Before daylight, each of these thirty zoospores may have put forth a filament which bores between the cells of the cotyledon, and begins to grow and branch in the tissues, destroying those cell-contents which it does not directly absorb, and so producing the discoloured disease-patches referred to. Supposing the weather to remain damp and warm, some of the hyphæ may begin to emerge again from the diseased and dying seedling on the fourth day after infection—or at any rate within the week—and this may go on hour after hour and day after day for several weeks, each hypha producing two or more conidia within a few hours of its emergence; hence hundreds of thousands of conidia may be formed in the course of a few days, and if we reflect how light the conidia are, and how their zoospores can flit about to considerable distances, it is not surprising that many of them are shed on to the surrounding seedlings, to repeat the story. If we further bear in mind that not only every puff of wind, but every drop of rain, every beetle, or fly, or mouse, &c., which shakes the diseased seedling may either shake conidia on to the next nearest

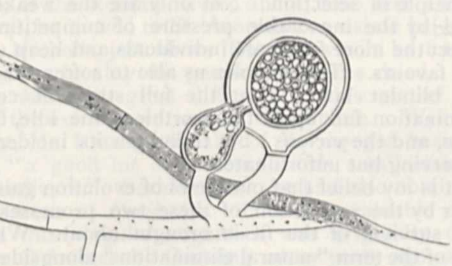

FIG. 39.—An oogonium and antheridium of *Phytophthora omnivora*. The oogonium is the larger rounded body, borne on a branch of the mycelium: it contains an oosphere, in process of being fertilized by the protoplasm of the antheridium (the smaller body applied to the side of the oogonium). The antheridium has pierced the wall of the oogonium, by means of a fertilizing tube, through which the contents pass into the oosphere, converting the latter into an oospore. (Very highly magnified: after De Bary.)

seedlings or even carry them further, it is clearly intelligible how the infection is brought about, and spreads through the seed-bed, gathering strength, as it were, hour by hour.

But, although we have explained the rapid infection from plant to plant, it still remains to see how it is that if we sow the seeds in this bed next year, the seedlings are almost certain to be generally and badly attacked with the disease at a very early stage.

When the fungus-mycelium in the cotyledons and other parts of the diseased seedlings has become fully developed, and has given off thousands of the conidia above described, many of the branches in the dying tissues commence to form another kind of spore altogether, and known as an oospore, or egg-like spore. This spore differs from the conidium in size, shape, and position, as well as in its mode of development and further behaviour, and if it were not that several observers have seen its formation on the same hyphæ as those which give rise to the conidia, it might be doubted by a beginner whether it really belongs to our fungus at all. As it is absolutely certain, however, that the oospore on germination gives rise to the fungus we are considering, the reader may rest satisfied on that point.

The spore in question is formed in a swelling of the free end of a branch of the hypha as follows. The protoplasm in the rounded end of the hypha becomes collected into a ball (the egg-cell or *oosphere*) and then a smaller branch with a distinct origin applies itself to the outside of this rounded swelling and pierces its wall by means of a narrow tube: protoplasm from the smaller branch (*antheridium*) is then poured through the tube into the "egg-cell," which thus becomes a fertilized "egg-spore" or *oospore*. This *oospore* then acquires a very hard coating, and possesses the remarkable peculiarity that it may be kept in a dormant state for months and even a year or more before it need germinate: for this reason it is often called a resting spore. It has been found that about 700,000 oospores may be formed in one cotyledon, and a handful of the infected soil sufficed to kill 8000 seedlings.

Now, when we know this, and reflect that thousands of these *oospores* are formed in the rotting seedlings and are washed into the soil of the seed-bed by the rain, it is intelligible why this seed-bed is infected. If seeds are sown there the next spring, the young seedlings are attacked as soon as they come up. These *oospores* are, in fact, produced in order that the fungus shall not die out as soon as it has exhausted the current year's supply of seedlings; whereas the *conidia*, which soon lose their power of germinating, are the means by which the parasite rapidly extends itself when the conditions are most favourable for its development and well-being.

It has already been mentioned that other plants besides the beech are destroyed by the ravages of this fungus. Not only has it been found to grow on herbaceous plants, such as *Sempervivum*, *Clarkia*, and many others, but it habitually attacks the seedlings of many timber-trees, such as, for instance, those of the spruce and silver firs, the Scotch pine, the Austrian and Weymouth pines, the larch, the maples, and particularly those of the beech.

It is obvious that this makes the question of combating this disease a difficult one, and the matter is by no means simplified when we learn that the fungus can live for a long time in the soil as a saprophyte, and apart from the seedlings. In view of all the facts, let us see, however, if anything can be devised of the nature of precautionary measures. It must at least be conceded that we gain a good deal by knowing so much as we do of the habits of this foe.

In the first place, it will occur to everybody never to use the same seed-bed twice; but it may be added that this precaution need not be taken as applying to anything but seeds and seedlings. Young plants, after the first or second year, are not attacked by the fungus—or rather are attacked in vain, if at all—and so the old beds may be employed for planting purposes. In the event of a patch of diseased seedlings being found in the seed-bed, as in our illustration quoted above, the procedure is as follows: cover the whole patch with soil as quietly and quickly as possible, for obviously this will be safer than lifting and shaking the spore-laden plantlets. If, however, the sharp eye of an intelligent gardener or forester detects one or two isolated seedlings showing the early stages of the disease, it is possible to remove the single specimens and burn them, care being taken that the fingers, &c., do not rub off spores on to other seedlings.

In the last event, the beds must be looked to every day to see that the disease is not spreading. All undue shading must be removed, and light and air allowed free play during part of the day at least; by such precautions, carefully practised in view of the above facts and their consequences, it is quite feasible to eradicate the disease in cases where ignorant or stupid mismanagement would result in the loss of valuable plants and time. In the case of other seedlings also, much may be done by intelligently applying our knowledge of the disease and its cause. It is not our purpose at present to deal with the diseases of garden-plants, &c., but it may be remarked in passing that in the large majority of cases the "damping off" of seedlings is due to the triumphant development of fungi belonging to the same genus as the one we have been considering, or else to the closely allied genus *Pythium*. In illustration of this I will mention one case only.

It is always possible to obtain well-grown specimens of the fungus *Pythium* by sowing cress seed fairly thick, and *keeping the soil well watered and sheltered*. Now what does this mean? Nobody imagines that the fungus arises spontaneously, or is produced in any miraculous manner; and in fact we need not speculate on the matter, for the fact is that by keeping the crowded cress seedlings moist and warm we favour the development of the *Pythium* (spores of which are always there) in somewhat greater proportion than we do the development of the cress. In other words, when the cress is growing normally and happily under proper conditions, it is not because the *Pythium* is absent, but because (under the particular conditions which favour the normal development of healthy cress) it grows and develops spores relatively so slowly that the young cress seedlings have time to grow up out of its reach. The recognition of this struggle for existence on the part of seedlings is of the utmost importance to all who are concerned with the raising of plants. H. MARSHALL WARD.

NATURAL SELECTION AND ELIMINATION.[1]

MR. DARWIN'S phrase, "natural selection," is applied to such processes, other than those involving the agency of man, as result under Nature in the survival of the fittest. These processes fall under two heads, which have not, I think, been sufficiently distinguished. For the first of these I here retain the word *selection*; for the other I suggest the term *elimination*.

In natural selection the favourable varieties are chosen out for survival: in natural elimination the failures or comparative failures are weeded out. In the one, Nature is employing conscious agents upon the upper or superior end of the scale: in the other, Nature is, through conscious or unconscious agencies, at work on the lower or inferior end of the scale.

Variation is constantly taking place; and the variations may be favourable or unfavourable or neutral. Under selection the favourable variations will be chosen out; the unfavourable and the neutral may go. Under elimination the unfavourable disappear; the favourable *and the neutral* remain. By how much the favourable variations are in excess, by so much will the race tend to advance. I see no reason why neutral variations should be eliminated, except in so far as—in the keen struggle for existence—they become relatively unfavourable.

In the valuable and suggestive paper in which Mr. G. J. Romanes dealt with physiological isolation, he brought forward the inutility of specific characters as one of the three cardinal difficulties in the way of natural selection considered as a theory of the origin of species. So long as we consider selection proper, this objection is valid. But under elimination (by far the more potent of the two) there is no reason why specific features without utilitarian significance should be weeded out. Undoubtedly, in the long run, useful variations will tend more and more to preponderate, since, the longer and keener the struggle, the greater the tendency for neutral variations to become relatively unfavourable. And this conclusion is in harmony with the teachings of biology. For, as Mr. Romanes remarks, "it is not until we advance to the more important distinctions between genera, families, and orders that we begin to find, on any large or general scale, unmistakable evidence of utilitarian meaning."

Natural elimination is intimately associated with the struggle for existence, which may indeed be regarded as the reaction of the organic world called forth by the action of natural elimination. The struggle for existence is the result of a threefold process of elimination (cf. "Origin of Species," chap. iii.). First, elimination by the direct action of surrounding conditions; secondly, elimination by enemies (including parasites); and, thirdly, elimination by competition.

Natural selection (in the narrower sense suggested) is a much rarer process, and one that only comes into play when intelligence, or (since it may be objected that selection is in some cases instinctive) when the mind-element comes definitely upon the scene of life. Perhaps one of the best examples is the selection of flowers and fruits by insects and fruit-eating animals. But even here (at least in the case of flowers) the process of elimination also comes into play: for the visitation of flowers by insects involves cross-fertilization, the advantages of which Mr. Darwin so exquisitely proved. So that we have here the double process at work, the fairest flowers being selected by insects, and those plants which failed to produce such flowers being eliminated as the relatively unfit.

If we turn to the phenomena of what Mr. Darwin termed "sexual selection," we find both selection and elimination brought into play. By the law of battle the weaker and less courageous males are eliminated, so far as the continuation of their kind is concerned. By the individual choice of the females, the finer, bolder, handsomer, and more tuneful wooers are selected.

When we have to consider the evolution of human folk, the principle of elimination is profoundly modified by the principle of selection. Not only are the weaker eliminated by the inexorable pressure of competition, but we select the more fortunate individuals and heap upon them our favours. This enables us also to soften the rigour of the blinder law; to let the full stress of competitive elimination fall upon the worthless, the idle, the profligate, and the vicious; but to lighten its incidence on the deserving but unfortunate.

It is my belief that our views of evolution gain in clearness by the separation of these two processes by which the survival of the fit is brought about. Whether the use of the term "natural elimination" alongside of and in subservience to "natural selection" would be of service to those who are students and teachers of evolution doctrines, I must leave others to judge.

C. LLOYD MORGAN.

[1] Abstract of a Paper read before the Bristol Naturalists' Society.

THE FAUNA AND FLORA OF THE LESSER ANTILLES.

ALTHOUGH much has been done of late years, both in the United States and in Europe, towards the investigation of the fauna and flora of the smaller West Indian Islands, or Lesser Antilles, as it is better to call them, much remains to be effected before we can be deemed to have an accurate knowledge of the natural products of these islands. And it is most important that steps should be taken to remedy this deficiency without further delay. As the tide of civilization advances—more slowly, perhaps, it is true, over these islands than in many other parts of the world's surface—the special peculiarities which each individual island possesses among its animal and vegetable indigens are fast becoming overwhelmed by the more powerful animals and plants that accompany the inroads of civilized man upon the wilderness of Nature. As in other places, where settlers from Europe arrive, rats and mice eat out the indigenous animals, and exotic weeds starve out the native plants. It is therefore most desirable that, while there is yet time, exact information should be obtained of the flora and fauna of these islands, every one of which seems to exhibit features more or less peculiar to itself.

This subject having been brought before the Committee of Section D at the Manchester meeting of the British Association by Mr. Sclater, a grant of £100 was made for the purpose of initiating investigations in this direction. At the instance of the same gentleman, a similar sum was recently obtained out of the Government grant administered by the Royal Society, shortly after which the separate Committees appointed to administer the two grants agreed to combine for the purpose "of reporting on the present state of our knowledge of the zoology and botany of the West India Islands, and of taking steps to investigate ascertained deficiencies in the fauna and flora."

The joint Committee thus formed consists of Prof. Flower, Mr. Carruthers, Mr. Thiselton Dyer, Dr. Günther, Prof. Newton, Mr. Sclater, Dr. Sharpe, Lieut.-Col. Feilden, and Mr. D. Morris. Prof. Flower has been elected Chairman of the Committee; Mr. Thiselton Dyer, Secretary; and Mr. Sclater, Treasurer.

Lieut.-Col. Feilden having accepted a colonial appointment in Barbados will be in future resident at Bridge-Town, where he will act as local Secretary of the Committee, while Dr. H. A. Alford Nicholls, F.L.S., C.M.Z.S., has kindly agreed to assist in the same capacity in Dominica. In order to commence their investigations without delay, the Committee have secured the services of Mr. George A. Ramage, who was lately associated with Mr. Ridley in his expedition to the island of Fernando Noronha, and has since been collecting in Pernambuco. Mr. Ramage arrived in Dominica in March last, and has proceeded to his work with great zeal. In May, after passing five weeks at Laudat, on the right bank of the Roseau River, about 2000 feet above the sea-level, he moved to St. Aroment, an estate belonging to Dr. Nicholls, just above Roseau, which he found to be a better locality for getting his plants dried. At Laudat he met with great difficulty in this matter on account of the extreme wetness of the climate. Writing in May last, Mr. Ramage speaks of having got, besides his plants, "a good lot of insects, lizards, small snakes, and land-molluscs." Besides these, he had also obtained three specimens of *Peripatus*. This is a valuable discovery, as this singular organism was originally discovered in Dominica by Guilding many years ago, and has not been since obtained in the same locality.

After exploring Dominica, Mr. Ramage will probably receive instructions to proceed to the other islands of the Leeward group, some of which are almost entirely unworked as regards their animal and vegetable life. Now that this important investigation has been so fairly started, it is hoped that little difficulty will be experienced in obtaining further assistance from the British Association and the Royal Society. It should, perhaps, be mentioned that complete sets of all the specimens obtained will be placed in the British Museum and Kew Herbarium, the Directors of these two Institutions being themselves both members of the Committee.

SONNET*

TO A YOUNG LADY WITH A CONTRALTO VOICE,

On her singing, on a warm summer's afternoon, without accompaniment, save the music of the birds heard through the open windows of the author's rooms overlooking the beautiful garden of New College, Oxford, the old English ditty,
"Deck not with gems that lovely form for me,"
in which occurs the line,
"I must have loved thee hadst thou not been fair."

THE startled, ambushed, nightingales despair
To match those notes, so tender sweet and low,
That poured through lips where Cupid lays his bow
Had made thee loved e'en hadst thou been less fair.
What need hast thou with gems to deck thy hair,
Of aught of wealth Golconda's mines bestow,
Rubies or pearls rash divers seek below!—
Thou canst in nobler wise thy worth declare.
Oft shall thy votary in his cloistered cell
In deep research of Nature's secret clue
Pause, to bid Memory with her magic spell,
Bring back thy face and sweet girl-form to view,
And in fond fancy hear thy voice anew
Till life to gladness breathes its last farewell.

Athenæum Club, July 25. J. J. S.

* This is the original form of the sonnet, published in the preceding number of NATURE, which, if perhaps superior to this in expression, is open to the reproach from which the original is free, pointed out to the author by his distinguished friend, the great Traveller and Orientalist (the translator, too, of Camoens' sonnets), Sir Richard Burton, of deviating from the Petrarchian model by its sestett having one rhyme in common with the octave. In my "Laws of Verse" (if I remember right) I have compared the octave and sestett of a sonnet to the body and the frame or bed of a carriage respectively. The effect of a rhyme common to the two may be likened to that of driving in a spike, which converts the previous springy connection of the two parts into a fixture. The much more common fault of English sonnets is the reverse of this, viz. that they contain too many distinct rhymes instead of too few. In the form-build of the two sonnets I may be said to have discovered a locket artistically adapted to receive either one of two miniatures, each in its own way equally exquisite, and worthy of ineffable regard and adoration. I left the Subject of this week's sonnet at the door of Magdalen College Chapel to attend the evening service there, and early the next morning, as it now reads, with the exception of changes in three lines only, it was in the hands of her parents.

With regard to the punctuation of this and other of my poetical pieces, I share to a great extent the opinion of the late deeply regretted Matthew Arnold, that in poetical composition the fewer points the better: grammatical or (so to say) choristic points as such should never be introduced except when necessary to prevent ambiguity or obscurity of meaning: consequently there will be many points left out in poetry which would be found in the same piece written in prose. But *per contra* I hold that points are sometimes useful or even necessary in poetry which would not be found in prose, viz. to mark brief pauses or almost insensible musical rests. The pointing I have adopted in the line from last week's sonnet—

Thy flashing, rushing, fingers to indue—

affords an exemplification of this latter principle. The commas on each side of *rushing* are not choristic but melodic, and would not appear in prose.

In law writings no points at all are introduced, and for reasons which in no wise conflict with the principles referred to above.

1°. A law document is expected and ought to be written in such a form as to be insusceptible of an equivocal or doubtful construction.

2°. No one expects a law document (unless maybe it were a marriage certificate or deed of separation by mutual consent) to have much music in its lines.

One of the official readers of the sonnet contained in the last number of NATURE has written to me to say that he cannot see the sense of lines 3 and 4. The answer is, I think, obvious. In the human organism all parts, faculties, and powers are connected and correlated. Consequently a voice whose notes are pure, sweet, and true affords a voucher (I do not say mathematical proof, but presumptive evidence which may be accepted in the absence of rebutting facts) of the character to which it appertains being sweet, pure, and true. But sweetness, purity, and truth are the prime ingredients of goodness. Therefore notes which are pure, sweet, and true vouch for the goodness of the person to whom the voice belongs. Q.E.D.

The argument in the text is put in the form of an enthymeme, the major premise—*All persons whose singing notes are sweet, pure, and true offer a presumption that they are good*—being suppressed. It is notorious that birds instinctively, and therefore on the surest ground, infer the worthiness (or according to their ethical code the goodness) of their partners from their superiority in song. Witness the distich from a sonnet familiar to many of my readers—

Like foolish bird who in the fowler's cry
Hears her loved mate's soft amorous melody

If I am wrong in supposing so, I hope that Mr. Romanes, or any other biologist (if such there be) of equal skill with him in Darwinian dialectics, will set me right in this point, and inform the readers of NATURE on what other intelligible ground can be explained the recourse had to song by the male bird to win the affections of his mate. If such be the case with birds, why should it not be equally true of the sometimes scarcely less volatile portion of the human race?

NOTES.

NEXT year there will be in Paris what promises to be a splendid Anthropological Exhibition under the auspices of the French Ministry of Public Instruction. It will be organized by Committees representing the Society, the School, and the Laboratory of Anthropology; and an appeal for aid has been addressed to all who are, or have at any time been, connected with one or other of these institutions. The Exhibition will include objects relating to all branches of anthropological science.

CAPTAIN JOHN ERICSSON, who retains much of his vigour and youthful activity, celebrated his eighty-fifth birthday at New York on Tuesday, July 31. The King of Sweden and Norway cabled orders to Consul-General Bors to call upon the eminent engineer, and convey to him on the occasion renewed assurances of His Majesty's esteem. "Consul-General Bors," says the *New York Daily News*, "was only too happy to execute this commission, and when he called at 36 Beach Street to-day to deliver the message he brought with him a beautiful bouquet that delighted the great engineer extremely when he received it. He very willingly granted Consul-General Bors an audience, and thanked him for the courteous message he brought from his Royal master. Captain Ericsson has a wonderful faculty of talking and working out the most exact mechanical drawings at the same time, and Mr. Bors's visit did not interrupt him in his work in the least. He chatted with him cheerily, and listened with an amused smile to the Consul's expressions of wonder at his marvellous health and mental vigour."

THE Congress for the study of tuberculosis, lately held at Paris, was very successful. Numerous and important papers were read, and there was always a large attendance of members. The next meeting will be held in 1890, under M. Villemin's presidency.

THE sixty-first meeting of German men of science and physicians will be held in Cologne from September 18 to 23 next.

MR. JAMES STEVENSON, late Executive Officer of the United States Geological Survey, died at Gilsey House, New York, on July 25. He was born, in 1840, at Maysville, Kentucky.

THE United States Senate has voted to pay the widow of the late Prof. Spencer F. Baird 50,000 dollars in recognition of his services as United States Fish Commissioner.

LAST year, Bedford College sustained a great loss by the death of Mr. Shaen, who had been one of its most active friends since its earliest days; and a wish was then widely expressed that some scheme should be devised which should permanently associate his name with Bedford College. The Council now propose that a building shall be erected on a site immediately behind the College, and that it shall be called the Shaen Wing. In this building there would be good laboratories and class-rooms, and it is believed that the premises could be so arranged as to provide accommodation, at a moderate charge, for a number of students. It would be hard to think of a more suitable memorial of Mr. Shaen, and we have no doubt that the entire amount necessary for the carrying out of the plan (£3000) will soon be subscribed. The proposal that a large part of the fund shall be devoted to science laboratories strikes us as an interesting and hopeful sign of the times. Bedford College has done much to help the movement for supplying women with better opportunities of study. Of the 452 women who have passed the various examinations of the London University, no fewer than 123 have been students of this institution; and about one-third of the present students are working for these examinations. It may be reasonably expected that when the new laboratories are opened the results will be even more satisfactory than those now achieved; for all the present laboratories are adaptations of former class-rooms, and, being deficient in light and space, are but imperfectly fitted for the purposes for which they are used.

IN his Report on the technological examinations of 1888 Sir Philip Magnus says that in the present year there has again been a large increase in the total number of candidates examined. In 1887, 5508 were examined, of whom 3090 passed; in 1888, 6166 were examined, of whom 3510 passed. The increase in the number of candidates is less this year than last year, being 658 as compared with 744. Examinations have been held this year in forty-nine different subjects, in seven of which less than ten candidates presented themselves. The subjects in which the least number of candidates presented themselves are those connected with the chemical industries, and the examiners in these subjects generally remark that few of the candidates are found to possess that combined knowledge of scientific principles and of technical processes which is desirable. The increase in the number of candidates has been most marked in cloth, cotton, linen, and jute manufacture, in plumbers' work, carriage-building, carpentry and joinery, and in brickwork and masonry. The average percentage of failures has fallen from 43·8 to 43·1; and from the separate reports of the examiners it appears that in most subjects there is a distinct improvement in the quality of the candidates' written answers and practical work. Of the 3510 successful candidates, 758, or 21·6 per cent., have passed in the honours grade, as against 21·9 per cent. last year. It appears that 10,404 students have received instruction in 475 registered classes connected with the City and Guilds of London Institute. These classes were in 183 different towns in the United Kingdom. The corresponding numbers for the previous year were 8613 students, 365 classes, and 121 towns. These numbers do not include the students at the Finsbury Technical College, the Yorkshire College, Leeds, and other Colleges the Professors of which do not receive grants on results, and the candidates from which are classed as "external" candidates. Sir Philip Magnus anticipates that with the establishment of new Polytechnic Institutions in different parts of London there will be a large increase in the number of students in the technical classes registered by the Institute and in the number of candidates for examination.

IN the Report, for the year 1886-87, presented by the Board of Managers of the Observatory of Yale University to the President and Fellows, complaint is made that too large a proportion of the clinical thermometers (foreign or American) sent to the Observatory for verification are despatched so soon after their manufacture that the corrections given are liable to change with a year's use. "Physicians," says Mr. Robert Brown, secretary of the Observatory, "would obtain much more exact indications of temperature if, estimating the probable annual breakage, they would provide themselves with two or three years' supply of well-made, well-graduated clinicals, and obtain tables of corrections only after the instruments were *known* to have attained a proper age of, say, one or two years. The comparatively small demand for clinicals whose *age* as well as correction is certified, seems to imply that the medical profession is not yet generally awake to the exactitude that is practicable in ascertaining body temperature."

THE sealer *Jason* has arrived in Norway from the Greenland coast, and reports that the Expedition under Dr. Fridtjof Nansen, which is to cross Greenland from east to west, left that ship on July 17 in latitude 65° 2' N. An ice-belt about ten English miles in width separated the ship from the shore, but it is believed that the members would have no trouble in crossing this, the floes being large. Dr. Nansen intended to land in the Sermilik Fjord, which is inhabited. Previous attempts at landing had failed on account of rain and fog.

IT is said that the Cincinnati Exposition is the best that has been held in America since the great one at Philadelphia in 1876. We reprint from *Science* the following account of it:—"People who were at New Orleans in 1885 say that this is enormously superior in all the arts, especially upon the mechanical and industrial side. The Exposition covers 15 acres in the very heart of the city, and in every part of this large area one meets evidences of taste, skill, ingenuity, and perseverance in adapting means to ends, which form a series of apparently never-ending surprises as one passes from one exhibit to another. The Government exhibits are all good and all characteristic. The Smithsonian Institution and the Geological Survey exhibits attract crowds. In the latter, Prof. F. W. Clark has some transparent photographic views, represented in colours by some new and as yet undisclosed process. The effect is wonderfully natural and beautiful, and if it is found to be durable it will prove a great discovery. The very fine models of the new classes of naval vessels now building attract crowds daily, as do the various forms of weapons for wholesale slaughter, in case we ever have another war. In close juxtaposition are the ingenious devices, for saving life in cases of shipwreck, of the Life-saving Service. The Fish Commission exhibit is not as yet complete. In such elaborate displays, requiring much preparatory work, more time should have been allowed for preparation. The Post Office Department and the Army exhibits are also incomplete, but a few days will find everything in order."

THE native birds of North America, which were supposed to be rapidly disappearing, reappeared in great numbers during the spring of the present year. This was first noted in the New York papers, and was promptly credited to the liberal destruction of the pugnacious English sparrow, unable to withstand the storm-beating received in the great March blizzard. But counter to this explanation, says *Science*, comes information from Illinois that the attention of all is attracted to the remarkably large number of birds that are to be seen. The groves, the woods, and the meadows in the country, and the many trees in the city, are peopled with these feathered visitors. The oldest inhabitant does not remember to have seen so many and such a variety of birds. And yet the great blizzard did not visit Illinois.

THE vapour-density of hydrofluoric acid has been subjected to a rigorous re-examination at the hands of Prof. Thorpe and Mr. F. J. Hambly. Prof. Mallet some time ago showed that, at a temperature of 30°·5 C., the density of hydrofluoric acid vapour corresponded to a molecule of the composition H_2F_2; consequently we have been accustomed to think of this substance as consisting of ordinary molecules of HF at higher temperatures, and of condensed molecules of H_2F_2 just above its boiling-point. But we have recently seen, from the experiments conducted in Prof. Victor Meyer's laboratory upon the molecular nature of sulphur, and also from the previous investigations concerning the composition of the molecules of the chlorides of aluminium, tin, and iron, that our older ideas as to the formation of condensed molecules, such as S_6 or Fe_2Cl_6, at particular temperatures were erroneous; that these condensed molecules were not capable of existence throughout any notable range of temperature. It therefore became an interesting question whether hydrofluoric acid would not behave in a similar manner. To test the question thoroughly, fourteen vapour-density determinations, at temperatures ranging from 26°·4 to 88°·3 C., have been carried out in the research laboratory of the Normal School of Science by means of an elaborate and expensive platinum apparatus. The first necessity was, of course, the pure anhydrous acid. This was freshly prepared, as required for each experiment, from the now famous double fluoride of hydrogen and potassium; it was afterwards re-distilled from the platinum retort through the density apparatus, which was placed in a bath of glycerol heated to the required temperature. The vessel, of known capacity, in which the hydrofluoric acid was eventually weighed consisted of a platinum cylinder completely closed, with the exception of the entrance and exit tubes, which could be closed at will by means of well-fitting platinum stopcocks of skilful workmanship. The whole operations could thus be conducted in platinum throughout, and are, therefore, of the most trustworthy character. As expected, the values obtained correspond to molecular weights ranging from 51·19 at 26°·4 to 20·58 at 88°·3, thus showing a continuous breaking down of the molecular grouping, until, finally, we arrive at the stage where the whole of the molecules consist simply of HF, corresponding to the normal density of 20. No other molecular condition than this is capable of existing throughout any considerable range of temperature. It is of the highest interest to consider what happens below 26°·4. The natural inference is that the molecular grouping becomes more and more complex, or condensed, until we reach a point where the substance becomes visible—a liquid; while still further condensation eventually brings us face to face with a solid.

THE Report of the Conservator of Forests in Ceylon for the past year says that though Sir Joseph Hooker in 1873 called attention to the rapid destruction of forests in that island, no steps were taken by the Government till 1882. In that year, as a result of a report of Mr. Vincent, of the Indian Forest Department, the Government turned its attention to the subject, and in 1885 the "Forest Ordinance" was issued. The objects of this Ordinance were, briefly, to select suitable areas of forest land and constitute them State forests, to buy off any interests which private individuals might have in those lands, to place them under effective protection, and generally to systematize the forest conservancy. Even now the Crown forests are plundered in a wholesale fashion by organized bands of thieves, but it is hoped in a short time to put an end to this, and make the forests of Ceylon as remunerative, comparatively speaking, as those of India, where they produce a substantial revenue. Ruin has threatened the Ceylon forests, just as it threatened the forests of Jinjira, in Western India, where three-fourths of a vast forest forty miles long, and from fifteen to a hundred miles in breadth, was destroyed, and the remainder with difficulty saved.

IN an interesting paper on ancient tide-lore, reprinted, with some other papers by the same author, from the Transactions of the New Zealand Institute, Mr. W. Colenso, F.R.S., describes the old belief of the Maories as to the ebbing and flowing of the sea. These phenomena, it seems, they attributed to a huge ocean monster, whose home was low down in the depths beyond the horizon. It was supposed to do its work by powerful and regular respiration, or ingurgitation and regurgitation of the water. The monster's name was Parata; and any one overtaken by great misfortune is said to have fallen into Parata's throat. In a myth relating to the first peopling of New Zealand, one of the chief canoes, named the *Arawa*, is represented as being carried into the enormous mouth of the monster, and as being with difficulty extricated by Ngatoroirangi, the courageous and cunning *tohunga* (= priest, or wise man) on board, who recited his powerful charm for the purpose. The words of this charm or spell are still preserved.

IN his Report to the Foreign Office on the agriculture of Yezo, the British Consul at Hakodadi says that though the Ainos are a hunting and fishing people, yet efforts have been made to induce them to cultivate the soil. In 1869 the influx of Japanese to the fishing grounds reduced them to great straits. This appears to have continued till 1882, when attention was drawn to their condition, and sums of money were distributed amongst them to relieve their distress, schools were built, and attempts were made to teach them farming. In 1886 the money gifts were stopped, but the efforts to teach them agriculture continued, and at the end of that year about 803 acres were cultivated by the Ainos. The Consul remarks that it is impossible to tell how many Ainos there are in Japan, from their carelessness or dislike to record the births and deaths; but it is calculated that there are about 3600 houses in Yezo—that is, about 14,000 people. The general impression is that they are gradually disappearing, but obviously the Government of Japan is doing all it can to aid the Ainos, and to foster in them a spirit of self-help.

THE last number (Session 1887–88) of the *Madras Journal of Literature and Science* contains the first part of a treatise by Prof. Oppert, of the Presidency College, Madras, on the original inhabitants of Bharatavarsa, or India, whom he describes as

Ganda-Dravidians. This term the learned writer explains by saying that the two special Ganda-Dravidian terms for mountain are *mala* and *ko*, both being widely used and prevalent throughout India. Those tribes, whose names are derived from *mala*, he calls Dravidians, and those whose names are derived from *ko*, Gandians. In this way the Mallas, Mālas, Malavas, Malayas, &c., and the Kōyis, Kōdulu, Kondas, Gondos, Kuruvas, &c., are classified as Dravidians and Gandians respectively. The presence of the Ganda-Dravidians in India can be proved at a very early period "from the north-west across to the north-east, and from both corners to the furthest south. On the arrival of the Aryans on the north-western frontier, the Ganda-Dravidians are already found in flourishing communities." In the present instalment of his work, Prof. Oppert endeavours to prove the antiquity of this race, especially of the Dravidian branch; in the next he will treat of the Gandians. His own summary of his positions in the concluding section is to this effect: in following the ramifications of the Dravidians throughout the peninsula, he points out the connection which exists between several tribes, apparently widely different from each other; he has identified the so-called pariahs of Southern India with the old Dravidian mountaineers, and establishes their relationship with a number of tribes forming, as it were, the first layer of the ancient Dravidian stratum, and he endeavours to show that various other different tribes are offshoots of the Dravidian race. He thinks also that much that is now considered Aryan in name and origin must be regarded as originally Dravidian. The various Dravidian tribes scattered over India are separately introduced into the discussion in order to establish their mutual kinship. Prof. Oppert, in fact, labours to restore the Dravidian "to those rights and honours of which he has so long been deprived." The spirit in which he has undertaken what is obviously a great work is sufficiently evident from the words with which he concludes the present article:—"My errors, too, may not be without use if, like stranded vessels, they serve to direct the explorer, warning him away from those shoals and rocks that beset the inquirer in his search after truth."

In the Berlin *Meteorologische Zeitschrift* for July, Dr. E. Brückner discusses the meteorological observations of the German Polar station at Kingua Fjord (Cumberland Sound), and also of the stations in Labrador and South Georgia, in the year 1882-83. The results represent three distinct types of winter climate. Kingua Fjord has a calm, severe winter, and cool summer, the warmest month being August, whereas July is usually the warmest month in Arctic North America. In Labrador the cold is often accompanied by stormy west winds, and although the temperature is higher than at Kingua Fjord, the cold is much more keenly felt. South Georgia naturally partakes of the oceanic character, but the yearly temperature, 34°·5, is much lower than at the neighbouring stations on the coast of South America, in the same latitude (54° 31′ S.), and is the lowest yet known in the southern hemisphere. Dr. P. Schreiber contributes an instructive article on the question of the deduction of true daily means of temperature from three or four observations daily. He gives a series of nine combinations, and their results, as compared with twenty-four hourly observations at Chemnitz. The result shows that the somewhat inconvenient hours of 6 a.m., 2 and 10 p.m., give the nearest true daily temperature. The inquiry is interesting as bearing upon the question of the necessity of continuing the expensive process of continuous records for an unlimited period.

Dr. Buys Ballot, the Director of the Meteorological Institute of the Netherlands, has published an excerpt paper from the Proceedings of the Amsterdam Academy of Sciences, on the distribution of temperature over the surface of the earth. Instead of representing the temperatures by the usual method of isothermal lines, he gives the departures for each 5° of latitude and longitude from the normal temperature at the equator, by means of figures, using ordinary and thick type to avoid the use of plus and minus signs. The variations of temperature for the typical months of January and July, and for the year, are very clearly shown by this method. The work is also accompanied by maps, connecting by curves all places having the same mean differences of temperature in the summer and winter months.

Among the contents of the new number of the *Internationales Archiv für Ethnographie* (Band i. Heft 4) we may note: a Singapore street scene, by Prof. G. Schlegel; a paper, by F. Grabowsky, on certain sacrificial customs in Borneo; another, by J. D. E. Schweltz, on South Sea relics; and various ethnographic notes from Mecca, by G. Snouck Hurgronje. All the articles are admirably illustrated with coloured plates.

A new autumn edition of "Walks in Epping Forest," by Percy Lindley, describing portions less known to pedestrians, is in preparation. Prof. Boulger has contributed to the same issue some notes upon the recent extensive tree-felling and "forestry" operations in Epping Forest.

A book on "The General Principles of Agriculture," by A. Larbalétrier (Reinwald), has just been published in Paris.

Gegenbauer's "Human Anatomy" is being translated into French. The first quarter of the book was recently published by Reinwald.

The *Odessa Gazette* reports the discovery of the remains of an ancient town on the right bank of the Volga. These remains are traceable over an area about two miles long, by three-quarters of a mile in width. The place has been visited by a deputation from the Commission of Archives. A very considerable quantity of Arabian, Persian, and Tartar coins has been found there, besides a multitude of other objects which bear witness to the cultivated state of the inhabitants. There were remains of marble blocks, of watercourses, &c.

An exploring party of eight persons, led by Lieut. Israel, have set out from South Australia to explore the country north-east of Newcastle in Western Australia, and particularly the territory around Lake Moore and Lake Manga. The objects of the expedition are said to be partly scientific and partly commercial, and the funds have been supplied by a number of Australian capitalists.

A correspondent—who says that everyone who looks through the series of photographs of lightning in the possession of the Royal Meteorological Society must be struck with the fact that many of the flashes exhibit a ribbon-like structure, while the appearance is totally absent from others—has made some experiments in order to ascertain whether a similar appearance can be produced by interposing a sheet of window-glass between a narrow brightly-illuminated slit and the camera. So far as these experiments have yet gone, he is not in a position to assert that all the peculiar band-like appearances can thus be imitated, but there is no doubt, he asserts, that a photograph of an unribboned flash taken obliquely through a window must exhibit appearances very similar, if not identical.

The additions to the Zoological Society's Gardens during the past week include a Weeper Capuchin (*Cebus capucinus* ♂) from Brazil, presented by Mr. Haddan; two Common Genets (*Genetta vulgaris*) from West Africa, presented by Mr. Philip Lemberg; three Palm Squirrels (*Sciurus palmarum*) from India, presented by Surgeon-Major W. G. King; an Orange-winged Amazon (*Chrysotis amazonica*) from South America, presented by the Hon. N. L. Melville; two Fulmar Petrels (*Fulmarus glacialis*) from St. Kilda, presented by Mr. W. C. Gilles; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Mr. Underwood; a Macaque Monkey (*Macacus cynomolgus* ♂) from India, an Ocelot (*Felis pardalis*), a Common Rhea (*Rhea americana*) from South America, a Ring-necked Parrakeet

(*Palæornis torquatus*) from India, a Grey-breasted Parrakeet (*Bolborhynchus monachus*) from Monte Video, two White-fronted Amazons (*Chrysotis leucocephalus*) from Cuba, two European Tree Frogs (*Hyla arborea*), European, deposited; a Barraband's Parrakeet (*Polytelis barrabandi*) from New South Wales, purchased; a Mountain Ka-Ka (*Nestor notabilis*) from New Zealand, received in exchange; two Canadian Beavers (*Castor canadensis*), three Gold Pheasants (*Thaumalea picta*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

FURTHER COMETARY DISCOVERIES.—Mr. W. R. Brooks, Smith Observatory, Geneva, New York, discovered a new comet, 1888 *c*, on August 7. The place for 8h. 46m., G.M.T., on August 7 is given as R.A. 10h. 5m., Decl. 44° 30′ N.. It was observed at Vienna on August 9, 9h. 53·5m., in R.A. 10h. 21m. 53s., Decl. 44° 49′ 26″. Faye's comet was picked up by M. Perrotin at the Nice Observatory on August 9, its place at 15h. 19·5m., Nice M.T., being R.A. 5h. 0m. 27·6s., Decl. 20° 0′ 42″ N. There are thus four comets now under observation. The following ephemeris, supplied in the *Dun Echt Circular*, No. 159, is derived from Dr. Kreutz's ephemeris for Faye's comet in the *Astr. Nachr.*, No. 2849, the time of perihelion passage having been increased by 2·6 days.

Ephemeris for Berlin Noon.

1888	R.A. h. m.	Decl. ° ′	1888	R.A. h. m.	Decl. ° ′
Aug. 20 ...	5 28·5	19 31 N.	Sept. 5 ...	6 9·5	17 58 N.
24 ...	5 39·0	19 13	9 ...	6 19·2	17 27
28 ...	5 49·4	18 51	13 ..	6 28·6	16 54
Sept. 1 ...	5 59·6	18 26 N.	17 ...	6 37·8	16 18 N.

Dr. Backlund's ephemeris for Encke's comet, given in the last issue of NATURE (p. 350), should also have been given for Berlin noon, and not for midnight. The resulting error of the ephemeris at the time of discovery thus becomes O – C; R.A. + 8s.; Decl. – 1′·3.

The following ephemeris, by Dr. H. Kreutz, for Brooks's comet is for Berlin midnight:—

1888.	R.A. h. m. s.	Decl. ° ′	1888.	R.A. h. m. s.	Decl. ° ′
Aug. 15	11 8 8	44 25·7 N.	Aug. 23	12 5 53	42 14·0 N.
19	11 37 41	43 32·9	27	12 32 21	40 33·4

ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 *AUGUST* 19–25.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 19

Sun rises, 4h. 54m.; souths, 12h. 3m. 18·2s.; sets, 19h. 12m.: right asc. on meridian, 9h. 56·4m.; decl. 12° 34′ N. Sidereal Time at Sunset, 17h. 6m.

Moon (Full on August 21, 16h.) rises, 18h. 18m.; souths, 22h. 38m.; sets, 3h. 3m.*: right asc. on meridian, 20h. 32·6m.; decl. 19° 20′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	4 21 ...	11 47 ...	19 13 ...	9 40·3 ...	15 45 N.
Venus.....	5 51 ...	12 46 ...	19 41 ...	10 39·3 ...	10 3 N.
Mars......	12 30 ...	16 58 ...	21 26 ...	14 52·2 ...	17 57 S.
Jupiter....	13 26 ...	17 48 ...	22 10 ...	15 41·9 ...	18 58 S.
Saturn....	3 28 ...	11 7 ...	18 46 ...	9 0·0 ...	17 47 N.
Uranus...	9 24 ...	15 1 ...	20 38 ...	12 54·9 ...	5 12 S.
Neptune..	22 23*...	6 10 ..	13 57 ...	4 2·1 ...	18 59 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Occultations of Stars by the Moon (visible at Greenwich).

Aug.	Star.	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image. ° °
21 ...	γ Capricorni ...	3½ ...	0 58 ...	2 10 ...	126 314
21 ...	50 Aquarii ...	6 ...	20 17	near approach	162 —
22 ...	ψ^3 Aquarii ...	5 ...	21 46 ...	22 30 ...	29 320
22 ...	ψ^2 Aquarii ...	4½ ...	21 55	near approach	172 —

Aug. h.
24 ... 1 ... Mercury in superior conjunction with the Sun.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.
Algol	3 0·9 ...	40 31 N. ...	Aug. 23,	0 55 *m*
			,, 25,	21 44 *m*
λ Tauri...	3 54·5 ...	12 10 N. ...	,, 20,	0 57 *m*
			,, 23,	23 49 *m*
T Monocerotis ...	6 19·2 ...	7 9 N. ...	,, 25,	4 0 *M*
R Canis Minoris...	7 2·6 ...	10 12 N. ...	,, 21,	*M*
δ Libræ	14 55·0 ...	8 4 S. ...	,, 23,	22 34 *m*
U Coronæ	15 13·6 ...	32 3 N. ...	,, 22,	21 7 *m*
S Herculis	16 46·8 ...	15 8 N. ...	,, 23,	*M*
U Ophiuchi... ...	17 10·9 ...	1 20 N. ...	,, 19,	2 48 *m*
		and at intervals of		20 8
W Sagittarii ...	17 57·9 ...	29 35 S. ...	Aug. 23,	20 0 *m*
U Sagittarii... ...	18 25·3 ...	19 12 S. ...	,, 23,	1 0 *m*
S Sagittarii	19 50·9 ...	16 20 N. ..	,, 19,	23 0 *M*
U Cygni	20 16·1 ...	47 33 N. ...	,, 20,	*m*
X Cygni	20 39·0 ...	35 11 N. ...	,, 22,	2 0 *M*
T Vulpeculæ ...	20 46·7 ...	27 50 N. ...	,, 19,	20 0 *M*
			,, 20,	21 0 *m*
R Vulpeculæ ...	20 59·4 ...	23 23 N. ...	,, 21,	*M*
δ Cephei	22 25·0 ...	57 51 N. ...	,, 25,	22 0 *M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near γ Camelopardalis...	54 ...	71 N. ...	Swift; streaks.
	290 ...	60 N. ...	Bright and slow; with trains.

GEOGRAPHICAL NOTES.

A WORK of great interest in the history of early European cartography has recently been published by Messrs. Stevens and Sons, of Great Russell Street, and the manner in which it came to be compiled is not a little curious. One of the most famous of the early European cartographers was Johann Schöner, Professor of Mathematics at Nuremberg in the early part of the sixteenth century. He is best known now by a series of terrestrial globes which he prepared, one about 1515, another in 1520, and a third in 1533, all three of which are still preserved at Frankfort, Nuremberg, and Weimar respectively. Here, so far as cartography is concerned, students would have believed Schöner's work to have ceased, were it not for a small Latin pamphlet of four pages which existed amongst his numerous writings, and which was, in substance, a letter to a high ecclesiastical authority of Bamberg descriptive of a globe on which were marked the discoveries made during Magellan's famous circumnavigation of the globe. Only three copies of this pamphlet were known to exist. It was dated 1523, and it obviously did not refer to the globes of 1515 or 1520, for these did not contain any references to the discoveries in question. Hence it was assumed that another globe, between 1520 and 1533 had been prepared by Schöner, but no trace of this could be found, and, if it existed at all, it seemed to be lost for ever. But in 1885 the late well-known bibliographer, Mr. Henry Stevens ("of Vermont") found in the catalogue of a Munich bookseller a facsimile of a globe which he at once recognized as the long lost work of Schöner. He promptly purchased it, and ultimately it found its way into the remarkable collection of works on early American geography and history made by Mr. Kalbfleisch, of New York, where it still is. But Mr. Stevens, who regarded it as "one of the keys to unlock the many mysteries of early American geography," determined to reproduce Schöner's letter and globe in facsimile, and to append a translation and an introductory sketch of the early historical geography of America. While still labouring at this work he died, but his son took it up, and, aided by Mr. C. H. Coote, of the Map Department of the British Museum, has now succeeded in bringing it to a conclusion. Schöner himself was entirely indebted for his knowledge of the results of Magellan's voyage to a letter written by one Maximilianus Transylvanus, a natural son of the Cardinal Archbishop of Salzburg, and then employed about the Court of the Emperor Charles V., describing for his father the expedition in question. This pamphlet is styled "De Molvccis," and from the descriptions here given, Schöner depicted the new portions of his globe, or, in his own words, "being desirous to make some small addition to this wonderful survey of the earth, so that what appears very extraordinary to the reader may appear more likely when thus illustrated, I have been at the pains to construct this globe." The differences between this and former globes are considerable, and mark a great advance in geographical knowledge. America, instead of being broken up into many islands, as in all earlier globes, is shown as one large continent of tolerably correct shape; Florida is named for the first time in print; "the Moluccas have found a local habitation and their true places, as well as many of the real isles of the sea, while all the monsters and bogus elements of American geography are made to disappear."

THE new volume issued by Mr. Stevens opens with a long, learned, and most interesting introduction by Mr. Coote, on early American geography generally, and especially on the globes and maps of the first part of the sixteenth century. Mr. Coote also narrates the life of Schöner, and furnishes an estimate of his services to geography. One of his discoveries relating to Schöner is that the place-name *Timiripa*, from which he dates some of his letters, and which has hitherto puzzled all students, is merely the translation of part of the name of a small parish of which Schöner was pastor. The introduction is followed by a facsimile of Schöner's letter of dedication of the globe to the Canon of Bamberg, by the letter of Maximilianus, and by translations of both, as well as by a bibliography of Schöner's works. But, next to the introduction, the portion of the book which will receive most attention will be the facsimiles at the end, which are as follows: (1) the famous Hunt-Lenox globe, attributed to 1506-7: (2) the Boulonger globe, supposed to have been executed in 1514-17; (3) Schöner's first globe of 1515; (4) his second globe of 1520; (5) the third globe of 1523, "being the earliest geographical document to delineate the first circumnavigation of the earth by the Spaniards, 1519-22"; (6) the Portuguese so-called Cantino map of 1502. The reproduction of the letters of Schöner and Maximilianus Transylvanus have been done in exact facsimile by the phototypographic process, all the defects and peculiarities of the originals appearing with faithful minuteness. The long-lost globe consists of twelve gores, and its distinguishing feature is a line drawn completely round the circumference, showing the route of Magellan's fleet in the first circumnavigation of the earth.

THE following message from Mr. Joseph Thomson and Mr. Harved Crichton-Browne, transmitted by the Eastern Telegraph Company's cable from Tangier, has been sent to the Royal Society, the Royal Geographical Society, and to the friends of the explorers:—"City of Morocco, July 28.—We returned to Amsmiz across mountains, safe and well, July 24; many interesting geographical and geological notes; so far successful beyond our expectations. We were prevented going direct from Glamoa to Gundaffy by tribal revolt. We shall start on August 6 for third trip across the Atlas, further south-west this time."

THE GASES OF THE BLOOD.[1]

I.

MR. PRESIDENT AND GENTLEMEN,—The subject I have chosen is a consideration of the gaseous constituents of the blood in relation to some of the problems of respiration. This has been selected both because it deals with a province of physiology in which there are many profound problems connected with the molecular phenomena of life, and also because it gives me the opportunity of illustrating some of the methods of physiological research. I purpose to treat the subject chiefly from the physical stand-point, and to demonstrate some of the phenomena as I would endeavour to do to a class of students, believing that this will be of more interest to many of my audience than if I placed before you anything like an encyclopædic account of recent researches. I cannot help adding that as I speak in the class-room of one of the most distinguished physicists of the day, I feel the genius of the place is hovering over me, and I will be impelled to guide you to the borderland of physics and of physiology. It is in this territory that we meet with the most profound questions regarding the nature of vital activity, and it is here that the physiologist and the physicist must join hands in working out their solution.

Respiration may be shortly defined as the function or group of functions by which an interchange occurs between the gases formed in the tissues of a living being and the gases of the medium in which it lives. It is interesting to take a brief survey of the investigations which laid the foundations of our knowledge of this subject, as it illustrates to us the fact taught by the history of all sciences that those truths which we now regard as elementary were at one time unknown, and have been gained only by laborious inquiry.

The oldest writers do not appear to have had any clear notions even as to the necessity for respiration. Hippocrates dimly recognized that during breathing a *spiritus* was communicated to the body. Many of the older anatomists, following Galen, thought that the "very substance of the air got in by the vessels of the lungs to the left ventricle of the heart, not only to temperate heat, but to provide for the generation of spirits." This notion of cooling the blood was held by Descartes (1596-1650) and his followers, and seemed to them to be the chief, if not the sole, use of respiration. In addition, they supposed it aided in the production and modulation of the voice, in coughing, and in the introduction of odours. The celebrated Van Helmont (1577-1664) strongly expresses these views, and attaches particular importance to the necessity for cooling the blood, which otherwise would become too hot for the body.

About the middle of the seventeenth century clearer notions began to prevail. These rested partly on an anatomical and partly on a physical discovery. Malpighi (1621-94) discovered that the minute bronchial tubes end in air vesicles, or membranous cavities, as he termed them, on the walls of which, in the frog, he saw with his simple microscope the blood flowing through capillaries. This pulmonary plexus was for many years termed the "rete mirabile Malpighii." The physical observations were made by the celebrated Robert Boyle (1627-91), who describes in his treatise entitled "New Experiments, Physico-Mechanical, touching the Spring of the Air," published in 1662, numerous experiments as to the behaviour of animals in the exhausted receiver of the air-pump. He showed that the death of the animals "proceeded rather from the want of air than that the air was over-clogged by the steam of their bodies." He also showed that fishes also enjoyed the benefits of the air, for, said he, "there is wont to lurk in the water many little parcels of interspersed air, whereof it seems not impossible that fishes may make some use, either by separating it when they strain the matter thorow their gills, or by some other way."

His conclusion is "that the inspired and expired air may be sometimes very useful by condensing and cooling the blood;" but "I hold that the depuration of the blood in that passage is not only one of the ordinary but one of the principal uses of respiration." Thus, by the use of the air-pump, invented by Otto von Guericke about 1650, Boyle was able to make a contribution of fundamental importance to physiological science.

He also first clearly pointed out the real cause of the influx of air into the lungs. The older anatomists, from Galen downwards, held that the lungs dilated actively, and thus sucked in the air; and there was much controversy as to whether the chest, with the contained lungs, resembled a pair of bellows, which was filled because it was dilated, or whether the lungs resembled a bladder, which is dilated because it is filled. Boyle shows clearly that the cavity of the chest is actively dilated, and that the lungs are distended because the "spring" of the air is then less on their outer than on their inner surface. This simple explanation was not generally accepted, because the minds of Boyle's contemporaries were under the influence of an ancient idea that air existed in the cavity of the chest external to the lungs. This prevented them from seeing the simplicity and accuracy of Boyle's explanation, and to be constantly on the outlook for some mechanism by which the lungs could actively dilate. Such notions were held by Willis, Malpighi, and Erasmus Darwin. The opinion of Darwin is shown by the following passages in the "Zoonomia":—

"By the stimulus of the blood in the right chamber of the heart, the lungs are induced to expand themselves, and the pectoral and intercostal muscles and the diaphragm act at the same time by their associations with them." And, again, "to those increased actions of the air-cells are superadded those of the intercostal muscles and diaphragm, by irritative association."

Boyle's observations were published in 1660, and in 1685 we

[1] Address to the British Medical Association at its annual meeting at Glasgow. Delivered on August 10 in the Natural Philosophy class-room University of Glasgow, by John Gray McKendrick, M.D., LL.D., F.R.SS.L. and E., F.R.C.P.E., Professor of the Institutes of Medicine in the University of Glasgow.

find Borelli (1608–79), in the second portion of his great work "De Motu Animalium," giving expression to very clear notions regarding respiration. Thus in the eighty-second proposition he shows that the lungs are not the effective causes of respiration, but are passively concerned in the movements; and in the eighty-third proposition he states that the efficient cause of inspiration is the muscular force by which the cavity of the chest is increased and permits the lungs to be filled by the elastic force of the air. Borelli was also the first, as shown in the eighty-first proposition of his work, to make an estimate of the quantity of air expelled by a single expiration. At the same time he attributed calm expiration to the elastic resiliency of the ribs, and he pointed out that the deepest expiration could not entirely empty the lungs of air (Propositions 92, 93, and 94). Whilst Borelli thus recognized the air as necessary to animal life, he naturally failed in explaining why this was so, being unacquainted with the composition of the air and of the so-called "fuligineous vapours" (carbonic acid, aqueous vapour, &c.) which were supposed to exist in expired air.

I find, in a work by Swammerdam (1637–80), dated 1667, and entitled "Tractatus Physico-Anatomico-Medicus de Respiratione usuque Pulmonum," at pp. 20, 21, a description of an experiment in which he immersed in a vessel of water a dog having a long tube inserted in the trachea, and he observed the rise and fall of the level of the water during respiration. This was practically the method followed by Borelli, but I am unable to say which experiment was first performed.

Here I may also refer to the curious experiments of Sanctorius, Professor of Medicine in Padua, who flourished from 1561 to 1636, as being probably the first quantitative estimate of substances escaping from the body. Sanctorius constructed a balance by which he weighed himself repeatedly, and observed what he gained by food and what he lost by excretion. The results appeared in his work "Ars de Staticâ Medicinâ," published in 1614, and he states the amount of matter separated by pulmonary exhalation at about half a pound in twenty-four hours. It is not easy to say precisely what these figures represent, and therefore we find the amount, on the authority of Sanctorius, differently stated by writers during the next century. His observations are of interest, however, as being a distinct step in physiological investigation.

Among the contemporaries of Boyle, Pascal, Spinosa, Barrow, Newton, and Leibnitz—all men of the first intellectual rank—was Dr. Robert Hooke, one of the most versatile and able of scientific thinkers. Hooke was born in 1635, and died in 1703. One of the founders of the Royal Society, its early Proceedings show that there was scarcely any department of science at the time to which he did not make important contributions. In particular, he showed a remarkable experiment, in October 1667, to the Royal Society. This experiment, as detailed in Lowthorp's "Abstract of the Philosophical Transactions," vol. iii. p. 67, showed that it was the fresh air, and not any alteration in the capacity of the lungs, which caused the renewal of the heart's beat. It has been said that a similar experiment was performed by Vesalius, but with this difference, that, whilst Vesalius observed the fact, he failed in giving a rational explanation. He supposed that the movements of the lungs affected the movements of the heart, but he did not see, as Hooke did, that the heart moved because it was supplied with blood containing fresh air. Hooke's experiment is one also of great practical importance as being the basis of the modern practice of using artificial respiration in cases of impending asphyxia.

We thus see that the necessity of a continual supply of fresh air was recognized as being essential to life. It was further surmised that the air imparted something to the blood, and received something in return; but no further advance was made in this direction until the researches of Mayow, a name now famous in the early history of chemistry and of physiology. John Mayow was born in 1645, and died at the early age of thirty-four. His principal work was published in Oxford in 1674. In it, by many ingenious experiments, he showed that combustion diminishes the volume of the air and alters its qualities; that respiration also affects the quality of the air; that an animal will die if kept in a confined space full of air—a fact to be explained, according to Mayow, by saying that the animal had used the respirable portion of the air, and that the residue was unfit for life; and, finally, he showed that an animal suffers if placed in an atmosphere the qualities of which have been injured by combustion. Further, he gave the name of "nitro-aërial spiritus" to the "principle" in the air which, he said, had to do with life, muscular action, and combustion. Thus he no doubt came near the discovery of oxygen, made by Priestley nearly a century later. It would be difficult to estimate the enormous influence on theories of combustion and of respiration exerted by the researches of Boyle, Hooke, and Mayow. They prepared the way in physiological science for the next great step—namely, the identification of the gaseous elements contained in respiration. The dependence of progress in physiology on the state of scientific opinion regarding chemical and physical questions could not be better illustrated than in the history of physiological ideas regarding respiration. Thus the researches of Boyle with the air-pump did much to explain the mere mechanism of breathing. Hooke made this even more apparent, and Mayow gave greater precision to the idea that in respiration the blood lost something and gained something. It is difficult to determine precisely, after the lapse of time, the contributions made by each of these distinguished observers, who were contemporaries; but I would venture to say that the germ of the ideas that bore fruit in the minds of Hooke, and more especially of Mayow, may be found in the writings of Robert Boyle.

The researches of Mayow, indicating the existence in the air of a "nitro-aërial spiritus" necessary to life, and the presence in expired air of something deleterious to life, did not immediately produce the fruits one would have expected. At first, his writings attracted considerable attention; they passed through two or three editions, and were translated for Continental readers; but from the beginning of the eighteenth century, nearly twenty years after Mayow's death, they passed almost into oblivion. Thus Hales vaguely refers to him in only two instances, and, as stated by Bostock, "in the discourse delivered by Sir John Pringle before the Royal Society, upon the assignment of Sir Godfrey Copley's medal to Dr. Priestley, which commences with a sketch of the discoveries that had been made in the science of aërology, previous to the period when this philosopher entered upon his experiments, the name of Mayow is not mentioned."

Mayow's writings were first again brought into notice in this country by Reinhold Forster, who gave a summary of Mayow's views in an introduction to his translation of Scheele's essay on "Air and Fire."

As another example of how Mayow's observations were neglected, it may be pointed out that Boerhaave (1668–1738), one of the most learned men of his time, states that he cannot explain the change which the air experiences by respiration; and even Haller, in his great work "Elementa Physiologiæ Corporis Humani," published in 1766, sums up his knowledge regarding expired air by stating that it is combined with a quantity of water and a noxious vapour, and has its elasticity diminished.

The next step in the physiology of respiration was the discovery, in 1754, of carbonic acid, by Joseph Black, then Professor of Medicine and Chemistry in this University. About this time there was much discussion in the medical world as to the use of lime-water in cases of stone and gravel. It was supposed that the lime-water dissolved calculi, and assisted in expelling them from the body. A discussion arose as to the virtues of lime-water produced from different substances. Two Professors in the University of Edinburgh—Alston and Whytt—specially investigated the subject, and Whytt asserted that the lime-water of oyster-shell lime had more power as a solvent than the lime-water of common stone lime. This led Black to examine the question. "I therefore," says he, "conceived hopes that, by trying a greater variety of the alkaline earths, some kinds might be found still more different by their qualities from the common kind, and perhaps yielding a lime-water still more powerful than that of oyster-shell lime."

This led Black to his celebrated investigation on magnesia. He showed that in the case of magnesia alba (carbonate of magnesia) the disappearance of the effervescence on treatment with an acid after heating was accompanied by a loss of weight. The substance thus given off he called "fixed air," or what we now term carbonic acid. This led to an examination of the salts of lime, and in 1757 he made two important physiological discoveries, namely: (1) that the fixed air was injurious to animal life; and (2) that fixed air was produced by the action of respiration. These important observations are thus described in his own words:—"In the same year, however, in which my first account of these experiments was published—namely, 1757—I had discovered that this particular kind of air, attracted by alkaline substances, is deadly to all animals that breathe it by the mouth and nostrils together; but that if the nostrils were kept shut, I was led to think that it might be breathed with safety. I found, for example, that when sparrows died in it in ten or eleven seconds, they would live in it for three or four minutes, when the nostrils were shut by melted suet. And I convinced myself that the change produced on wholesome air by breathing it, consisted chiefly, if not solely, in the conversion of part of it into fixed air. For I found that by blowing through a pipe into lime-water, or a solution of caustic alkali, the lime was precipitated, and the alkali was rendered mild. I was partly led to these experiments by some observations of Dr. Hales, in which he says that breathing through diaphragms of cloth dipped in alkaline solutions made the air last longer for the purposes of life."

Fifteen years afterwards—namely, in 1772—Joseph Priestley examined the chemical effects produced by the burning of candles and the respiration of animals upon ordinary air; and he made the important discovery that, after air had lost its power of supporting combustion, as by the burning of candles, this property might be restored by the agency of plants. Pushing his experiments still further, he found that air, deteriorated by the breathing of animals, might again become suitable for respiration by the action of plants. In these experiments he employed mice for ascertaining how far an air was impure or unfit for respiration. In 1774, Priestley obtained oxygen by heating red precipitate by means of the sun's rays concentrated by a burning-glass. This led to an investigation of the constitution of the atmosphere, and it was shown that it was not a homogeneous elementary body, but consisted of two gases, and that its constitution was remarkably uniform. Priestley showed that by fermentation, combustion, the calcination of metals, and respiration, the air lost a portion of one of its constituents, oxygen.

Thus the chemical researches of Black and Priestley proved that in respiration oxygen was consumed and carbonic acid produced, although the latter fact, owing to the theoretical views of Priestley as to phlogiston, was not fully appreciated by him.

Within a year after Priestley's discovery, a paper on respiration was written by Lavoisier (1743–94), in which he showed that Priestley was correct in stating that the air lost oxygen in breathing, but Lavoisier specially pointed out that it had gained carbonic acid. No doubt Lavoisier was well acquainted with Black's researches, as is shown by the correspondence between these distinguished men. Lavoisier was the first, however, to make a quantitative examination of the changes produced in the air by breathing. In 1780, he performed a remarkable experiment, in which a guinea-pig was confined over mercury in a jar containing 248 cubic inches of gas consisting principally of oxygen. In an hour and a quarter the animal breathed with much difficulty, and, being removed from the apparatus, the state of the air was examined. Its bulk was found to be diminished by 8 cubic inches, and of the remaining 240 inches, 40 were absorbed by caustic potash, and consequently consisted of carbonic acid. Still later, he performed a more accurate experiment, giving quantitative results. During 1789 and 1790, by a special apparatus, Lavoisier and his friend Seguin attempted to measure the changes in the air produced by the breathing of man. These researches are not of value so much for the results they gave as for the method employed. Lavoisier constructed a still more elaborate apparatus, with which he began experiments. This research, however, he never finished, as, in 1794, he fell a victim to the blind fury of Robespierre. It is narrated that he earnestly requested a respite of a few days to give him time to prepare for publication the results of his investigations. This was denied, and thus perished one of the greatest scientific sons of France.

Stephen Hales (1677–1761) attempted to measure the amount of aqueous vapour given off by the lungs by breathing through a flask filled with wood-ashes, which absorbed the moisture, and he estimated the amount at about 20 ounces in twenty-four hours. Similar observations were afterwards made by Menzies and by the eminent surgeon, Mr. Abernethy. Lavoisier also attacked the problem by an indirect method. Thus he determined the quantity of oxygen consumed and of carbonic acid produced, and, assuming that the amount of oxygen was more than sufficient to form the carbonic acid, he came to the conclusion that the excess united with hydrogen in the lungs, and passed off as water. As may be supposed, this method gave widely different results.

Various other attempts were made to estimate the amount of the respiratory changes. In particular, Sir Humphry Davy, in March 1798, investigated the physiological action of nitrous oxide gas. In this research, published in 1800, he began by observations upon animals; and observations as to the effect of the gas on life, on muscular irritability, on the action of the heart, and on the colour of the blood are recorded with great precision. He then passed on to observations on the respiration of hydrogen, and this led him to a repetition of the experiments of Lavoisier and Goodwin. Next he subjected himself and friends to experiment, and recorded a number of interesting physiological and psychical phenomena. This research is of great historical interest as being the first leading to the discovery of a method of producing anæsthesia, or insensibility to pain, by breathing vapours or gases.

Another eminent man who contributed largely to the physiology of respiration was Lazarus Spallanzani, who was born in 1729 and died in 1799. He was educated under the direction of the Jesuits. When about sixteen years of age he went to Bologna, and studied at that University, specially under the tuition of his cousin, Laura Bassa, a woman celebrated in her day for eloquence and scientific knowledge, and who was then a Professor in the University. His biographer, Senebier, says:—"Under the direction of this enlightened guide he learned to prefer the study of Nature to that of her commentators, and to estimate their value by comparing them with the originals they professed to describe. The scholar at once perceived the wisdom of these counsels, and quickly experienced their happy effects. He evinced his gratitude to his instructress in a Latin dissertation published in 1765, which was dedicated to Laura Bassa, and in which he recounted the applauses she received at Modena when, entering the hall, where her pupil, on being appointed a Professor, was defending a thesis, 'De Lapidibus ab Aquâ Resilientibus,' she opposed it with the graces of an amiable woman and the wisdom of a profound philosopher."

Spallanzani became Professor of Logic, Mathematics, and Greek in Reggio in 1754, and about this date he published researches on Infusoria. In 1760, he became Professor in the University of Modena. In 1765, he showed that many microscopic animalcula were true animals, and in 1768 he published his celebrated researches on the reproduction of portions of the body removed from worms, snails, salamanders, and toads. He paid special attention to the great question of spontaneous generation, showing that infusions of animal and vegetable substances exposed to a high temperature, and hermetically sealed, never produced living things. He also investigated respiration, more particularly in invertebrates. He proved that many such animals breathed by means of the skin as well as by the special breathing organs. He placed many animals, but more especially different species of worms, in atmospheres of hydrogen and nitrogen, and found that, even in these circumstances, carbonic acid was produced. He also showed the production of carbonic acid by the dead bodies of such animals, and reasoned from this that the carbonic acid was produced directly from the dead tissues and not from the action of the oxygen of the air. He contrasts the respiration of cold-blooded and warm-blooded animals, and shows the peculiarities of respiration in hibernating animals. Nor were these by any means superficial observations. They were usually quantitative, and by the use of the eudiometer, he analyzed the air before and after respiration. Probably the most important contribution made by Spallanzani to the subject was showing what he states in the following paragraph:—

"I inquire not here why the quantity of carbonic acid gas was greater in azotic and hydrogen gas than in common air. I shall only conclude, from these experiments, that it is clearly proved that the carbonic acid gas produced by the living and dead snails in common air resulted not from atmospheric oxygen, since an equal and even a greater quantity of it was obtained in azotic and hydrogen gas; consequently, in the oxygen gas destroyed by the presence of these animals, its base alone is absorbed by them either during life or after death."

But Spallanzani supposed that the carbonic acid thus produced was formed by digestion in the stomach, passed through the tissues, and was then exhaled. Thus he missed a great step in discovery—namely, that the carbonic acid is produced by the tissues themselves. It was, however, pointed out in 1823, by W. F. Edwards, in his work on the "Influence of Physical Agents on Life," that the amount of carbonic acid produced by animal breathing was too great to be accounted for by the amount of oxygen in their lungs at the beginning of the experiment, or by carbonic acid supposed to be in the stomach. The importance of this observation will be seen when we discuss the phenomena of the breathing of the tissues.

In 1809 the subject of aquatic breathing was investigated with great care by Provençal and Humboldt. They collected and analyzed the gases of water before and after fishes had lived in it for a certain time, and showed that oxygen was consumed and carbonic acid produced by these creatures.

We have now seen how gradually knowledge was arrived at as to the respiratory exchanges. At the beginning of the present century it was recognized that expired air had lost oxygen, gained carbonic acid and aqueous vapour, and had become hotter. Since then many researches have been carried on to determine with accuracy the quantities of these substances. In all of these, as shown in these diagrams,[1] the method followed has been to draw through a chamber containing the animal a steady constant stream of air, the quantity and composition of which is known. Thus, suppose a certain quantity of dry air, free from carbonic acid, and consisting only of oxygen and nitrogen, is passed through such a chamber. In the chamber some of the oxygen is consumed, and a certain amount of carbonic acid and of aqueous vapour is given up by the animal. The air is drawn onwards through bulbs or glass tubes containing sub-tances such as baryta-water, to absorb the carbonic acid, and chloride of calcium or sulphuric acid, to absorb the aqueous vapour. It is evident that the increased weight of these bulbs and tubes, after the experiment has gone on for some time, will give the amounts of carbonic acid and aqueous vapour formed. Thus Andral and Gavarret in 1843, Vierordt in 1845, Regnault and Reiset in 1849, von Pettenkofer in 1860, and Angus Smith in 1862, determined the quantities both by experiments on animals and on human beings.

The results are—first, the expired air, at its own temperature, is saturated with aqueous vapour; secondly, the expired air is less in volume than the inspired air to the extent of about one-fortieth of the volume of the latter; thirdly, the expired air contains about 4 per cent. more carbonic acid and from 4 to 5 per cent. less oxygen than inspired air; fourthly, the total daily excretion of carbonic acid by an average man amounts to 800 grammes in weight, and 406 litres in bulk. This amount of carbonic acid represents 218·1 grammes of carbon and 581·9 grammes of oxygen. The amount of oxygen, however, actually consumed is about 700 grammes; so that nearly 120 grammes of oxygen absorbed are not returned by the lungs, but disappear in the body. It must be remembered, however, that carbonic acid escapes by the skin and other channels. These figures may be taken as averages, and are subject to wide variations depending on nutritional changes.

There is, however, another side to the problem of respiration—namely, a consideration of the chemical changes involved in the process.

According to Lavoisier, respiration was really a slow combustion of carbon and of hydrogen. The air supplied the oxygen, and the blood the combustible materials. The great French chemist, however, did not entirely commit himself to the opinion that the combustion occurred only in the lungs. He says that a portion of the carbonic acid may be formed immediately in the lung, or in the blood-vessels throughout the body, by combination of the oxygen of the air with the carbon of the blood. Lavoisier's opinions were understood correctly by only a few of his contemporaries, and a notion prevailed that, according to him, combustion occurred only in the lungs, and that the changes in these organs were the main sources of animal heat. Such a notion, however, was contrary to the opinion of the great mathematician Lagrange, announced in 1791, a few years after the first publication of Lavoisier's on respiration. Lagrange saw that, if heat were produced in the lungs alone, the temperature of these organs might become so high as to destroy them; and he therefore supposed that the oxygen is simply dissolved in the blood, and in that fluid combined with carbon and hydrogen, forming carbonic acid and aqueous vapour, which were then set free in the lungs. It will be observed that this opinion of Lagrange in 1791 was practically the same as that stated by Lavoisier in 1789.

Now, if the production of carbonic acid in a given time depended upon the amount of oxygen supplied in the same time, these views of Lavoisier and Lagrange would be correct; but Spallanzani had shown that certain animals confined in an atmosphere of nitrogen or of hydrogen exhaled carbonic acid to almost as great an extent as if they had breathed air. He was therefore obliged to say that carbonic acid previously existed in the body, and that its appearance could not be accounted for by the union of oxygen with the carbon of the blood. Spallanzani therefore thought that in the lung there was simply an exhalation of carbonic acid and an absorption of oxygen. These views were supported by the experiments of W. Edwards, published in 1824. Edwards showed that animals in an atmosphere of hydrogen produced an amount of carbonic acid not to be accounted for by any oxygen supposed to exist free in the body. In 1830, Collard de Martigny performed many similar experiments, and stated that carbonic acid was secreted in the capillaries and excreted by the lungs. This opinion was supported by Johannes Müller, who repeated the experiments of Spallanzani.

It might thus be said that two theories of respiration were before physiologists—the one, that combustion occurred in the lungs or venous blood, furnishing carbonic acid and aqueous vapour, which were exhaled by the lungs; the other, that there was no such combustion, but that oxygen was absorbed by the lungs and carried to the tissues, whilst in these carbonic acid was secreted, absorbed by the blood, carried to the lungs, and there exhaled. Some writers, soon after Lavoisier, misunderstood, as I have already stated, the opinions of that distinguished man, and taught that in the lungs themselves there was a separation of carbon, which united immediately with the oxygen to form carbonic acid. But this was really not Lavoisier's opinion; and we have to do, therefore, with two theories, which have been well named—the theory of combustion, and the theory of secretion.

The difficulty felt by the older physiologists in accepting the secretion theory was the absence of proof of the existence of free oxygen and carbonic acid in the blood. This difficulty also met those who rejected the notion of combustion occurring in the lungs, and substituted for it the idea that it really occurred in the blood throughout the body, because, if this were true, free gases ought to be found in the blood. Consequently, so long as physiologists had no definite knowledge regarding gases in the blood, the combustion theory, in the most limited sense, held its ground. This theory, although fruitful of many ideas regarding respiration and animal heat, was abandoned in consequence of the evidence afforded by two lines of inquiry—namely, researches regarding the gases of the blood, and researches as to the relative temperature of the blood in the right and left cavities of the heart.

Let me first direct your attention to the gradual development of our knowledge regarding the gases of the blood. The remarkable change in the colour of the blood when it is exposed to, or shaken up with, air was observed so long ago as in 1665 by Fracassati, and is also alluded to by Lower (1631–91), Mayow, Cigna (1773), and Hewson (1774); but Priestley was the first to show that the increased redness was due to the action of the oxygen of the air, and that the blood became purple when agitated with carbonic acid, hydrogen, and nitrogen. The presence of gas in the blood was first observed about 1672 by Mayow. I find in a paper of Leeuwenhoek (1632–1723), entitled "The Author's Experiments and Observations respecting the Quantity of Air contained in Water and other Fluids," published in 1674, a description of a method devised by this ingenious man for detecting the existence of air in certain fluids, and amongst them in the blood. It consisted of a kind of syringe, by which he was able to produce a partial vacuum. He then observed bubbles of gas to escape, and he estimated, in the case of human blood, that the air in the blood amounted to 1/1000 or 2/1000 part of the volume of the blood. He argues, from this interesting observation, against one of the prevalent medical theories of the time, that various diseases were caused by fermentations in the blood. How, said he, was such a theory consistent with the existence of so small a quantity of gas? He made the mistake, from the inefficiency of his apparatus, of stating that blood, when it issues from the veins, contains no air.

Gas was also obtained from the blood in 1799 by Sir Humphry Davy, in 1814 by Vogel, in 1818 by Brand, in 1833 by Hoffmann, and in 1835 by Stevons. On the other hand, John Davy, Bergmann, Johannes Müller, Mitscherlich, Gmelin, and Tiedemann failed in obtaining any gas. The first group of observers, either by heating the blood, or by allowing it to flow into a vacuum, or by passing through it a stream of hydrogen, obtained small quantities of carbonic acid. Sir Humphry Davy was the first to collect a small quantity of oxygen from the blood. John Davy, by an erroneous method of investigation, was led, in 1828, to deny that the blood either absorbed oxygen or gave off carbonic acid. He was shown to be wrong, in 1830, by

[1] Diagrams exhibited on wall.

Christison, who devised a simple method of demonstrating the fact.

So long as the evidence in favour of the existence of gases in the blood was so uncertain, the combustion theory of respiration held its own. At last, in 1836, appeared the researches of Heinrich Gustav Magnus, latterly Professor of Physics and Technology in the University of Berlin. He first attempted to drive off carbonic acid from the blood by a stream of hydrogen, and thus obtained as much as 34 cubic centimetres of carbonic acid from 62·9 cubic centimetres of blood. He then devised a mercurial air-pump, by which it was possible to exhaust a receiver to a much greater extent than could be done by the ordinary air-pump. When blood was introduced into such a vacuum, considerable quantities of carbonic acid, oxygen, and nitrogen were obtained. This research marks an epoch in physiological discovery, as it threw a new light on the function of respiration by demonstrating the existence of gases in the blood.

In order to appreciate the value of this evidence, and the method employed, let me direct your attention to the laws regulating the diffusion of gases. As a mass of gaseous matter has no independent form, like that of a solid body, nor a fixed volume like that of a liquid, but consists of an enormous number of molecules which, in consequence of their mutual repulsions, endeavour more and more to separate from each other, it is easy to see that if two masses of gas are brought into contact, they will mix—that is, their molecules will interpenetrate, until a mixture is formed containing an equal number of the molecules of each gas. The force by which the molecules repel each other, and by which they exercise pressure in all directions, is known as the pressure or tension of the gas. It is evident that the greater the number of gas molecules in a given space, the greater will be the tension of the gas, and from this it follows that the tension of a gas is in the inverse proportion to its volume (this is known as Boyle's law). Suppose now that two gases are separated by a porous partition; the two gases will mix, and the rapidity of the diffusion will vary according to the specific weight of the gases. Thus light gases, like hydrogen or coal-gas, will diffuse more quickly than air, or chlorine, or carbonic acid.

It is important also to note the laws regulating the absorption of gases by fluids. If we allow a little water to come into contact with ammonia gas above mercury, the gas is rapidly absorbed by the water (1 volume of water absorbs 730 volumes NH_3) all the gas above disappears, and in consequence of this the pressure of outer air drives up the mercury in the tube. The higher the temperature of the fluid the less gas it absorbs. At the boiling-point of the fluid its absorption is = 0, because at that temperature, the fluid itself changes into gas. The power of absorption of different fluids for the same gas, and the absorptive power of the same fluid for different gases fluctuates between wide limits. Bunsen defined the coefficient of absorption of a fluid for a gas as that number which represents the volume of gas (reduced to 0° and 760 mm. barometric pressure) which is taken up by 1 volume of the fluid. Thus 1 volume of distilled water takes up the following volumes:—

Temp. Cent.	N.	O.	CO_2.	Air.
0°	0·02	0·041	1·797	0·025
5	0·018	0·036	1·5	0·022
15	0·015	0·03	1·002	0·018
37	—	0·02	0·569	—

Again, 1 volume of distilled water at 0° C. absorbs 0·00193 volumes of hydrogen, while it can take up no less than 1180 volumes of ammonia; again, 1 volume of water at 0° C. absorbs only 0·2563 volumes of olefiant gas, but 1 volume of alcohol, at the same temperature, will take up as much as 3·595 volumes. The volume of gas absorbed is independent of the pressure, and the same volume of gas is always absorbed whatever the pressure may happen to be. But as according to Boyle's law the density of a gas, or in other words the number of molecules in a given space, is in proportion to the pressure, and as the weight is equal to the product of the volume and the density, so while the volume absorbed always remains the same, the quantity or weight of the absorbed gas rises and falls in proportion to the pressure (this is the law of Dalton and Henry). It therefore follows that a gas is to be considered as physically absorbed by a fluid, if it separates from it not in volumes but in quantities, the weights of which are in proportion to the fall of pressure.

When two or more gases form an atmosphere above a fluid, the absorption takes place in proportion to the pressure which each of the constituents of the mixture would exercise if it were alone in the space occupied by the mixture of gases, because, according to Dalton's law, one gas does not exercise any pressure on another gas intermingled with it, but a space filled with one gas must be considered, so far as a second gas is concerned, as a space containing no gas, or in other words a vacuum. This pressure, which determines the absorption of the constituents of a gaseous mixture, is termed, according to Bunsen, the partial pressure of the gas. The partial pressure of each single gas in a mixture of gases depends, then, on the volume of the gas in question in the mixture. Suppose atmospheric air to be under a pressure of 760 mm. of mercury, then, as the air consists of 21 volumes per cent. of O and 79 volumes per cent. of N, $\frac{760 \times 21}{100} = 159·6$ mm. of mercury, will be the partial pressure under which the oxygen gas is absorbed, while the absorption of nitrogen will take place under a pressure of $\frac{760 \times 79}{100} = 600$ mm. of mercury. Suppose, again, that above the fluid containing a gas, say carbonic acid, which has been absorbed, there is an atmosphere of another gas, say atmospheric air, then as carbonic acid exists in the air only in traces, its tension is equal to zero, and carbonic acid will escape from the fluid until the difference of tension between the carbonic acid in the water and the carbonic acid in the air above it has been balanced—that is, until the carbonic acid which has escaped into the air has reached a tension equal to that of the gas still absorbed by the fluid. By the phrase "tension of the gas in a fluid" is understood the partial pressure in millimetres of mercury which the gas in question has to exercise in the atmosphere, when no diffusion between the gas in the fluid and the gas in the atmosphere takes place.

The method followed by Magnus will now be understood. By allowing the blood to flow into an exhausted receiver surrounded by hot water, gases were set free. These were found to be oxygen, carbonic acid, and nitrogen. He further made the important observation that both arterial and venous blood contained the gases, the difference being that in arterial blood there was more oxygen and less carbonic acid than in venous blood. Magnus concluded that the gases were simply dissolved in the blood, and that respiration was a simple process of diffusion, carbonic acid passing out and oxygen passing in, according to the law of pressures I have just explained.

Let us apply the explanation of Magnus to what occurs in pulmonary respiration. Venous blood, containing a certain amount of carbonic acid at the temperature of the blood and under a certain pressure, is brought to the capillaries, which are distributed on the walls of the air-vesicles in the lungs. In these air-vesicles, we have an atmosphere at a certain temperature and subject to a certain pressure. Setting temperature aside, as it may be assumed to be the same in the blood and in the air-cells, let us consider the question of pressure. If the pressure of the carbonic acid in the blood be greater than that of the carbonic acid in the air-cells, carbonic acid will escape until an equilibrium is established between the pressure of the gas in the blood and the pressure of the gas in the air-cells. Again, if the pressure or tension of the oxygen in the air-cells be greater than that of the oxygen in the venous blood, oxygen will be absorbed until the tensions become equal. This theory has no doubt the merit of simplicity, but it will be observed that it depends entirely on the assumption that the gases are simply dissolved in the blood. It was pointed out by Liebig that, according to the experiments of Regnault and Reiset, animals used the same amount of oxygen when breathing an atmosphere composed of that gas alone as when they breathed ordinary air, and that the vital processes are not much affected by breathing the atmosphere of high altitudes where the amount of oxygen taken in is only about two-thirds of that existing at the sea level. It was also shown at a much later date, by Ludwig and W. Müller, that animals breathing in a confined space of air will use up the whole of the oxygen in the space, and it is clear that as the oxygen is used up the partial pressure of the oxygen remaining must be steadily falling. Liebig urged the view that the gases were not simply dissolved in the blood, but existed in a state of loose chemical combination which could be dissolved by the diminished pressure in the vacuum, or by the action of other gases. He also pointed out the necessity of accurately determining the coefficient of absorption of blood for the gases—that is, the amount absorbed under a pressure of 760 mm. of mercury

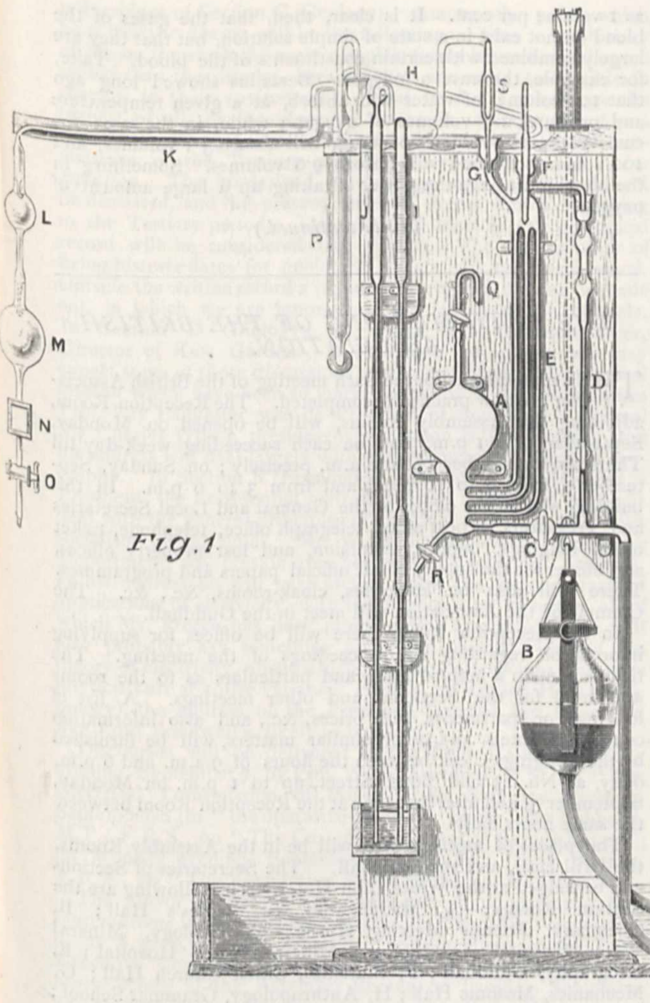

Fig.1

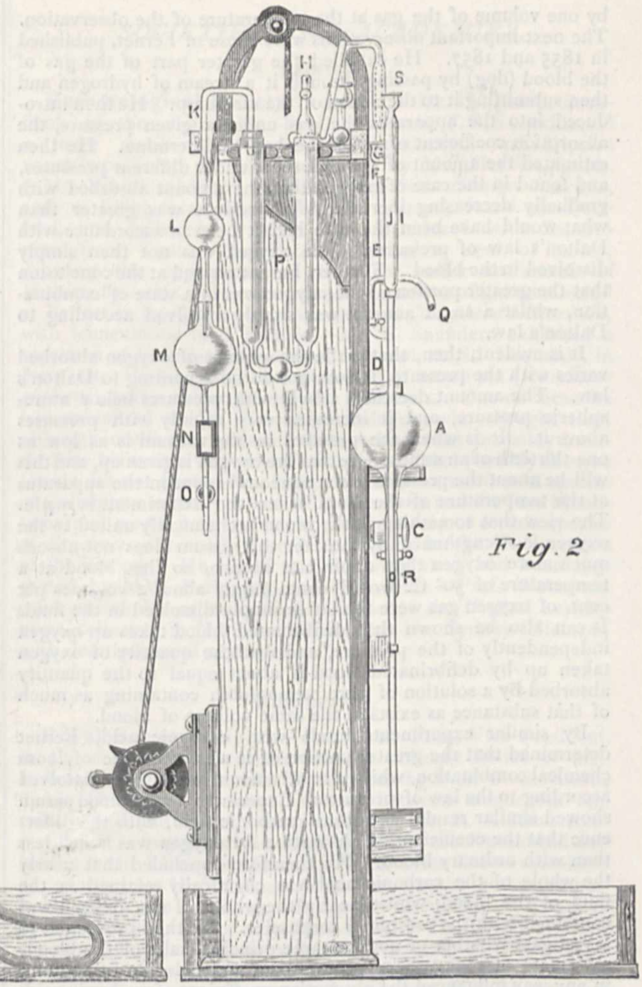

Fig.2

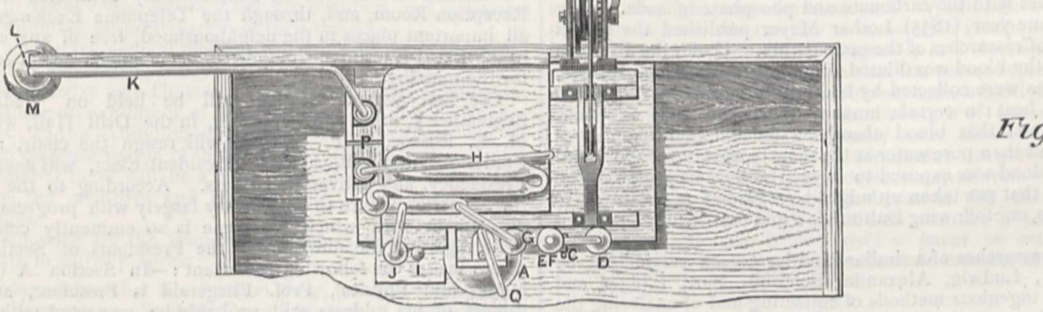

Fig.3

DESCRIPTION OF FIGURES.

FIGS. 1, 2, and 3.—Views of a gas pump constructed for the purpose of extracting and collecting the gases of the blood and suitable for the physiological lecture table. These views have been correctly drawn on the scale of 1 to 10 by my friend the Rev. A. Hanns Geyer.[1] Fig. 1, front view: A, glass bulb connected by horizontal glass tube with bulb B; this tube guarded by stopcock C. By elevating B, A is filled with mercury, stopcock of delivery tube Q is closed, and B is lowered; A is thus exhausted and air is drawn into it by tubes E, connected by G with drying apparatus and blood chamber. I, permanent barometer; J, barometer gauge tube connected with part of instrument to be exhausted. Both I and J dip into mercury trough seen below; S, a glass float to prevent mercury from running into drying apparatus when B is raised. After A and the drying apparatus and the blood chamber have been well exhausted, B is raised and mercury may be allowed to pass up D, and then the apparatus acts as a Sprengel pump by the three tubes E. Fig. 2, side view of apparatus: same references. Fig. 3, drying apparatus, placed on a shelf at the top of the pump, consisting of H, tubes containing solid phosphoric acid, and U-tube P, seen in Fig. 2, containing sulphuric acid. The tube K passes to receiver. In the drawing it is seen to be connected with an apparatus suitable for projecting the spectrum of oxy-hæmoglobin by lime or electric light on screen; then exhausting the blood of oxygen and showing the spectrum of reduced hæmoglobin. L and M, froth chambers with traps; N, parallel-sided chamber for blood; O, stopcock. The whole pump is modelled on one I obtained about ten years ago from Messrs. Mawson and Swan, of Newcastle, but it has been much altered and added to so as to make it suitable for physiological demonstration. It is evident that the gases can be readily obtained for analysis by driving out of A by delivery tube Q. A rough demonstration of the gases can be made in from five to ten minutes.

[1] The pump can be obtained from Mr. W. Potter, glass-blower, Physical and Physiological Laboratories, University of Glasgow, who will give information as to cost.

by one volume of the gas at the temperature of the observation. The next important observations were those of Fernet, published in 1855 and 1857. He expelled the greater part of the gas of the blood (dog) by passing through it a stream of hydrogen and then submitting it to the action of the air-pump. He then introduced into the apparatus the gas under a given pressure, the absorption coefficient of which he had to determine. He then estimated the amount of gas absorbed, under different pressures, and found in the case of oxygen that the amount absorbed with gradually decreasing increments of pressure was greater than what would have been the case had it been in accordance with Dalton's law of pressures. The oxygen was not then simply dissolved in the blood. Further, Fernet arrived at the conclusion that the greater portion of the oxygen was in a state of combination, whilst a small amount was simply dissolved according to Dalton's law.

It is evident, then, that while the amount of oxygen absorbed varies with the pressure, it does not do so according to Dalton's law. The amount decreases slowly with pressures below atmospheric pressure, and it increases very rapidly with pressures above it. It is when the pressure in the vacuum is as low as one-thirtieth of an atmosphere that the oxygen is given up, and this will be about the pressure of the aqueous vapour in the apparatus at the temperature of the room, when the experiment is made. The view that something in the blood is chemically united to the oxygen is strengthened by the fact that serum does not absorb much more oxygen than water can absorb, so that blood at a temperature of 30° C. would contain only about 2 volumes per cent. of oxygen gas were the latter simply dissolved in the fluid. It can also be shown that defibrinated blood takes up oxygen independently of the pressure, and that the quantity of oxygen taken up by defibrinated blood is about equal to the quantity absorbed by a solution of pure hæmoglobin containing as much of that substance as exists in the same volume of blood.

By similar experiments made with carbonic acid, Fernet determined that the greater portion of it was in a state of loose chemical combination, whilst a small amount was simply dissolved according to the law of pressures. Experiments with blood serum showed similar results as regards carbonic acid, with the difference that the coefficient of absorption for oxygen was much less than with ordinary blood. He therefore concluded that nearly the whole of the carbonic acid was chemically retained in the fluid of the blood, whilst nearly the whole of the oxygen was combined with the red blood corpuscles. He then proceeded to investigate whether or not the three principal salts of the blood, carbonate of soda, phosphate of soda, and chloride of sodium, in any way influenced the absorption coefficient of carbonic acid. He found (1) that the addition of these salts to distilled water in the proportion in which they exist in the serum slightly diminishes the absorption coefficient; (2) that chloride of sodium has no influence on the absorption coefficient; and (3) that carbonic acid combines with the carbonate and phosphate of soda.

In the same year (1855) Lothar Meyer published the results of a series of researches of the same nature. Under the direction of Bunsen, the blood was diluted with ten times its bulk of water, and the gases were collected by boiling the liquid *in vacuo* at a very gentle heat; a certain amount of gas was thus obtained. He also found that blood absorbs a much larger quantity of carbonic acid than pure water at the same temperature, and stated that when blood was exposed to oxygen at various pressures the quantity of that gas taken up might be regarded as consisting of two portions, one following Dalton's law and the other independent of it.

Further researches of a similar kind have been carried out by Setschenow, Ludwig, Alexander Schmidt, Bert, Pflüger, and others, and ingenious methods of collecting and of analyzing the gases have been devised. To Prof. Pflüger and his pupils, in particular, are we indebted for the most complete series of gas analyses on record. The result has been to enable us to give the average composition of the gases of the blood as follows. From 100 volumes of dog's blood there may be obtained—

	Oxygen.	Carbonic Acid.	Nitrogen.
Arterial	18·4 to 22·6, mean 20	30 to 40	1·8 to 2
Venous	Mean 11·9	43 to 48	1·8 to 2

the gases being measured at 0° C. and 760 mm. pressure. The venous blood of many organs may contain less than 11·9 per cent. of carbonic acid, and the blood of asphyxia may contain as little as 1 volume per cent. It is clear, then, that the gases of the blood do not exist in a state of simple solution, but that they are largely combined with certain constituents of the blood. Take, for example, the case of oxygen. Berzelius showed long ago that 100 volumes of water will absorb, at a given temperature and pressure, 2·9 volumes of oxygen; while, in the same circumstances, 100 volumes of serum will absorb 3·1 volumes, and 100 volumes of blood will absorb 9·6 volumes. Something in the blood must have the power of taking up a large amount of oxygen.

(*To be continued.*)

THE BATH MEETING OF THE BRITISH ASSOCIATION.

THE arrangements for the Bath meeting of the British Association are now practically completed. The Reception Room, adjoining the Assembly Rooms, will be opened on Monday, September 3, at 1 p.m., and on each succeeding week-day till Thursday, September 13, at 8 a.m. precisely; on Sunday, September 9, from 8 to 10 a.m., and from 3 to 6 p.m. In this building will be the offices of the General and Local Secretaries and Treasurers, a post office, telegraph office, telephone, ticket office, lodgings, inquiry, excursion, and lost property offices, and offices for the supply of all official papers and programmes. There will also be lavatories, cloak-rooms, &c., &c. The Council of the Association will meet in the Guildhall.

In the Reception Room there will be offices for supplying information regarding the proceedings of the meeting. The tickets contain a map of Bath, and particulars as to the rooms appointed for the Sectional and other meetings. A list of lodgings, or apartments, with prices, &c., and also information concerning hotels, and other similar matters, will be furnished by the Lodgings Clerk between the hours of 9 a.m. and 6 p.m. daily, at No. 13 Old Bond Street, up to 1 p.m. on Monday, September 3, and after that time at the Reception Room between the same hours daily.

The places of meeting, &c., will be in the Assembly Rooms, the Drill Hall, and the Guildhall. The Secretaries of Sections will be lodged at the White Lion Hotel. The following are the Section Rooms:—A, Mathematics, St. James's Hall; B, Chemistry, Friends' Meeting House; C, Geology, Mineral Water Hospital; D, Biology, Mineral Water Hospital; E, Geography, Guildhall; F, Statistics, Christ Church Hall; G, Mechanics, Masonic Hall; H, Anthropology, Grammar School; Sub-Sections C and D, Blue-Coat School.

By the courtesy and liberality of the Directors of the Western Counties and South Wales Telephone Company, the whole of the Section Rooms will be telephonically connected with the Reception Room, and, through the Telephone Exchange, with all important places in the neighbourhood, free of any expense to the Local Executive Committee, or members and associates, for the meeting.

The first general meeting will be held on Wednesday, September 5, at 8 p.m. precisely, in the Drill Hall, when Sir H. E. Roscoe, M.P., F.R.S., will resign the chair, and Sir Frederick Bramwell, F.R.S., President-Elect, will assume the Presidency, and deliver an address. According to the *Times*, Sir Frederick is sure to deal pretty largely with progress in the department with which his name is so eminently connected. With regard to the addresses of the Presidents of Sections the *Times* makes the following statement:—In Section A (Mathematics and Physics), Prof. Fitzgerald is President, and the subject of his address will probably be connected with Clerk-Maxwell's theory that electric and magnetic forces are produced by the same medium that propagates light, and some recent experimental proofs of that theory. In Section B (Chemistry), Prof. W. A. Tilden, of Birmingham, is President, and his address will be concerned with the history of the teaching of chemistry practically, and will review the existing provision for efficient teaching of chemistry in this country. This will be followed by some discussion of the methods actually used or proposed for teaching chemistry either as a constituent part of a liberal education or for technical purposes, together with an endeavour to trace the causes of the unproductiveness of the English schools in respect to advanced studies, and especially in regard to the results of original research. Prof. Boyd Dawkins is President of Section C (Geology). Among other points which he is likely to discuss will be the following:—That in the history of life on the earth the more complex forms have changed more swiftly than the simpler, because they are more susceptible to changes in their environment. That in the Tertiary age the highest of all, or the placental mammals, are the only forms which have changed with sufficient swiftness to mark the subdivisions of the Tertiary period. They alone are *en pleine évolution*. The borderland between geology and history will be discussed, and the present series of events shown to belong to the Tertiary period. The place of man in the geological record will be considered (pre-glacial). The impossibility of fixing historic dates for geological events will also be discussed. Outside the written record a sequence of events can alone be made out, in which we are ignorant of the length of the intervals. In Section D (Biology), of which Mr. Thiselton Dyer, Director of Kew Gardens, is President, no doubt we may expect some of those discussions on subjects of general biological interest which have been so marked a feature of the Section since Prof. Ray Lankester was its President at Southport. Colonel Sir Charles Wilson presides over Section E (Geography), and his address will deal largely with the commercial aspects of geography. In Section F (Economics), of which Lord Bramwell is President, the Presidential address is likely to be brief, and will deal with the general principles of political economy, and with socialism in particular. Mr. W. H. Preece, of the Telegraph Department, will preside over Section G (Mechanical Science). In his address he will pass under review the various practical applications of electricity, with the introduction of nearly all of which Mr. Preece has been more or less associated. He will also probably say something about the present views of the theory of electricity, about which practical electricians and pure physicists are at entire variance. Finally, in Section H (Anthropology), the address of the President, General Pitt-Rivers, is, like Lord Bramwell's, likely to be short.

Discourses will be delivered in the Drill Hall—on Friday evening, September 7, by Prof. W. E. Ayrton, F.R.S., on "The Electrical Transmission of Power"; on Saturday Evening, September 8 (to "the operative classes"), by Sir John Lubbock, M.P., F.R.S., on "The Customs and Ideas of Savage Races"; on Monday evening, September 10, by Prof. T. G. Bonney, F.R.S., on "The Foundation Stones of the Earth's Crust."

The Mayor of Bath invites the members and associates to a *conversazione* in the Assembly Rooms on Thursday, September 6, at 8.30 p.m. The Chairman and members of the Local Executive Committee invite the members and associates to a *conversazione* at the Assembly Rooms, on Tuesday, September 11, at 8.30 p.m. On this occasion the Bath Microscopical Society, assisted by the Bristol Microscopical Society, have arranged for a display of objects in the various departments of natural history, &c. No special cards of invitation will be issued to these *conversaziones*, but all members and associates will be admitted on presentation of their tickets.

The concluding general meeting will be held on Wednesday, the 12th of September, at 2.30 p.m.

On Wednesday and Thursday, the 5th and 6th of September, there will be an exhibition of fruits, flowers, &c., in the Sydney Gardens; to this exhibition all members and associates will be admitted on presentation of their tickets. On the 12th and 13th of September there will be a horse show in Bath; but on this occasion the members and associates will have no special advantages.

The following are the proposed excursions, arrangements for which are in active progress:—

Saturday, September 8.—Stanton Bury, Stanton Drew, Maes Knoll: Bannerdown, Sodbury Camp, Dyrham, Lansdown: Box Quarries, Corsham, Lacock Abbey: Bradford, Farleigh Castle, Wraxall: Cirencester, Museum and College: Tytherington and Thornbury: Swindon, G.W. Works: Berkeley Castle: Wells, *viâ* Maesbury and Shepton Mallet, Ebbor, Wookey Hole: Barry Docks and Cardiff.

Thursday, September 13.—Stonehenge, Salisbury, Wilton: Silbury, Avebury, Bowood, Wansdyke, Beckhampton: Stourton, Pen Pits, White Sheet, Longleat: Frome Valley, Nunney Whateley: Maesbury, Wells, Glastonbury, Street: Sandford and Banwell, Churchill, Dolbury, Rowberrow, Burrington, the two Charterhouses, Mendip Gorge, Cheddar Cliffs: Severn Tunnel, Chepstow, Tintern, Wyndcliffe: Radstock, Wellow, Littleton.

SOCIETIES AND ACADEMIES.

London.

Entomological Society, August 1.—Dr. D. Sharp, President, in the chair.—Mr. F. D. Godman, F.R.S., exhibited a large number of species of Lepidoptera and Diptera recently collected for him in Mexico by Mr. Herbert Smith.—Mr. White exhibited parasites bred from *Bombyx neustria*, and a living example of *Heterodes guyoni*, found at Dartford, and believed to have been introduced with Esparto grass from Tunis.—Mr. Enock exhibited a stem of barley, showing the appearance of the plant under an attack of Hessian fly.—Mr. Stevens exhibited a number of galls collected at Byfleet in July last; also a specimen of *Coleophora solitariella*, with ichneumons bred from it.—Mr. E. Saunders exhibited a specimen of *Catephia alchymista*, captured at St. Leonards, in June last. He also exhibited specimens of a rare ant (*Anochetus ghiliani*), taken at Tangier by Mr. G. Lewis. One of these he had submitted to Dr. Emery, of Bologna, who thought that, although ocelli were present, the specimen was probably intermediate between a worker and a female, and that possibly the true female did not exist.—Mr. Pascoe exhibited a number of species of Coleoptera recently collected in Germany and the Jura Mountains, and read a note correcting the synonymy of certain species of *Brachycerus* recently described by him in the Transactions of the Society. He stated that the corrections had been suggested by MM. Peringuey and Aurivillius.—Prof. Westwood communicated a paper entitled "A List of the Diurnal Lepidoptera collected in Northern Celebes by Dr. Sydney Hickson, with descriptions of new species."

Edinburgh.

Royal Society, July 16.—Rev. Prof. Flint, Vice-President, in the chair.—Dr. Traquair read an obituary notice of Mr. Robert Gray, Vice-President.—A paper by Prof. C. G. Knott, Tokio University, on some relations between magnetism and twist in iron and nickel, was submitted.—Mr. R. Kidston communicated a paper on the fossil plants in the Ravenhead collection in the Liverpool Museum.—Prof. Crum Brown submitted an investigation by Mr. Alex. Johnstone on the action of carbonic acid water on olivine.—In a paper discussing the question, Is Talbot's law true for very short stimuli? Dr. G. N. Stewart, Owen's College, describes experiments designed to test whether it is possible to make the luminous stimuli so short that the separate effects cannot be summed. He was able, by means of a rotating mirror, to reduce the length of each stimulus to something like 1/8,000,000 sec. Up to this limit he could detect no variation from the law.—Another paper by Dr. Stewart, on some colour phenomena observed with intermittent stimulation with white light, was communicated. When light of moderate intensity is used, and the rate of stimulation gradually increased, the colour is seen to change regularly in a manner which can be explained on the assumption that the curves representing the course of the excitation in the three hypothetical fibre-groups run in such a way that with a certain length of stimulation time the violet fibres are proportionally more stimulated than the others; with a shorter time of stimulation the green fibres are more stimulated; with a still shorter time, the red.—Dr. H. R. Mill, Scottish Marine Station, discussed the specific gravity of the water in the Firth of Forth and the Clyde sea-area.—Dr. J. Macdonald Brown read a paper on arrested twin development.—The Chairman made some remarks in closing the session.

Paris.

Academy of Sciences, July 30.—M. Janssen, President, in the chair.—On the relations of atmospheric nitrogen to vegetable soil, by M. Th. Schlœsing. The conclusion already arrived at from previous researches (see *Comptes rendus* for March 19 and 26, 1888) is fully confirmed by the results of the subsequent series of experiments here described. Whether exposed to renewed contact with the air, or kept in closed vessels with a confined but oxygenated atmosphere, the soil with which the experiments have been made has in no case fixed any appreciable quantity of gaseous nitrogen. The author supplements this communication with some remarks on the quantitative analysis of the carbon and nitrogen in vegetable earths. The main object of these remarks is to enable chemists to judge for themselves as to the degree of confidence his conclusions are entitled to.—On the density of chlorine and on the vapour density of ferric chloride, by MM. C. Friedel and J. M. Crafts. For chlorine the mean at 21° C. is here determined at 2·471, and at 440° C. 2·448, while between 321° and 442° C. the perchloride of iron is shown to have a somewhat constant density corresponding to the formula Fe_2Cl_6.—On the vapour density of the perchloride of gallium, by MM. C. Friedel and J. M. Crafts. According to Lecoq de Boisbaudran's determinations the perchloride of gallium (Ga_2Cl_6) melts at 75°·5 and boils at 215° to 220°. Here the density at 237° and 307° is found to be 11·73 and 10·61 respectively, or somewhat less than the theoretic density. Above 307° it diminishes considerably, falling to 8°·5 at 357°, and 6°·6 at 440°.—On the gigantic dimensions of some fossil mammals, by M. Albert Gaudry. These remarks are made in connection with the accurate measurements of the St. Petersburg mammoth (*Elephas primigenius*) supplied by Tilesius. The skeleton, a photograph of which has recently been taken by M. Strauch, is 3·42 metres high to the top of the head, as compared with the 4·22 of the Durfort skeleton (*Elephas meridionalis*) in the new gallery of the Paris Museum. Comparing these with the remains of *Dinotherium giganteum* and other monsters of the Upper Miocene and later epochs, the author groups the larger extinct mammals according to their dimensions in five classes, as follows: (1) *Dinotherium giganteum* of the Upper Miocene, Attica; (2) *Elephas antiquus* of the Quaternary, neighbourhood of Paris; (3) *Elephas meridionalis* of the Upper Pliocene, Durfort (Gard); (4) *Mastodon americanus*, of the Quaternary, United States; (5) *Elephas primigenius*, of the Quaternary, Siberia, this last being about the same size as the living elephants.—Observations of the comet 1888 *a*, by M. Cruls. These observations were made at the Imperial Observatory of Rio Janeiro for the period from February 24 to April 2.—Positions of the comet 1888 I., measured with the 8-inch equatorial of the Observatory of Besançon, by M. Gruey. The positions of the comet and comparison stars are given for the period from June 7 to June 19.—An isochronous regulator, by M. Baudot. The object of this apparatus is to maintain at a uniform velocity the rotation of the distributor employed by the inventor in his multiple printing telegraph system, despite the variations of the motor power and those of the resisting force caused by the action of the several parts of the instrument, or by any other disturbing element. Its action consists in introducing into the motor mechanism a resistance varying automatically whenever necessary, thus maintaining a perfect equilibrium between the total motor and resisting forces.—On a telephone with closed magnetic field, and plaque with equal concentric cylindrical sections, by M. Krebs. With the appliance here described the vibrations preserve a large degree of amplitude, while the section is saturated at no point of the magnetic circuit. These dispositions greatly facilitate the construction of powerful instruments of all sizes.—Magnetic charts of the West Mediterranean basin, by M. Th. Moureaux. The magnetic charts which the author now presents to the Academy have been mainly prepared from the data supplied by the series of observations described in the last number of the *Comptes rendus*. They comprise, besides the chief islands, the whole of the European seaboard from Cadiz to the Strait of Messina, and the North African coast between Tangier and Tripoli.—The storage of electricity and thermodynamics, by M. Gouy. In this paper the author endeavours to connect the principle of the preservation of electricity with the general laws of thermodynamics, taking as his experimental starting-point the first law of electric actions.—On the electric conductibility of mixtures of salts in solution, by MM. E. Bouty and L. Poincaré. In the present communication the authors deal mainly with the special case of the nitrates of potassa and soda, their object being to ascertain whether it be possible to deduce the electric conductibility of a mixture of saline solutions, without chemical action, from the conductibility of each, assuming this to be a known quantity.—On the production of ozone by electric shocks, by MM. Bichat and Guntz. Here the authors propose to study the various circumstances which influence the production of ozone by means of explosive discharges. The results obtained show that the formation of ozone is primarily connected with the greater or less elevation of the temperature of the oxygen under the action of the electric shocks.—Notes follow, by M. A. Carnot, on the lithine present in mineral waters; by M. J. Ribau, on a method of analyzing and separating zinc; by M. de Forcrand, on the glycol-alcoholate of soda; by M. J. Meunier, on a dibenzoic ether derived from mannite; by M. E. Gley, on the comparative toxic properties of wabaine and strophanthine; and by M. Prillieux, on an efficaceous treatment of black rot, a disease of the vine which has spread from America to France.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Speaking Parrots, Part 4: Dr. K. Russ (L. U. Gill).—British Dogs, No. 22: H. Dalziel (L. U. Gill).—*Challenger* Expedition Reports—Zoology, vol. xxvi. (Eyre and Spottiswoode).—Contributions to the Natural History of Alaska, No. 2: L. M. Turner (Washington).—A New Theory of Parallels; C. L. Dodgson (Macmillan).—Atlantic Weather Charts, Part 4 (Eyre and Spottiswoode).—Arithmetical Exercises and Examination Papers: H. S. Hall and S. R. Knight (Macmillan).—Entomology for Beginners: Dr. A. S. Packard (Holt, New York).—Catalog der Conchylien-Sammlung, Liefg. 8: F. R. Paetel (Berlin).—The Structure and Classification of the Mesozoic Mammalia: H. F. Osborn (Philadelphia).—Insect Life (Washington).—Il Terremoto nel Vallo Cosentino del 3 Dicembre, 1887: G. Agamennone (Roma).—Morphologisches Jahrbuch, Band 14, Heft 1 (Williams and Norgate).—Annalen der Physik und Chemie, 1888, No. 9 (Leipzig).—Verhandlungen des Naturhistorischen Vereines, 5 Jahrg. Erste Hälfte (Bonn).—Annual Report of the American Museum of Natural History, Central Park, New York, for the Year 1887–88.

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