seems as if the aurora were cast out of its exterior edge, but in reality there is nothing but a common stratus-cloud, or a low-lying frost-mist, which extends upon a certain part of the horizon, and which has no other connection with the aurora than to diminish its brillancy, whereby the apparent horizon is a little elevated above the true one. The dark segment seemed in this case to be yet darker, and the light seemed to be cast out of the edge of the cloud. "I can maintain with full certitude," Baron Nordenskjöld says, "that the lighted segment of clouds which we saw during the winter of 1878–79 had this origin; and most probably, several luminous mists which we saw during the nights of March 18 and 20, close by our ship, *close by the ice*, were due to the same cause; but I cannot affirm that quite certainly."

The observations and measurements which were made at the *Vega* winter-quarters have led Nordenskjöld to the following conclusions as to the nature of auroræ:—

"Our globe," he says, "even during a minimum aurora year, is adorned with an almost constant crown of light, single, double, or multiple, whose inner edge was usually,

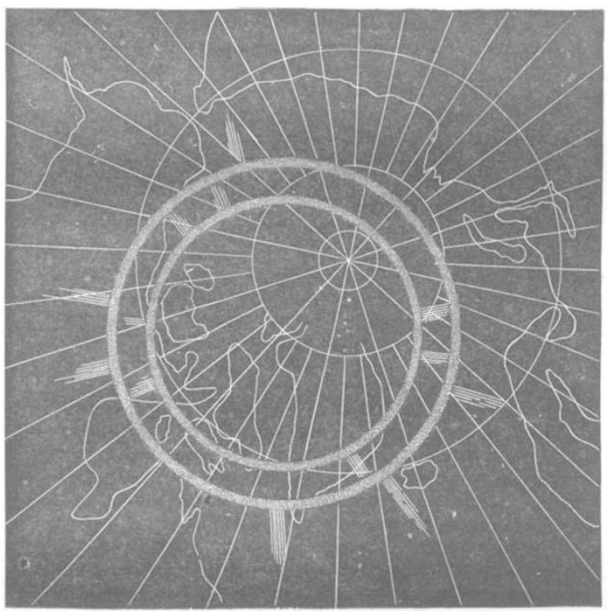

FIG. 2.—Map showing the position of the aurora-glory.

during the winter of 1878–79, at a height of about 0·03 radius of the earth above its surface, whose surface was somewhat *under* the earth's surface, a little north of the magnetic pole, and which, with a diameter of about 0·32 radius of the earth, extends in a plane perpendicular to the earth's radius which passes through the centre of this luminous ring." An idea of this double luminous crown, which Nordenskjöld has named the "aurora-glory," will be conveyed by the drawing, Fig. 2.

Of these two luminous rings of the aurora-glory, the interior, or the "common arc," is the most regular, and it is almost permanent. But it is visible only in such parts of the Arctic regions as are mostly not inhabited by people of European origin; and this circumstance, together with its feeble brilliancy, was the cause of its not having attracted till now the attention it deserves. It is known that even in Sweden the auroræ begin sometimes with the appearance of a halo-like arc, not divided into rays, and which must not be confounded with the ray-auroræ which also often take the shape of a luminous arc. But this regular arc which sometimes is seen in Sweden is not that which was observed at the *Vega*'s winter-quarters: it is a second outer ring situated in the same plane as the interior one, but does not have the same regularity nor permanency. As to the ray-auroræ, visible in more southern regions, they are but a particular form of the aurora considered as a whole; they are but emissions of rays from the crowns of light, or aurora glories, which surround the Polar regions of our globe.

The true position of the permanent inner circle of the aurora glory could be easily determined if we had simultaneous measurements made at two distant points. But such observations not being made, Nordenskjöld tries to determine it from measurements made at Kolutchin Bay, admitting the following most probable suppositions:—That the glory is situated in a plane perpendicular to the earth's radius, which passes through its centre; that it is circular, and that its centre is situated somewhere in the neighbourhood of the magnetic pole. Admitting these suppositions, and with the measurements made during the wintering of the *Vega*, Nordenskjöld arrives, by means of calculations, at the conclusion that the centre of the aurora glory does not coincide with the magnetic pole, but is situated about 81° N. latitude, and 80° E. longitude, and, to avoid mistakes, he proposes to give to this pole the name of the "Auroral Pole." The summit of the common aurora arc being visible in the direction of the magnetic North when seen from places situated beyond the projection of the glory on the earth's surface, and in the magnetic South for observers situated within this projection, it is most probable that the centre of the glory is within the ellipse which circumscribes that part of the Arctic regions where the inclination is 90°. But a glance on a map representing the magnetic meridians shows that this hypothesis is far better satisfied when admitting that the aurora-pole is situated at the above-mentioned place, than if we admit that it coincides with the magnetic pole. The sections of the great circles tangential to the magnetic meridians at a distance of 20° to 30° from the magnetic pole, meet the surface of the earth about this same place. But it should be remembered that the section of the luminous crown, as also the position of its centre undergo certain changes. Under ordinary circumstance these changes are slow and within certain narrow limits; but during aurora-storms they are both rapid and wide. In these cases luminous arcs having different centres may appear at once. It is probable that it would not be difficult to determine, from observations made at two distant places, the laws of these changes; but with the measurements we have now at our disposal it is impossible. "We can," Nordenskjöld says, "only point out the main features of the phenomenon, and the above-mentioned figures are intended only to facilitate the understanding of the conception of auroræ which I try to establish." P. K.

(*To be continued.*)

## *THEODOR SCHWANN*

THE death is announced of the distinguished physiologist whose name will be for ever associated with the history of the 'cell-theory.' He was born at Neuss near Dusseldorf in 1810, and was therefore in his seventy-second year. The most important fact in the history of his mental development, is that he came under the influence of the greatest teacher and worker in biological science whom Germany rich in such men, has ever produced, namely Johannes Müller. Schwann was by nine years the junior of his great master, who died whilst in the full tide of active work, at the comparatively early age of fifty-seven. When Schwann was twenty-three years of age, having completed his medical studies, he became Joh. Müller's assistant in the Anatomical Museum of Berlin and remained there for five years. In 1839 he was called to the chair of Anatomy in the Catholic University of Louvain, being then in his twenty-eighth

year. In 1848 he migrated to the chair of Anatomy in the University of Liège, where he remained to the time of his death, having exchanged after a time, the chair of Anatomy for that of Physiology. It is noteworthy that Schwann was a Catholic, which probably had some influence in his selection by De Ram, the ecclesiastical Rector of Louvain University, for the chair which he first occupied, and he appears to have retained the confidence of the Catholic hierarchy in the later years of his life, if we may judge by the fact that an attempt was made by the clergy to procure him as an expert witness in the case of the reputed miraculous "stigmata" of Louise Latour.

Only four years ago—the professors of Liège and the scientific men of Belgium organized a festival to celebrate Schwann's fortieth year of professorship in his adopted country. From all parts of Europe addresses of congratulation flowed in, and public honours of all kinds were showered upon the head of "the founder of the Cell-theory." Schwann was naturally a man of retiring disposition, and simple habits of life. He had visited London twice within the last thirty years, and had not cared to make himself personally known to his colleagues there; he was equally unknown in the laboratories and scientific gatherings of his German fatherland. As he had published very little if anything since 1845,—though actively engaged in his professorial teaching at Liège which was very highly appreciated—Schwann had become to most biologists, one of the great names of the past—a revered historical character. To sit with him in front of a café in the pleasant streets of Louvain, and hear him discourse of the progress of histology and the germ-theory of disease some six years ago, was, for the present writer, a pleasure only less startling than that which could be conferred by one risen from the dead.

His modesty did not prevent Schwann from keenly enjoying the festival offered to him by his colleagues in 1878; and for some time after that event, he was busy in arranging the publication, for circulation among his friends, of a volume which contains an excellent photograph of himself and a complete report of the eulogistic speeches, and a reproduction of the hundred or more addresses from foreign universities and academies which the occasion of his festival called forth.

Among the many honours which Schwann received in 1878 or had previously acquired, may be mentioned the foreign memberships of the Royal Society of London, and of the Academy of Sciences of Vienna, and the Prussian cross 'pour le mérite'; whilst as early as 1845 he received from the Royal Society of London its most coveted decoration, the Copley medal.

Three important pieces of work are due to Theodor Schwann, each of which was the starting point of endless researches carried out by his successors, and to each is still directly and clearly traceable a distinct and vastly important line of investigation which, up to the present day, is being pursued with ever increasing activity. The first of these consists in his observations and reflections relative to the cell-structure of organisms; the second is his discovery of the organic nature of yeast, of the yeast plant as the cause of alcoholic fermentation, and of organisms as the cause of putrefaction in general; the third is his investigation of the laws of muscular contraction which is declared by the competent authority of Du Bois Reymond to have been "the first occasion on which an eminently vital force was examined as a physical force, and the laws of its action expressed mathematically in numbers."

Schwann's name is very generally known only in connection with his "microscopical researches into the accordance in the structure and growth of animals and plants," and as it seems to us somewhat erroneously, his merit is apt to be associated prominently or even exclusively with the history of Histology. In reality Schwann's merit as an anatomical histologist is comparatively a minor affair; the striking features in his *Microscopical Researches* are his breadth of view and the physiological generalizations which really constitute his cell-theory. Schwann started the conception of a physiology (*i.e.* a truly chemico-physical physiology) of the cell and without using the word "protoplasm" laid down in principle all that it implies. He established in so many words the difference between "crystalloids" and "colloids," and attributed the peculiar growth of cells to the capacity possessed by their substance of imbibing liquids; and further suggested that a peculiar molecular arrangement may exist in these colloid units comparable to the molecular structure of true crystals.

Both in animals and in plants "cells" had been recognized as a very general feature of their structure, previously to 1838. Comparisons had been made between the "cells" known to form plant-tissues and the "cells" seen in some animal tissues. Johannes Müller had especially compared the cells of notochordal tissue to the cells of vegetable parenchyma and had led Schwann to give attention to this matter. But as yet there had been no notion that the cells of plants were the *same* kind of things as the cells discovered in animals. Mirbel followed by Schleiden now propounded the view that *all* vegetable tissues are formed of cells more or less modified, and are produced by the developmental transformation of a primitive cellular tissue. This conception, as Schwann states, fired his imagination and the hypothesis occurred (in 1837) to him that animal and vegetable cells are of identical character, the structural and physiological units of organic nature, and that not only vegetable tissues but animal tissues also are ultimately to be traced to cells. He proceeded most laboriously to test his hypothesis by searching for cell-structure in every kind of animal tissue upon which he could bring his microscope to bear. He confirmed his hypothesis and not only that, but he made a number of important discoveries, in detail, as to the structure of animal tissues, and published his "Researches" in 1839.

The merit of transferring the botanical doctrine of cell-structure to animals and of thus raising it from special to universal application, was undeniably a great one and belongs to Schwann, as does also the merit of having securely established this doctrine by new observations—a task which speculative naturalists are often, in similar cases, disposed to leave to the care of their disciples.

But it is not this *morphological* generalization as to cell-structure which is Schwann's greatest claim to our regard. That is to be found rather in his *physiological* cell-theory, in the masterly chapter in which he lays down the view that the physiological processes occurring in these units called cells are, when summed up, that which we call "life," and *that these processes may be traced to mechanical* (that is to physico-chemical) *causes*. The later "protoplasm-theory" is scarcely an advance upon Schwann, as compared with the great gap which separates his "cellular physiology" from all that preceded it.[1]

[1] The following extracts from Schwann's last chapter of his "Researches," entitled "The Theory of Cells," cannot fail to interest and even astonish the reader when he reflects that they were written five-and-forty years ago, when the doctrine of evolution was almost if not entirely ignored by naturalists. It is also instructive to note that the man who held these views and proclaimed them was an orthodox catholic, and was not considered unfit to be called from Berlin to a Belgian university by the clergy, nor subsequently did a Liberal Ministry fear to promote him from the Chair of Louvain to that of Liège.

(A) "In physics all those suggestions which were suggested by a teleological view of nature, such as 'norror vacui,' and the like, have long been discarded. But in animated nature, adaptation—individual adaptation—to a purpose, is so prominently marked, that it is difficult to reject all teleological explanations. Meanwhile it must be remembered that such explanations which explain at once all and nothing, can be but the last resource, when no other view can possibly be adopted. In the case of organised bodies there is no such necessity for admitting the teleological view. The adaptation to a purpose which is characteristic of organised bodies differs only in degree from what is apparent also in the inorganic part of nature; and the explanation that organised bodies are developed, like all the phenomena of inorganic nature, by the operation of

It is seldom given to one man to fully establish so vast an innovation in scientific doctrine as is the "cell-theory" in its complete form. Schwann had not this good fortune. His position may be indicated in his own words taken from his "Microscopical Researches" published in Berlin in 1839 immediately before his departure for the chair at Louvain. He says: "The elementary parts of all tissues are formed of cells in an analagous though very diversified manner, so that it may be asserted, *that there is one universal principle of development for the elementary parts of organisms however different, and that this principle is the formation of cells.* This is the chief result of the foregoing observations." So far Schwann has only been confirmed and established by all succeeding observers. But when he came to attempt to explain the formation of the cells themselves, Schwann signally failed. He proceeds: "A structureless substance is present in the first instance, which lies either around or in the interior of cells already existing, and cells are formed in it in accordance with certain laws."

Schwann put forward the notion that cells are produced by a sort of aggregative process in a structureless mother-substance; he did not recognize any more than his botanical contemporaries the universal origin of cells by the division of pre-existing cells, although he very fully and correctly identified the animal ovum with a single cell, its "germinal vesicle" with the cell-nucleus and the "germinal spot" with the cell-nucleouls discovered by him, The enunciation of the doctrine "omnis cellula e cellulâ" was reserved for later workers. Von Mohl in plants, and Kölliker and Remak in the cephalopods and vertebrates respectively, made observations on cell-division which have contributed more than any others to the filling out of Schwann's cell-theory by the true doctrine of cell-genesis. It may in truth be said that up to the present day a large part of the progress in both vegetable and animal histology since Schwann's time, has consisted in the demonstration in case after case of the erroneous nature of his doctrine of the free formation of cells.

It is not an easy matter to estimate Schwann's influence in the history of that exact experimental physiology, which his researches on muscular contraction inaugurated. It is sufficient to point to the enormous development of that branch of enquiry within his lifetime, and to insist upon the wide range of capacity (however much we may recognise in its activity the influence of the great Johannes Müller) which enabled one and the same man to establish the generalisation known as the cell-theory, and, at the same time, to make the first exact measurements of the operation of forces in a living body, by the methods and instruments proper to the physicist.

Schwann's merit in relation to the doctrine of organisms as the cause of putrefaction and of fermentation, requires to be more fully noticed since the history of recent research in these subjects has been such as to place a French chemist, M. Pasteur, before the scientific world in the position which truly belongs to Schwann. The latter appears never to have followed up the brilliant experiments by which he demonstrated that putrefactive and fermentative processes depend upon the access of organic germs to the fluids in which those processes occur. But in his "Microscopic Researches" there is an important note on "the theory of fermentation set forth by Cagniard-Latour and myself," in which the yeast-cell is described as an elementary organism, and its activities are discussed as "the simplest representation of the process which is repeated in each cell of the living body." It is a remarkable fact that although Schwann communicated his "cell-theory" to the Academy of Sciences of Paris in 1838, and although his experiments on putrefaction and fermentation form the basis of the observations which have since been conducted with so much approval by M. Pasteur, who has received ample recognition from that body, yet no honour of any kind was ever conferred upon Schwann by the French Academy of Sciences. Even in his old age, at the celebration in 1878, France stood last of all European countries — behind even Switzerland, Holland, and Spain—in the expression of appreciation of, and interest in Schwann's work, as shown by the printed collection of addresses and letters.

It seems therefore not unfitting to state precisely on the present occasion that the discovery of the relation of those ubiquitous organisms, the Bacteriaceæ, to putrefaction (and thus indirectly the immense benefits obtained by our Lister's treatment of wounds) is due in the first place to Theodor Schwann, who also discovered the organic origin of alcoholic fermentation, and devised and carried to a high pitch of perfection those methods of experimenting upon this subject which have since been amplified and extended by M. Pasteur.

E. RAY LANKESTER

## *WOORARA*

NOTWITHSTANDING the deference with which every statement that Claud Bernard has made ought to be treated, it seems probable that he was mistaken in his ideas regarding the effect of woorara on sensory nerves. The indications of sensibility under the action of woorara are afforded by the limb of a frog to which the poison has not had access, so that the endings of the motor nerves in it are not paralysed. On pinching a portion of the skin anywhere in such an animal, even on the poisoned leg, it is noticed that movement takes place only on the unpoisoned one, while all the poisoned parts remain perfectly limp and motionless. But this movement, while it might indicate pain, does not necessarily do so, and may only indicate simple reflex action. The difference between these two conditions, in which the movement is alike, is that which exists between the effect of tickling the sole of the foot in man with a feather and running a pin into it. In both cases the foot would be drawn up, perhaps even more so with the feather than with the pin, but the pin would cause pain, and the feather would not. The movement of the frog's leg in woorara poisoning much resembles that caused by the feather, for it will occur as readily, or more so, if the brain has been removed. We know that in cases where the spinal cord has been broken by accident in man reflex occurs in the legs quite readily, but of this the patient himself is utterly unconscious excepting by seeing the movements in the same way as a by-stander. Increased movement, therefore, in the curarised frog, instead of indicating increased sensibility to pain, may only indicate increased irritability of the

blind laws, coeval with the existence of matter itself, cannot be rejected as impossible. Reason certainly requires some ground for such adaptation, but for her it is sufficient to assume that matter, with the powers inherent in it, owes its existence to a rational Being. Once established and preserved in their integrity, these powers may, in accordance with their immutable laws of blind necessity, very well produce combinations, which manifest, even in a high degree, individual adaptation to a purpose. If, however, rational power interposes after creation merely to sustain, and not as an immediately active agent *then it may, so far as natural science is concerned, be entirely excluded from consideration in relation to the creation.*"

(B) The first development of the many forms of organised bodies—the progressive formation of organic nature indicated by geology—is also much more difficult to understand according to the teleological than the physical view.

(C) "An explanation of the teleological kind is only admissible where the physical can be shown to be impossible. Assuredly it conduces more directly to the object of science to at least make the effort to obtain a physical explanation. And I would repeat that when speaking of a physical explanation of organic phenomena, it is not necessary to understand an explanation tion by *known* physical powers, such, for instance, as that universal refuge, electricity, and the like; but an explanation by means of forces which operate *like* the physical forces, in accordance with the strict laws of blind necessity, whether they are also to be found in organic nature or not.

"We set out, therefore, with the supposition that *an organised body is not produced by a fundamental power which is guided in its operation by a definite idea*, but is developed, according to blind laws of necessity, by powers which, like those of inorganic nature, are established by the very existence of matter."