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A CENTURY OF BIOLOGICAL SCIENCE

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In name, this science is little more than one hundred years old. It arose from the more ancient and broader field of natural history.

In earlier times the register of knowledge of fact was considered of two kinds: one which bore no relation to the will or actions of man, known as natural history, and the other which is a register of man's transactions, his failures and achievements, known as civil history.

With the march of time and the advance of knowledge, it became recognized that certain aspects of nature might be approached through experiment as well as by mere observation and recorded fact; and thus it was that natural history became subdivided into such branches as physics, chemistry, earth science, and that section which embraces the study of the living organism, biology.

The term biology was used for the first time in its history by the French scientist Lamarck. It derived from the Greek word *bios*, which the Greeks used to apply more particularly to man, his nature, and his activities. But whether it is the proper word or not, it has persisted as a label for a certain body of science for more than a century.

By virtue of its nature the field of biology reaches in very definite ways into the life and affairs of men. Inferences concerning man's organic nature have been correctly drawn from the investigations made on other animal forms. We cannot take man into the laboratory and experiment on him. This would hardly be considered good form by society, and so for the most part, we have to use other animals for this purpose.

As early, at least, as the second century, Galen dissected dogs and drew inferences concerning human anatomy and physiology. Harvey performed experiments and dissections upon deer at the court of King James and made deductions pertaining to the circulation of the blood in man. Pasteur and Koch used rabbits and sheep in experiments with disease and concluded that the behavior of disease organisms was similar in man and in other animals. And we know now that almost bone for bone, muscle for muscle, and nerve for nerve the dog and monkey compare favorably with the human being.

We use animals for the production of antitoxins by means of which we render ourselves immune to disease, and we go to the slaughter houses to obtain glands of swine, cattle, and sheep for extracts which we use to supplement our own secretions for more normal functioning. So much of the knowledge of nature has also become the knowledge of man that it is impossible to consider man anything else than a part of nature. This is a fact so familiar to us now that it seems incredible that at the close of the last century Darwin's statement was so shocking to the mass of intelligent people of his day—"Man still bears in his bodily frame the indelible stamp of his lowly origin."

With this concept accepted for the past seventy years at least, man has been studied in his proper setting and the chief approach to the understanding of him in this setting has been through the science of biology.

The years 1938 and 1939 mark the one-hundredth anniversary of the presentation of the cell theory by Schwann, a German zoologist, and Schleiden, a German botanist. We are not interested to what extent these men were in error in their pronouncements; it suffices to say that their work marked a new era in the study of the organic world. Not only did it create a stimulus for extensive and intensive research, but it provided a common avenue of approach to all living organisms both plant and animal, including man. All living organisms were brought together in kinship as regards foundational structure and function, and the cell became the unit for the analysis of all living forms.

A little over one hundred years ago embryology became definitely established as a branch of biology through the work of Karl Ernst von Baer. This great student, careful observer, and judicious investigator raised the techniques and study of embryology to new levels, established comparative embryology, and developed what has been called the "germ layer theory." This latter conception holds that the developing egg cell very early, through its proliferation, in the higher animals forms three layers of cells and from each of these layers definite parts and organs arise, each layer producing the same general organs and systems for all of the animals, from fish to man. Not only did the work of von Baer push observation of development back to much earlier stages in the embryo, but the theory has done a great deal to aid in the establishment of the evolutionary relationships of man and the lower vertebrates.

Embryology as a necessary supplement to the study of comparative anatomy was emphasized in the middle of the last century by Richard Owen and in the latter part of that century by Thomas Huxley. Other workers, such as Roux, Spemann, Harrison, Lillie, and Morgan, in the latter part of the last and early part of the present centuries, carried the problems of embryology into the germ cells themselves. The quest here has been to ascertain by what means and processes the developing egg cell marshals its materials in such a manner as to ultimately give expression to the physical individuality which emerges from it. Embryology is here resolved into a study of the patterns and dynamics of cell organization. No one can deny the difficulties and the challenge offered by this branch of biology which leads through a sort of no-man's-land from the gene to its expressed end product in the form of the individual.

It has been discovered that very early in the development of the embryo there are areas over the cell mass whose destinies will lead them in expression to different ends. Parts of the developing mass soon come to differ from other parts so as to relate the form of the whole and the position of the parts. This principle has been taken advantage of in the advance of experimental embryology. In the past twenty-five years embryological research has been largely concerned with the influence of part on part in the course of early development. By observing the behavior of different potential fields or parts of the cell mass when placed in abnormal positions, a knowledge of the influence of part on part has been ascertained, and thus the environmental factors within the embryo itself which are instrumental in determining the expression of cells in different fields of the embryo are known and established. One thinks of Detwiler and Hoadley as outstanding contemporary workers in this field.

The great subject of genetics really began its career as an established science in the present century when Mendel's laws were rediscovered a little less than forty years ago. Those of us who were born thirty years too soon have seen this science which was conceived in and given birth to by botany into the hands of Mendel, christened by Bateson, nursed and studied by Punnett, Davenport, Wilson, Castle, Conklin, and Morgan and his coworkers grow and become of age. We have followed it as it has wormed its way through garden peas, four-o'clock, primroses, jimson weeds, rabbits, guinea pigs, rats, mice, and fruit flies to the place where it now largely reposes in the salivary glands of the lowly maggot of *Drosophila*, and, for the most part, it is in the custody of Morgan, Painter, Muller, and the other members of that fraternity of creative biologists: a science barely 35 years of age with an accumulated literature beyond the compass of a single mind! The story left in the trail through the pursuit of the hereditary determiner called the gene is paralleled nowhere else unless in the quest of the electron.

It seems now that we are almost in sight of the gene. These centers of hereditary determination, whose positions on the chromosomes have been charted for twenty years, are now known to reside on definite visible entities which are capable of being followed by experiment and microscope from generation to generation. The chromosomes in the cells of the salivary glands of the larval fruit fly are nearly one hundred times as large as those from other regions of this animal, and here is being made a structural analysis of the chromosome to such a degree as never before.

About eighty years ago there was announced to the world a concept of the evolution of species by Charles Darwin. He gathered together the fragments of the past, especially those which fell from the hands of Lamarck, added his own massive researches, and formulated a doctrine which shook the foundations of civilization. The conception swept like fire into all categories of human knowledge and new horizons and new vistas spread before the human mind.

Darwin definitely established man's place in nature. Man could certainly now be approached by the techniques of all the sciences and analyzed as an organism amenable to the laws of nature, adaptation, reproduction, disease, ageing and death just as are also his kinfolk, the lower animals, which we study in field and laboratory. The old categories of the knowledge of nature and of man became one and inseparable for all time. Much of science and philosophy was revolutionized and an impetus was given to biological pursuit and interpretation which cannot be measured.

Another branch of biology which gained great impetus in the past century is that of physiology. As regards its scientific basis, physiology was early established by such men as Galen, Harvey, Paracelsus, and Haller. But it was just about one hundred years ago that Wohler accomplished the artificial synthesis of urea. This started new trends in physiology and laid the foundations of biochemistry. The work of Fischer, Liebig, and others of this period gave impetus to this trend, and to these men is to be given the credit of first applying physiological apparatus in the form of biographs and other devices to the study of physiological processes.

Associated with the latter part of the last century are the names of Du Bois-Reymond, Helmholtz, and Claude Bernard. Du Bois-Reymond and Helmholtz are known especially for the application of the principles of physics to physiological problems. They studied the electrical phenomena of animals and Helmholtz measured the velocity of the nervous impulse, a thing which had been given up by his contemporaries as impossible. Aside from the many original contributions of Claude Bernard he paved the way for modern physiology as it takes its form in relation to the internal secretions.

The biological approach to disease had its origin in the past century very largely in the hands of Pasteur, Lister, and Koch. The work of these men revealed the relation of parasite to host, the nature of toxins and antitoxins, and the principles of antisepsis. As never before, from that time to the present, a warfare has been waged on human disease which has been both relentless and telling.

At the time Pasteur announced his discoveries, one might have expected to reach the "old age" of about 35 years. Today that expectation is extended to the age of 59. A person today has 35 chances in 100 to live to the age of 72; 13 chances to live to be 82; and 1.3 chances out of 100 to live to be 92, if a male. And if one is a female, there is the favored addition of .6 chance—or 1.9 chances in 100 to live to be 92.

But while a person in Pasteur's day having attained the age of 35 years might expect to live twenty-five years more, vital statistics show that today this expectation is not materially greater. The increase in longevity is due to the removal or decrease in the disease hazards of infancy and childhood. Many of the infectious diseases have been brought well under control. Others such as influenza and, until recently at least, pneumonia, have sternly resisted the attacks of science. The functional disorders of middle age and later life stand as a challenge now to medical biology. We are thinking of arteriosclerosis, apoplexy, high blood pressure, cancer, general senescence, etc. The work of such men as Child in the last thirty years will no doubt make significant contributions to the ultimate understanding of these problems which relate to the ageing of tissues and their functional decline.

The vast accomplishments in the past twenty-five years in the field of the endocrines and vitamins cannot be reviewed at this time. Some of the most brilliant researches in medical biology and biochemistry have been done in this field. The recent work of Banting in the discovery of insulin stands before us as an example. The biologists have been busily engaged in the field of endocrines in the past twenty years; and whereas fifteen years ago the functions of the pituitary gland were merely hinted at, at the present time no less than ten hormones of that gland are listed, with the functions of most of them specifically indicated. The pathways of experimental biology and biochemistry converge in the endocrines and vitamins. In fact, the most active lines of physiological research at the present time are in these fields. Chemistry is lending a significant hand in properly isolating and synthesizing these products, thus facilitating the administration of these substances to offset our glandular deficiencies and placing the products within reach of rich and poor alike.

The biologist throughout the present century has been intensely engaged in the pursuit of the fundamental nature of life. This research arose with the work of Max Schultze who formulated the protoplasm doctrine seventy-eight years ago. With the rise of physical chemistry, much new light has been shed on the nature of the living substance which Schultze called protoplasm. But, with all the aid that has come to the biologist from colloidal chemistry, he is less optimistic as to the ultimate explanation of fundamental vital phenomena on the basis of physics and chemistry than he was fifteen years ago. It is possible that life in its most elemental entity or unity is expressed in the viruses rather than in the more complex cell. But there is a state of impasse at present as relates the basic explanation of these evasive substances which express attributes of organismal individuality.

As one follows the researches in the field of protoplasm today, he often finds himself proceeding with breathless interest in the consciousness that we must be standing on the threshold between the animate and inanimate. The interplay between the fields of chemistry, physics, and biology is hot and fast. Sometimes it seems, as expressed by some, that the task shall never end. The biologist carries his problem as far as his abilities permit and hands it to the chemist or physicist, who pursues the task for a time only to hand it back with the statement, "I have gone as far as I can; study it a little longer from the biological point of view and maybe I can do something about it later."

To what extent the fundamental life phenomena depend for their expression upon the organized cell and to what extent we may be able to penetrate their secrecy in the more elemental forms such as the viruses is yet to be demonstrated. But in the cell, we are dealing with many levels of systems. There are, from lower to higher, the hierarchies of electrons, atoms, molecules, mixtures of molecules, genes, chromosomes, and other formed substances or physical objects of the protoplasm. And to explain man biologically we must pass to other hierarchies of cells, of tissues, organs, and systems. All of these hierarchies are in a constant state of flux. No one entity is halted for observation before another has changed in composition or form.

A statement from the eminent physicist Bohr may prove to be final, at least for a long period of time: "There is a fundamental limit to the analysis of the phenomena of life in terms of physical concept, since the interference necessitated by an observation which would be as complete as possible from the point of view of the atomic theory would cause death of the organism."

Coker makes a similar statement in the following: "There seems to be no ultimate solution of the problem of determining the organization of the vital substance until we find a means of attack to which the substance itself does not respond."

Sir Francis Galton, about seventy years ago, though ignorant of the modus operandi of the laws of inheritance, undertook the task of applying those laws to the study and betterment of the human race. A group of individuals, Karl Pearson, Davenport, Raymond Pearl, Julian Huxley, Popenoe, and others, have been the proponents of the idea of applying genetics to racial betterment, and we call this branch of applied genetics eugenics. The purpose of eugenics is to conserve the best there is in the human race and relieve society of the burden of that which is undesirable.

We are now in possession of the knowledge of the racial background of the human species, and we have become familiar with the hereditary system to a degree sufficient to enable us scientifically to improve the species of plants and animals of domestication. Thus we know vastly more about these techniques as they relate to man than we shall likely apply in human breeding for generations to follow. Society seems not yet ready for the application of these principles to human affairs. Eugenics appeals more to the intelligence than to politicians and to idealism rather than to realism. It has small appeal to those who are more interested in the acquisition and enjoyment of the luxuries of this generation than in the fundamental needs and enjoyments of the next. It may be hopeless to convert the aged but it may yet be possible to present to youth the accumulated facts of biology concerning reproduction and race betterment with their sobering effects if shorn of the attitude of bravado.

No branch of science can long stand still. There are three aspects of activity in any field of science; that of scientific research, that of teaching, and that of the scientific application of science itself. Society will sooner or later demand that science can no longer claim neutrality as regards human values. It may yet be shown that the happiness of man is more important than a mass of science improperly applied. As research workers and teachers in all fields of science, let us rejoice that our tasks may indefinitely go on. In research we shall relentlessly pursue. As teachers let us so train young men and women as to awaken their imagination and initiative and so discipline their intellects that they will do great things for humanity in the future.

As students of the scientific application of science to human affairs, let us meet our responsibility boldly and without apology. Let us exercise our scientific judgment as we deal with the issues of politics, industry, and society at large and demand that that for which we labor to give to humanity shall be used to make man truly happy and make men free.

As we go back to our tasks for another year, I wish to leave with you the words of William Henry Welch, late dean of American medicine who was a great teacher and student of medical biology. "It is my inclination even at fourscore years, to look forward rather than backward and to avoid a feeling of self complacency through the rehearsal of past triumphs. All along the line so much more remains to be done than has been accomplished. How wide is the gap between what has been achieved and what might be realized!"