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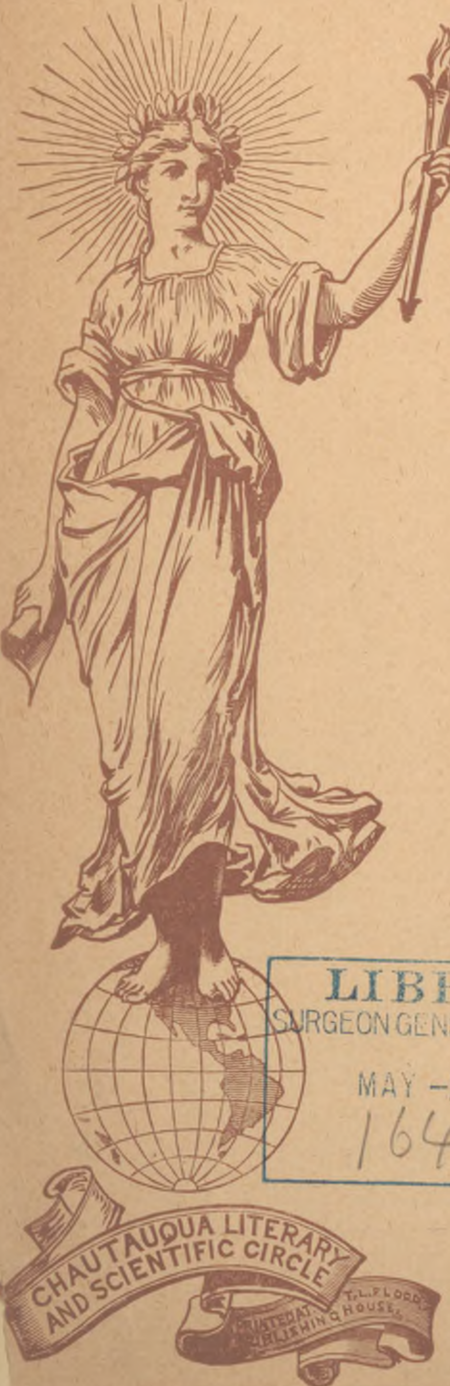

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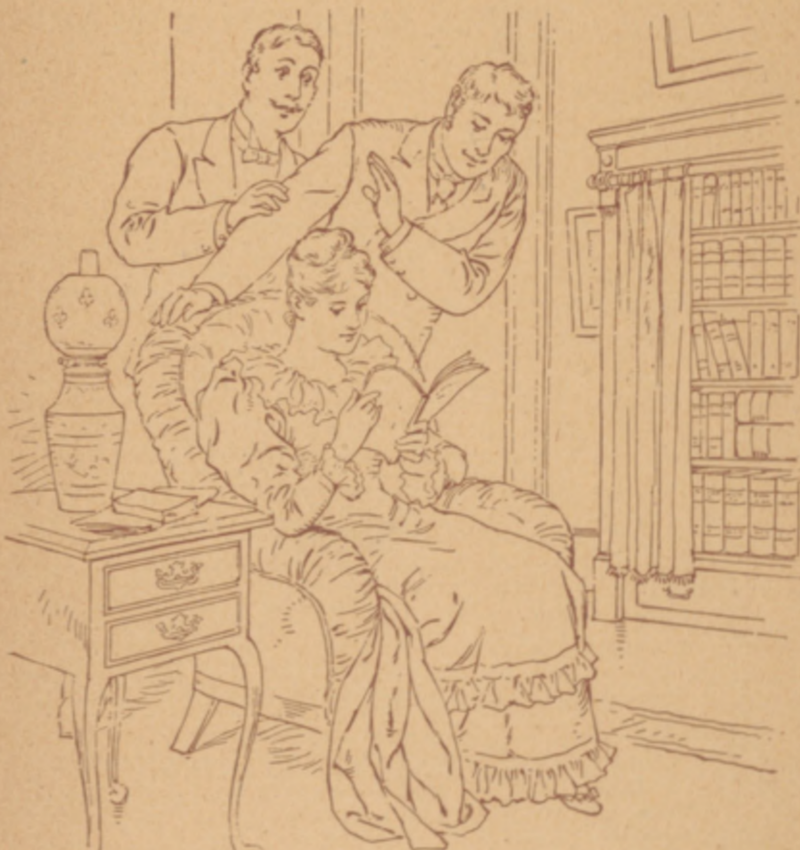

WHAT IS BIOLOGY?

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THE term biology is used in such a variety of ways, and by so many specialists in different lines of work that it is extremely difficult to give a clear definition of it without evoking contradiction from many quarters. The reasons for this are very apparent when we consider that a biologist may be a zoölogist, botanist, etc., or only a biologist in the general sense. This shows that the term, regardless of its origin, has a different meaning according to the kind of specialist that employs it. In addition to this difficulty we have another in the geographical distribution of the various schools of specialists. In different countries the term biology is more or less loosely attached to one or the other of the above departments so that, in certain cases, it may be wholly monopolized by any one of them.

The general tendency in America is to consider biology as composed of botany, zoölogy, physiology, etc. This is by no means incorrect since the above branches all deal with living beings and must necessarily include the phenomena of life. If we attempt to define biology from any other standpoint, I fear that little headway will be made. Another definition is the study of a living being as a whole. At first sight the two definitions are diametrically opposed to each other, but more careful consideration shows them to be nearly identical.

When the structure and form of a given plant or animal are studied we call it anatomy, or sometimes, as modern usage has decided, morphology. This study may be farther extended into embryology, or the development of a more complex being from a single cell. Now it has been shown that all organisms are composed of but a single cell or of a great colony of cells. This at once compels us to ask ourselves the relation, if any, of the unicellular being to the multicellular. We cannot make much headway in this question if we wish to compare all forms of living matter at the same time so it has become necessary for certain individuals to study certain tissues; others to study certain groups, and finally we have developed a science known as comparative anatomy.

Going into the problem a step further we find that unicellular and multicellular organisms are both independent beings, although the latter arise from a single cell while the former always has been a single cell. We can also place the development of the organisms side by side and find that the more complex beings of a certain class passed through more stages of development than the simpler of the same class. This complexity continues to such an extent that it is often very difficult, in fact often impossible, to compare one organism with another.

The above shows that from the anatomy and embryology alone it is impossible to prove that there is any genetic* relation between the various living organisms although the hint is very strong.

We have a clear idea of the term anatomy, of either plants or animals, but no one would be inclined to consider it to be biology. Neither can we consider the modern physiologist a biologist. The same applies to most botanists and zoölogists, although any of the above specialists may deal with biological as well as with physical questions. Only when we consider the living beings as a whole, or when the importance of a part is viewed from the same standpoint are we inclined to call a question biological.

The idea then that the study of a living being as a whole is biology gains strength. We can, however, extend the study of morphology through many generations, by direct observation, and at the same time take advantage of the various experiments nature has made for us.

The geologist in studying the layers of the earth's crust has given us the experiment of nature while the breeder of domestic animals has given us many of the data of direct observation.

The study of fossils, or paleontology,† has

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*Greek, *genesis*, origin, source, generation. Relationship by direct descent.

†[Pa-le-on tŏl'o-jy.] The science which treats of the ancient life of the earth or of fossils.

naturally dealt with the more resistant portions of plants and animals as they are the more likely to be preserved. In a nutshell, paleontology has confirmed that which comparative anatomy and embryology have already hinted at. In the deeper strata we find the remnants of the more simple organisms while in the more superficial strata the remnants of the more complex organisms are brought to light. Through all these successive geological stages there has been found almost a countless number of intermediate animals and plants no longer living at the present day.

Take for instance osteology;* it is not biology. Neither is comparative osteology biology. But when osteology is studied in connection with paleontology it begins to throw light upon living beings as a whole which is a biological question.

Many other similar examples in the comparative anatomy of plants and animals connected with embryology or with paleontology, or both, could be given.

It also has been found that heat, cold, moisture, and other agents varying on different portions of the earth have had a marked influence upon the life and form of living beings. So the geographical distribution of plants and animals has also played its part in throwing light upon the organisms as a whole and has aided in making the study of botany and zoölogy biological.

Many of the above statements were well known at the beginning of the present century but were not sufficient arguments to make most naturalists accept evolution as taught at that time. The experiments upon breeding were little known and the data not accurate until they were systematically studied and tested by Darwin. By direct experimentation it was possible to produce such marked varieties of animals and plants that they could almost be considered new species. Physics has long ago told us that coming to conclusions by means of deduction is very liable to lead to error and more liable to lead to discussion than to discovery. It is a remarkable fact that the followers of Darwin have not used his most powerful tool, experimentation, in trying to confirm his theory. Darwin did show that new species could be formed by means of selecting animals and plants in which the variation was great, but it has not been shown, or only to a slight degree, what the cause of a certain variation is.

When we begin to study living animals and experiment upon them we are dealing with physiology, but to the present date most physiologists have not been experimenting upon organisms as a whole. They have rather interested themselves with the functions of the different organs and tissues but not with the general principles regarding whole plants and animals. To the extent in which they deal with the organisms as a whole their problems become biological and the physiological botanist deserves greatest praise in this respect. During the last few years also the animal physiologist has contributed to the study of biology and at present the greatest hope in biological investigation lies in his hands.

It is useless to hope that the individuals educated only in the descriptive sciences can contribute much to an experimental science for the methods of thinking and investigating are so different and the aims often so widely separated. When by experiment it is possible to compel animals to move to or from the light, when growth can be arrested or accelerated by different chemical compounds, when by varying the amount of moisture a wingless insect can be converted into a winged one it is possible for the physiologist to contribute to biology. This has all been done. We may call this environment and not be far amiss, and our artificial means may possibly, under certain circumstances, be produced by the individual itself from generation to generation, and thus cause variation to be continued, *i. e.*, inherited.

It is almost an axiom that the offspring is nearly identical with the parent but the axiom was considered of no scientific value until it was called heredity. The causes of variation are to a great extent unknown, but there seems to be a sufficient number of experiments to suggest that some direct influence upon the parent may influence the offspring. The evidence comes, to a great extent, from pathology, or the "science of disease." The realm of pathology is so great that we have in its classification practically all the subdivisions of biology, which together are sometimes called pathological biology. If we consider the rule as *normal* we can consider the exception as *abnormal*. Possibly in plainer language we can consider embryology the formation of the organism;

*[Os-te-ŏl'o-jy.] The science which treats of the bones of animals.

anatomy, the study of its parts; physiology, what they do; and pathology what they do improperly. But when a broken wheel in a machine causes it to run too rapidly we can as well say that it is normal for a pathological machine, as pathological for a normal machine. All variation, however, seems to be brought about (if we accept the natural selection theory) by means of the exceptions, or pathology. As soon as the exception is established it no longer remains the pathological but becomes the normal.

So we see that pathology contributes its great share to biology and therefore must be considered one of the biological sciences. With all of its bearings in medicine it can doubly well add to the study of biology because of the comparative ease in selecting statistics and in the performing of experiments which cover the area of a continent.

During the last few years pathology has gradually become more and more comparative in nature and offers itself better to experimentation than a generation ago. It is very necessary in an experimental science to be able to control all the factors excepting the one we wish to test. An excellent example in pathology is the study of the disease tet′anus, or lockjaw. It was known for a long time that in some cases of lockjaw there was an accompanying wound; in others not. These two varieties of tetanus were called traumatic * and idiopathic † respectively.

Before any further observation was made it was surmised by careful clinicians ‡ that there could be but one kind of tetanus and it must be the one associated with a wound. Later it was discovered that the wounds accompanying tetanus were usually filled with dirt and the experimenters began to look to it for the cause of lockjaw. By inoculating garden soil under the skin of rats it was possible to produce tetanus in them and somewhat later the germ was discovered. The germ was next employed and experimenters were soon able to produce the disease in any number of animals and microscopic study showed that the wound in human tetanus also contained a germ which was identical with the one obtained from garden soil. This did not satisfy the investigator and it was soon discovered that the germ produced an albuminoid compound which produced all the symptoms of the disease in animals poisoned with it. So it is not the germ which produces the disease but a poison excreted by it.

Pathologists know that diseases may be cured, or at least patients often *get well.* So they began to experiment with the blood of an animal which had survived tetanus, as well as with the products of the tetanus germ on blood outside of the body, and soon were able to make healthy animals immune * from the disease by a method of vaccination.

This series of experiments made by a host of investigators in botany, chemistry, hygiene, pathology, histology,† and bacteriology, is not only of the greatest benefit to mankind but is also biological from beginning to end.

The above discoveries do not apply to tetanus alone but to many other kinds of diseases investigated during the last ten years. At one time it seemed as if tuberculosis ‡ would also fall in with the list under control and investigators in bacteriology are now as hopeful as ever regarding it. During the last year it seems as if the germs of cholera and diphtheria had also fallen into the hands of their enemy and will soon be, we hope, completely under control.

Bacteriology, the study of the lowest forms of vegetable life, is the great science which has accomplished so much. Scarcely twenty years old, it has revolutionized surgery and medicine and promises to do much for biology and mankind. There are no better objects than bacteria upon which to study heredity. It is possible to change their powers with great ease and this power is inherited for thousands of generations. When certain disease-producing germs are once weakened they no longer destroy the animal into which they are inoculated but often produce a certain change so that when the virulent germ comes it no longer has any effect. This is one of the phases of immunity. And as heredity is one

* [Traw-măt-ik.] From the Greek word for wound. Of or pertaining to wounds.

† [Id-i-o-path′ik.] A word derived from Greek, meaning feeling for oneself alone, affected in a peculiar way.

‡ [Kli-nish′an.] One who makes a practical study of disease in the persons of those afflicted by it.

* A word in rare use, meaning exempt; specially, protected by inoculation.

† "That branch of anatomy which is concerned with the structure, especially the microscopic structure, of the various tissues of the body."

‡ [Tu-ber-ku-lō′sis.] A disease affecting most of the tissues of the body, characterized by the formation of tubercles, or swellings, and the presence in the diseased parts of the tubercle bacillus.

of the great problems in biology so is immunity the great one in medicine.

But immunity is a biological problem as much as heredity. In fact rational medicine is nothing else than a biological science. In bacteriology the lowest vegetable forms and the highest animal are the objects which interest us most. When the bacterium produces disease in man the changes which take place in both parasite and host are biological, as in both cases we study the individual as a whole. Yet we say that it is disease, or abnormal, for man while it is health, or normal, for the parasite. In this union there is a tendency to destroy the host and to favor the parasite. The study of the distribution of bacteria as well as the varieties of animals and plants they may infect is equally as scientific and as biological as the study of the geographical distribution of plants and animals.

Another standpoint from which to study bacteria is the one in agricultural chemistry. We have here a variety of aims in view, but the problems are often biological. Its great usefulness is almost as unlimited in this field as it is in medicine. Yet we need not ignore that biology may be as practical in one direction, as physics is in the other. Still these truly biological problems must interest the investigator more than their immediate practical bearings, for new discoveries must be made before they can be applied.

Another biological problem is symbiosis, or the union of two beings for the mutual benefit of each other. Often it seems as if an animal is absolutely dependent upon a plant and in turn the plant upon the animal. In general this is true for all living organisms but the benefit and dependency is usually distributed through many different organisms. Our own society seems to be built up after the same plan, and how could it be otherwise? A sharp contrast to symbiosis is parasitism or the condition in which one organism is wholly dependent upon the other and the host is injured rather than benefited.

We see that the biological problems are solved by the investigators in at least a dozen branches which are of sufficient importance to rank as independent sciences. This shows the great value of biological problems, all of which deal, I think without exception, with the organism as a whole, rather for many than for a single generation. It is convenient, but I think wrong, to consider biology simply as a conglomerate of these sciences, as wrong as to consider mathematics as composed of physics, astronomy, and chemistry, simply because the latter constantly have to employ mathematics. Physiology might as well be subdivided into all the branches of medicine because they constantly have to deal with and employ physiological methods.

In general then biological problems do not apply to a portion of a single plant or animal but rather to the whole organism for more than one generation. This is the reason why the various sciences dealing with the various portions of the animal and vegetable kingdoms so often touch upon biological questions.

The great hope for the future of biology in America rests to a great extent in the organization of biological departments in which are represented all the sciences which deal with biological questions. Nearly all of our leading universities have but a few of the sciences represented in their biological laboratories and they will never be on a par with European institutions until biology is greatly strengthened. With such an organization they could not only train students and investigators from many standpoints but also take charge of the first few years of medical education. This is not only necessary before we can hold a proper position in biology but will also aid to a very great extent in developing the science, and at the same time will help materially to raise our standard of medicine to the dignified position it holds in Europe.