generated gas might force the oil up the fissured crust to the surface. Only where it makes its appearance do we know for certain that there must be some oil below, but whether in quantity sufficient even to repay the cost of boring for it cannot be predicted.

But before our coal supplies are worked out, and whether or not we discover subterranean supplies of oil, we may surely hope that some of the sources of power which are now unused will be harnessed to the service of man. To the waterfalls, tides, and winds, which have long been considered, Sir Charles Parsons in 1904 suggested another possible source of power in the internal heat of the globe, and in his recent presidential address to the British Association he has returned to the subject. His proposal is to sink a bore-hole 12 miles deep, which would cost five million pounds and require about eighty-five years for its completion. With the use of a fresh source of power and an extended development of electricity,

we should doubtless be able to hold our own in the competition of the nations.

It may be allowed to me to end this article on a more personal note. To the foresight, energy, and constant attention bestowed on *NATURE* by its founder, Sir Norman Lockyer, the world of science has been indebted during half a century for the possession of a journal which with persistent force has sustained the cause of science in this country, has been an invaluable medium for recording the progress of research and discovery, and has played a most useful part as a medium for the discussion of questions of general interest and for public intercommunication between the cultivators of science, to whom it has become indispensable. I contributed to its first number, and have often sent communications since then, and now I am proud to be asked to write a preface to this jubilee issue and to wish continued life and prosperity to my old and valued friend, the founder of the journal.

THE FOUNDATION OF BIOLOGICAL SCIENCES.

By SIR E. RAY LANKESTER, K.C.B., F.R.S.

WHEN the first number of *NATURE* was published in November, 1869, the word "biology" had not the currency now given to it. The word had been adopted by Whewell, and was used by Treviranus and philosophical writers of the early half of last century. What is now called hypnotism was termed "electro-biology," but the extent of the great field of exploration signified by "biology" was little understood. The great event in the history of biological science occurred ten years before the appearance of the first issue of *NATURE*, namely, in 1859, when Darwin published his book "On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life."

The new conception of organic phenomena brought about by Darwin's work took deep root in the ten years from 1859 to 1869, and the main lines of study necessitated by it had been boldly laid by the pioneers, chief of whom were Huxley and Hooker. One main line of work set going, and ever since continued, was the production of further evidence of the kind brought forward by Darwin and Wallace. The period was one of intense activity and movement. The Darwinian theory spread in every direction, and new evidence in its favour was accumulated by naturalists, collectors, and explorers. By a remarkable coincidence, the year 1859 was marked not alone by the publication of the "Origin of Species," but—owing to the work of Joseph Prestwich and a small group of English geologists—it is definitely distinguished as the date when the occurrence of flint implements in the gravels of the Somme was recognised as proving (as had been maintained since 1847 by M. Boucher de Perthes and

denied by the French *savants*) the existence of man as a contemporary of the mammoth and the woolly rhinoceros.

When this journal started its career we had already Darwin's additional volume on the "Variation of Animals and Plants under Domestication," which was followed in 1871 by the "Descent of Man." Practically the whole scientific world (and much of the thinking world outside it) had been convinced of the truth of the doctrine of organic evolution and also of the vast antiquity of man. The evolution of man from animal ancestry, with all its consequences as to the development of the human mind, became an inevitable inference.

Elementary Biology.

By the year 1869 the triumph of the Darwinian theory was assured. In that year Huxley began his course of lectures and laboratory work on elementary biology. The class numbered about a hundred, and Huxley's three assistants were (Sir) Michael Foster, Rutherford (then professor at King's College, London, afterwards professor at Edinburgh), and myself. This course of lectures to teachers, which was given also in the following year, largely emphasised the unity of animals and plants, and it aroused great enthusiasm. Each lecture by Huxley was followed by demonstrations by his assistants in the laboratory, which lasted all day. This became the model for the courses in biology in all English-speaking countries, and formed the basis of the examinations in the University of London.

Huxley by no means sought to put forward zoology at the expense of physiology and botany. In the new laboratories at South Kensington the

first course of botany dealing with the vegetable kingdom as a whole, and not, as heretofore, merely with flowering plants, was given at Huxley's invitation by Thiselton-Dyer. It included the very complete study of lower as well as higher plants. This and the publication of the translation of Sach's "Text-book of Botany," in which Dyer was chiefly concerned, were the starting points of the rapid and remarkable development in botany in the English-speaking universities, which has continued very actively ever since. Profs. Vines and Marshall Ward and others who became leaders in botany were pupils of Dyer at that time.

About the same date, and as part of the same general movement, the development of "physiology" began, so far as this country is concerned. This name has been curiously, by sheer chance, assigned to a study which would more properly be called "organology." Originally physiology meant the study of Nature, but it has been whittled down until now it means essentially the activities of organisms. Burdon Sanderson, together with Michael Foster and Rutherford, were especially active in the introduction of the laboratory study of physiology in connection with physical measuring apparatus, such as the kymograph and other devices already in use in German and French universities. This has resulted during these fifty years in great progress in both the teaching and the understanding of physiology in every university in Great Britain and America.

In 1868 our greatest teacher of physiology in London—Prof. Sharpey, of University College—used to exhibit the mode of record by means of a kymograph by fitting a piece of paper round his tall hat and slowly rotating it on the lecture-table! There was no physiological laboratory in the place at that time.

Methods of Research.

Another great development connected with the new outburst of biology was the improvement both of the microscope itself and of methods of microscopical research. In 1870 all biological workers and teachers became convinced that the long tube and immensely complicated brass-work of English microscopes were superfluous, and that the smaller microscopes of the Continent were better suited to ordinary work. Moreover, the high powers made by Hartnack, of Paris, especially the No. 10 immersion, were found to be more suitable for work upon living and biological material generally than the equivalent powers of English makers. In Vienna in 1869 I worked with Stricker in his laboratory, and learnt from him the method of embedding in waxy materials for the purpose of section-cutting, of which he was the actual inventor. I also studied the methods which he had devised for the investigation of living protoplasm—the outwandering of white corpuscles in inflammation, movements of the large connective tissue-cells of the cornea, etc.

In 1870, owing to the connection thus established, Dr. Emmanuel Klein came to London as

assistant to Burdon Sanderson, and was afterwards, by his appointment at Bartholomew's Hospital, the chief teacher of Continental methods of staining, section-cutting, and refined histology, which at once took firm root in English schools of medicine. Previous to this it was not realised in England that it was easy to watch the movements of the white corpuscles of the blood and other living cells of the animal body.

Also previous to 1870 a few individuals, such as Lockhart Clark, had in this country used the method of carmine staining for the study of such tissues as the spinal cord. But the method of hardening in various fluids, passing the sections from absolute alcohol to chloroform and ultimately to Canada balsam or Dammar varnish, and so rendering them transparent, was practically unknown. But since 1870 the methods of staining and section-cutting have enormously developed in this country. English workers are especially responsible for the development of the microtome and the methods of producing long ribbons of consecutive sections, which has had an immense effect on the study of the microscopic structure of all organisms.

Embryology.

Obviously, a line of research the importance of which was greatly accentuated by the Darwinian point of view was embryology. The discovery in 1866, by Kowalevsky, of the identity in the early stages of cell arrangement in embryos of the Ascidians and Amphioxus gave an enormous impulse to the study of embryology, and raised the hope that secrets of organic relationship in plants and animals might be revealed in other cases. Indeed, Kowalevsky's great discovery may be considered to rank in biology with that of his fellow-countryman Mendeléeff in chemistry. For he showed that the study of cell development could be carried further, and laid the foundation of cellular embryology, which culminated in what is called the ascertainment of "cell-lineage." That remarkably accurate pursuit had its inception in a paper by Whitman published in the *Quarterly Journal of Microscopical Science* in 1878, and has been largely continued by Conklin and others in America.

The actual study of embryology took a new departure in this country under the influence of Frank Balfour, who published papers on the development of the Elasmobranchs, and established the origin of the notochord and the coelomic cavity in Vertebrates as identical with that shown in Amphioxus and Ascidians by Kowalevsky. My own part in this embryological work was chiefly in regard to the Mollusca, but general conceptions were, I think, facilitated by the introduction by me of the terms "archenteron," "blastopore" (orifice of invagination by which the two-cell-layered sac, called by Haeckel the gastrula, is formed), "stomodæum," and "proctodæum" (the in-pushing of the outer layer relating respectively to the mouth and anus). The German terms "Vorderdarm" and "Hinterdarm," referring merely to the anterior and posterior ends

of the alimentary canal, were not identical with my terms, which apply only to portions of ectodermal origin. The doctrine that the coelom throughout the animal kingdom is actually or implicitly an out-growth or a series of out-growths of the archenteron was maintained by me in opposition to the views of Haeckel and Gegenbaur and others, and was finally established by the observations of Sedgwick on *Peripatus*. It was further proved by me that the vascular system was an organic unit entirely independent of the coelom, and my conception of "phlebædesis" made an end of the German misinterpretations of the body-cavities of Arthropods and Molluscs. The abundant cumulative study of embryology during these years has led to most important conceptions with regard to the relationship of various animals—e.g. the origin of vertebrate limbs. Present conclusions are really based on inquiries into embryological beginnings, and the whole interpretation of morphology in its embryological aspect is still in progress.

The Cell.

The study of the structure of the cell itself, and of the processes of cell division, shortly after 1869 made a very great advance. Chromosomes and their importance, and the whole subject of mitosis, became a part of our fundamental knowledge. This very naturally, in view of the importance of heredity with regard to the whole theory of organic evolution, led to the minute study of the structural facts connected with the egg- and sperm-cells, as well as fertilisation and the earliest divisions of the fertilised egg-cell to form the embryo. This study, beginning about the commencement of the period under consideration, is still actively proceeding. Whilst it seems that in the chromosome we have got very much closer to an understanding of the actual visible features relating to the phenomena of heredity, yet there are important facts in course of discovery.

Oceanic Research.

Another line which also suddenly came into activity and has been a prominent feature since 1869 is deep-sea exploration, which began with the voyage of the *Challenger*. When the first number of *NATURE* was published, this was having its initiation under Dr. W. B. Carpenter and Prof. Wyville Thompson, who, led by the discoveries made by those who laid the first deep-sea cables, had conceived the notion of exploring great depths of the ocean by means of the dredge. They obtained the brief loan of a war-ship from the Government for the purpose of their explorations. This led to the three years' voyage of the specially fitted ship *Challenger* and its staff of scientific experts, and the publication afterwards of a magnificent series of reports. This example of the *Challenger* has been followed by every country, and valuable explorations of the ocean—oceanographical research as it is called—has become an established branch of scientific inquiry.

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A complement of the pursuit of oceanography by means of ships and apparatus for deep-sea dredging has been the establishment of zoological laboratories in specially suitable localities on the seashore. The one organised on an international basis by Dr. Anton Dohrn was the first to become widely known and useful, although the French naturalists had some years before this founded marine laboratories—Coste at Concarneau and Lacaze-Duthiers at Roscoff. Now they are established everywhere.

Palaeontology.

Beginning with our starting point, and more especially connected with the founders of the Darwinian theory, there has been an immensely important and productive activity in palaeontology. A large part of Huxley's scientific work consists of the thirty or more valuable memoirs on the remains of extinct fishes and reptiles published by him as naturalist of the Geological Survey. By his palaeontological studies he was led to views as to the genealogical history and connection of the birds and reptiles, and also as to the special development of certain mammalian forms, such as the horse. Also at this period there developed in America an enormous activity in palaeontological discovery. Up to 1869 we knew some few of the extinct animals of America through the work of Leidy. Marsh and Cope then burst upon the scene with most astonishing and valuable accounts of extinct dinosaurs, birds, and mammals. These have been followed ever since by a stream of important discoveries in which Henry Fairfield Osborn is now the leader. The stimulus of this work for the Darwinian theory and its vast importance in relation to that theory are obvious.

Pathology.

A study which has greatly developed, and has had an effect on Darwinism and been reacted upon in turn by Darwinism, is that of the whole field of pathology. Before 1869 the germ theory and the importance of bacteria in disease had begun through Pasteur's work to be appreciated. Since then knowledge has accumulated, and the work of Lister has fundamentally altered views as to the effective nature of asepsis in the treatment of wounds. The outcome of this is an immensely increased study and knowledge of bacteria and other parasitic organisms, and also of the means of resistance to their attack.

Special importance attaches to the recognition by Metchnikoff of the function of the colourless corpuscles as scavengers in the blood and tissues—his doctrine of phagocytosis and the rôle of phagocytes in immunity. Perhaps most strikingly significant is his explanation of inflammation, which is now seen in the light of the Darwinian theory to be a life-preserving property of the higher organisms in which, by local arrest or slackening of the circulation, the access

of phagocytes to injured and diseased tissues is facilitated.

General Retrospect.

All these developments will be found recorded in successive volumes of *NATURE*, in reviews of books, correspondence, and articles. In this way greater perfection of record and comprehensiveness of treatment have been attained than in any other scientific journal.

Whilst all these studies were going on, the more direct observations by the Darwinian method have been accumulating enormously. Classification and general views on morphology have been affected accordingly. Various serious attempts have been made to improve upon or to add to Darwinian theory, perhaps to its detriment. One example of this is Romanes's notion of physiological selection. Another is the attention given to the experiments and conclusions as to hybrid breeding of the Abbé Mendel. Mendel's conclusions differ but little from those contained in Darwin's own work, as was pointed out in a letter to *NATURE* for August 14 last, p. 463. No doubt the breeding experiments which are now carried out in the name of Mendel might equally well be performed in the name of Darwin. The importance of this work was little assisted by those interested in Mendelism, when in the early days they called it a "new science."

Within the limits of a short survey it is impossible to measure the heights of more than a few peaks of biological science, or to describe the boundaries of even a few fields of work. Others will deal with particular branches of biology, including psychology, which will be developed in the near future as the basis of anthropology, and should be to education what physiology is to medicine. Physiology itself has yet to come

under the full influence of the Darwinian doctrine—"the preservation of favoured races in the struggle for life." As yet there has been no investigation of the *development* and survival of functions. It is necessary to study their evolution from simpler types and to analyse by experiment the progressive series of chemical activities involved in digestion, secretion, excretion, and so on. At present physiology is as incomplete as morphology would be if no forms below terrestrial vertebrates had been studied.

In concluding this sketch I desire to bear testimony to the valuable services in the promotion of scientific progress which *NATURE* has rendered throughout its existence. In the hundred and three volumes which have been published since 1869 the names of all the most active workers in the realm of natural knowledge will be found in their pages, not only in papers and books recorded and epitomised, but also as the authors of articles, letters, and other contributions. Every man of science knows the useful function performed by *NATURE*, and appreciates its essential importance to the vitality of the scientific organism. I am particularly glad that my friend, Sir Norman Lockyer, has lived to see the completion of the fiftieth year of the journal established by him. The high and secure position which *NATURE* occupies is due to the sympathetic, impartial, and honourable editorial traditions gained for it by him and still maintained. As a personal friend I cherish the recollection of association with the founder of the journal throughout the long period of its existence, and with all other scientific workers I tender him grateful congratulations for what he has done through it to stimulate the increase and application of knowledge.

SCIENCE AND THE CHURCH.

BY THE VEN. JAMES M. WILSON, D.D., CANON AND VICE-DEAN OF WORCESTER.

THE Editor of *NATURE* reminds me that in its first year of publication I was one of its contributors, and he asks me to write something for its jubilee issue. He goes on, further, to assign me a subject—"The General Attitude of the Church and the Religious Laity towards Science now compared with what it was fifty years ago"—and he limits me to "about a thousand words." It is a sufficiently large subject for, say, ten or twenty thousand, and yet I am going to double that subject by adding the words "and that of the scientific world towards the Church." I think there has been an equal change in both, and I take the latter half first.

About fifty years ago I was more at home in the scientific than in the clerical world. I was

a fair mathematician; an enthusiastic, though ill-equipped, teacher of science; an observer in astronomy; on the council of the Royal Astronomical Society; and associated with Huxley and Tyndall in a small British Association Committee on teaching science in schools. They were among my friends. I had also many friends among the rank and file of men of science. Such are my credentials to speak of the attitude at that time of men of the scientific world to the Church.

That world, impressed and dazzled as it was by the vast extension of the sphere of the natural—that is, of what was sure to recur in like physical circumstances—felt, speaking generally, that "the Church," which insisted on the super-

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