THURSDAY, AUGUST 21, 1879

WEATHER CHARTS FOR THE NORTHERN HEMISPHERE

WE present to our readers with this number a copy of the latest work of the United States Signal Office—the Monthly International Weather Chart of the Northern Hemisphere based on simultaneous observations. The copies are the first published for distribution in Europe, and are at our request furnished from Washington. The work marks an important step in meteorological progress. The origin and purposes of the chart and its connection with others are sufficiently set forth in the following extracts from the Annual Report of the Chief Signal Officer to the Hon. Secretary of War of the United States:—

"The proposition adopted at the congress of persons charged with meteorological duties, assembled at Vienna in 1873, and to the affect that it is desirable, with a view to their exchange, that at least one uniform observation, of such character as to be suited for the preparation of synoptic charts, be taken and recorded daily and simultaneously at as many stations as practicable throughout the world, has continued to have practical effect.

"By authority of the War Department, and with the courteous co-operation of scientific men and chiefs of meteorological services representing the different countries, a record of observations taken daily, simultaneously with the observations taken throughout the United States and the adjacent islands, is exchanged semi-monthly. These reports are to cover the territorial extent of Algiers, Austria, Australasia, Belgium, Great Britain, China, Central America, Denmark, France, Germany, Greece, Greenland, India, Italy, Iceland, Japan, Mexico, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, Tunis, British North America, the United States, the Azores, Sandwich Islands, Malta, Mauritius, West Indies, South Africa, and South America.

"On July 1, 1875, the daily issue of a printed bulletin, exhibiting these international simultaneous reports, was commenced at this office, and has been since maintained. A copy of this bulletin is furnished each co-operating observer. The results to be had from the reports thus collated are considered as to be of especial importance. The bulletin combines, for the first time of which there is record, the labours of the nations in a work of this kind for their mutual benefit. There is needed only the assistance to be had from the naval forces of the different powers (that of the navies of the United States and of Portugal being as heretofore related already given to extend the plan of report upon the seas) to bring more fully within the scope of study observations practically extending around the northern hemisphere. This end is to a great extent already attained.

"In this connection the office has to acknowledge the cordial and valuable co-operation of the meteorological services of the different countries, represented as follows:—

"Algiers, by General Teissier, Commandant Supérieur du Génie; Austria, by Prof. Dr. Julius Hann, Director of the Imperial and Royal Central Meteorological Institute at Vienna; Belgium, by J. C. Houzeau, Director of the Royal Observatory at Brussels; Great Britain, by Robert H. Scott, F.R.S., Secretary of the Meteorological Council, London; Alexander Buchan, M.A., F.R.S.E., Secretary of the Scottish Meteorological Society, Edinburgh, and the respective observers; Costa Rica, by Señor Federico Maison, Director of the Central Office of Statistics and Meteorology; Denmark, by Capt. N. Hoffmeyer, Director of the Royal Danish Meteorological Institute at Copenhagen; France, by U. J. Le Verrier, Director of the Paris Observatory, Prof. E. Mascart, Director of the Central Meteorological Bureau of France, and the respective observers; Germany, by Prof. Dr. Geo. Neumayer, Director of the German Naval Observatory, Hamburg; Greece, by Prof. Dr. J. F. Julius Schmidt, Director of the Royal Observatory at Athens; India, by H. F. Blanford, Meteorological Reporter to the Government of India; Italy, by the Minister of Agriculture, Industry, and Commerce, and the respective observers; Japan, by the Imperial Meteorological Observatory, and the Imperial University of Tokei, Japan; Mexico, by Señor Mariano Barcena, Director of the Central Meteorological Observatory in the City of Mexico, and the respective observers; Netherlands, by Prof. Buys Ballot, Director of the Royal Meteorological Institute of the Netherlands at Utrecht; Norway, by Prof. H. Mohn, Director of the Royal Norwegian Meteorological Institute at Christiania; Portugal, by J. C. de Brito Capello, Director of the Meteorological Observatory of the Infante Don Luiz, at Lisbon; Russia, by Prof. H. Wild, Director of the Imperial Central Physical Observatory of Russia, at St. Petersburg; Spain, by Antonio Aguilar, Director of the Royal Observatory at Madrid, and the respective observers; Sweden, by Prof. R. Rubenson, Director of the Royal Swedish Meteorological Institute at Stockholm, and of Dr. H. H. Hildebrandsson, Chief of the Meterological Division of the Upsala Observatory; Switzerland, by Prof. R. Wolf, Director of the Observatory at Zurich, and of Prof. E. Plantamour, Director of the Observatory at Geneva; Turkey, by A. Coumbary, Effendi, Director of the Central Observatory at Constantinople, and of Prof. C. V. A. van Dyck, Superintendent of the Lee Observatory at Beirut; Canada, by Prof. G. T. Kingston, Director of the Magnetic Observatory at Toronto, and Superintendent of the Meteorological Office of the Dominion of Canada, and the respective observers; United States Navy, by Navy Department, through Rear-Admiral Daniel Ammen, and Commodore W. D. Whiting, U.S.N., Chiefs of the Bureau of Navigation; and by individual observers at other points.

"The Office has to regret the death since the date of the last annual report of the following distinguished colabourers in the work:—Urbain Jean Joseph Le Verrier, Director of the Paris Observatory, Prof. Ernst Quetelet, Director of the Royal Observatory at Brussels, Prof. Edward Heis, of Münster, and Prof. Pietro Angelo Secchi, of Rome.

"A number of observations taken on vessels at sea to complement the synchronous reports of the service, and at the request of the department, have been received on the form provided for the purpose, paper 49. Their utility is evident in the study of storms approaching our coasts or which endanger vessels sailing from our ports.

"The co-operation of the navy of the United States in the taking of observations simultaneously with the system adopted at this office, wherever naval vessels of the United States may be, as assured by the general order of the Secretary of the Navy, dated December 25, 1876, has largely increased the data of this class. This co-operation has been skilfully rendered by the Navy Department and the United States Navy, through the Chief of the Bureau of Navigation.

"The people of the United States are thus the first nation whose army and navy co-operate, as all armies and navies should, under official orders, in the taking of simultaneous observations wherever the forces may be.

"In view of the existence of the system of simultaneous reports to be made at sea by the vessels of the naval and commercial marines of the United States and other nations, and to provide for its extension, carefully tested barometers of the best make have, since the date of the last annual report, been prepared and located, as standards, at the ports of New York and San Francisco.

"These barometers have been publicly located to afford means for comparison of the ships' barometers of the shipping of all nations. The instruments, while carefully guarded, are easily accessible. Public notice is given of the location, and a sergeant of the Signal Corps attends daily to give information and to take charge of any ship's barometer which may be brought for comparison (Paper 48).

"The standard barometer for the use of shipping in the Atlantic Ocean is located at the Maritime Exchange, in New York City; the standard barometer for the use of shipping in the Pacific Ocean is located at the Merchants' Exchange, in the city of San Francisco.

"The officers of the Signal Service at the different cities and ports of the United States and upon the sea-coast offer every facility and aid in their power to the vessels of any nation.

"With the plans for charting now adopted at this office, and with the reports now received here, it appears that the meteoric changes occurring over a great portion of the continents north of the equator can be charted with an accuracy sufficient to permit careful and valuable study. This charting to be of the best attainable value, must be supplemented from the records of observations had on the seas. A ship at sea becomes one of the best of stations for a simultaneous system. The value of the record is enhanced by the change of the ship's location occurring within each period of twenty-four hours. There is no sea-going vessel but which carries human life, and each ought to carry by compulsion, if need be, meteorological instruments. The smallest craft, in caring for its own safety, may use them enough to add to the value of the most extensive record. There is no nation without interest in the work proposed to be based upon exchanged simultaneous reports, and none has hitherto hesitated, when the subject has been properly presented, to aid in a duty which, so easily done as to require very little effort on the part of any one person, has for its object a good to mankind. The work cannot, from its nature, be for the selfish good of any section.

"A number of the great steamship companies, foreign and domestic, operating the principal commercial sea-routes, have promised and will give their powerful influence and aid.

"The office has the co-operation of the Pacific Mail Steamship Company, through its agents, Williams, Blanchard and Co.; the White Star Line, through its agents, Ismay, Imrie and Co., Liverpool, and R. J. Curtis, New York; the Occidental and Oriental Steamship Company, through its president, George H. Bradbury; the North German Lloyd, through its agents, A. Schumacher and Co.; the American Steamship Company, through its president, H. D. Welsh; the Red Star Line, through its president, James A. Wright, and the Allan Line, through its agents, A. Schumacher and Co.

"The United States bear, in the cases of all maritime observers co-operating in this system, all expenses for forms, postages, &c., when so desired, and not infrequently, and, when necessary, loan the required instruments.

"The number of observations made daily on separate vessels at sea is 100 (Paper 13).

"Research has already gone far enough to indicate the paths by which, if it cannot be directly predicted, it can at least be studied, to learn what sequences to follow conditions reported on or near the eastern coast of Asia, or on the Pacific, will be found on our own western coasts.

"Similar studies will have reference to our own southern and eastern coasts, and to the western coasts of the European continent. The time cannot be far distant when vessels leaving any Atlantic port may be informed whether any notable disturbance exists at sea and where it is likely to threaten the voyage.

"The establishment of permanent ocean stations in lines traversing the oceans over or near the telegraphic cables, and in telegraphic communication with either continent, is not considered impracticable, and has been referred to in a preceding report.

"There is reason to hope that a progress has been made which will eliminate from the study of practical international meteorology some of the difficulties hitherto encountered.

"There are grounds to hope also that the atmospheric conditions and changes of condition can be charted with sufficient accuracy over any extent of the earth's surface.

"If the hope has fruition, meteorological barriers will, as against study, practically cease to exist.

"A copy of the International Bulletin herewith (Paper 27) exhibits the character of the international reports, and that of the information had from each station. The chart accompanying this bulletin shows as nearly as practicable the location of the stations, and foreshadows the duties and reports had from them will make practicable. The number of stations reporting increases.

"While the stations are crowded in some localities, each is useful—each serving to check the work of the other, and each aiding to close the gaps the failure of other stations might sometimes cause. The work is not likely to be abandoned by those in the different countries who have taken part in establishing it, and who share its benefits. If it serve no other purpose than to maintain, as it does, the pleasant co-operation of those charged with the meteorological duties of the different countries, it would be of value. It is hoped that by systems of observations thus extensive, generalisations may be had to permit the announcement of meteoric changes for periods longer in advance than have been hitherto practicable.

"The average number of daily simultaneous observations now made in foreign countries is 293. The total number of *stations* on land and *on vessels at sea from which reports* are entered in the bulletin regularly is 557. The co-operation of the different nations secured by this plan of exchange, as above described, renders the additional cost to the United States of the grand system of reports it makes possible but little more than that of the cost of the preparation, paper, and binding of the International Bulletin and the accompanying charts, a cost which would have to be met in great part for the proper preservation of the records themselves even if the bulletins were not distributed.

"The Chief Signal Officer is gratified to announce in this report that the work of the collection of the reports of international simultaneous observations, carried on in foreign countries in co-operation with the United States, as well as within the territories of the United States and upon the seas thus above referred to, has in the year just passed so far progressed as to have attained one principal result for which it was set on foot. On July 1, 1878, it became possible for the first time in the history of this office to commence the issue, on that date, of a daily international weather map, charted daily and issued daily, each chart based upon the data appearing upon the International Bulletin of simultaneous reports of similar date. The charting extends around the world, and embraces for its area the whole northern hemisphere.

"The daily issue of a chart of this kind, thus daily issued for the first time by the United States, is without a precedent in history. It exhibits the co-operation, for for a single purpose, of the civilised powers of the world north of the equator.

"The studies such charts make possible, the improvement which will come as the work progresses and the area of the chart is better filled with reports of observations carefully elaborated, are fully appreciated by scientific men. The questions as to the translations of storms from continent to continent, and of the times and directions they may take in such movements; the movement of areas of high and of low barometer; the conditions of temperature, pressure, and wind-direction existing around the earth at a fixed instant of time, permitting thus the effects of day and night to be contrasted; the distribution and amount of rainfall, and other studies, many and valuable, only suggested by this enumeration, may be by such studies settled. It seems not impossible that in the future questions of climatology, and perhaps others bearing upon the prediction of weather changes far in advance of the time at which these changes may happen, or questions of the character of coming seasons even, may be answered by the researches these charts will make practicable.

"The very great aid and material furnished in this elaborated form gives to the search for generalisation, or for data in the support of theories, was referred to in the last annual report. In frequent cases little more than collation is necessary.

"As a means of better combining the work and the interests of the several nations; of certainly securing that co-operation at sea which will enable the lines of the charting to be drawn as fully and as well over oceans as over continents; and which will give the world ultimately a knowledge as practical of the movement of areas of disturbance in the midst of the seas as is now had of such movements on some continents, the undertaking is of much importance.

"It is an advantage of the charting draughted from simultaneous reports that studies by normals, not possible in any other way, can be made. The normal pressure, temperature, &c., arrived at from observations taken at any one place, at the same and a fixed instant of time every day, become established as to that place and time with accuracy. Many causes of error are eliminated.

"The intercomparison of these normals with the normals taken at other places simultaneously with the first and under the similar condition that the normals to be found for those places are to be from observations taken at those places at a fixed time and on every day, gives results reliable and different from those to be had by the use of normal readings arrived at in any other manner. Normals for the year, for the season, and for the month, may be determined by such procedure. The comparison of such normals will show in the case of abnormal changes in any district or section for any season whether and how they are compensated by compensating variations elsewhere. There are interesting studies as to what sequences there may be to follow such atmospheric variations occurring over any region or country—either in that region or country, or elsewhere—and how and where the compensating variations occur, and with what concomitants or sequences of meteoric changes.

"There is the hope to gain in this way or by studies such study will suggest information to affect the commercial and agricultural interests of the world.

"There is the further hope that as it is more fully realised by the different peoples, how close in the future the practice of such investigations draws, each member of the family of nations will find its own interests in labours of this description, and draw more closely the bonds and join with energy in a work which has so begun to connect them. The undertaking, world-wide in extent, is capable of rendering a world-wide benefit."

The chart before our readers bears information condensed from thirty—one for each day of the month—of the world weather charts above described, and exhibits one path of study to be pursued. It shows for one month the lines of mean pressure, mean temperature, and average wind direction on land and sea within the limits of civilisation on the Northern Hemisphere. The appearance of the map marks the commencement of the first actual and current study of the atmosphere of the whole Northern Hemisphere for practical use.

It will be noticed from the Report that the Chief Signal Officer, General Myer, while pressing forward month after month his plan, commenced on the American Continent nine years ago—in 1870—of mapping by weather charts and simultaneously the Northern Hemisphere, and fixing its success, reaches out a helping hand to every people. The Report asks all nations to stand side by side with the United States in carrying forward the work now marked out, and announces that so far as the United States is concerned the least of the co-operators shall receive the perfected work as fully as the greatest. Every separate observer or ship at sea co-operating in this work receives a copy of the chart he has helped to make. Aside from any national benefit the work is to benefit the human race.

THE BRITISH ASSOCIATION

THE Forty-ninth Annual Meeting of the British Association was opened yesterday at Sheffield, under the presidency of Prof. Allman, F.R.S. The new secretary, Mr. J. E. H. Gordon, has made several innovations in the conduct of the business of the Association, which, when fairly established, will no doubt be decided improvements.

At the end of last week all the arrangements for the meeting were in an unusually forward state. Circulars had been sent to every member of the Association, and all the more prominent members who had replied have been well provided for by private hospitality, unless they desired to be otherwise accommodated. It is expected that the meeting will in all respects be a very good one. At all events, no efforts have been spared by the town of Sheffield to make it so, and the local secretaries and other officers have been at their posts from soon after eight in the morning to late every evening. A handy Guide-Book to Sheffield and its neighbourhood has been compiled for the special use of those attending the meeting of the Association.

There will be an excellent display of all the more recent scientific inventions at the second *soirée* given by the Local Committee on Tuesday the 26th. Independently of the large number of excursions arranged for Saturday the 23rd, and Thursday the 28th, most of the leading manufactories will be opened to the members, or will be visited by parties invited for special days. The Firth College, the gift to the town of Mr. Mark Firth, will now be used for the first time, and will be found admirably adapted for the reception-room and offices. It is to be formally opened for educational purposes in October by Prince Leopold. At one time much anxiety was felt with reference to this building. The long and severe winter delayed operations so much, that but for subsequent great energy it could not have been finished for the meeting. For the last two weeks it has been used for the temporary offices of the Association, though the secretaries and others have been compelled to carry on their business along with all sorts of workmen. If, as originally fixed, the meeting had commenced on August 6, it would have been almost impossible to have used the college for the reception-room.

The Local Committee have had a good deal of trouble, we believe, in the matter of lodging accommodation; but this has happily been surmounted. The citizens of Sheffield have most liberally responded to the request for hospitality, and special arrangements have been made for the adequate refreshment of members who conscientiously attend to the thirsty and appetising work of the Sections; for it seems Sheffield is rather scantily provided with hotels and restaurants. The list of excursions seems unusually large, there being twenty-four in all for Saturday the 23rd, and Thursday the 28th; all the arrangements for these bespeak the greatest thoughtfulness for the comfort of the members. On Friday evening, the 22nd, a twilight exhibition of Bessemer steel manufacture is to be shown to 100 members at the Phœnix Bessemer Works, Iccles, Rotherham, and on Wednesday next Nunnery and Aldwarke Collieries will be visited.

Ample entertainment has been arranged for in the way of banquets and *conversazioni*, and on Sunday the Archbishop of York and Canon Tristram are to preach in the Parish Church. Altogether the Sheffield meeting promises, if not to be unusually large, to be thoroughly satisfactory so far as local arrangements go.

INAUGURAL ADDRESS OF PROF. G. J. ALLMAN, M.D., LL.D., F.R.S.S.L. and E., M.R.I.A., Pres. L.S., PRESIDENT.

IT is no easy thing to find material suited to an occasion like the present. For on the one hand there is risk that a presidential address may be too special for an audience necessarily large and general, while on the other hand it may treat too much of generalities to take hold of the sympathies and command the attention of the hearers.

It may be supposed that my subject should have been suggested by the great manufacturing industries of the town which has brought us together; but I felt convinced that a worker in only the biological sciences could not do justice to the workers in so very different a field.

I am not, therefore, going to discourse to you of any of those great industries which make civilised society what it is—of those practical applications of scientific truth which within the last half century have become developed with such marvellous rapidity, and which have already become interwoven with our everyday life, as the warp of the weaver is interwoven with the woof. Such subjects must be left to other occupiers of this chair, from whom they may receive that justice which I could not pretend to give them; and I believe I shall act most wisely by keeping to a field with which my own studies have been more directly connected.

I know that there are many here present from whom I have no right to expect that previous knowledge which would justify me in dispensing with such an amount of elementary treatment as can alone bring my subject intelligibly before them, and my fellow-members of the British Association who have the advantage of being no novices in that department of biology with which I propose to occupy you, will pardon me if I address myself mainly to those for whom the field of research on which we are about to enter has now been opened for the first time.

I have chosen, then, as the matter of my address to you to-night, a subject in whose study there has during the last few years prevailed an unwonted amount of activity, resulting in the discovery of many remarkable facts, and the justification of many significant generalisations. I propose, in short, to give you in as untechnical a form as possible some account of the most generalised expression of living matter, and of the results of the more recent researches into its nature and phenomena.

More than forty years have now passed away since the French naturalist, Dujardin, drew attention to the fact that the bodies of some of the lowest members of the animal kingdom consist of a structureless, semi-fluid, contractile substance, to which he gave the name of Sarcode. A similar substance occurring in the cells of plants was afterwards studied by Hugo von Mohl, and named by him Protoplasm. It remained for Max Schultze to demonstrate that the sarcode of animals and the protoplasm of plants were identical.

The conclusions of Max Schultze have been in all respects confirmed by subsequent research, and it has further been rendered certain that this same protoplasm lies at the base of all the phenomena of life, whether in the animal or the vegetable kingdom. Thus has arisen the most important and significant generalisation in the whole domain of biological science.

Within the last few years protoplasm has again been made a subject of special study; unexpected and often startling facts have been brought to light, and a voluminous literature has gathered round this new centre of research. I believe, therefore, that I cannot do better than call your attention to some of the more important results of these inquiries, and endeavour to give you some knowledge of the properties of protoplasm, and of the part it plays in the two great kingdoms of organic nature.

As has just been said, protoplasm lies at the base of every vital phenomenon. It is, as Huxley has well expressed it, "the physical basis of life." Wherever there is life, from its lowest to its highest manifestations, there is protoplasm; wherever there is protoplasm, there, too, is life. Thus, coextensive with the whole of organic nature—every vital act being referable to some mode or property of protoplasm—it becomes to the biologist what the ether is to the physicist; only that instead of being a hypothetical conception, accepted as a reality from its adequacy in the explanation of phenomena, it is a tangible and visible reality, which the chemist may analyse in his laboratory, the biologist scrutinise beneath his microscope and his dissecting needle.

The chemical composition of protoplasm is very complex, and has not been exactly determined. It may, however, be stated that protoplasm is essentially a combination of albuminoid bodies, and that its principal elements are, therefore, oxygen, carbon, hydrogen, and nitrogen. In its typical state it presents the condition of a semi-fluid substance—a tenacious, glairy liquid, with a consistence somewhat like that of the white of an unboiled egg.[1] While we watch it beneath the microscope movements are set up in it; waves traverse its surface, or it may be seen to flow away in streams, either broad and attaining but a slight distance from the main mass, or else stretching away far from their source, as narrow liquid threads, which may continue simple, or may divide into branches, each following its own independent course; or the streams may flow one into the other, as streamlets would flow into rivulets and rivulets into rivers, and this not only where gravity would carry them, but in a direction diametrically opposed to gravitation; now we see it spreading itself out on all sides into a thin liquid stratum, and again drawing itself together within the narrow limits which had at first confined it, and all this without any obvious impulse from without which would send the ripples over its surface or set the streams flowing from its margin. Though it is certain that all these phenomena are in response to some stimulus exerted on it by the outer world, they are such as we never meet with in a simply physical fluid—they are spontaneous movements resulting from its proper irritability, from its essential constitution as living matter.

Examine it closer, bring to bear on it the highest powers of your microscope—you will probably find disseminated through it countless multitudes of exceedingly minute granules; but you may also find it absolutely homogeneous, and, whether containing granules or not, it is certain that you will find nothing to which the term *organisation* can be applied. You have before you a glairy, tenacious fluid, which, if not absolutely homogeneous, is yet totally destitute of structure.

And yet no one who contemplates this spontaneously moving matter can deny that it is alive. Liquid as it is, it is a living liquid; organless and structureless as it is, it manifests the essential phenomena of life.

The picture which I have thus endeavoured to trace for you in a few leading outlines is that of protoplasm in its most generalised aspect. Such generalisations, however, are in themselves unable to satisfy the conditions demanded by an exact scientific inquiry, and I propose now, before passing to the further consideration of the place and purport of protoplasm in nature, to bring before you some definite examples of protoplasm, such as are actually met with in the organic world.

A quantity of a peculiar slimy matter was dredged in the North Atlantic by the naturalists of the exploring ship *Porcupine* from a depth of from 5,000 to 25,000 feet. It is described as exhibiting, when examined on the spot, spontaneous movements, and as being obviously endowed with life. Specimens of this, preserved in spirits, were examined by Prof. Huxley, and declared by him to consist of protoplasm, vast masses of which must thus in a living state extend over wide areas of sea bottom. To this wonderful slime Huxley gave the name of *Bathybius Haeckelii*.

Bathybius has since been subjected to an exhaustive examina-

[1] In speaking of protoplasm as a liquid, it must be borne in mind that this expression refers only to its physical consistence—a condition depending mainly on the amount of water with which it is combined, and subject to considerable variation, from the solid form in which we find it in the dormant embryo of seeds, to the thin watery state in which it occurs in the leaves of Valisneria. Its distinguishing properties are totally different from those of a purely physical liquid, and are subject to an entirely different set of laws.

tion by Prof. Haeckel, who believes that he is able to confirm in all points the conclusions of Huxley, and arrives at the conviction that the bottom of the open ocean, at depths below 5,000 feet, is covered with an enormous mass of living protoplasm, which lingers there in the simplest and most primitive condition, having as yet acquired no definite form. He suggests that it may have originated by spontaneous generation, but leaves this question for future investigations to decide.

The reality of Bathybius, however, has not been universally accepted. In the more recent investigations of the *Challenger* the explorers have failed in their attempts to bring further evidence of the existence of masses of amorphous protoplasm spreading over the bed of the ocean. They have met with no trace of Bathybius in any of the regions explored by them, and they believe that they are justified in the conclusion that the matter found in the dredgings of the *Porcupine* and preserved in spirits for further examination, was only an inorganic precipitate due to the action of the alcohol.

It is not easy to believe, however, that the very elaborate investigations of Huxley and Haeckel can be thus disposed of. These, moreover, have received strong confirmation from the still more recent observations of the Arctic voyager, Bessels, who was one of the explorers of the ill-fated *Polaris*, and who states that he dredged from the Greenland seas masses of living undifferentiated protoplasm. Bessels assigns to these the name of Protobathybius, but they are apparently indistinguishable from the Bathybius of the *Porcupine*. Further arguments against the reality of Bathybius will therefore be needed before a doctrine founded on observations so carefully conducted shall be relegated to the region of confuted hypotheses.

Assuming then, that Bathybius, however much its supposed wide distribution may have been limited by more recent researches, has a real existence, it presents us with a condition of living matter the most rudimental it is possible to conceive. No law of morphology has as yet exerted itself in this formless slime. Even the simplest individualisation is absent. We have a living mass, but we know not where to draw its boundary lines; it is living matter, but we can scarcely call it a living being.

We are not, however, confined to Bathybius for examples of protoplasm in a condition of extreme simplicity. Haeckel has found, inhabiting the fresh waters in the neighbourhood of Jena, minute lumps of protoplasm, which when placed under the microscope were seen to have no constant shape, their outline being in a state of perpetual change, caused by the protrusion from various parts of their surface of broad lobes and thick finger-like projections, which, after remaining visible for a time, would be withdrawn, to make their appearance again on some other part of the surface.

These changeable protrusions of its substance, without fixed position or definite form, are eminently characteristic of protoplasm in some of its simplest conditions. They have been termed "Pseudopodia," and will frequently come before you in what I have yet to say.

To the little protoplasmic lumps thus constituted, Haeckel has given the name of *Protamœba primitiva*. They may be compared to minute detached pieces of Bathybius. He has seen them multiplying themselves by spontaneous division into two pieces, which, on becoming independent, increase in size and acquire all the characters of the parent.

Several other beings as simple as *Protamœba* have been described by various observers, and especially by Haeckel, who brings the whole together into a group to which he gives the name of MONERA, suggested by the extreme simplicity of the beings included in it.

But we must now pass to a stage a little higher in the development of protoplasmic beings. Widely distributed in the fresh and salt waters of Britain, and probably of almost all parts of the world, are small particles of protoplasm closely resembling the *Protamœba* just described. Like it, they have no definite shape, and are perpetually changing their form, throwing out and drawing in thick lobes and finger-like pseudopodia, in which their body seems to flow away over the field of the microscope. They are no longer, however, the homogeneous particle of protoplasm which forms the body of *Protamœba*. Towards the centre a small globular mass of firmer protoplasm has become differentiated off from the remainder, and forms what is known as a nucleus, while the protoplasm forming the extreme outer boundary differs slightly from the rest, being more transparent, destitute of granules, and apparently somewhat firmer than the interior. We may also notice that at one spot a clear spherical space has made its appearance, but that while we watch it has suddenly contracted and vanished, and after a few seconds has begun to dilate so as again to come into view, once more to disappear, then again to return, and all this in regular rhythmical sequence. This little rhythmically pulsating cavity is called the "contractile vacuole." It is of very frequent occurrence among those beings which lie low down in the scale of life.

We have now before us a being which has arrested the attention of naturalists almost from the commencement of microscopical observation. It is the famous *Amœba*, for which ponds and pools and gutters on the house roof have for the last 200 years been ransacked by the microscopist, who has many a time stood in amazement at the undefinable form and Protean changes of this particle of living matter. It is only the science of our own days, however, which has revealed its biological importance, and shown that in this little soft nucleated particle we have a body whose significance for the morphology and physiology of living beings cannot be over estimated, for in *Amœba* we have the essential characters of a CELL, the morphological unit of organisation, the physiological source of specialised function.

The term "cell" has been so long in use that it cannot now be displaced from our terminology; and yet it tends to convey an incorrect notion, suggesting, as it does, the idea of a hollow body or vesicle, this having been the form under which it was first studied. The cell, however, is essentially a definite mass of protoplasm having a nucleus imbedded in it. It may, or may not, assume the form of a vesicle; it may, or may not, be protected by an enveloping membrane; it may, or may not, contain a contractile vacuole; and the nucleus may, or may not, contain within it one or more minute secondary nuclei or "nucleoli."

Haeckel has done good service to biology in insisting on the necessity of distinguishing such non-nucleated forms as are presented by *Protamœba* and the other *Monera* from the nucleated forms as seen in *Amœba*. To the latter he would restrict the word *cell*, while he would assign that of "cytode" to the former.[1]

[1] In every typical cell three parts may be distinguished. There is first the more or less liquid granular protoplasm; secondly the nucleus; and thirdly an external more firm zone of protoplasm, known as the 'cortical layer'—the Hautschicht of the German histologists. All these parts may be regarded as portions differentiated out of the original simple protoplasm. Cells do not, however, always remain on a stage of such simplicity as that presented by *Amœba*. The nucleus is always at its origin quite homogeneous, but as it increases in size it usually manifests a differentiation resulting in a constitution which recent research has shown to be more complex than had been previously supposed; for we often find it to present an external firmer layer, or nuclear membrane, including within it the softer nuclear protoplasm, in which again a network of filaments has been in many instances described.

The structure of the nucleus has been quite recently studied by Flemming (*Arch. f. mikr. Anat.*, Band xvi. Heft 2, 1878), who has given particular attention to this intranuclear network. He maintains that in its completed state the nucleus consists of a parietal firm layer, which incloses, besides specially differentiated nucleoli, a framework (Gerüst) of filaments with a more fluid intervening substance. He further insists on the fact that, with the differentiation of a nucleus, there is introduced a chemical difference between its substance and that of the surrounding cell substance, as shown not only by a different behaviour of the nucleus towards re-agents, but by an actually determined difference of chemical composition.

Klein (*Quarterly Journ. Micr. Sci.* vol. xviii. p. 315) has shown that in the cells of the stomach of *Triton cristatus* there is a delicate intranuclear network of filaments in all respects resembling that described by Flemming; and he further maintains that the network of the nucleus is here continuous, through minute apertures near the poles of the nuclear membrane, with a similar network in the surrounding cell-substance. In this cell-substance he distinguishes two parts—the homogeneous ground substance and the intracellular network of filaments.

Flemming, however, will not admit this connection between intra-nuclear and intra-cellular filaments, and Schleicher, as the result of his very recent researches on the division of cartilage-cells ("Die Knorpelzelltheilung," *Arch. f. mikr. Anat.*, Band xvi. Heft 2, 1878), concludes that in these there is no true intra-cellular network, the nucleus being here composed of a multitude of separate rodlets, filaments, and granules surrounded by the nuclear membrane.

The minute granules which are generally seen in the soft protoplasm of the cell do not seem to be essential constituents. They are probably nutritive matter introduced from without, and in process of assimilation and conversion into proper protoplasm. Hanstein has distinguished by the term Metaplasm these granules from the proper homogeneous protoplasm in which they are suspended. The external cortical layer is quite destitute of them; on this devolves the property of protecting the contents from the unfavourable action of outer influences, and to it alone in plants is allocated the property of secreting the cellulose boundary wall.

Several recent observers, but more especially Strasburger ("Studien über das Protoplasma," *Jenaische Zeitschr.*, 1876), have described in the cortical layer of various cells a radial striation, as if formed by excessively delicate rodlets (Stäbchen), placed vertically to the surface and in close proximity to one another. He has seen a relation between these and the cilia on the swarm spores of Vaucheria, where each cilium seems to be supported by a rodlet. That this condition of the cortical layer, however, has not a general feature of cell protoplasm, is certain; it is but a special case of structural differentiation. Indeed, the complex structure which has been detected in the nucleus and in the surrounding cell-protoplasm can scarcely be other-

Let us observe our *Amœba* a little closer. Like all living beings, it must be nourished. It cannot grow as a crystal would grow by accumulating on its surface molecule after molecule of matter. It must *feed.* It must take into its substance the necessary nutriment; it must assimilate this nutriment, and convert it into the material of which it is itself composed.

If we seek, however, for a mouth by which the nutriment can enter into its body, or a stomach by which this nutriment can be digested, we seek in vain. Yet watch it for a moment as it lies in a drop of water beneath our microscope. Some living denizen of the same drop is in its neighbourhood, and its presence exerts on the protoplasm of the *Amœba* a special stimulus which gives rise to the movements necessary for the prehension of nutriment. A stream of protoplasm instantly runs away from the body of the *Amœba* towards the destined prey, envelops it in its current, and then flows back with it to the central protoplasm, where it sinks deeper and deeper into the soft yielding mass, and becomes dissolved, digested, and assimilated in order that it may increase the size and restore the energy of its captor.

But again, like all living things, *Amœba* must multiply itself, and so after attaining a certain size its nucleus divides into two halves, and then the surrounding protoplasm becomes similarly cleft, each half retaining one-half of the original nucleus. The two new nucleated masses which thus arise now lead an independent life, assimilate nutriment, and attain the size and characters of the parent.

We have just seen that in the body of an *Amœba* we have the type of a cell. Now both the fresh waters and the sea contain many living beings beside *Amœba* which never pass beyond the condition of a simple cell. Many of these, instead of emitting the broad lobe-like pseudopodia of *Amœba,* have the faculty of sending out long thin threads of protoplasm, which they can again retract, and by the aid of which they capture their prey or move from place to place. Simple structureless protoplasm as they are, many of them fashion for themselves an outer membranous or calcareous case, often of symmetrical form and elaborate ornamentation, or construct a silicious skeleton of radiating spicula, or crystal clear concentric spheres of exquisite symmetry and beauty.

Some move about by the aid of a flagellum, or long whip-like projection of their bodies, by which they lash the surrounding waters, and which, unlike the pseudopodia of *Amœba,* cannot, during active life, be withdrawn into the general protoplasm of the body; while among many others locomotion is effected by means of cilia—microscopic vibratible hairs, which are distributed in various ways over the surface, and which, like the pseudopodia and flagella, are simple prolongations of their protoplasm.

In every one of these cases the entire body has the morphological value of a cell, and in this simple cell reside the whole of the properties which manifest themselves in the vital phenomena of the organism.

The part fulfilled by these simple unicellular beings in the economy of nature has at all times been very great, and many geological formations, largely built up of their calcareous or silicious skeletons, bear testimony to the multitudes in which they must have swarmed in the waters of the ancient earth.

Those which have thus come down to us from ancient times owe their preservation to the presence of the hard persistent structures secreted by their protoplasm, and must, after all, have formed but a very small proportion of the unicellular organisms which peopled the ancient world, and there fulfilled the duties allotted to them in nature, but whose soft, perishable bodies have left no trace behind.

In our own days similar unicellular organisms are at work, taking their part silently and unobtrusively in the great scheme of creation, and mostly destined, like their predecessors, to leave behind them no record of their existence. The Red Snow Plant, to which is mainly due the beautiful phenomenon by which tracts of Arctic and Alpine snow become tinged of a delicate crimson, is a microscopic organism whose whole body consists of a simple spherical cell. In the protoplasm of this little cell must reside all the essential attributes of life; it must grow by the reception of nutriment; it must repeat by multiplication that form which it has itself inherited from its parent; it must be able to respond to the stimulus of the physical conditions by which it is surrounded. And there it is, with its structure almost on the bounds of extremest simplification, taking its allotted part in the economy of nature, combining into living matter the lifeless elements which lie around it, redeeming from sterility the regions of never-thawing ice, and peopling with its countless millions the wastes of the snow land.[1]

But organisation does not long rest on this low stage of unicellular simplicity, for as we pass from these lowest forms into higher, we find cell added to cell, until many millions of such units become associated in a single organism, where each cell, or each group of cells, has its own special work, while all combine for the welfare and unity of the whole.

In the most complex animals, however, even in man himself, the component cells, notwithstanding their frequent modification and the usual intimacy of their union, are far from losing their individuality. Examine under the microscope a drop of blood freshly taken from the human subject, or from any of the higher animals. It is seen to be composed of a multitude of red corpuscles, swimming in a nearly colourless liquid, and along with these, but in much smaller numbers, somewhat larger colourless corpuscles. The red corpuscles are modified cells, while the colourless corpuscles are cells still retaining their typical form and properties. These last are little masses of protoplasm, each enveloping a central nucleus. Watch them. They will be seen to change their shape; they will project and withdraw pseudopodia, and creep about like an *Amœba.* But, more than this, like an *Amœba,* they will take in solid matter as nutriment. They may be fed with coloured food, which will then be seen to have accumulated in the interior of their soft transparent protoplasm; and in some cases the colourless blood corpuscles have actually been seen to devour their more diminutive companions, the red ones.

Again, there are certain cells filled with peculiar coloured matters, and called pigment cells, which are especially abundant, as constituents of the skin in fishes, frogs, and other low vertebrate, as well as many invertebrate, animals. Under certain stimuli, such as that of light, or of emotion, these pigment cells change their form, protrude or retract pseudopodial prolongations of their protoplasm, and assume the form of stars or of irregularly lobed figures, or again draw themselves together into little globular masses. To this change of form in the pigment cell the rapid change of colour so frequently noticed in the animals provided with them is to be attributed.

The animal egg, which in its young state forms an element in the structure of the parent organism, possesses in the relations now under consideration a peculiar interest. The egg is a true cell, consisting essentially of a lump of protoplasm inclosing a nucleus, and having a nucleolus included in the interior of the nucleus. While still very young it has no constant form and is perpetually changing its shape. Indeed, it is often impossible to distinguish it from an *Amœba;* and it may, like an *Amœba,* wander from place to place by the aid of its pseudopodial projections. I have shown elsewhere[2] that the primitive egg of the remarkable hydroid *Myriothela,* manifests amœboid motions; while Haeckel has shown[3] that in the sponges certain *Amœba*-like organisms, which are seen wandering about in the various canals and cavities of their bodies, and had been until lately regarded as parasites which had gained access from without, are really the eggs of the sponge; and a similar amœboid condition is presented by the very young eggs of even the highest animals.

Again, Reichenbach has proved[4] that during the development of the crayfish the cells of the embryo throw out pseudopodia by which, exactly as in an *Amœba,* the yolk spheres which serve as nutriment for the embryo are surrounded and engulphed in the protoplasm of the cells.

I had shown some years ago[5] that in *Myriothela,* pseudopodial processes are being constantly projected from the walls of the alimentary canal into its cavity. They appear as direct extensions of a layer of clear, soft, homogeneous protoplasm which lies over the surface of the naked cells lining the cavity, and which I now regard as the "Hautschicht" or cortical layer of these cells. I then suggested that the function of these

wise regarded than as an expression of an early differentiation in the structure of the cell, and not, as has been maintained, an ultimate or "plastidular" condition of protoplasm

[1] The Red Snow Plant (*Protococcus nivalis*) acts on the atmosphere through the agency of chlorophyll, like the ordinary green plants. As in these, chlorophyll is developed in it, and is only withdrawn from view by the predominant red pigment to which the *Protococcus* owes one of its most striking characteristics.

[2] "On the Structure and Development of *Myriothela,*" *Phil. Trans.,* vol. clxv., 1875, p. 552.

[3] *Jenaische Zeitschr.,* 1871.

[4] "Die Embryonanlage und erste Entwickelung des Flusskrebse," *Zeitschr. f. wissens. Zoologie,* 1877.

[5] *Loc. cit.*

pseudopodia lay in seizing, in the manner of an *Amœba*, such alimentary matter as may be found in the contents of the canal, and applying it to the nutrition of the hydroid.

What I had thus suggested with regard to *Myriothela* has been since proved in certain planarian worms by Metschnikoff,[1] who has seen the cells which line the alimentary canal in these animals act like independent *Amœbæ*, and engulph in their protoplasm such solid nutriment as may be contained in the canal. When the planaria was fed with colouring matter these amœboid cells became gorged with the coloured particles just as would have happened in an *Amœba* when similarly fed.

But it is not alone in such loosely aggregated cells as those of the blood, or in the amœboid cells of the alimentary canal, or in such scattered constituents of the tissues as the pigment cells, or in cells destined for an ultimate state of freedom, as the egg, that there exists an independence. The whole complex organism is a society of cells, in which every individual cell possesses an independence, an autonomy, not at once so obvious as in the blood cells, but not the less real. With this autonomy of each element there is at the same time a subordination of each to the whole, thus establishing a unity in the entire organism, and a concert and harmony between all the phenomena of its life.

In this society of cells each has its own work to perform, and the life of the organism is made up of the lives of its component cells. Here it is that we find most distinctly expressed the great law of the physiological division of labour. In the lowest organisms, where the whole being consists of a single cell, the performance of all the processes which constitute its life must devolve on the protoplasm of this one cell; but as we pass to more highly organised beings, the work becomes distributed among a multitude of workers. These workers are the cells which now make up the complex organism. The distribution of labour, however, is not a uniform one, and we are not to suppose that the work performed by each cell is but a repetition of that of every other. For the life processes, which are accumulated in the single cell of the unicellular organism become in the more complex organism differentiated, some being intensified and otherwise modified and allocated to special cells, or to special groups of cells, which we call organs, and whose proper duty is now to take charge of the special processes which have been assigned to them. In all this we have a true division of labour —a division of labour, however, by no means absolute; for the processes which are essential to the life of the cell must still continue common to all the cells of the organism. No cell, however great may be the differentiation of function in the organism, can dispense with its irritability, the one constant and essential property of every living cell. There thus devolves on each cell or group of cells some special work which contributes to the well-being of all, and their combined labours secure the necessary conditions of life for every cell in the community, and result in those complex and wonderful phenomena which constitute the life of the higher organisms.

We have hitherto considered the cell only as a mass of active nucleated protoplasm, either absolutely naked, or partially inclosed in a protective case, which still permits free contact of the protoplasm with the surrounding medium. In very many instances, however, the protoplasm becomes confined within resisting walls, which entirely shut it in from all direct contact with the medium which surrounds it. With the plant this is almost always so after the earliest stages of its life. Here the protoplasm of the cells is endowed with the faculty of secreting over its surface a firm, resisting membrane, composed of cellulose, a substance destitute of nitrogen, thus totally different from the contained protoplasm, and incapable of manifesting any of the phenomena of life.

Within the walls of cellulose the protoplasm is now closely imprisoned, but we are not on that account to suppose that it has lost its activity, or has abandoned its work as a living being. Though it is now no longer in direct contact with the surrounding medium, it is not the less dependent on it, and the reaction between the imprisoned protoplasm and the outer world is still permitted by the permeability of the surrounding wall of cellulose.

When the protoplasm thus becomes surrounded by a cellulose wall it seldom retains the uniform arrangement of its parts which is often found in the naked cells. Minute cavities or vacuoles make their appearance in it; these increase in size and run one into the other, and may finally form one large cavity in the centre, which becomes filled with a watery fluid, known as the Cell Sap. This condition of the cell was the first observed, and it was it which suggested the often inapplicable term "cell." By the formation of this central sap cavity the surrounding protoplasm is pushed aside, and pressed against the cellulose wall, over which it now extends as a continuous layer. The nucleus either continues near the centre, enveloped by a layer of protoplasm, which is connected by radiating bands of protoplasm with that of the walls, or it accompanies the displaced protoplasm, and lies embedded in this on the walls of the cell.

We have abundant evidence to show that the imprisoned protoplasm loses none of its activity. The *Characeæ* constitute an exceedingly interesting group of simple plants, common in the clear water of ponds and of slowly-running streams. The cells of which they are built up are comparatively large, and, like almost all vegetable cells, are each inclosed in a wall of cellulose. The cellulose is perfectly transparent, and if the microscope, even with a low power, be brought to bear on one of these cells, a portion of its protoplasm may be seen in active rotation, flowing up one side of the long tubular cell and down the other, and sweeping on with it such more solid particles as may become enveloped in its current. In another water plant, the *Valisneria spiralis*, a similar active rotation of the protoplasm may be seen in the cells of the leaf, where the continuous stream of liquid protoplasm sweeping along the green granules of chlorophyll, and even carrying the globular nucleus with it in its current, presents one of the most beautiful of the many beautiful phenomena which the microscope has revealed to us.

In many other cells with large sap cavities, such as those which form the stinging hairs of nettles and other kinds of vegetable hairs, the protoplasmic lining of the wall may send off into the sap cavity projecting ridges and strings, forming an irregular network, along which, under a high power of the microscope, a slow streaming of granules may be witnessed. The form and position of this protoplasmic network undergo constant changes, and the analogy with the changes of form in an *Amœba* becomes obvious. The external wall of cellulose renders it impossible for the confined protoplasm to emit, like a naked *Amœba*, pseudopodia from its outer side; but on the inner side there is no obstacle to the extension of the protoplasm, and here the cavity of the cell becomes more or less completely traversed by protoplasmic projections from the wall. These often stretch themselves out in the form of thin filaments, which, meeting with a neighbouring one, become fused into it; they show currents of granules streaming along their length, and after a time become withdrawn and disappear. The vegetable cell, in short, with its surrounding wall of cellulose, is in all essential points a closely imprisoned Rhizopod.

Further proof that the imprisoned protoplasm has lost by its imprisonment none of its essential irritability, is afforded by the fact that if the transparent cell of a Nitella, one of the simple water plants just referred to, be touched under the microscope with the point of a blunt needle, its green protoplasm will be seen to recede, under the irritation of the needle, from the cellulose wall. If the cellulose wall of the comparatively large cell which forms the entire plant in a Vaucheria, a unicellular alga, very common in shallow ditches, be ruptured under the microscope, its protoplasm will escape, and may then be often seen to throw out pseudopodial projections and exhibit amœboid movements.

Even in the higher plants, without adducing such obvious and well-known instances as those of the Sensitive Plant and Venus's Flytrap, the irritability of the protoplasm may be easily rendered manifest. There are many herbaceous plants in which if the young succulent stem of a vigorously growing specimen receive a sharp blow, of such a nature, however, as not to bruise its tissues, or in any way wound it, the blow will sometimes be immediately followed by a drooping of the stem commencing at some distance above the point to which the stroke had been applied; its strength appears to have here suddenly left it, it is no longer able to bear its own weight, and seems to be dying. The protoplasm, however, of its cells, is in this instance not killed, it is only stunned by the violence of the blow, and needs time for its restoration. After remaining, it may be for some hours, in this drooping and flaccid state, the stem begins to raise itself, and soon regains its original vigour. This experiment will generally succeed well in plants with a rather large terminal spike or raceme when the stroke is applied some little distance below the inflorescence shortly before the expansion of the flower.

[1] "Ueber die Verdauungsorgane einiger Süsswasser-Turbellarien," *Zoologischer Anzeiger*, December, 1878.

In the several instances now adduced the protoplasm is in the mature state of the plant entirely included within a wall of cellulose. Some recent beautiful observations, however, of Mr. Francis Darwin have shown that even in the higher plants truly naked protoplasm may occur. From the cells of certain glandular hairs contained within the cup-like receptacles formed by the united bases of two opposite leaves in the Teazel (*Dipsacus*) he has seen emitted long pseudopodia-like projections of the protoplasm. What may be the significance of this very exceptional phenomenon is still undetermined. It is probably as Mr. Darwin supposes connected with the absorption of nitrogenous matter.

That there is no essential difference between the protoplasm of plants and that of animals is rendered further evident by other motor phenomena, which we are in the habit of regarding as the exclusive attribute of animals. Many of the more simply organised plants give origin to peculiar cells called spores, which separate from the parent, and, like the seeds of the higher plants, are destined to repeat its form. In many cases these spores are eminently locomotive. They are then termed "swarm-spores," and their movements are brought about, sometimes by changes of shape, when they move about in the manner of an *Amœba*, but more frequently by minute vibratile cilia, or by more strongly developed flagella or whip-like projections of their protoplasm. These cilia and flagella are absolutely indistinguishable from similar structures widely distributed among animals, and by their vibratory or lashing strokes upon the surrounding water the swarm-spores are rapidly carried from place to place. In these motions they often present a curious semblance of volition, for if the swarm-spore meet with an obstacle in its course, it will, as if to avoid it, change the direction of its motion, and retreat by a reversion of the stroke of its cilia. They are usually attracted by light, and congregate at the light side of the vessel which contains them, though in some cases light has the opposite effect on them, and they recede from it.

Another fact may here be adduced to show the uniform character of protoplasm and how very different are its properties from those of lifeless matter, namely, the faculty which all living protoplasm possesses of resisting the entrance of colouring matter into its substance. As many here present are aware, microscopists are in the habit of using in their investigations various colouring matters, such as solutions of carmine. These act differently on the different tissues, staining some, for example, more deeply than others, and thus enabling the histologist to detect certain elements of structure, which would otherwise remain unknown. Now if a solution of carmine be brought into contact with living protoplasm, this will remain, so long as it continues alive, unaffected by the colouring matter. But if the protoplasm be killed, the carmine will at once pervade its whole substance, and stain it throughout with a colour more intense than even that of the colouring solution itself.

But no more illustrative example can be offered of the properties of protoplasm as living matter, independently of any part it may take in organisation, than that presented by the Myxomycetæ.

The Myxomycetæ constitute a group of remarkable organisms, which, from their comparatively large size and their consisting, during a great part of their lives, of naked protoplasm, have afforded a fine field for research, and have become one of the chief sources from which our knowledge of the nature and phenomena of protoplasm has been derived.

They have generally been associated by botanists with the fungi, but though their affinities with these are perhaps closer than with any other plants, they differ from them in so many points, especially in their development, as to render this association untenable. They are found in moist situations, growing on old tan or on moss, or decaying leaves or rotten wood, over which they spread in the form of a network of naked protoplasmic filaments, of a soft creamy consistence, and usually of a yellowish colour.

Under the microscope the filaments of the network exhibit active spontaneous movements, which, in the larger branches, are visible under an ordinary lens, or even by the naked eye. A succession of undulations may then be noticed passing along the course of the threads. Under higher magnifying powers a constant movement of granules may be seen flowing along the threads, and streaming from branch to branch of this wonderful network. Here and there off-shoots of the protoplasm are projected, and again withdrawn in the manner of the pseudopodia of an *Amœba*, while the whole organism may be occasionally seen to abandon the support over which it had grown, and to creep over neighbouring surfaces, thus far resembling in all respects a colossal ramified *Amœba*. It is also curiously sensitive to light, and may be sometimes found to have retreated during the day to the dark side of the leaves, or into the recesses of the tan over which it had been growing, and again to creep out on the approach of night.

After a time there arise from the surface of this protoplasmic net oval capsules or spore cases, in which are contained the spores or reproductive bodies of the Myxomycetæ. When the spore-case has arrived at maturity, it bursts and allows the spores to escape. These are in the form of spherical cells, each included in a delicate membranous wall, and when they fall into water the wall becomes ruptured, and the little cell creeps out. This consists of a little mass of protoplasm with a round central nucleus, inclosing a nucleolus, and with a clear vacuole, which exhibits a rhythmically pulsating movement. The little naked spore thus set at liberty is soon seen to be drawn out at one point into a long vibratile whip-like flagellum, which by its lashing action carries the spore from place to place. After a time the flagellum disappears, and the spore may now be seen emitting and withdrawing finger-like pseudopodia, by means of which it creeps about like an *Amœba*, and like an *Amœba* devours solid particles by engulfing them in its soft protoplasm.

So far these young *Amœba*-like Myxomycetæ have enjoyed each an independent existence. Now, however, a singular and significant phenomenon is presented. Two or more of these Myxamœbæ, as they have been called, approach one another, come into contact, and finally become completely fused together into a single mass of protoplasm, in which the components are no longer to be distinguished. To the body thus formed by the fusion of the Myxamœbæ the name of "plasmodium" has been given.

The plasmodium continues, like the simple amœbiform bodies of which it is composed, to grow by the ingestion and assimilation of solid nutriment, which it envelopes in its substance; it throws out ramifying and mosculating processes, and finally becomes converted into a protoplasmic network, which in its turn gives rise to spore-cases with their contained spores, and thus completes the cycle of its development.

Under certain external conditions, the Myxomycetæ have been observed to pass from an active mobile state into a resting state, and this may occur both in the amœbiform spores and in the plasmodium. When the plasmodium is about to pass into a resting state, it usually withdraws its finer branches, and expels such solid ingesta as may be included in it. Its motions then gradually cease, it breaks up into a multitude of polyhedral cells, which, however, remain connected, and the whole body dries into a horny brittle mass, known by the name of "sclerotium."

In this condition, without giving the slightest sign of life, the sclerotium may remain for many months. Life, however, is not destroyed, its manifestations are only suspended, and if after an indefinite time the apparently dead sclerotium be placed in water, it immediately begins to swell up, the membranous covering of its component cells becomes dissolved and disappears, and the cells themselves flow together into an active amœboid plasmodium.

We have already seen that every cell posseses an autonomy or independent individuality, and from this we should expect that, like all living beings it had the faculty of multiplying itself, and of becoming the parent of other cells. This is truly the case, and the process of cell-multiplication has of late years been studied, with the result of adding largely to our knowledge of the phenomena of life.

The labours of Strasburger, of Auerbach, of Oscar Hertwig, of Eduard van Beneden, Bütschli, Fol, and others, here come prominently before us, but neither the time at my disposal nor the purport of this address will allow me to do more than call your attention to some of the more striking results of their investigations.

By far the most frequent mode of multiplication among cells shows itself in a spontaneous division of the protoplasm into two separate portions, which then become independent of one another, so that instead of the single parent cell two new ones have made their appearance. In this process the nucleus usually takes an important part. Strasburger has studied it with great care in certain plant cells, such as the so-called "corpuscula" or "secondary embryo-sacs" of the Coniferæ and the cells of Spirogyra; and has further shown a close correspondence between cell division in animals and that in plants.

It may be generally stated as the results of his observations on the corpuscula of the Coniferæ, that the nucleus of the cell about to divide assumes a spindle shape, and at the same time presents a peculiar striated differentiation, as if it were composed of parallel filaments reaching from end to end of the spindle. These filaments become thickened in the middle, and there form by the approximation of the thickened portions a transverse plate of protoplasm (the "nucleus-plate"). This soon splits into two halves, which recede from one another towards the poles of the spindle, travelling in this course along the filaments, which remain continuous from end to end. When arrived near the poles they form there two new nuclei, still connected with one another by the intervening portion of the spindle.

In the equator of this intervening portion there is now formed in a similar way a second plate of protoplasm (the "cell-plate"), which, extending to the walls of the dividing cell, cuts the whole protoplasm into two halves, each half containing one of the newly-formed nuclei. This partition plate is at first single, but it soon splits into two laminæ, which become the apposed bounding surfaces of the two protoplasm masses into which the mother cell has been divided. A wall of cellulose is then all at once secerted between them, and the two daughter cells are complete.

It sometimes happens in the generation of cells that a young brood of cells arises from the parent cell by what is called "free cell formation." In this only a part of the protoplasm of the mother cell is used up in the production of the offspring. It is seen chiefly in the formation of the spores of the lower plants, in the first foundation of the embryo in the higher, and in the formation of the endosperm—a cellular mass which serves as the first nutriment for the embryo—in the seeds of most Phanerogams. The formation of the endosperm has been carefully studied by Strasburger in the embryo-sac of the kidney bean, and may serve as an example of the process of free cell formation. The embryo-sac is morphologically a large cell with its protoplasm, nucleus, and cellulose wall, while the endosperm which arises within it is composed of a multitude of minute cells united into a tissue. The formation of the endosperm is preceded by the dissolution and disappearance of the nucleus of the embryo-sac, and then in the midst of the protoplasm of the sac several new nuclei make their appearance. Around each of these as a centre the protoplasm of the mother cell is seen to have become differentiated in the form of a clear spherule, and we have thus corresponding to each of the new nuclei a young naked cell, which soon secretes over its surface a membrane of cellulose. The new cells, when once formed, multiply by division, press one on the other, and so combining into a cellular mass, constitute the completed endosperm.

Related to the formation of new cells, whether by division or by free cell formation, is another very interesting phenomenon of living protoplasm known as "rejuvenescence." In this the whole protoplasm of a cell, by a new arrangement of its parts, assumes a new shape and acquires new properties. It then abandons its cellulose chamber, and enters on a new and independent life in the surrounding medium.

A good example of this is afforded by the formation of swarm-spores in Œdogonium, one of the fresh-water algæ. Here the whole of the protoplasm of an adult cell contracts, and by the expulsion of its cell-sap changes from a cylindrical to a globular shape. Then one spot becomes clear, and a pencil of vibratile cilia here shows itself. The cellulose wall which had hitherto confined it now becomes ruptured, and the protoplasmic sphere, endowed with new faculties of development and with powers of active locomotion, escapes as a swarm-spore, which, after enjoying for a time the free life of an animal, comes to rest, and develops itself into a new plant.

The beautiful researches which have within the last few years been made by the observers already mentioned, on the division of animal cells, show how close is the agreement between plants and animals in all the leading phenomena of cell division, and afford one more proof of the essential unity of the two great organic kingdoms.

There is one form of cell which, in its relation to the organic world, possesses a significance beyond that of every other, namely, the egg. As already stated, the egg is, wherever it occurs, a typical cell, consisting essentially of a globule of protoplasm enveloping a nucleus (the "germinal vesicle"), and with one or more nucleoli (the "germinal spots") in the interior of the nucleus. This cell, distinguishable by no tangible characters from thousands of other cells, is nevertheless destined to run through a definite series of developmental changes, which have as their end the building up of an organism like that to which the egg owes its origin.

It is obvious that such complex organisms as thus result—composed, it may be, of countless millions of cells—can be derived from the simple egg cell only by a process of cell multiplication. The birth of new cells derived from the primary cell or egg thus lies as the basis of embryonic development. It is here that the phenomena of cell multiplication in the animal kingdom can in general be most satisfactorily observed, and the greater number of recent researches into the nature of these phenomena have found their most fertile field in the early periods of the development of the egg.

A discussion of the still earlier changes which the egg undergoes in order to bring it into the condition in which cell multiplication may be possible, would, however full of interest, be here out of place; and I shall therefore confine myself to the first moments of actual development—to what is called "the cleavage of the egg"—which is nothing more than a multiplication of the egg cell by repeated division. I shall further confine myself to an account of this phenomenon as presented in typical cases, leaving out of consideration certain modifications which would only complicate and obscure our picture.

The egg, notwithstanding the preliminary changes to which I have alluded, is still at the commencement of development, a true cell. It has its protoplasm and its nucleus, and it is, as a rule, enveloped in a delicate membrane. The protoplasm forms what is known as the vitellus, or yolk, and the surrounding membrane is callled the "vitellary membrane." The division which is now about to take place in it is introduced by a change of form in the nucleus. This becomes elongated, and assumes the shape of a spindle, similar to what we have already seen in the cell-division of plants. On each pole of the spindle transparent protoplasm collects, forming here a clear spherical area.

At this time a very striking and characteristic phenomenon is witnessed in the egg. Each pole of the spindle has become the centre of a system of rays which stream out in all directions into the surrounding protoplasm. The protoplasm thus shows, enveloped in its mass, two sun-like figures, whose centres are connected to one another by the spindle-shaped nucleus. To this, with the sun-like rays streaming from its poles, Auerbach gives the name of "Karyolitic figure," suggested by its connection with the breaking up of the original nucleus, to which our attention must next be directed.

A phenomenon similar to one we have already seen in cell-division among plants now shows itself. The nucleus becomes broken up into a number of filaments, which lie together in a bundle, each filament stretching from pole to pole of the spindle. Exactly in its central point every filament shows a knot-like enlargement, and from the close approximation of the knots there results a thick zone of protoplasm in the equator of the spindle. Each knot soon divides into two halves, and each half recedes from the equator and travels along the filament towards its extremity. When arrived at the poles of the spindle each set of half knots becomes fused together into a globular body, while the intervening portion of the spindle, becoming torn up, and gradually drawn into the substance of the two globular masses, finally disappears. And now, instead of the single fusiform nucleus whose changes we have been tracing, we have two new globular nuclei, each occupying the place of one of its poles, and formed at its expense.[1] The egg now begins to divide along

[1] Though none of the above-mentioned observers to whom we owe our knowledge of the phenomena here described seem to have thought of connecting the fibrous condition assumed by the spindle with any special structure of the quiescent nucleus, it is highly probable that it consists in a rearrangement of fibres already present. That this is really the case is borne out by the observations of Schleicher on the division of cartilage cells. ("Die Knorpelzelltheilung," *Arch. für mikr. Anat.*, Band xvi. Heft 2, 1878.) From these it would appear that in the division of cartilage cells the investing membrane of the nucleus first becomes torn up, and then the filaments, rodlets, and granules, which, according to him, form its body, enter into a state of intense motor activity, and may be seen arranging themselves into star-like, or wreath-like, or irregular figures, while the whole nucleus, now deprived of its membrane, may wander about the cell, travelling towards one of its poles, and then towards the other; or it may at one time contract, and then again dilate, to such an extent as nearly to fill the entire cell. To this nuclear activity Schleicher applies the term "Karyokinesis." It results in a nearly parallel arrangement of the nuclear filaments. Then these converge at their extremities and become more widely separated in the middle, so as to give to the nucleus the form of a spindle. The filaments then become fused together at each pole of the spindle, so as to form the two new nuclei, which are at first nearly homogeneous, but which afterwards become broken up into their component filaments, rods, and granules.

a plane at right angles to a line connecting the two nuclei. The division takes place without the formation of a cell plate such as we saw in the division of the plant cell, and is introduced by a constriction of its protoplasm, which commences at the circumference just within the vitelline membrane, and extending towards the centre, divides the whole mass of protoplasm into two halves, each including within it one of the new nuclei. Thus the simple cell which constituted the condition of the egg at the commencement of development becomes divided into two similar cells. This forms the first stage of cleavage. Each of these two young cells divides in its turn in a direction at right angles to the first division-plane, while by continued repetition of the same act the whole of the protoplasm or yolk becomes broken up into a vast multitude of cells, and the unicellular organism—the egg, with which we began our history—has become converted into an organism composed of many thousands of cells. This is one of the most widely distributed phenomena of the organic world. It is called "the cleavage of the egg," and consists essentially in the production, by division, of successive broods of cells from a single ancestral cell—the egg.

It is no part of my purpose to carry on the phenomena of development further than this. Such of my hearers as may desire to become acquainted with the further history of the embryo, I would refer to the excellent address delivered two years ago at the Plymouth meeting of the Association by one of my predecessors in this chair—Prof. Allen Thompson.

That protoplasm, however, may present a phenomenon the reverse of that in which a simple cell becomes multiplied into many, is shown by a phenomenon already referred to—the production of plasmodia in the Myxomycetæ by the fusion into one another of cells originally distinct.

The genus *Myriothela* will afford another example in which the formation of plasmodia becomes introduced into the cycle of development. The primitive eggs are here, as elsewhere, true cells with nucleolated nuclei, but without any boundary membrane. They are formed in considerable numbers, but remain only for a short time separate and distinct. After this they begin to exhibit amœboid changes of shape, project pseudopodial prolongations which coalesce with those of others in their vicinity, and finally a multitude of these primitive ova become fused together into a common plasmodium, in which, as in the simple egg cell of other animals, the phenomena of development take place.

In many of the lower plants a very similar coalescence is known to take place between the protoplasmic bodies of separate cells, and constitutes the phenomenon of conjugation. *Spirogyra* is a genus of Algæ, consisting of long green threads common in ponds. Every thread is composed of a series of cylindrical chambers of transparent cellulose placed end to end, each containing a sac of protoplasm with a large quantity of cell sap, and with a green band of chlorophyll wound spirally on its walls. When the threads have attained their full growth they approach one another in pairs, and lie in close proximity, parallel one to the other. A communication is then established by means of short connecting tubes between the chambers of adjacent filaments, and across the channel thus formed the whole of the protoplasm of one of the conjugating chambers passes into the cavity of the other, and then immediately fuses with the protoplasm it finds there. The single mass thus formed shapes itself into a solid oval body, known as a "zygospore." This now frees itself from the filament, secretes over its naked surface a new wall of cellulose, and, when placed in the conditions necessary for its development, attaches itself by one end, and then, by repeated acts of cell division, grows into a many-celled filament like those in which it originated.

The formation of plasmodia, regarded as a coalescence and absolute fusion into one another of separate naked masses of protoplasm, is a phenomenon of great significance. It is highly probable that, notwithstanding the complete loss of individuality in the combining elements, such differences as may have been present in these will always find itself expressed in the properties of the resulting plasmodia—a fact of great importance in its bearing on the phenomena of inheritance. Recent researches, indeed, render it almost certain that fertilisation, whether in the animal or the vegetable kingdom, consists essentially in the coalescence and consequent loss of individuality of the protoplasmic contents of two cells.

In by far the greater number of plants the protoplasm of most of the cells which are exposed to the sunlight undergoes a curious and important differentiation, part of it becoming separated from the remainder in the form usually of green granules, known as chlorophyll granules. The chlorophyll granules thus consist of true protoplasm, their colour being due to the presence of a green colouring matter, which may be extracted, leaving behind the colourless protoplasmic base.

The colouring matter of chlorophyll presents under the spectroscope a very characteristic spectrum. For our knowledge of its optical properties, on which time will not now permit me to dwell, we are mainly indebted to the researches of your townsman, Dr. Sorby, who has made these the subject of a series of elaborate investigations, which have contributed largely to the advancement of an important department of physical science.

That the chlorophyll is a living substance, like the uncoloured protoplasm of the cell, is sufficiently obvious. When once formed, the chlorophyll granule may grow by intussusception of nutriment to many times its original size, and may multiply itself by division.

To the presence of chlorophyll is due one of the most striking aspects of external nature—the green colour of the vegetation which clothes the surface of the earth; and with its formation is introduced a function of fundamental importance in the economy of plants, for it is on the cells which contain this substance that devolves the faculty of decomposing carbonic acid. On this depends the assimilation of plants, a process which becomes manifest externally by the exhalation of oxygen. Now it is under the influence of light on the chlorophyll-containing cells that this evolution of oxygen is brought about. The recent observations of Draper and of Pfeffer have shown that in this action the solar spectrum is not equally effective in all its parts; that the yellow and least refrangible rays are those which act with most intensity; that the violet and other highly refrangible rays of the visible spectrum take but a very subordinate part in assimilation; and that the invisible rays which lie beyond the violet are totally inoperative.

In almost every grain of chlorophyll one or more starch granules may be seen. This starch is chemically isomeric with the cellulose cell wall, with woody fibre, and other hard parts of plants, and is one of the most important products of assimilation. When plants whose chlorophyll contains starch are left for a sufficient time in darkness, the starch is absorbed and completely disappears; but when they are restored to the light the starch reappears in the chlorophyll of the cells.

With this dependence of assimilation on the presence of chlorophyll a new physiological division of labour is introduced into the life of plants. In the higher plants, while the work of assimilation is allocated to the chlorophyll-containing cells, that of cell division and growth devolves on another set of cells, which, lying deeper in the plant, are removed from the direct action of light, and in which chlorophyll is therefore never produced. In certain lower plants, in consequence of their simplicity of structure and the fact that all the cells are equally exposed to the influence of light, this physiological division of labour shows itself in a somewhat different fashion. Thus in some of the simple green algæ, such as *Spirogyra* and *Hydrodictyon*, assimilation takes place as in other cases during the day, while their cell division and growth takes place chiefly, if not exclusively, at night. Strasburger, in his remarkable observations on cell divisions in *Spirogyra*, was obliged to adopt an artificial device in order to compel the *Spirogyra* to postpone the division of its cells to the morning.

Here the functions of assimilation and growth devolve on one and the same cell, but while one of these functions is exercised only during the day, the time for the other is the night. It seems impossible for the same cell at the same time to exercise both functions, and these are here accordingly divided between different periods of the twenty-four hours.

The action of chlorophyll in bringing about the decomposition of carbonic acid is not, as was recently believed, absolutely confined to plants. In some of the lower animals, such as *Stentor* and other infusoria, the Green Hydra, and certain green planariæ and other worms, chlorophyll is differentiated in their protoplasm, and probably always acts here under the influence of light exactly as in plants.

Indeed, it has been proved[1] by some recent researches of Mr. Geddes, that the green planarias when placed in water and exposed to the sunlight give out bubbles of gas which contain from 44 to 55 per cent. of oxygen. Mr. Geddes has further shown that these animals contain granules of starch in their tissues, and

[1] "Sur la Fonction de la Chlorophyll dans les Planaires vertes," *Comptes Rendus*, December, 1878.

in this fact we have another striking point of resemblance between them and plants.

A similar approximation of the two organic kingdoms has been shown by the beautiful researches of Mr. Darwin—confirmed and extended by his son, Mr. Francis Darwin—on Drosera and other so-called carnivorous plants. These researches, as is now well known, have shown that in all carnivorous plants there is a mechanism fitted for the capture of living prey, and that the animal matter of the prey is absorbed by the plant after having been digested by a secretion which acts like the gastric juice of animals.

Again, Nägeli has recently shown [1] that the cell of the yeast fungus contains about 2 per cent. of peptine, a substance hitherto known only as a product of the digestion of azotised matter by animals.

Indeed, all recent research has been bringing out in a more and more decisive manner the fact that there is no dualism in life,—that the life of the animal and the life of the plant are, like their protoplasm, in all essential points identical.

But there is, perhaps, nothing which shows more strikingly the identity of the protoplasm in plants and animals, and the absence of any deep-pervading difference between the life of the animal and that of the plant, than the fact that plants may be placed, just like animals, under the influence of anæsthetics.

When the vapour of chloroform or of ether is inhaled by the human subject, it passes into the lungs, where it is absorbed by the blood, and thence carried by the circulation to all the tissues of the body. The first to be affected by it is the delicate nervous element of the brain, and loss of consciousness is the result. If the action of the anæsthetic be continued, all the other tissues are in their turn attacked by it and their irritability arrested. A set of phenomena entirely parallel to these may be presented by plants.

We owe to Claude Bernard a series of interesting and most instructive experiments on the action of ether and chloroform on plants. He exposed to the vapour of ether a healthy and vigorous sensitive plant, by confining it under a bell-glass into which he introduced a sponge filled with ether. At the end of half an hour the plant was in a state of anæsthesia, all its leaflets remained fully extended, but they showed no tendency to shrink when touched. It was then withdrawn from the influence of the ether, when it gradually recovered its irritability, and finally responded, as before, to the touch.

It is obvious that the irritability of the protoplasm was here arrested by the anæsthetic, so that the plant became unable to give a response to the action of an external stimulus.

It is not, however, the irritability of the protoplasm of only the motor elements of plants that anæsthetics are capable of arresting. These may act also on the protoplasm of those cells whose function lies in chemical synthesis, such as is manifestsd in the phenomena of the germination of the seed and in nutrition generally, and Claude Bernard has shown that germination is suspended by the action of ether or chloroform.

Seeds of cress, a plant whose germination is very rapid, were placed in conditions favourable to a speedy germination, and while thus placed were exposed to the vapour of ether. The germination, which would otherwise have shown itself by the next day, was arrested. For five or six days the seeds were kept under the influence of the ether, and showed during this time no disposition to germinate. They were not killed, however, they only slept, for on the substitution of common air for the etherised air with which they had been surrounded, germination at once set in and proceeded with activity.

Experiments were also made on that function of plants by which they absorb carbonic acid and exhale oxygen, and which, as we have already seen, is carried on through the agency of the green protoplasm or chlorophyll, under the influence of light —a function which is commonly, but erroneously, called the respiration of plants.

Aquatic plants afford the most convenient subjects for such experiments. If one of these be placed in a jar of water holding ether or chloroform in solution, and a bell-glass be placed over the submerged plant, we shall find that the plant no longer absorbs carbonic acid or emits oxygen. It remains, however, quite green and healthy. In order to awaken the plant, it is only necessary to place it in non-etherised water, when it will begin once more to absorb carbonic acid, and exhale oxygen under the influence of sunlight.

[1] "Ueber die chemische Zusammensetzung der Hefe," *Sitzungsbericht der math. phys. Classe der k.k. Akad. der Wissens. zu München*, 1878.

The same great physiologist has also investigated the action of anæsthetics on fermentation. It is well known that alcoholic fermentation is due to the presence of a minute fungus, the yeast fungus, the living protoplasm of whose cells has the property of separating solutions of sugar into alcohol, which remains in the liquid, and carbonic acid, which escapes into the air.

Now, if the yeast plant be placed along with sugar in etherised water it will no longer act as a ferment. It is anæsthesiated, and cannot respond to the stimulus which, under ordinary circumstances, it would find in the presence of the sugar. If, now, it be placed on a filter, and the ether washed completely away, it will, on restoration to a saccharine liquid, soon resume its duty of separating the sugar into alcohol and carbonic acid.

Claude Bernard has further called attention to a very significant fact which is observable in this experiment. While the proper alcoholic fermentation is entirely arrested by the etherisation of the yeast plant, there still goes on in the saccharine solution a curious chemical change, the cane sugar of the solution being converted into grape sugar, a substance identical in its chemical composition with the cane sugar, but different in its molecular constitution. Now it is well known from the researches of Bertholet that this conversion of cane sugar into grape sugar is due to a peculiar inversive ferment, which, while it accompanies the living yeast plant, is itself soluble and destitute of life. Indeed it has been shown that in its natural conditions the yeast fungus is unable of itself to assimilate cane sugar, and that in order that this may be brought into a state fitted for the nutrition of the fungus, it must be first digested and converted into grape sugar, exactly as happens in our own digestive organs. To quote Claude Bernard's graphic account:—

"The fungus ferment has thus beside it in the same yeast a sort of servant given by nature to effect this digestion. The servant is the unorganised inversive ferment. This ferment is soluble, and as it is not a plant, but an unorganised body destitute of sensibility, it has not gone to sleep under the action of the ether, and thus continues to fulfil its task."

In the experiment already recorded on the germination of seeds the interest is by no means confined to that which attaches itself to the arrest of the organising functions of the seed, those namely which manifest themselves in the development of the radicle and plumule and other organs of the young plant. Another phenomenon of great significance becomes at the same time apparent—the anæsthetic exerts no action on the concomitant chemical phenomena which in germinating seeds show themselves in the transformation of starch into sugar under the influence of diastase (a soluble and non-living ferment which also exists in the seed), and the absorption of oxygen with the exhalation of carbonic acid. These go on as usual, the anæsthesiated seed continuing to respire, as proved by the accumulation of carbonic acid in the surrounding air. The presence of the carbonic acid was rendered evident by placing in the same vessel with the seeds which were the object of the experiment, a solution of barytes, when the carbonate became precipitated from the solution in quantity equal to that produced in a similar experiment with seeds germinating in unetherised air.

So, also in the experiment which proves the faculty possessed by the chlorophyllian cells of absorbing carbonic acid and exhaling oxygen under the influence of light may be arrested by anæsthetics, it could be seen that the plant, while in a state of anæsthesia, continued to respire in the manner of animals; that is, it continued to absorb oxygen and exhale carbonic acid. This is the true respiratory function which was previously masked by the predominant function of assimilation, which devolves on the green cells of plants, and which manifests itself under the influence of light in the absorption of carbonic acid and the exhalation of oxygen.

It must not, however, be supposed that the respiration of plants is entirely independent of life. The conditions which bring the oxygen of the air and the combustible matter of the respiring plant into such relations as may allow them to act on one another are still under its control, and we must conclude that in Claude Bernard's experiment the anæsthesia had not been carried so far as to arrest such properties of the living tissues as are needed for this.

The quite recent researches of Schützenberger, who has investigated the process of respiration as it takes place in the cell of the yeast fungus, have shown that vitality is a factor in this process. He has shown that fresh yeast, placed in water, breathes like an aquatic animal, disengaging carbonic acid, and causing the oxygen contained in the water to disappear. That this phenomenon is a function of the living cell is proved by the fact that, if the yeast be first heated to 60° C. and then placed in the oxygenated water, the quantity of oxygen in the water remains unchanged; in other words, the yeast ceases to breathe.

Schützenberger has further shown that light exerts no influence on the respiration of the yeast cell—that the absorption of oxygen by the cell takes place in the dark exactly as in sunlight. On the other hand, the influence of temperature is well marked. Respiration is almost entirely arrested at temperatures below 10° C., it reaches its maximum at about 40° C., while at 60° C. it again ceases.

All this proves that the respiration of living beings is identical, whether manifested in the plant or in the animal. It is essentially a destructive phenomenon—as much so as the burning of a piece of charcoal in the open air, and, like it, is characterised by the disappearance of oxygen and the formation of carbonic acid.

One of the most valuable results of the recent careful application of the experimental method of research to the life phenomena of plants is thus the complete demolition of the supposed antagonism between respiration in plants and that in animals.

I have thus endeavoured to give you in a few broad outlines a sketch of the nature and properties of one special modification of matter, which will yield to none other in the interest which attaches to its study, and in the importance of the part allocated to it in the economy of nature. Did the occasion permit I might have entered into many details which I have left untouched; but enough has been said to convince you that in protoplasm we find the only form of matter in which life can manifest itself; and that, though the outer conditions of life—heat, air, water, food—may all be present, protoplasm would still be needed, in order that these conditions may be utilised, in order that the energy of lifeless nature may be converted into that of the countless multitudes of animal and vegetable forms which dwell upon the surface of the earth or people the great depths of its seas.

We are thus led to the conception of an essential unity in the two great kingdoms of organic Nature—a structural unity, in the fact that every living being has protoplasm as the essential matter of every living element of its structure; and a physiological unity, in the universal attribute of irritability which has its seat in this same protoplasm, and is the prime mover of every phenomenon of life.

We have seen how little mere form has to do with the essential properties of protoplasm. This may shape itself into cells, and the cells may combine into organs in ever-increasing complexity, and protoplasm force may be thus intensified, and, by the mechanism of organisation, turned to the best possible account; but we must still go back to protoplasm as a naked formless plasma if we would find—freed from all non-essential complications—the agent to which has been assigned the duty of building up structure and of transforming the energy of lifeless matter into that of living.

To suppose, however, that all protoplasm is identical where no difference cognisable by any means at our disposal can be detected would be an error. Of two particles of protoplasm, between which we may defy all the power of the microscope, all the resources of the laboratory, to detect a difference, one can develop only to a jelly-fish, the other only to a man, and one conclusion alone is here possible—that deep within them there must be a fundamental difference which thus determines their inevitable destiny, but of which we know nothing, and can assert nothing beyond the statement that it must depend on their hidden molecular constitution.

In the molecular condition of protoplasm there is probably as much complexity as in the disposition of organs in the most highly differentiated organisms; and between two masses of protoplasm indistinguishable from one another there may be as much molecular difference as there is between the form and arrangement of organs in the most widely separated animals or plants.

Herein lies the many-sidedness of protoplasm; herein lies its significance as the basis of all morphological expression, as the agent of all physiological work, while in all this there must be an adaptiveness to purpose as great as any claimed for the most complicated organism.

From the facts which have been now brought to your notice there is but one legitimate conclusion—that life is a property of protoplasm. In this assertion there is nothing that need startle us. The essential phenomena of living beings are not so widely separated from the phenomena of lifeless matter as to render it impossible to recognise an analogy between them; for even irritability, the one grand character of all living beings, is not more difficult to be conceived of as a property of matter than the physical phenomena of radial energy.

It is quite true that between lifeless and living matter there is a vast difference, a difference greater far than any which can be found between the most diverse manifestations of lifeless matter. Though the refined synthesis of modern chemistry may have succeeded in forming a few principles which until lately had been deemed the proper product of vitality, the fact still remains that no one has ever yet built up one particle of living matter out of lifeless elements—that every living creature, from the simplest dweller on the confines of organisation up to the highest and most complex organism, has its origin in pre-existent living matter—that the protoplasm of to-day is but the continuation of the protoplasm of other ages, handed down to us through periods of indefinable and indeterminable time.

Yet with all this, vast as the differences may be, there is nothing which precludes a comparison of the properties of living matter with those of lifeless.

When, however, we say that life is a property of protoplasm, we assert as much as we are justified in doing. Here we stand upon the boundary between life in its proper conception, as a group of phenomena having irritability as their common bond, and that other and higher group of phenomena which we designate as consciousness or thought, and which, however intimately connected with those of life, are yet essentially distinct from them.

When the heart of a recently-killed frog is separated from its body and touched with the point of a needle, it begins to beat under the excitation of the stimulus, and we believe ourselves justified in referring the contraction of the cardiac fibres to the irritability of their protoplasm as its proper cause. We see in it a remarkable phenomenon, but one nevertheless in which we can see unmistakable analogies with phenomena purely physical. There is no greater difficulty in conceiving of contractility as a property of protoplasm than there is of conceiving of attraction as a property of the magnet.

When a thought passes through the mind, it is associated, as we have now abundant reason for believing, with some change in the protoplasm of the cerebral cells. Are we, therefore, justified in regarding thought as a property of the protoplasm of these cells, in the sense in which we regard muscular contraction as a property of the protoplasm of muscle? or is it really a property residing in something far different, but which may yet need for its manifestation the activity of cerebral protoplasm?

If we could see any analogy between thought and any one of the admitted phenomena of matter, we should be justified in accepting the first of these conclusions as the simplest, and as affording a hypothesis most in accordance with the comprehensiveness of natural laws; but between thought and the physical phenomena of matter there is not only no analogy, but there is no conceivable analogy; and the obvious and continuous path which we have hitherto followed up in our reasonings from the phenomena of lifeless matter through those of living matter here comes suddenly to an end. The chasm between unconscious life and thought is deep and impassable, and no transitional phenomena can be found by which as by a bridge we may span it over; for even from irritability, to which, on a superficial view, consciousness may seem related, it is as absolutely distinct as it is from any of the ordinary phenomena of matter.

It has been argued that because physiological activity must be a property of every living cell, psychical activity must be equally so, and the language of the metaphysician has been carried into biology, and the "cell soul" spoken of as a conception inseparable from that of life.

That psychical phenomena, however, characterised as they essentially are by consciousness, are not necessarily coextensive with those of life, there cannot be a doubt. How far back in the scale of life consciousness may exist we have as yet no means of determining, nor is it necessary for our argument that we should. Certain it is that many things, to all appearance the result of volition, are capable of being explained as absolutely unconscious acts; and when the swimming swarm-spore of an alga avoids collision, and, by a reversal of the stroke of its cilia, backs from an obstacle lying in its course, there is almost certainly in all this nothing but a purely unconscious act. It is but a case in which we find expressed the great law of the adaptation of living beings to the conditions which surround them. The irritability of the protoplasm of the ciliated spore responding to an external stimulus sets in motion a mechanism derived by inheritance from its ancestors, and whose parts are correlated to a common end—the preservation of the individual.

But even admitting that every living cell were a conscious and thinking being, are we therefore justified in asserting that its consciousness, like its irritability, is a property of the matter of which it is composed? The sole argument on which this view is made to rest is that from analogy. It is argued that because the life phenomena, which are invariably found in the cell, must be regarded as a property of the cell, the phenomena of consciousness by which they are accompanied must be also so regarded. The weak point in the argument is the absence of all analogy between the things compared, and as the conclusion rests solely on the argument from analogy, the two must fall to the ground together.

In a lecture[1] to which I once had the pleasure of listening—a lecture characterised no less by lucid exposition than by the fascinating form in which its facts were presented to the hearers, Prof. Huxley argues that no difference, however great, between the phenomena of living matter and those of the lifeless elements of which this matter is composed should militate against our attributing to protoplasm the phenomena of life as properties essentially inherent in it; since we know that the result of a chemical combination of physical elements may exhibit physical properties totally different from those of the elements combined; the physical phenomena presented by water, for example, having no resemblance to those of its combining elements, oxygen and hydrogen.

I believe that Prof. Huxley intended to apply this argument only to the phenomena of life in the stricter sense of the word. As such it is conclusive. But when it is pushed further, and extended to the phenomena of consciousness, it loses all its force. The analogy, perfectly valid in the former case, here fails. The properties of the chemical compound are like those of its components, still physical properties. They come within the wide category of the universally accepted properties of matter, while those of consciousness belong to a category absolutely distinct—one which presents not a trace of a connection with any of those which physicists have agreed in assigning to matter as its proper characteristics. The argument thus breaks down, for its force depends on analogy alone, and here all analogy vanishes.

That consciousness is never manifested except in the presence of cerebral matter or of something like it, there cannot be a question; but this is a very different thing from its being a property of such matter in the sense in which polarity is a property of the magnet, or irritability of protoplasm. The generation of the rays which lie invisible beyond the violet in the spectrum of the sun cannot be regarded as a property of the medium which by changing their refrangibility can alone render them apparent.

I know that there is a special charm in those broad generalisations which would refer many very different phenomena to a common source. But in this very charm there is undoubtedly a danger, and we must be all the more careful lest it should exert an influence in arresting the progress of truth, just as at an earlier period traditional beliefs exerted an authority from which the mind but slowly and with difficulty succeeded in emancipating itself.

But have we, it may be asked, made in all this one step forward towards an explanation of the phenomena of consciousness or the discovery of its source? Assuredly not. The power of conceiving of a substance different from that of matter is still beyond the limits of human intelligence, and the physical or objective conditions which are the concomitants of thought, are the only ones of which it is possible to know anything, and the only ones whose study is of value.

We are not, however, on that account forced to the conclusion that there is nothing in the universe but matter and force. The simplest physical law is absolutely inconceivable by the highest of the brutes, and no one would be justified in assuming that man had already attained the limit of his powers. Whatever may be that mysterious bond which connects organisation with psychical endowments, the one grand fact—a fact of inestimable importance—stands out clear and freed from all obscurity and doubt, that from the first dawn of intelligence there is with every advance in organisation a corresponding advance in mind. Mind as well as body is thus travelling onwards through higher and still higher phases; the great law of Evolution is shaping the destiny of our race; and though now we may at most but indicate some weak point in the generalisation which would refer consciousness as well as life to a common material source, who can say that in the far off future there may not yet be evolved other and higher faculties from which light may stream in upon the darkness, and reveal to man the great mystery of Thought?

1 "The Physical Basis of Life" (see "Essays and Reviews," by T. H. Huxley).

SECTION D

BIOLOGY

OPENING ADDRESS BY PROF. ST. GEORGE MIVART, F.R.S., SEC.L.S., V.P.Z.S., PRESIDENT OF THE SECTION

IN responding to the honour which the authorities of the British Association have conferred in nominating me to fill this chair, I have deemed it best not to occupy your very valuable time with any matter of detail at which I may happen to have worked, but rather to offer to you a few remarks on questions which seem to me to have a general biological interest.

Last year my esteemed friend, Prof. Flower, called your attention to the great name of LINNÆUS. I propose this year to refer to Linnæus's illustrious contemporary, BUFFON—not, however, in the character of a rival of Linnæus. Each was a man of genius, each did good work in his own way—work still bringing forth fruit. It must be admitted, however, that they were men of a very different stamp, and if it is necessary to express a relative judgment with respect to them, I should myself feel inclined to say that Buffon's mind had the greater aptitude for sagacious speculation, with an inferior power of acquiring and arranging a knowledge of facts of structure.

Various circumstances have concurred to favour our recollection of the merits of the great Swede, and to obscure those of the French naturalist. The well-earned fame of Linnæus is kept ever fresh in our memories by the necessarily frequent references to him in matters of nomenclature. On the other hand, not only are Buffon's claims on our esteem in no similar way brought before us, but those very speculative opinions of his, which are a merit in our eyes, have gained him disfavour with our immediate predecessors, whose opinions and sentiments we more or less inherit.

No one, however, can dispute Buffon's title to our grateful respect on account of the very powerful effect his writings had in stimulating men's love of nature, an effect which I think is not sufficiently appreciated.

It is fitting that I should call attention to his (once generally recognised) claims in this respect; since my own love of natural history is probably due to the circumstance that his great work was always accessible to me in my childhood, and was one of the earliest books with the pictures of which I was familiar.

Buffon was indeed Linnæus's contemporary, for the same year (1707) saw the births of both. In 1733 he was elected a member of the Academy of Sciences, and six years later was appointed superintendent of the Jardin du Roi,[1] which was the occasion of that work to which he is indebted for his fame, and to perfect which he displayed so much zeal in collecting specimens and in obtaining information respecting the various kinds of animals with which he became acquainted. His "Histoire Naturelle générale et particulière" began to appear in 1749, and in 1767 was published the fifteenth volume, which closed his history of mammals. Herein are contained those numerous anatomical illustrations (due, with their accompanying descriptions, to Daubenton) which have been again and again copied down to the present time. Next came nine volumes on birds, then his history of minerals, and, finally, seven supplementary volumes, the last of which appeared in 1789, the year after his death. His life was thus prolonged ten years beyond that of his illustrious contemporary, Linnæus.

Buffon can claim no merit as a classifier. With the exception of the Apes of the old and new worlds (which respectively fill the fourteenth and fifteenth volumes of his work), the beasts treated of are hardly arranged on any system, beyond that of beginning with the best known and most familiar—a system necessarily applicable to but a few forms.

1 The Jardin du Roi was first instituted by Louis XIII. in 1628, and definitively established in 1635. It cannot be affirmed that Buffon enriched the incipient museum—the Cabinet du Roi—so much as might have been expected; although the skeletons which served for Daubenton's descriptions were, at least in many instances, preserved. It is to Geoffroy St. Hilaire that the magnificent museum of the Jardin des Plantes, which now exists, is most indebted.

But Buffon deliberately rejected the Linnæan classification—a grave error, certainly, yet one not altogether without excuse. Indeed, some of the objections he brought against that classification have considerable force. Such were his objections to the association of the hippopotamus, the shrew-mouse, and the horse in one order, and of the monkey and the manis in another.[1] What indeed could be more preposterous than the separation of the bat, *Noctilio leporinus*, from the other bats, and its association with the rodents, on the ground of its having (as supposed) only two incisor teeth above and two below?—an anomaly of arrangement of which you were reminded last year. It scarcely seems possible for the pedantry of classification to go farther than this. Yet, perhaps, the association in one group of the walrus, the elephant, the ant-eater, the sloth, and the manatee, was hardly less unphilosophical. Moreover, zoologists should not forget, in blaming Buffon for his want of appreciation of the classification of Linnæus, that one great portion of that classification—the classification of plants—has been superseded by us. Had he lived to witness the publication of Jussieu's "Genera Plantarum,"[2] it might have given him a truer insight into biological classification, and have led him to endeavour to improve on Linnæus' system instead of only criticising it.

But it is Buffon's speculative views which have most interest for us. Those views exercised a very wide-spread influence in their day, though the time was not ripe for them. Indeed, it is far from improbable that writers whose speculations have been made public at a more propitious season, owe much to their comparatively forgotten predecessor.

Amongst Buffon's various speculations we might glance at his "Théorie de la Terre" (put forth in the very first volume of his work), and at his "Epoques de la Nature," which fills the fifth volume of his supplement. We might consider his speculations concerning the formation of mountain and valley by water, and the evidence that there was present to the ear of his imagination:—

"The sound of streams, which, swift or slow,
Tear down Æolian hills and sow
The dust of continents to be."

That he saw, in thought, the projection of the planets from the sun's mass; the primitive fluidity of the earth, and the secular refrigeration of the sun. Such considerations, however, are foreign to this section. I will therefore select two which are of biological interest.

In the first place I may refer to Buffon's speculations concerning ANIMAL VARIATION. In this matter Isidore Geoffroy St. Hilaire has affirmed that Buffon stands to the doctrine of animal variability in a position analogous to that in which Linnæus stands to the doctrine of the fixity of species.

Buffon, in his chapter on the animals of the Old and New World, remarks,[3] "It is not impossible that the whole[4] of the new world's animals are derived from the same source as those of the old, whence they have descended." . . . . "Nature is in a state of perpetual flux." In this chapter on the degeneration of animals[5] he sums up saying, "After comparing all the animals, and arranging them each in their own group, we shall find that the two hundred kinds described here may be reduced to a small number of original forms, whence it may be all the rest have issued."

As to the modes and causes of the origin of new forms, he entertained four connected opinions:

(1) He attributed much modifying efficacy to migrations;

(2) Also to the direct action of external conditions;

(3) He believed largely in the origin of new forms by degradation; and

(4) He regarded each animal as the manifestation of an individuating force, living, as it were, at the root of the changes manifested by it.

The view that MIGRATION (with isolation) is a necessary antecedent to the origin of new species is one which has been advocated by a modern naturalist, Moritz Wagner;[6] who does not hesitate to affirm[7] that the formation of a nearly new species "will only succeed when a few individuals, having crossed the barriers of their station, are able to separate themselves for a long time from the old stock."

In support of his view the author brings forward a multitude of interesting facts, one of the most significant of which appears to me to be the following. It concerns Beetles of Tropical America of the genus *Tetracha*. In Venezuela, and in the western part of Central America, he tells us rivers flow partly through savannahs, where they have undermined the light tufaceous soil, forming deep beds with high precipitous banks. According to Prof. Wagner, individual beetles from the highlands have thus been isolated, and in no longer time than has been required by the rivers to undermine the loose soil of the savannah, have given rise to a distinct species markedly different in form and colour. It is to similar causes—migration and complete isolation—that he traces the formation of distinct races of men: a formation he deems no longer possible, while the wide diffusion of mankind renders more and more difficult the evolution of new species of animals of any kind.

Instances which appear to support this view will readily suggest themselves to the naturalist—instances, that is, of forms which are both peculiar in structure and remote and isolated as to their habitat.[1] Thus for example, even in the group which structurally most resembles us, we have the Orang confined to very limited tracts in Borneo and Sumatra, and the Gorilla to a small portion of Western Africa. The Proboscis Monkey is found nowhere but in Borneo, while the singular ape named "Roxellana," (from its wonderfully "tip-tilted" nose) is confined to the lofty and isolated mountains of Monpin in Thibet. The very peculiar black ape (*Cynopithecus*) is limited to Celebes and Batchian, while the Baboon, which has the baboon character of muzzle most developed, was found at the extreme south of the African continent.

Again, if we take the group of Lemur-like animals (*Lemuroidea*) as having had their home and starting-point in or near their present head-quarters—Madagascar—then some of the most aberrant forms are those which must have migrated farthest. The character which is perhaps the most peculiar of any which the group presents, is the elongation of two of the ankle-bones, as we find it in the Madagascar genus *Cheirogaleus*. But this character is more exaggerated in migrants to Africa—the Galagos—and most so of all in the more isolated emigrant, the Tarsier, now found in Celebes and Borneo.

The sub-family of slow-lemurs (*Nycticebinæ*) would, on this view, seemed to have migrated in opposite directions, as we find the slender slow-lemur (*Loris*) in Madras, Malabar, and Ceylon; the typical slow-lemur (*Nycticebus*) in South China, Borneo, and Java; the Potto (*Perodicticus*) in Sierra Leone, and the Angwantibo (*Arctocebus*) in Old Calabar. Of these, it is the African forms which have the index-finger most atrophied—a tendency to its atrophy existing in the whole sub-family.

It would, of course, be very easy to multiply instances of the kind; but it would be also easy to cite a number of cases which appear to conflict with the view in question. Thus familiar to us as it is, few animals are more peculiar in structure than the common mole, which gives no present evidence of isolated origin; and the most aberrant of all bats, the Vampire (*Desmodus*), is rather widely distributed in South America. Again, with regard to the Lemur group, the most absolutely exceptional is the Aye-Aye (*Cheiromys*), which, on the hypothesis supposed, has remained persistently at the head-quarters of the group, *i.e.* in Madagascar.

Even, however, if no exception existed to the co-existence now of singularity of form and isolation and remoteness of situation, we could not safely draw any decided conclusion from such facts, because fossil remains show us that forms which have now a very limited distribution, were either widely spread in earlier times, or existed in regions very remote from those they now inhabit. Thus, in Eocene times there existed in Europe true opossums (now confined to America), Tapirs, and a form like the African Potto before mentioned. In Miocene times we had in Europe long-armed apes (creatures now found only in Eastern Asia), with the now exclusively African Secretary Bird and Cape Ant Eater (*Orycteropus*). In the same period the Orang—or a nearly allied form—seems to have ranged over

[1] "Hist. Nat." tome i. p. 39.

[2] This appeared in 1789.

[3] *Op. cit.* vol. ix. p. 127.

[4] He thought that the American Jaguars, Ocelots, &c., and even the Peccary, were positive degradations of old world forms. He thought that the Llama, the American Apes, Agoutis, and Ant-eaters might be examples of such forms; but the Opossum, Sloths, and Tapirs he took to be original species. (See vol. xiv. pp. 272, 273.)

[5] Vol. xiv. p. 358.

[6] In a paper read before the Royal Academy of Sciences at Munich on March 2, 1868. This has been translated by Mr. James L. Laird, and published by Edward Stanford in 1873.

[7] *Op. cit.* p. 29.

[1] Isolation, it ought to be remembered, may take place as the result not only of changes in inorganic nature (such as the formation of islands, and the excavation of river beds), but also by the presence of enemies in intermediate tracts, by the circumstance that the food of the species is found only in certain restricted localities, and by whatever other causes determine the extinction of a species in a given place.

India. What are more emphatically old world forms than the camel, horse, and elephant, with the typical porcupine? Yet all these existed in America in Pliocene times. Did we know the Tapir in only one of the two widely-separated stations in which it dwells to-day, we might well deem its evolution to be due to migration and isolation. But we know from palæontology that it existed in Europe from the Eocene to the Pliocene period.

Such facts as these do not, of course, disprove the doctrine that migration and isolation are necessary antecedent conditions to specific genesis, but they show how much caution must be used in drawing the conclusion that they are necessary, from the distribution of animals much less likely to be found fossil than mammals are.

But an argument in favour of the views of Buffon and of Wagner may be obtained from our own species, which exhibits some singular coincidences between peculiarity of form and isolation. Among such instances may be mentioned the Tasmanians, the Andaman Islanders, and the Aïnos or Aborigines of Japan. One of the most striking examples is that of the Eskimo—a people representing many peculiarities, some of which exaggerate the characters of the highest races of mankind. Thus, the pelvis differs from the European pelvis in an opposite direction to that by which the negro pelvis differs from the European, and the same is the case with the proportions of the limbs, while the skulls of the Eskimo have the largest and narrowest nasal aperture of all races, being in this respect the very opposite to the Australians. The Eskimo have migrated eastwards, not reaching the south of Greenland till the fourteenth century, and the race characters are most marked in the most easterly tribes. These facts were brought forward by Prof. Flower in his Hunterian lectures for the present year,[1] when he said that the characters of this peculiar race "must be attributed to those gradual modifications produced by causes at present little understood, by which most of the striking variations met with in the human species have been brought about—modifications more strongly expressed the more completely isolated the race has become, and the farther removed from its original centre of distribution." I think, then, that though we have not data for conclusively answering the question as to how far migration (together with isolation) may be necessary for specific genesis, it is certain that it is of very great efficacy and importance, and that credit is justly due to Buffon for his early appreciation of its importance.

The next question to which I would advert is that concerning THE DIRECT ACTION UPON ORGANISMS, OF THE EXTERNAL CONDITIONS WHICH SURROUND THEM.

Buffon's belief was[2] that changes of specific form were brought about by change of temperature and climatic change generally, as well as by change of food.

The curious effects of stimulating food on colour—as of cayenne pepper with canaries, and hemp-seed with parrots—is notorious.

The direct action of the environment on organisms has, I think, been of late somewhat undervalued. Amongst evidences in favour of its importance, I would refer to some of Mr. Alfred Wallace's observations.[3] He tells us that in the small island of Amboina, the butterflies (twelve species of nine different genera) are larger than those of any of the more considerable islands about it, and that this is an effect plainly due to some local influence. In Celebes, a whole series of butterflies are not only of a larger size, but have the same peculiar form of wing. The Duke of York's Island seems, he tell us, to have a tendency to make birds and insects white or at least pale, and the Philippines, to develop metallic colours, while the Moluccas and New Guinea seem to favour blackness and redness in parrots and pigeons. Species of butterflies which in India are provided with a tail to the wing, begin to lose that appendage in the islands, and retain no trace of it on the borders of the Pacific. The Æneas group of Papilios never have tails in the equatorial region of the Amazon Valley, but gradually acquire tails, in many cases, as they range towards the northern and southern tropics. Mr. Gould says that birds are more highly coloured under a clear atmosphere than in islands or on coasts—a condition which also seems to affect insects, while it is notorious that many shore plants have fleshy leaves. I need but refer to the English oysters mentioned by Costa, which, when transported to the Mediterranean, grew rapidly like the true Mediterranean oyster, and to the twenty different kinds of American trees, said by Meehan to differ in the *same manner* from their nearest European allies, as well as to the dogs, cats, and rabbits which have been proved to undergo modifications directly induced by climatic change.

[1] The lecturer also said: "The large size of the brain of all the hyperborean races, Lapps as well as Eskimo, seems not necessarily to be connected with intellectual development, but may have some other explanation not at present apparent." I would suggest that in this case—as in the large brains of Cetaceans—it may be due to the need in their climate of generating much heat to sustain the necessary temperature of the body.

[2] *Op. cit.*, vol. xiv. p. 317.

[3] See "Tropical Nature," pp. 254–259.

It appears, then, that much may be said in favour of that direct effect of surrounding circumstances on organisms in which Buffon believed.

Lastly, I would refer to Buffon's belief that new species have arisen by DEGRADATION. This again is an opinion which, after a period of disfavour, or at least of neglect, has been of late revived, and has acquired considerable influence. I may here refer to Anton Dohrn, who has recently advocated the very widely-spread and effective action of degradation as a cause of specific change. It will, I think, be generally admitted that such exceptional Copepod crustaceans as *Tracheliastes* and *Lerneocera* are due to degradation, and the probability seems to me very strong that the Rhizocephala, at least many cirripeds, and the certoid worms, are also degraded organisms. Very interesting would it be to know whether existing Ascidians are also examples of degradation, as not a few zoologists now suppose; but most interesting of all is that parasite of cuttle fishes, *Dicyema*, the structure of which has been recently investigated by Prof. Eduard van Beneden, and made the type of a new primary division of animals. Should this small worm-like organism hereafter turn out to be a degraded form, it will show what an extreme degree of retrograde metamorphosis may occasionally be brought about. I think, then, that we have considerable ground for suspecting that degradation has acted much and widely in the field of Biology, and if so, Buffon is fairly entitled to a certain amount of esteem on account of the views he entertained with regard to it in so early a day and in so undeveloped a condition of zoological science. For it must not be forgotten that migration, the influence of external conditions, and degradation, are connected points: parts of one view. Degradation is most conspicuous under violent changes of condition (such as parasitism), while migration only acts by bringing organisms under new conditions.

These reflections lead me to urge upon such of my hearers as may have any unusual facilities for experimental investigation, a course of inquiry which seems to be very desirable.

What is needed in order to solve as far as possible the question of specific genesis, is a knowledge of the laws of variation, which must, I think, be deemed the true cause and origin of species.

We may, I think, accept as true two propositions:—

1. Animals may change in various ways, and amongst them, by degradation.

2. Changes in the environment with isolation, induce and favour changes in form.

I would urge, then, that inquiries should be pursued in two directions simultaneously.

A. There might be undertaken one set of inquiries to investigate the effects on different species of the same variations of environment.

B. Other inquiries might be undertaken with a view to ascertaining the effects of different changes of environment on one and the same species. By series of experiments contrived with these ends in view, and carried on with various selected animals and plants which reproduce with rapidity, we may possibly be able to determine what to attribute to external influences (shown by such influence having the same effects on all), and what to the peculiar nature and innate powers and tendencies of different organisms—shown by the diverging reactions of the latter under the same changes in their environment.

I next desire to direct your attention to another matter treated of by Buffon—I mean THE RESEMBLANCES AND DIFFERENCES WHICH EXIST BETWEEN THE MIND OF MAN AND THE HIGHER PSYCHICAL FACULTIES OF ANIMALS.

This question is eminently a question of our own day, and one which I feel cannot but excite interest in this section.

But its accurate investigation is attended with special difficulculties, and amongst them are two temptations, which are apt to beset the inquirer;

1. The first of these arises from the wide-spread love for the marvellous of whatsoever kind, and the tendency to inverted anthropomorphism.

2. The other is the temptation to strain or ignore facts to serve a favourite theory.

As to the former of these dangers, I may perhaps be permitted to quote some remarks made by Mr. Chambers, approvingly cited by Prof. Bain: "There are two subjects where the love of the marvellous has especially retarded the progress of correct knowledge—the manners of foreign countries, and the instincts of the brute creation. . . . . It is extremely difficult to obtain true observations" as to the latter "from the disposition to make them subjects of marvel and astonishment." . . . . "It is nearly as impossible to acquire a knowledge of animals from anecdotes as it would be to obtain a knowledge of human nature from the narratives of parental fondness and friendly partiality." This I believe to be most true, and that here the danger of mistaking inference for observation is exceptionally great. The inquirer ought not to accept as facts marvellous tales without criticism and a careful endeavour to ascertain whether the alleged facts are facts and not unconscious fictions.

As to the second danger, the lamented George Henry Lewes, whom no one can suspect of any hostility to evolution in its most extreme form, remarks (in his posthumous work[1] just published) that the researches of various eminent writers on animal psychology have been "biassed by a secret desire to establish the *identity* of animal and human nature," and certainly no one can deny that those who do assert that identity, are necessarily exposed to the temptation referred to. Of course persons who desire to disprove this identity are exposed to the opposite temptation; but it cannot be maintained that there is evidence of Buffon having been influenced by any such desire.

The obvious difference between the highest powers of man and animals has led the common sense of mankind to consider them to be of radically distinct kinds, and the question which naturalists now profess to investigate is whether this is so or no.

But we may doubt, whether many who enter upon this inquiry do not enter upon it with their minds already made up that no such radical difference can by any possibility exist. To admit it, they think, would be tantamount to admitting some non-natural origin of man, to accepting, as a fact, something not harmonising with our views as to nature generally, leading to we know not what results—possibly even to lending some support to Christianity. To admit it, would be to deny the principle of continuity. There cannot, therefore, be any essential difference between man and brute, and their mental powers must be the same in kind. This, I think, is no unfair representation of the state of mind in which this question is very likely to be entered upon at the present time. Surely, however, if we profess to investigate a question, we ought in honesty to believe that there *is* a question to investigate, or else leave the matter to others; and if evidence should seem to show that "intellect" *cannot* be analysed into sense, but is an ultimate, it ought to be accepted, at the least provisionally, as such, even at the cost of having to regard its origin as at present inexplicable. Can we explain the origin of "motion?" But what rational man thinks of denying it on that account? Let us not reject anything, then, which may be evident, on account of certain supposed speculative consequences.

But that no such consequences as those referred to need follow from the admission of the radical distinctness of human reason, seems evident from the views of Aristotle. He certainly was free from theological prejudices or predispositions, and yet to his clear intellect the difference between the merely sentient and the rational natures was an evident difference, and the facts which are open to our observation are the same as those which presented themselves to his.

To enter on this inquiry with any fair prospect of success, it is not only necessary to guard against such temptations as these, but it is also necessary to be provided with a certain amount of knowledge of a special kind; namely, with a clear knowledge of what our own intellectual powers are. I conceive that, great as is the danger of exaggeration and false inference as to the faculties of animals, the danger of misapprehending and underrating our own powers is far greater.

Buffon held very decided views as to the distinctness of the mind of man from the so-called minds of animals. But an ingenious and gifted writer,[2] who has recently done good service in supporting Buffon's claims to greater consideration than he commonly receives, has, nevertheless, done him what I believe to be strange injustice in attributing to his great work an ironical character, and this in spite of Buffon's protest[1] against irony in such a work as his. I cannot venture to take up your time with controversy on this subject; but apart from Buffon's protest against "équivoque," it is incredible to me that he should have carried on a sustained irony through so voluminous a work—thus making its whole teaching absolutely mendacious. One remark of Buffon's, which has been strangely misinterpreted by this writer, I shall have occasion to notice directly; but I think it may suffice to clear Buffon's character from the aspersion of his admiring assailant, to point out that in the table of contents in the final volume of his "History of Mammals"[2] (which table gives the pith and gist of his several treatises), he distinctly affirms the distinctions maintained in the body of his work.

The following were Buffon's views. In his "Discourse on the Nature of Animals,"[3] he says, "Far from denying feelings to animals, I concede to them everything except thought and reflection" . . . . "they have sensations, but no faculty of comparing them one with another, that is to say, they have not the power which produces ideas." He is full of scorn[4] for that gratuitous admiration for the moral and intellectual faculties of bees, which Sir John Lubbock's excellent observations and experiments have shown to be indeed gratuitous. Speaking of the ape, most man-like (and *so* man-like) as to brain, he says:[5] "Il ne pense pas: y a-t-il une preuve plus évidente que la matière seule, quoique parfaitement organisée, ne peut produire ni la pensée, ni la parole qui en est le signe, à moins qu'elle ne soit animée par un principe supérieur?"[6] Buffon has been accused of vacillation with respect to his doctrine concerning animal variation, but no one has accused him of vacillation with respect to his views concerning reason and instinct.

I come now to the passage which I said has been so strangely misunderstood. It is that in which he expresses his conviction that "animals have no knowledge of the past, no idea of time, and consequently no memory." But to quote this passage without explanation is gravely to misrepresent the illustrious French naturalist. Buffon was far from ignoring, indeed he distinctly enumerates the various obtrusive phenomena which often lead the vulgar to attribute, without qualification, both knowledge and memory to brutes. But, in fact, he distinguishes between[7] memory' and memory. His words are: "Si l'on a donné quelque attention à ce que je viens de dire, on aura déjà senti que je distingue deux espèces de mémoire infiniment différentes l'une de l'autre par leur cause, et qui peuvent cependant se ressembler en quelque sorte par leurs effets; la première est la trace de nos idées, et la seconde, que j'appellerais volontiers réminiscence[8] plutôt que mémoire, n'est que le renouvellement de nos sensations," and he declares[9] true memory to consist in the recurrence of ideas as distinguished from revived sensuous imaginations.

This distinction is one which it is easy to perceive. That we have automatic memory, such as animals have, is obvious; but the presence of intellectual memory (or memory proper) may be made evident by the act of searching our minds (so to speak) for something which we know we have fully remembered before, and thus intellectually remember to have known, though we cannot now bring it before our imagination.

As with memory, so with other of our mental powers, we may, I think, distinguish between a higher and a lower faculty of each; between our higher, self-conscious, reflective mental acts—the acts of our intellectual faculty—and those of our merely sensitive power. This distinction (to which I have elsewhere[10] called attention) I believe to be one of the most fundamental of all the distinctions of biology, and to be one the apprehension of which is a necessary preliminary to a successful investigation of animal psychology. It is, of course, impossible for us thoroughly to comprehend the minds of dogs or birds, because we cannot enter into the actual experience of such animals, but by understanding the distinction between our own higher and

[1] "Problems of Life and Mind." Third Series, 1879, p. 122.
[2] Mr. Samuel Butler. See his "Evolution, Old and New." (Hardwicke and Bogue, 1879.)

[1] *Op. cit.* tome i. p. 25. [2] *Op. cit.* tome xv. [3] *Op. cit.* tome iv. p. 41.
[4] *Op. cit.* tome iv. p. 91. [5] *Op. cit.* tome xiv. p. 61.
[6] Mr. Butler cites objections brought forward in a certain passage (from pp. 30 and 31, vol. xiv.), as if they were Buffon's own. But they are the objections of an imagined opponent whose views Buffon himself combats. It is worthy of note that Buffon long anticipated our contemporaries with respect to man's place in nature in so far as concerns his mere anatomy. For he did not hesitate to affirm that the Orang differs less from us structurally than it differs from some other apes.
[7] *Op. cit.* tome iv. p. 60.
[8] Here he follows, without citing, the old distinction of Aristotle between memory and reminiscence.
[9] *Op. cit.* tome iv. p. 56.
[10] "Lessons from Nature" (Murray, 1876), p. 196.

lower faculties,[1] we may, I think, more or less approximate to such a comprehension.

It may, I believe, be affirmed that no animal but man has yet been shown to exhibit true concerted action, or to express by external signs distinct intellectual conceptions—processes of which all men are normally capable. But just as some plants simulate the sense perception, voluntary motions and instincts of animals, without there being a real identity between the activities thus superficially similar, so there may well be in animals actions simulating the intellectual apprehensions, ratiocinations, and volitions of man without there being any necessary identity between the activities so superficially alike. More than this, it is certain, *à priori*, that there must be such resemblance, since our organisation is similar to that of animals, and since sensations are at least indispensable antecedents to the exercise of our intellectual activity.

I have no wish to ignore the marvellous powers of animals or the resemblance of their actions to those of man. No one can reasonably deny that many of them have feelings, emotions, and sense-perceptions similar to our own; that they exercise voluntary motion and perform actions grouped in complex ways for definite ends; that they to a certain extent learn by experience, and can combine perceptions and reminiscences so as to draw practical inferences, directly apprehending objects standing in different relations one to another, so that, in a sense, they may be said to apprehend relations. They will show hesitation, ending apparently, after a conflict of desires, with what looks like choice or volition, and such animals as the dog will not only exhibit the most marvellous fidelity and affection, but will also manifest evident signs of shame, which may seem the outcome and indication of incipient moral perceptions. It is no great wonder, then, that so many persons, little given to patient and careful introspection, should fail to perceive any radical distinctions between a nature thus gifted and the intellectual nature of man.

But, unless I am greatly mistaken, the question can never be answered by our observations of animals, unless we bear in mind the distinctions between our own higher and lower faculties.

Now I cannot here even attempt to put before you what I believe to be the true view of our own intellectual processes. Still I may, perhaps, be permitted to make one or two passing observations.

Everybody knows his own vivid feelings (or sensations), and those faint revivals of feelings, simple or complex, distinct or confused, which are imaginations and emotions; but the same cannot be said as to thought. Careful introspection will, however, I think, convince any one that a "thought" is a thing widely different from an "imagination"—or revival of a cluster of faint feelings. The simplest element of thought seems to me to be a "judgment," with an intuition of reality concerning some "fact," regarded as a fact real or ideal. Moreover, this judgment is not itself a modified imagination, because the imaginations which may give occasion to it persist unmodified in the mind side by side with the judgment they have called up. Let us take, as examples, the judgments "that thing is good to eat," and "nothing can be and not be at the same time and in the same sense." As to the former, we vaguely imagine "things good to eat," but they exist *beside* the judgment, not *in* it. They can be recalled, compared, and seen to co-exist. So with the other judgment, the mind is occupied with certain abstract ideas, though the imagination has certain vague "images" answering respectively to "a thing being" and "a thing not being," and to "at the same time" and "in the same sense;" but the images do not *constitute* the judgment itself any more than human "swimming" is made up of "limbs and fluid," though without such necessary elements no such swimming could take place.

This distinction is also shown by the fact that one and the same idea may be suggested to, and maintained in, the mind by the help of the most incongruous images, and very different ideas by the very same image. This we may see to be the case with such ideas as "number," "purpose," "motion," "identity," &c.

[1] Certain writers (as, for example, Prof. Ewald Hering, of Prague) have used the word "memory" to denote what should properly be called "organic habit," *i.e.*, the power and tendency which living beings have to perpetuate in the future, effects wrought on them in the past. But to call such action, as that by which a tree as it grows, preserves the traces of scars inflicted on it years before, "memory," is a gross abuse of language—a use of the word as unreasonable as would be the employment of the word "sculptor" to denote a quarryman, or "sculpture" to indicate the fractures made in rocks by the action of water and frost.

But the distinctness of "thought" from "imagination" may perhaps be made clearer by the drawing out fully what we really do when we make some simple judgment, as, *e.g.*, that "a negro is black." Here, in the first place, we directly and explicitly affirm that there is a conformity between the external thing, "a negro," and the external quality, "blackness"—the negro possessing that quality. We affirm secondarily and implicitly a conformity between the two external entities and the two corresponding internal concepts. And thirdly, and lastly, we also implicitly affirm the existence of a conformity between the subjective judgment and the objective existence.

All that it seems to me evident that sentience can do is to associate feelings and images of sensible phenomena, variously related, in complex aggregations, but not to apprehend sensations as "facts" at all, still less as internal facts, which are the signs of external facts. It may be conceived as marking successions, likenesses and unlikenesses of phenomena, but not as recognising such phenomena as *true*. Animals, as I have fully admitted, apprehend things in different relations, but no one that I know of has brought any evidence that they apprehend them *as* related, or their relations *as* relations. A dog may feel shame, or possibly (though I do not think probably) a migrating bird may feel agony at the imagination of an abandoned brood; but these feelings have nothing in common with an ethical judgment, such as that of an Australian, who, having held out his leg for the punishment of spearing, judges that he is wounded more than his common law warrants.

Animals, it is notorious, act in ways in which they would not act had they reason; while, as far as I have observed or read, all they do is explicable by the association of sensations, imaginations, and emotions, such as take place in our own lower faculties. We cannot, of course, prove a negative, but we have no right to assume the existence of that for which there is no evidence, without which all the facts can be explained, and which, if it did exist, would make a multitude of observed facts impossible. Apes (like dogs and cats) warm themselves with pleasure at deserted fires, yet, though they see wood burning and other wood lying by, though they have arms and hands as we have, and the same sentient faculties, they have never, so far as I know, been recorded to have added fuel to maintain their comfort. Swallows will continue to build on a house which they see has begun to be pulled down, and no animal can be shown to have made use of antecedent experience to *intentionally* improve upon the past.

If, on the other hand, animals were capable of deliberately acting in concert, the effects would soon make themselves known to us so forcibly as to prevent the possibility of mistake.

Mr. Lewes has not hesitated to affirm[1] that "between animal and human intelligence there is a gap which can only be bridged over by an addition from without," and he also says:[2] "The animal world is a continuum of smells, sights, touches, tastes, pains, and pleasures: it has no objects, no laws, no distinguishable abstractions, such as self and not self. . . . If we see a bud, after we have learned that it is a bud, there is always a glance forward at the flower and backward at the seed . . . . but what animal sees a bud at all except as a visible sign of some other sensation?" As a friend of mine, Prof. Clarke,[3] has put it: "In ourselves sensations presently set the intellect to work; but to suppose that they do so in the dog is to beg the question that the dog has an intellect. A cat to bestir itself to obtain its scraps after dinner, need not entertain any *belief* that the clattering of the plates when they are washed is usually accompanied by the presence of food for it, and that to secure its share it must make certain movements; for quite independently of such belief, and by virtue of mere association, the simple objective conjunction of the previous sounds, movements, and consequent sensations of taste, would suffice to set up the same movements on the present occasion." Let certain sensations and movements become associated, and then the former need not be noted: they only need to exist for the association to produce its effects, and simulate apprehension, deliberation, inference, and volition. "When the circumstances of any present case differ from those of any past experience, but imperfectly resemble those of many past experiences, parts of these, and consequent actions, are irregularly suggested by the laws of resemblance, until some action is hit on which relieves pain or gives pleasure. For instance . . . . let a dog be lost by his mistress in a field in which he has never been before. The presence of the group of

[1] "Problems of Life and Mind," vol. i. p. 156.
[2] *L.c.*, p. 140.
[3] "Questions on Psychology," p. 9.

sensations which we know to indicate his mistress is associated with pleasure, and its absence with pain. By past experience an association has been formed between this feeling of pain and such movements of the head as tend to recover some part of that group, its recovery being again associated with movements which, *de facto*, diminish the distance between the dog and his mistress. The dog, therefore, pricks up his ears, raises his head and looks round. His mistress is nowhere to be seen; but at the corner of the field there is visible a gate at the end of a lane which resembles a lane in which she has been used to walk. A phantasm (or image) of that other lane, and of his mistress walking there, presents itself to the imagination of the dog; he runs to the present lane, but on getting into it she is not there. From the lane, however, he can see a tree at the other side of which she was wont to sit; the same process is repeated, but she is not to be found. Having arrived at the tree he thence finds his way home." By the action of such feelings, imaginations, and associations—which we know to be *veræ causæ*—I believe all the apparently intelligent actions of animals may be explained without the need of calling in the help of a power, the existence of which is inconsistent with the mass, as a whole, of the phenomena they exhibit.

But if there *is* a radically distinct intellectual power or force in man, is such a distinction of kind so isolated a fact as many suppose? May there not exist between the forces which living beings exhibit other differences of kind?

Each living being consists of an aggregation of parts and functional activities which are evidently knit together into a unity. Each is somehow the seat or theatre of some unifying power or condition which synthesises their varied activities, and is a PRINCIPLE OF INDIVIDUATION. This seems certainly to have been the opinion of Buffon, and it is to this opinion that I referred in speaking of the fourth cause to which he attributed the changes in organic forms. And to me it seems that we must admit the existence of such a living principle. We may analyse the activities of any animal or plant, and by consideration of them separately find resemblances between them and mere physical forces. But the *synthesis* of such forces as we find in a living creature is certainly nowhere to be met with in the inorganic world.

To deny this would be to deny the plainest evidence of our senses. To assert that each living body is made up of minute independent organisms, each with its own "principle of individuation," and without subordination or co-ordination, is but to multiply difficulties, while such a doctrine conflicts with the evidence of our own perceptions, which lead each of us to regard himself as one whole—a true unity in multiplicity.

The existence in each creature of a peculiar, co-ordinating, polar force, seems to be specially pointed to by the phenomena of serial and bilateral symmetry, by the symmetrical character of certain diseases, by the phenomena of monstrous growths and by the symmetrical beauty of such organisms as the Radiolarian Rhizopods.

It also seems to me to be made evident, by the various activities of each animal, which are, as a fact, grouped in one in mutual interaction—an organism having been described by Kant as a creature, the various parts of which are reciprocally ends and means.

I think now I hear the exclamation—This is "Vitalism!" while some of my hearers may deem these matters too speculative for our Section.

But consciously or unconsciously, general conceptions of the kind exist in the minds of all biologists, and influence them in various ways, and their consideration therefore can hardly be out of place here; while as to "Vitalism," I am convinced I shall not be wasting your time in endeavouring to remove a widespread misconception.

The "Vitalism" which is so reasonably objected to, is that which supposes the existence in each living creature of some separate entity inhabiting the body—an extra-organic force within the living creature, and acting by and through it, but numerically distinct from it. But the view which I venture to put before you as that which is to my judgment a reasonable one, is that of a peculiar form of force which is *intra-organic*, so that it and the visible living body are one thing, as the impress on stamped wax and the wax itself are one, though we can ideally distinguish between the two. It is, in fact, a mode of regarding living creatures with prime reference to their activities rather than to their material composition, and every creature can of course be regarded either statically or dynamically. It is to regard any given animal or plant, not as a piece of complex matter played upon by physical forces, which are transformed by what they traverse, but rather as a peculiar immanent principle [1] or form of force (whensoever and howsoever arising), which for a time manifests itself by the activities of a certain mass of complex material, with which it is so entirely one that it may be said to constitute and *be* such animal or plant much rather than the lump of matter which we can see and handle can be said to constitute such animal or plant. On this view a so-called "dead bird" is no bird at all, save by abuse of language, nor is a "corpse" really a "dead man"—such terms being as self-contradictory as would be the expression "a dead living creature."

Thus the real essence, the substantial constituent of every living thing is something which escapes our senses, though its existence and nature reveal themselves to the intellect.

For of course our senses can detect nothing in an animal or plant beyond the qualities of its material component parts. But neither is the function of an organ to be detected save in and by the actions of such organ, and yet we do not deny it its function or consider that function to be a mere blending and mixture of the properties of the tissues which compose it. Similarly it would seem to be unreasonable to deny the existence of a living principle of individuation because we can neither see nor feel it, but only infer it. This power or polar force, which is imminent in each living body, or rather which is that body living, is of course unimaginable by us, since we cannot by imagination transcend experience, and since we have no experience of this force, save as a body living and acting in definite ways.

It may be objected that its existence cannot be verified. But what *is* verification? We often hear of "verification by sensation," and yet even in such verification the ultimate appeal is not really to the senses, but to the intellect, which may doubt and which criticises and judges the actions and suggestions of the senses and imagination. Though no knowledge is possible for us which is not genetically traceable to sensation, yet the ground of all our developed knowledge is not sensational, but intellectual, and its final justification depends, and *must* depend, not on "feelings," but on "thoughts." I must apologise to such an audience as that I have the honour of addressing for expressing truths, which, to some of my hearers, may appear obvious. I would gladly suppress them as superfluous did not my own experience convince me that they are not superfluous. To proceed: "Certainty" does not exist at all in *feelings* any more than doubt. Both belong to thought only. "Feelings" are but the materials of certainty, and though we can be perfectly certain about our feelings, that certainty belongs to thought and to thought only. "Thought," therefore, is our absolute criterion. It is by self-conscious thought only that we know we have any feelings at all. Without thought, indeed, we might feel, but we could not know that we felt or know ourselves as feeling. If, then, we have *rational* grounds for the acceptance of such a purely intellectual conception as that of an immanent principle as the essence of each living creature, the poverty of our powers of imagination should be no bar to its acceptance. We are continually employing terms and conceptions—such, *e.g.*, as "being," "substance," "cause," &c.—which are intelligible to the intellect (since they can be discussed), though they transcend the powers of the imagination to picture.

It seems to me that the spirit which would deny such realities is the same spirit which would deny our real knowledge of an external world at all, and represent any material object as "state of consciousness," and at the very same time represent "a state of consciousness" as the accompaniment of a peculiar state of a material object—the body.[2] This mode of representation may

[1] The word "principle" has been used to denote that activity which, together with material substance, constitutes a living creature, because that word calls up a less sensuous, and therefore less misleading, phantasm than any other. The old term ψυχή, or soul, has in modern times come to be associated with the idea of a substance numerically distinct from the living body, and capable of surviving the destruction of the latter. But as structure and function ever vary together (as do the convexities and concavities of a curved line), so "the principle of individuation" or soul of an animal or plant and its material organisation must necessarily arise, vary, and be destroyed simultaneously, unless some special character, as in the case of man, may lead us to consider it exceptional in nature. Even in man, however, there seems no adequate reason for believing in the existence of any principle of individuation, save that which exerts its energy in all his functions, the humblest as well as the most exalted.

[2] Those who deny that we have a real power of perceiving objects, refute themselves when they speak of "purely physical changes," or of anything "physical" of which feelings are but the "accompaniment" or "subjects." For according to them "matter" is but a term for certain "states of consciousness," while they represent each state of consciousness as a function of matter. According to this, let *a* represent a "state of consciousness, and

be shortly, but not unjustly, described as a process of intellectual "thimble-rigging," by which the unwary spectator is apt to be cheated out of his most valuable mental possession—his rational certainty.

The same spirit asserts that our psychical powers never themselves enter into the circuit of physical causation, and yet few things would seem more certain to a plain man than that (supposing him to have received a message saying his house is on fire) it is his *knowledge* of what has been communicated which sets him in motion. To deny this is to deny the evident teaching of our consciousness. It is to deny what is necessarily the more certain in favour of what is less so. If I do not know this I know *nothing*, and discussion is useless. As a distinguished writer has said: "That we are conscious, and that our actions are determined by sensations, emotions, and ideas, are facts which may or may not be explained by reference to material conditions, but which no material explanation can render more certain." The advocate of "natural selection" may also be asked, How did knowledge ever come to be, if it is in no way useful, if it is utterly without action, and is but a superfluous accompaniment of physical changes which would go on as well without it?

As we may be confident that thought not only is but also acts, as well as that there are things which are not psychical, but which are physical; so I would urge that the conception of living things, which I venture to put before you, is one which may be rationally entertained.

Assuming for the moment and for argument's sake that it may be accepted, what light does our knowledge of ourselves throw upon the intimate life-processes of lower organisms? We know that with us a multitude of actions, which are at first performed with consciousness, come to be performed unconsciously; we know that we experience sensations[1] without perceiving them; we know also that countless organic activities take place in us under the influence and control of the nervous system, which either never rise into consciousness at all, or only do so under abnormal conditions. Yet we cannot but think that those activities are of the same generic nature, whether we feel, perceive, or attend to them or not. The principle of individuation in ourselves, then, evidently acts with intelligence in some actions, with sentience in many actions, but constantly in an unperceived and unfelt manner. Yet we have seen it undeniably intervene in the chain of physical causation.

An animal is an organism all the actions of which are necessarily determined by the adjustments of its various organs, and by its environment. But even its sensations cannot be regarded as mere accompaniments of its activities, but as guides and directing agencies intervening in the circle of its actions, and as facts, in the chain of physical causation. The sight of a stick may change the course of actions which a dog would otherwise have pursued—that is, the feeling of the moment, together with the faint recurrence of various past feelings and emotions therewith associated which the sight of the stick calls up, may cause such change. Besides its feelings, the general and the organic movements of the dog are, like our own, governed by a multitude of organic influences which are not felt, but which operate through the nervous system, and so must be taken as parallel with those which are felt, *i.e.* as unfelt, nervous psychoses. The animal, then, like each of us, is a creature of activities partly physical, partly psychical, the latter—both the felt and the unfelt—being directive and controlling.

As we descend to the lowest animals, the evidence as to sentience fades. Yet from the resemblances of the lowest animals and plants, and from the similarity of the vegetative functions in all living creatures, we may, I think, analogically conclude that activities also take place in plants which are parallel with, and analogous to, the unfelt psychoses of animals. As Asa Gray has said with respect to their movements: "Although these are incited by physical agents (just as analogous kinds of movements are in animals), and cannot be the result of anything like volition, yet nearly all of them are inexplicable on mechanical principles. Some of them at least are spontaneous motions of the plant or organism itself, due to some inherent power which is merely put in action by light, attraction, or other external influences."

I have already adverted to insectivorous plants, such as *Dionæa*. In such plants we have susceptibilities strangely like those of animals. An impression is made, and appropriate resulting actions ensue. Moreover, these actions do not take place without the occurrence of electrical changes similar to those which occur in muscular contraction. Hardly less noteworthy are the curious methods by which the roots of some plants seek moisture as if by instinct, or those by which the tendrils of certain climbers seek and find appropriate support, and having found it, cling to it by a pseudo-voluntary clasping, or, finally, those by which the little "Mother-of-a-thousand" explores surfaces for appropriate hollows in which to deposit her progeny.

Nevertheless, nothing in the shape of vegetable nervous or muscular tissue has been detected, and as structure and function necessarily vary together, it is impossible to attribute sensations, sense perceptions, instincts, or voluntary motions to plants, though the principle of individuation in each acts as in the unfelt psychoses of animals and harmonises its various life-processes.

The conception, then, which commended itself to the clear and certainly unbiassed Greek intellect of more than 2,000 years ago, that there are three orders of internal organic forces, or principles of individuation, namely, the rational, the animal, and the vegetal,[1] appears to me to be justified by the light of the science of our own day.

I come now to the bearing of these remarks on the science of biology generally.

Animals and plants may, as I have before said, be regarded either *statically*, by anatomy, or *dynamically*, by physiology.

Physiology, as usually understood, regards the properties of the ultimate morphological components of organisms, the powers of the various aggregations of such components, *i.e.* of the various "tissues" and the functions of the different special aggregations and arrangements of tissues which constitute "organs."

But as each living creature is a highly complex unity—both a unity of body and also a unity of force, or a synthesis of activities—it seems to me that we require a distinct kind of physiology to be devoted to the investigation of such syntheses of activities as exist in each kind of living creature. I mean to say that just as we have a physiology devoted to the several activities of the several organs, which activities are the functions of those organs, so we need a physiology specially directed to the physiology of the living body considered as one whole, that is, to the power which is the function, so to speak, of that whole, and of which the whole body, in its totality, is the organ.

In a word, we need a *physiology of the individual*. This science, however, needs a distinct appellation. I think an adequate one is not far to seek.

Such a line of inquiry may be followed up, whatever view be accepted as to the nature of those forces or activities which living creatures exhibit. But if we recognise, as I myself think our reason calls on us to recognise, the existence in each living being of such a "principle of individuation" as I have advocated the recognition of, then an inquiry into the total activity of any living being, considered as one whole, is tantamount to an

b "a physical state." Then a sensation and its physical accompaniment may be represented by the symbol $a + b$. But a physical state is itself but a state of consciousness with its objective correlate, and is, therefore, $a + b$. We thus get an equation infinitely more erroneous than $b = a + b$, because the b of the $a + b$ is itself ever again and again $a + b$.

[1] As when having gazed vacantly through a window we revert to the pages of a manuscript we may be writing and see there the spectra of the window bars we had before unconsciously seen. Here the effect on the organism must have been similar to what it would have been had we attended to it—*i.e.*, it was unfelt sensation.

[1] Difficult as it confessedly is to draw the dividing line between animals and plants, such difficulty is not inconsistent with the existence of a really profound difference between the two groups. That there should be a radical distinction of nature between two organisms, which distinction our senses nevertheless, more or less fail to distinguish, is a fact which on any view must be admitted, since animals of very different natures may be indistinguishable by us in the germ, and in the earlier stages of their development. The truth of this is practically supported by the late Mr. Lewes, who says (as to the difference between the protoplasms from which animals and plants respectively arise): "That critical differences must exist is proved by the divergence of the products. The vegetable cell is not the animal cell; and although both plants and animals have albumen, fibrine, and caseine, the *derivatives* of these are unlike. Horny substance, connective tissue, nerve tissue, chitine, biliverdine . . . and a variety of other products of evolution or of waste, never appear in plants; while the hydrocarbons abundant in plants are, with two or three exceptions, absent from animals. Such facts imply differences in elementary composition; and this result is further enforced by the fact that when the two seem to resemble, they are still different. The plant protoplasms form various cells, but never form a cartilage cell, or a nerve cell; fibres, but never a fibre of elastic tissue; tubes, but never a nerve tube; vessels, but never a vessel with muscular coatings; solid "skeletons," but always from an organic substance (*cellulose*), not from phosphates and carbonates. In no one character can we say that the plant and the animal are identical; we can only point throughout the two kingdoms to a great similarity accompanying a radical diversity."—"The Physical Basis of Mind," p. 129.

inquiry into the nature of its principle of individuation. Such an inquire becomes "*psychology*" in the widest and in the original signification of that term—it is the psychology of Aristotle.

Mr. Herbert Spencer has already made a great step towards reverting to this original use of the term, for he has made his "psychology" conterminous with the animal kingdom, having made it a history of the psychoses of animals. But the activities of plants must not be ignored. A science which should include the impressionability and reactions of a Rhizopod and exclude the far more striking impressionability and reactions of Venus's fly-trap, and of other insectivorous plants, the recognised number of which is greatly on the increase, must be a very partial and incomplete science. If psychology is to be extended (as I think Mr. Spencer is most rational in extending it) to the whole animal kingdom, it must be made to include the vegetable kingdom also. Psychology, thus understood, will be conterminous with the whole of biology, and will embrace one aspect of organic dynamics, while physiology will embrace the other.

PHYSIOLOGY will be devoted (as it is now) to the study of the activities of tissues, of organs, and of functions, *per se*, such, *e.g.*, as the function of nutrition as exhibited in all organism from the lowest plants to man, the functions of respiration, reproduction, irritability, sensation, locomotion, &c., similarly considered, as manifested in the whole series of organic forms in which such powers may show themselves.

PSYCHOLOGY will be devoted (according to its original conception) to the study of the activities of each living creature considered as one whole—to the form, modes, and conditions of nutrition and reproduction as they may coexist in any one plant; to these, as they may coexist with sensibility and motility in any kind of animal, and finally to the coexistence of all these with rationality as in man, and to the interactions and conditions of action of all these as existing in him, and here the science which corresponds to the most narrow and restricted sense of the word, psychology, *i.e.*, the subjective psychology of introspection, will find its place.

Psychology in the widest sense of the term, in its oldest and in what I believe will be its ultimate meaning, must necessarily be, as to its details, a science of the future. For just as physiology requires as a necessary, antecedent condition, a knowledge of anatomy—since we must know that organs *exist* before we investigate what they *do*—so psychology requires as a necessary, antecedent condition, an already advanced physiology. It requires it because we must be acquainted with the various functions before we can study their synthesis and interactions.

When, however, this study has advanced, one most important result of that advance will be a knowledge, more or less complete, of the innate powers of organisms, and therefore of their laws of variation. By the acquisition of such knowledge we shall be placed in a position whence we may advance, with some prospects of success, to investigate the problem of the "origin of species"—the biological problem of our century.

This reflection leads me back once more to my starting-point, the merits of the great French naturalist of the last century, whose views as to variation and as to animal psychosis, have enabled me to bring before you the questions on which I have presumed to enter. Buffon's claims on our esteem have, I think, been too much forgotten, and I rejoice in this opportunity of paying my debt of gratitude to him by recalling them to recollection. As to the questions which his words have suggested to me and upon which I have thus most imperfectly touched, the considerations I have ventured to offer may or may not commend themselves to your approval; but, at least, they are the result of not a few years of study and reflection, and I am persuaded they have consequences directly or indirectly affecting the whole field of biological inquiry, which belief has alone induced me to make so large a call upon your patience and your indulgent kindness.

NOTES

AMONGST other lectures announced for the coming Baden-Baden meeting of the German Association of Naturalists, to which we have not referred in our note last week, we may mention that at the opening of the first general meeting on September 18, Prof. Kussmaul, of Strasburg, will deliver a memorial address in memory of the late Dr. Benedict Stilling, of Cassel, the first secretary of last year's meeting. The second and third general meetings will take place on September 20 and 24 respectively, and will be partly occupied with the following lectures:—Prof. Ecker, of Freiburg, "On Lorenz Oken, in connection with the Centenary of his Birth;" Prof. Goltz, of Strasburg, "On the Heart;" Prof. Jaeger, of Stuttgart, "On Affections of the Mind." The sectional meetings will take place on September 19, 22, and 23. For these up to the present no less than seventy-six papers have been announced, comprising all domains of natural science and medicine. The following may be of more general interest:—"On the Colour Sense among the Ancients and among Modern Uncivilised Tribes," by Prof. Hartmann, of Berlin; "On the Injurious Effects of the Refuse of Factories, specially of Bleaching Works, with regard to Fish," by Dr. Weichelt, of Rufach; "On the Physiology of the Brain," by Prof. Goltz, of Strasburg; "On Sea Climates and Sea Voyages, from a Physiological and Pathological Point of View," by Dr. Faber, of Stuttgart; "On Crimes and Insanity," by Dr. Kornfeld, of Wohlau; "Experimental Lecture on the Brain," by Prof. Rüdinger, of Munich; "On the Present State of Animal Vaccination and the Corresponding Institutions in Germany, Holland, and Belgium," by Dr. Fürst, of Leipzig.

THE Sanitary Congress and Exhibition of the Sanitary Institute of Great Britain will this year be held at Croydon. Dr. Richardson, F.R.S., has accepted the office of President of the Congress, and a large and influential committee, of which Mr. John Corry is the chairman, has been formed. The Sanitary Congress is divided into three sections, viz.:—Section 1.—Sanitary Science and Preventive Medicine; president, Alfred Carpenter, M.D., London, J.P. Section 2.—Engineering and Sanitary Construction; president, Capt. Douglas Galton, R.E., C.B., F.R.S. Section 3.—Meteorology and Geology; president, G. J. Symons, F.R.S. Arrangements have also been made for one or more lectures, one of which will be delivered by Prof. Corfield.

THE Fourth Annual General Meeting of the Mineralogical Society of Great Britain and Ireland, to receive the Report of the Council, and elect Officers for the ensuing year, and for general business, will be held at the Freemasons' Hall, Surrey Street, Sheffield, on Friday, August 22, at 3 P.M. The following papers will be read:—"On the Production of Different Secondary Forms of Crystalline Minerals," by H. C. Sorby, F.R.S.; "New Scottish Minerals," by Prof. M. F. Heddle; "On some Cornish Serpentinous Rocks," by J. H. Collins, F.G.S.

THE Fifth Annual Conference of the Cryptogamic Society of Scotland will be held at Forres, on September 17 and following days. The programme of arrangements has been garnished with several not inappropriate quotations from Shakespeare, whose "Macbeth" is naturally suggested by Forres.

DR. JOHN M'KENDRICK, Professor of the Institutes of Medicine in Glasgow University, has been appointed Lecturer in Natural Science and Theology for Session 1879-80, under the Banchory Bequest, at Aberdeen Free Church College, in succession to Dr. Lauder Brunton.

WE regret to record the death of Sir Thomas Moncreiffe of Moncreiffe, Bart., President of the Perthshire Society of Natural Science, and late President of the Cryptogamic Society of Scotland. Sir Thomas was an enthusiastic entomologist and did much to foster and promote the study of natural history in Perthshire. Amongst the schemes which he had at heart was the establishment of an efficient local museum and other aids to the promotion of the study of science in Perth. He was a frequent contributor to the pages of the *Scottish Naturalist*, among his latest contributions being a catalogue of the lepidoptera observed within one square mile at Moncreiffe, which included no less than upwards of 600 species, and is valuable for the notes on the habits and for the light thrown on the geographical distribution of the species in Britain. Sir Thomas, who was Vice-Lieutenant of Perthshire, died on August 16, in his fifty-seventh year.

THE death is announced of Dr. Immanuel Hermann von Fichte, formerly Professor of Philosophy at Bonn and Tübingen Universities, and son of the celebrated Jena professor. Dr. von Fichte was born at Jena in 1797, and died at Stuttgart on August 8 last.

THE fifth Russian Archæological Congress will be held at Tiflis in September, 1881, and will be specially devoted to the investigation of ancient monuments. A committee meeting will take place at Moscow in January, 1880, when the detailed programme of the Congress will be arranged.

IN one of the recently submerged coal mines in the Dux district (Bohemia) a remarkable phenomenon has occurred which Dr. Braumüller, an eminent Austrian mining engineer, describes. It appears that in the subterranean waters of the "Fortschritt" mine regular tides have been observed for the last six months. Both the Berlin and the Vienna Academies of Sciences, are devoting considerable attention to the strange phenomenon. A satisfactory explanation has, however, not yet been arrived at by either.

THE electric light has made its way to the highest hotel of Europe, *i.e.*, to the hotel which is situated at the greatest elevation above the sea-level. The "Engadiner Kulm" Hotel at St. Moritz, in the Upper Engadine, boasts of an elevation of 1,856 metres above the sea, and the proprietor announces that the establishment now possesses eight Jablochkoff lamps. A waterwheel is the motor of the electric machine feeding the lamps.

THE National Water-Supply Exhibition was inaugurated at the Alexandra Palace last Thursday by the Lord Mayor; Mr. Chadwick, C.B., Col. Bolton, Mr. Wanklyn, Prof. Seeley, and others interested in the water-supply question, were present at the luncheon. The exhibition, which covers a wide and varied field of appliances and products in connection with the supply and uses of water, is really interesting, and ought to attract the attention of visitors. We trust it will have the educational effect hoped for. It is intended to keep it open till the spring, and as the object is to collect information as well as to spread it, it is hoped that those who have any maps, or tables referring to water-supply, will send them. Information respecting the aims of the committee may be obtained from Mr. A. T. Atchison, M.A., 34, Great George Street, Westminster. From the remarks of Mr. Cross on Mr. Fawcett's motion last week, it would seem as if Government had determined to deal with this all-important question.

THE Giffard monster captive balloon burst on the 16th inst., a little before six o'clock, when a moderate wind was blowing from the south-east. It will be remembered that M. Henri Giffard placed his balloon in the hands of a company of uneducated aëronauts, who neglected to follow his advice, and for economy's sake left his balloon partly uninflated. The wind acting on the vacuum left in the lower part of the balloon, agitated the canvas in so extraordinary a manner that it gave way. It will not be restored this year, the season being too far advanced for the purpose.

THE French Academy of Meteorological Ascents made two successful experiments, one at St. Germain on the 9th inst., and the other at Cambrai, to test whether it was possible to prognosticate, with the help of pilot balloons, the path which the mounted aërostat would follow. The results were satisfactory. At St. Germain the wind was very light and uncertain, but at Cambrai the velocity was forty kilometres an hour. A competent colombophile had been placed in the car, and a number of carrier-pigeons were liberated from the balloon, and a narrative of the principal incidents of the journey was posted in the city before the aërial travellers had landed. The system had been explained by M. de Fonvielle in a lecture given in the morning in the town-hall.

THE correspondent of a Swiss paper warns collectors of antiquities to beware of fabricated specimens of articles purporting to belong to the age of bronze and to have been found among the remains of lake dwellings and in the beds of rivers. He says there is a regular manufactory of these things near the Lake of Bienne, and that bronze swords are being offered at 100f. each which are not worth as many centimes.

TWO streams of lava flowed on the 15th from Mount Vesuvius to the base of the cone. There was no eruption on the 16th.

M. MOREL FATRO, who is conducting some extensive explorations at the lacustrine station of Corcelettes, Canton Vaud, announces the discovery of a large canoe in an excellent state of preservation. It is formed of a single pine log 32 feet long and 2¾ feet wide; and though the stern is slightly damaged, the bow, which is carved and ornamented, is perfect. This interesting find will be placed in the museum of Lausanne, which now contains the richest collection of lacustrine relics in Europe.

THE new part of the *Transactions* of the Asiatic Society of Japan contains much interesting matter; the most important paper, however, is one on the transliteration of the Japanese Syllabary, by Mr. Ernest M. Satow, of H.M.'s Legation at Yedo, who has industriously applied himself to the study of the language for the past eighteen years, and is one of the greatest authorities on the subject. There are also two papers worthy of notice, the one on inscriptions in Shimabara and Amakusa, and the other on the foreign travel of modern Japanese adventurers.

A PARTY recently visiting the Daly River, North Australia, appear to have met with an alligator far larger than any hitherto seen. Nothing but the head was visible, but this is described as being about 4 feet in length and 2 feet 6 inches in width. On being fired at the monster disappeared, and the precise size of its body could not be ascertained.

IN a valley at the foot of the so-called Habichtswald, near Cassel, a short distance from the castle of Wilhelmshöhe, a new ferruginous mineral spring has been discovered. The water of the new spring belongs to the class of alkaline earthy iron-waters, and besides salts of iron, contains a great quantity of carbonate of lime. It strongly resembles the Schwalbach waters both in taste and composition.

THE Government of Western Australia has offered a reward for the discovery of new guano islands. Valuable deposits are believed to exist on the north coast between the Lacepedes and Camden harbour.

MR. WM. HUGHES' "Outlines of Geology and Geological Notes of Ireland" has reached a third edition, which the author states has been almost rewritten. It contains a considerable number of illustrations. Gill and Son of Dublin are the publishers.

"THE Students' Catalogue of British Plants, arranged according to the Students' Flora of the British Isles, by Sir J. D. Hooker, C.B.," is the title of a useful list compiled by the Rev. George Henslow, and published by Bateman, of Portland Town, London.

THE *Proceedings* of the Bristol Naturalists' Society contains as usual several excellent papers. Mr. Stoddart's papers on the geology of the Bristol coal field are continued; Mr. Bucknall contributes a list of the fungi of the Bristol district; Dr. Fripp an account of some experiments on insect hearing; Mr. A. E.

Hudd part 2 of a catalogue of the Lepidoptera of the Bristol district.

"SCIENCE Teaching in Living Nature, a Popular Introduction to the Study of Physiological Chemistry and Sanitary Science," is the title of a little volume by Mr. W. H. Watson, F.C.S., just published by Stanford.

THE additions to the Zoological Society's Gardens during the past week include two Diana Monkeys (*Cercopithecus diana*) from West Africa, presented by Mr. F. J. Crocker; a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mr. C. F. S. Day; a Malbrouch Monkey (*Cercopithecus cynosurus*) from West Africa, presented by Miss Agnes Barker; a Black Stork (*Ciconia nigra*) from Jutland, presented by Prof. J. Reinhardt, F.M.Z.S.; a Rose-crested Cockatoo (*Cacatua moluccensis*) from Moluccas, presented by Miss Foster; fourteen Golden Tench (*Tinca vulgaris*, var.), presented by Lord Walsingham, F.Z.S.; a Common Buzzard (*Buteo vulgaris*), European, deposited; two Black-footed Penguins (*Spheniscus demersus*) from South Africa, purchased; two Crested Pigeons (*Ocyphaps lophotes*), two Geoffroy's Doves (*Peristera geoffroii*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN

THE ELONGATED NEBULÆ.—The amateur provided with an equatorial of fair aperture and a parallel-wire micrometer might do good service by the accurate determination of the angles of position of the elongated or greatly-extended nebulæ, of which so far the number of reliable measures is but small, though such objects are pretty commonly distributed. The necessity for further observations in this direction is well illustrated by the note to No. 2501 of Sir John Herschel's General Catalogue = H. I. 94; H. made the nebula by one observation extended n. to s., by another nf. to sp., while two observations by Sir John Herschel agree in making it extended in the parallel; "Surely," he remarks, "it does not rotate?" D'Arrest ("Siderum Nebulosorum") merely says: "Circa directionem axis nihil annotatum fuit."

In 1874 Mr. Cleveland Abbe called attention to this subject, and in the *American Journal of Science and Arts*, January, 1875, has collected the approximate places of about sixty elongated nebulæ from Herschel's catalogue, and has appended formulæ by which the right ascension and declination of the poles of a very much extended nebula may be calculated. These formulæ he has applied to such measures or estimations, often rough ones, of the angles of position as were then published.

THE NEW BINARY STAR τ CYGNI.—This star, the duplicity of which was detected by Mr. A. G. Clark in October, 1874, with the 26-inch object-glass manufactured for Mr. McCormick, of Chicago, well deserves following up; in the $3\frac{1}{2}$ years to 1878·4, when measures were made by Mr. Burnham, the angle of position had retrograded 25°, with but little change of distance, though a slight decrease may be suspected. The components are about 4·5 and 8. Right ascension for 1880, 21h. 10m. 8s.; declination, 37° 32'. If the motion in angle has been equable since 1874, the position may now be about 140°.

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. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

"Report of an Unusual Phenomenon Observed at Sea"

AS the unusual phenomena observed in the Persian Gulf, described in NATURE, vol. xx. p. 291, has hitherto called forth no remarks, I venture to put forward a suggestion that may be of service in elucidating the matter.

First, I would observe that the so-called parallel waves were probably arcs of large concentric circles, whose common centre lay south-south-west of H.M.S. *Vulture's* first, and east of her last, position. The distance between these positions was about a knot and a half, therefore the vessel was never nearer this centre than about half a mile, and a short arc of a circle of this radius might well be deemed straight.

The accompanying diagram, drawn from the data, shows the position of the centre of disturbance, and of the luminous waves, with relation to the course of the ship, taking the above view, which I think is borne out by the character of the second series of luminous waves through which H.M.S. *Vulture* passed.

Most living creatures possessing phosphorescence have more

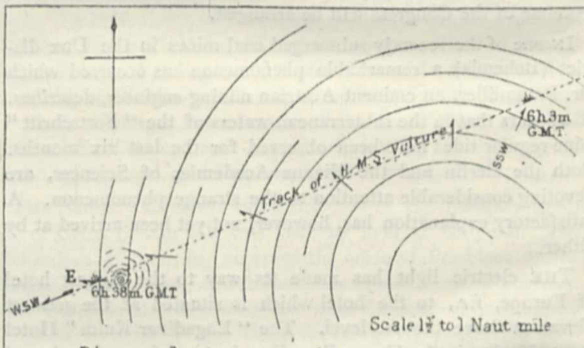


Diagram showing position of luminous wave centres

or less control over its display. In the case of the fire-fly, the light that one emits calls forth almost instantaneously answering flashes from others. No dweller in the tropics can have failed to observe the manner in which trees are lit up by the simultaneous flash of thousands of fire-flies, and the period of darkness that intervenes before the next flash. If then we consider the *Vulture* to have passed through a shoal (if I may so term it) of animalculæ, possessing the power of exhibiting phosphorescence intermittently, and exciting each other to do so, the impulse travelling from one to another at the rate of 125 feet a second, and the display of light to the dark interval bearing the ratio 1 to 3 (in time, $\frac{1}{4}$ of a second to $\frac{3}{4}$), we have accounted for the phenomena so far as the luminous waves are concerned.

What were the central disturbances that originated the action, it is impossible to say, though it is easy to imagine several causes

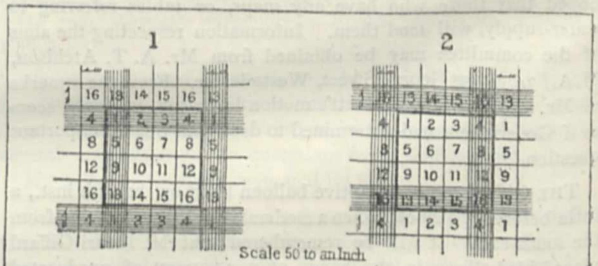


Diagram showing intersections of luminous waves.

of irritation, that would not have been detected by the simple observations taken on board the vessel.

The luminous waves of the smaller series "meeting the parallel waves from south-east did not cross, but appeared to obliterate each other at the moving point of contact." The above is difficult to explain, if the luminosity of the waves was obliterated at the actual intersections. It can however be readily shown that close to the intersections are spaces where the phosphorescence of the animalculæ would have to be displayed for twice as long a period as in other positions, and we have but to admit a want of energy to meet this call, and dark spaces will appear in each system of waves, immediately following the passage of the crossing wave.

This would certainly give the appearance of one wave obliterating the other.

A second diagram explains this simply. Here a portion of ocean is divided into numbered squares of 25 feet, and the advance of the 25′ luminous waves, 75′ apart is shown in two following positions. It will be seen that spaces numbered 4 and 13 fall successively under the impulses. Similarly, in the next 25′ advance of the waves, would all those numbered 12 and 15, and so on, the assumed dark spaces following in the wake of each intersection, as it pursues its diagonal course.

Beckenham, August 5 EDWARD H. PRINGLE

The Planet Jupiter

IN the bright zone south of the south equatorial belt may now be seen a strange and beautiful feature like a flame—red elliptical cloud surrounded by a brilliant white aureole. I first observed it near midnight on the 14th inst., when approaching the middle of its apparent course across the disk.

In November, 1869, Mr. Gledhill discovered an elliptical figure in the same zone, but it was dark, with an interior space bright and colourless.

Gledhill's No. 2 belt (*Ast. Register*, April, 1870), which was a most striking feature for some years, disappeared in 1874, reappeared in May, 1875, again disappeared, and is now again faintly visible. It is *under* (north of) the north equatorial belt.

The south equatorial belt seems of a slate-blue, the north of a russet or dark red colour. The bright central space is crossed by dark, irregular bridges slanting from south-west to north-east—the invariable direction of all the oblique formations that I have ever remarked on Jupiter.

The north polar region seems occupied by a number of apparently close, narrow belts. The south has a pretty similar appearance, but the belts here are not so numerous nor so distinct. JOHN BIRMINGHAM

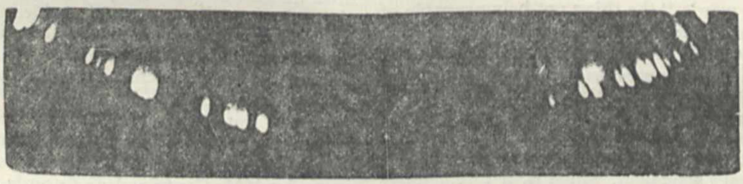
August 15

Twenty-nine Gleams of Sunshine, August 7, 8, 9, in Nine Hours

IN a paper, about weather, written by Mr. Ellis, of Greenwich Observatory, and published in NATURE, vol. xx. p. 313, mention is made of work done with an instrument for registering sunshine, which I contrived, got made, and gave to the Observatory. It consists of a glass sphere, a stand for it, and a metal bowl. The spherical surfaces have a common centre, and radii so measured that the focal cone of sunshine condensed by the glass is cut, by blackened cardboard fixed in the bowl, at the same distance, and at right angles, whatever the sun's position may be in the visible sky. The temperature near the point is at least 700° when the weather is clear. The sun's circular image describes a circle about the common centre, and it burns a trace on cardboard when the sun shines clearly. I can think of nothing better or simpler for the purpose of registering sunshine and counting clouds daily.

The inclosed printer's block was engraved in the focal cone of a cast glass sphere. The flat surface, blackened with shoeblacking, was set roughly parallel to the plane of the equator, and the hot point was brought to bear upon it, at about 1 P.M. on August 7. Thus arranged the section of the cone is not circular, but is an ellipse, which is longer or shorter in proportion to the clearness of the atmosphere. The ellipse describes a circle on the boxwood plane. Hollows burned out by it print white, the surface left prints black. Clouds which crossed the sun's path may be counted between white oval spots. There are twenty-nine spots, the rest was cloud. In common weather parlance the morning of the 7th was "sunny," but the blue sky was veiled by a broken roof of thin detached clouds, moving eastward. They hindered heat waves. Between them were narrow clearer openings. When one of these passed the sun the cone of sunshine burned the block instantly. Afternoon about two, the broken cloud roof mended, rain fell, and the evening was dark and sunless. The night was wet. The morning of the 8th was "cloudy." Not a patch of blue sky was visible big enough to make a pair of breeches for a Dutchman. But the weather "looked as if it might clear up." The sun was "trying to shine." Birds sung notes which forecast a fine day,

2 P.M. 10 A.M.



and the day was "fine." The official forecast was "cloudy" and the day was very cloudy. The sun was seen "wading through mist" at intervals. At 10 A.M. one brighter gleam burned a mark; but that was all the bright sunshine that reached this garden. For a great depth the air was full of water condensed into the shape of the burning glass. Each spherical drop acted on sunshine as the bulb of a spirit thermometer acts—in "absorbing heat," in stopping, refracting, and dispersing waves of solar radiation. There was more shade than sunshine at the ground. The morning of the 9th was sunny, hazy, and cloudy. But large patches of very pale blue sky were visible. Birds foretold a fine day, and they were true prophets. The sun's image came on the block at 9.30 A.M., and it was set carefully at 10, and left till 2 P.M. The air was "thick" all day, the blue of the sky was very pale, and the sunshine "watery." The record shows when brighter gleams occurred during the time of exposure. About noon, as commonly happens, clouds gathered and hid the sun. The brightest time came after noon.

This bit of "thermographic wood engraving" may give readers in brighter climes some notion of the dismal cloudy sky of this abnormal English summer. There has not been a cloudless day since the year began. The blue of the sky never has been the dark indigo of Egyptian and Californian skies.

The cause of this excess of cloud I take to be excess of solar radiation, and consequent evaporation to our westward. Condensation has been in proportion along the European Atlantic coasts, where the ground was chilled by a late and severe winter, and has been little warmed and dried since by sunshine. According to casual and official weather reports, public and private, the heat has been great in America, on the Atlantic, in Spain, in the south of France, in Eastern Russia, in Egypt, and on the Red Sea. The sun shines fiercely upon the ground beyond the edge of a great cloud which has come persistently from the Western Ocean to overshadow our islands, and to drench and batter them with rain and hailstones. Our shadow is the result of sunshine. Our grass is green, our health is good, our gardens are gay in spite of the clouds, or because of them.

Believing in this theory I am going eastward in search of brighter weather, and I send this record of watery sunshine for your acceptance before I start. J. F. CAMPBELL

Niddry Lodge, Kensington, August 9

Electric Clocks

THE various contrivances for electric clocks all depend on producing contacts with the pendulum, which is confessedly undesirable; and they nearly all produce these contacts when the pendulum is at rest at the highest point, which is the worst position.

There seems no reason why a pendulum with a coil-bob traversing over a short permanent magnet, as is usual, should not be independent of contacts. While descending the lower part of the stroke it reaches the magnet, and a current is thus excited in the coil, which is conveyed out at the knife-edges and works a switch; this sends a battery current through the coil for a short period while the pendulum is beginning its ascent, and so drives it forwards by repulsion from the magnet. The same process is repeated in the back stroke. The interval between the production of the excited current and the battery current, and also the duration of the battery current, may be regulated by a small pendulum whose single swing is equal to the interval, and which is liberated by the excited current. The details are so easily arranged that it is scarcely worth while to particularise them. Of course the battery current thus liberated by the excited current could be used for controlling other clocks.

The effect on the pendulum is thus restricted to the quicker parts of its swing; and consists of slightly retarding the descent, and accelerating the ascent, apart from all mechanical friction or contacts. Thus each action is produced at the most suitable time.

Possibly a pendulum cutting off heat rays from a thermopile might thus work a switch, and be even less affected than by producing an excited current in the coil-bob, as proposed above.

Bromley, Kent W. M. FLINDERS PETRIE

Did Flowers Exist during the Carboniferous Epoch?

NOTICING in your pages under the above heading a discussion on *fossil* butterflies and moths, &c., and being struck with the deep interest taken in the question as evidenced by the letter of the Rev. A. E. Eaton (vol. xx. p. 315), I thought that I would ask for a very small space for an intercommunication which may forward investigation.

I have in my collection what appears to me to be a butterfly (using the word without any regard to scientific nomenclature), as a carbonaceous impress on a piece of shale from the Slievardagh coal-field, Tipperary; and by way of contributing my mite towards an inquiry which it gives me pleasure to find so earnestly pursued, I shall be happy to forward the specimen for examination to any of the scientific gentlemen interested who will furnish me his address, or in turn to as many as it will be convenient so to accommodate, on *condition that the specimen be returned to me in good order and without unreasonable delay*.

I may be allowed to add that I have no sympathy whatever with the discussion in its present bearings.

Earlshill Colliery, Thurles, August 7 WILLIAM MORRIS

"Euclid and His Modern Rivals"

MR. DODGSON thinks "it worth while to point out a mistake made in the paragraph about Mr. Morell's book" (NATURE, vol. xx. p. 240). In the words "the thing not being capable of proof," the "thing" referred to is Mr. Morell's assertion that "the perimeter *MDQRSTM* is less than the perimeter *MPQRSTM*," which is not necessarily true, and of course is incapable of proof. Surely this assertion, which I quote two lines before "thing" occurs, is its grammatical antecedent? *You* refer it back to the theorem itself, which Mr. Morell is trying to prove—a theorem which *is* true and easily proved." I gladly accept Mr. Dodgson's statement, which is, if I remember rightly—for I am here far away from Mr. Dodgson's book—perfectly correct—and apologise for having inaccurately represented his meaning.

THE WRITER OF THE NOTICE OF
"EUCLID AND HIS MODERN RIVALS"

Penzance, August 8

SOCIETIES AND ACADEMIES

LONDON

Entomological Society, August 6.—J. W. Dunning, M.A., F.L.S., vice-president, in the chair.—Mr. Philips exhibited living specimens (both sexes) of *Spercheus emarginatus*, taken at West Ham.—Mr. Stainton exhibited, on behalf of Mr. Grigg, of Bristol, larvæ of *Rösterstammia erxlebella*, a genus of which the larva had hitherto been unknown.—Miss Ormerod read a paper entitled "Sugar-cane Borers of British Guiana," and exhibited specimens of the insects referred to, in different stages of development. The exhibition was made on behalf of the Colonial Company, who were anxious to receive any information as to available and practical methods of dealing with these insects. Mr. Distant stated that the circumstances were almost the same on the sugar estates in the Straits Settlements at Malacca, where burning the infected canes was the usual remedy applied. —Mr. Swinton communicated a note with reference to the urticating properties of the larva of *Liparis auriflua*, and a communication was also received from Mr. McLachlan on correlation of mutilation in the larva with deformity in the imago, being the substance of a notice by M. Melise on the subject in the *Compte Rendu* of the Belgian Entomological Society.

VIENNA

Imperial Academy of Sciences, June 13.—On two new *Notodelphyides*, with remarks on some features in the organisation of this family, by Herr Kerschner.—On the yearly period of the insect fauna of Austria-Hungary, No. IV., by Herr Fritsch. —On the motion of plates between the electrodes of a Holtz machine, by Herr Doubrava.—On the perfect pentagon, by Herr Kohn.—On the specific viscosity of a liquid and its relation to chemical constitution, by Prof. Pribram and Dr. Handl.—On the crystalline form and optical properties of isodulcite, by Prof. Urba.—Determination of the inclination from oscillation of a magnetic bar, by Prof. Pscheidl.—The Ferdinandsbrunn spring at Marienbad in Bohemia, by Prof. Gintl.

PARIS

Academy of Sciences, August 11.—M. Daubrée in the chair.—Experimental researches on the erosive action of highly compressed and highly heated gases, and their application to the history of meteors and bolides, by M. Daubrée.—On the acids generated when the crude acids resulting from the saponification of neutral fats are distilled in a current of super-heated steam, by MM. A. Cahours and Demarçay.—Reply to M. Berthelot's note on hydrate of chloral, by M. Wurtz.—On the generation of electricity by the Rays, by M. Ch. Robin.—On the eclipse of July 19 last, observed at Marseilles, by M. J. Janssen. —Second and last observation by M. A. Ledieu, on M. Bouquet de la Grye's paper on atmospheric waves.—M. Palacciano was elected correspondent in the Medical and Surgical Section of the Academy, in place of the late M. Lebert.—On some properties of quadratic forms, by M. Poincaré.—On hydrodynamical principles and the application of these principles, by M. G. Clère.—On the formation of nitric ether in wine, by M. Romanet du Caillaud.—On the distillation of liquids under the influence of static electricity, by M. D. Gernez.—On Ampère's currents, by M. Trève.—On the vapour densities of some organic substances with high boiling points, by M. L. Troost.—On the density of chlorine at high temperatures, by M. Ad. Lieben.—On the synthesis of phenol glucoside, and of ortho-formylglucoside or helicine, by M. A. Michael.—On a combination of chromic acid with fluoride of potassium, by M. L. Varenne.—On the production of crystallised metallic oxides by means of cyanide of potassium, by the same.—On the identity of hydrate of diisoprene and of caoutchine with terpene.—On the conservation of green fodder, by M. G. Lechartier.—On the latent irritation of the muscle in frogs and in man, both in the healthy and the diseased states, by M. M. Mendelssohn.—On the electric irritation of the apex of the heart, by MM. Dastre and Morat.—On the action of the poison from *Bethrops jararacussu*, by MM. Couty and de Lacerda.—Causes of the alteration of animal temperature produced by ether, chloral and chloroform, by M. Arloing.—On the structure of the cephalic ganglions of insects, by M. W. Wagner.—On the rot of the vine, by M. A. Millardet.—On the temperature of the month of July, 1879, by M. E. Renou.—On the history of perfect numbers, by M. L. Hugo.

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