

with three young birds found July 10, 1911.

**Sialia currucoides*: Mountain Bluebird. Winter resident, very numerous. Sixty-one seen on Marselus Bros. ranch December 3, 1918.

VI. PRESENT DAY OBJECTIVES IN ZOOLOGY

A. Richards

From the Zoology Department, University of Oklahoma.
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An attempt to define present day objectives in Zoology involves an examination of the problems upon which professional zoologists are working and an inquiry into the reasons for choosing these particular problems. The principal aim of science is to discover the character of the facts which constitute the realities of nature and to approximate as near as possible the explanation of these facts. The criterion of the accuracy of a scientific explanation, theory, or hypothesis is the extent to which predictions based upon it are borne out in subsequent happenings, and this implies the method of experiment.

There are few conclusions in science that may be regarded as absolutely and finally proven, for in the nature of the case absolute proof is unattainable. We regard conclusions in science as proved if they are supported by the available scientific evidence, if they are not contradicted by any scientific evidence, and if they are supported as time goes on by new discoveries. Persons not schooled in science or scientific logic sometimes demand a measure of proof which is unattainable. Many of the facts that science deals with involve processes of extremely long duration compared with which the span of human life is but a moment. The nature of the proof which can be used for such matters is very different from that which demands a short experiment that can be performed in a few moments with test tubes.

In the lifetime of many persons now living biology has developed from a descriptive science into an experimental one; indeed the most marked tendency of present day researches is the reliance upon the method of experiment and the attempt to state biological results in the exact terms of chemistry, physics and mathematics. In its early stages biology was purely descriptive. The problems which occupied the time of our great grandfathers in zoology were systematic in character. That is, they dealt with the classification of animals and the description of species. Then came the period of morphology and comparative anatomy, in which the attempt was made to trace structural relationships be-

tween the various organs of an animal's body and between different animals. Along with these two lines of biological research went investigations in embryology, paleontology, geological and geographical distribution, the whole culminating in the last half of the nineteenth century in the doctrine of evolution. The last quarter of the nineteenth century saw the most phenomenal advances in microscopic investigations particularly in the early phases of embryology, and in the structure and behavior of the animal and the plant cell. All of these researches however had a morphological background and a morphological point of view. In saying that Systematic Zoology, Economic Zoology, Morphology, Embryology, etc., were the main researches of the last century, we do not by any means imply that they are no longer the subject of investigation. As a matter of fact the actual output in each of these branches is doubtless greater in volume than at any time in the past. But the attack of these problems is not now purely a morphological one and the main interest of today is in problems of different character. The main current may move steadily forward in a certain direction but a broad stream touches much that is outside the main current.

Thus far we have shown what the main objectives of the present in zoological research are not. It may be added that the evolution doctrine as it is commonly understood, that is, the study of its evidences and factors, is not one of the main objectives. So far as professional biologists are concerned the fact of evolution is a settled one. We do not seek further evidence concerning this fact although such evidence is piling up mountain high as the result of every investigation which we have undertaken. Every available line of argument leads directly to this conclusion. To be sure the causes and the manner in which evolution works is by no means clearly understood. Neither is the manner in which radioactivity operates clearly understood. But the investigations in radioactivity for example have merely lead us to a new conception of the doctrine of the conservation of matter, not to its overthrow. So we may regard the evolution doctrine as established though we still search for information as to the details of its processes.

At the present time there are four fields in zoological science in which research is particularly active. These are the study of heredity (genetics); of the cell both as the physical basis of heredity and as the seat of the physico-chemical phenomena associated with life itself (cytology and general physiology) and the study of internal secretions or hormones and their effects (endocrinology).

These are the four fields which are most worked at the present time.

If the evolutionary problem be critically analyzed it becomes apparent that our conceptions must depend upon studies of inheritance, for the heart of the problem is the means by which the transmission of characters from one generation to the succeeding is accomplished. This, the present day approach to the evolution problem, is the field of genetics. E. B. Wilson, one of the world's greatest zoologists, in his address of 1914 as president of the American Association for the Advancement of Science, said, "Biologists turned aside from general theories of evolution and their deductive application to special problems of descent, in order to take up objective experiments on variation and heredity for their own sake. This was not due to any doubts concerning the reality of evolution or to any lack of interest in its problems. It was a policy of masterly inactivity deliberately adopted; for further discussions concerning the causes of evolution had clearly become futile until a more adequate and critical view of existing genetic phenomena had been obtained."

Modern genetics is little more than a dozen years old, but in that time it has accomplished wonders. "Inheritance includes all qualities or characters which have physical basis in the fertilized egg cell, . . . and which become expressed during the development of the organism." We understand that in the germ cell, that is, the egg or sperm cell, there exist units or factors, technically called genes, that represent every character that comes to expression during the later development of the organism. There may be seen at certain stages in the division of every cell of the body, if microscopically examined, definite bodies, which in general are constant in size, shape, and number, and which are called chromosomes because of their tendency to stain dark with many dyes that are used for the purpose. These chromosomes are found to be the seat of the hereditary characters, and according to the present conception the genes are arranged in linear order along these chromosomes. Since there are only a few chromosomes in the cell of any one animal, and since the genes are very numerous indeed, it follows that in inheritance many characters must be bound together in groups; these groups are known as linkage groups, all the genes that are located in any one chromosome being thus linked together. But it sometimes happens that in the early stages of cell division a pair of chromosomes will become twisted about each other, so that when they separate, an exchange of material takes place and each chromosome gets part of the chromatin of the other; this is

"crossing-over" which expresses itself in a regrouping of the adult characters in arrangements other than that which the parents displayed. These manifestations of the laws which govern the transmission of characters are examples of the main problem of present day genetics, namely the manner and the mechanism of the distribution of the genes. As information is accumulating upon the manner of distribution, some geneticist are turning their attention to the more fundamental problem of the origin of the genes and the processes by which they may be modified, with the consequent production of new races. When this problem shall have been adequately investigated we shall be in a position to affirm the nature of the processes by which evolution has been accomplished.

The second of the main trends in zoology is in the study of the cell or cytology. Since the cell is the unit of organization both of animals and plants, its study carries the investigator far into the fundamental problems of life. The great interest in the laws of inheritance has stimulated much cytological research, for obviously the problems of inheritance are focused in the germ cells. Since the hereditary factors must all be combined in the male and female germ cells it follows that information concerning one field illuminates the other. In fact, although cytology has traditionally been the special activity of the microscopist, genetics itself may be looked upon as another means for obtaining knowledge of the cell and in that sense as a branch of cytology. Among the special problems of current cytological investigations, are identification of body character with special chromosomes, the individuality of the chromosomes, the chromosome mechanism as involved in the distribution of genes, the cytological basis of Mendelism, the means by which the union of the egg and sperm cell is accomplished in fertilization, structure of protoplasm, especially by micro-dissection studies of the living cell, and the relation of substances of the egg cell to the later developing organs of the embryo.

Cytology is also closely related to the field of general physiology as developed in recent years. The cell is looked upon, from this standpoint, as an object for such experimentation as seeks to apply the laws of physics and chemistry to living protoplasm, and to interpret its functions in terms of those laws. The problems of artificial parthenogenesis (the development of an egg without the aid of the sperm) of fertilization, of conductivity of stimuli, are now problems of physical chemistry and colloidal chemistry, and the knowledge of the phenomena of osmosis, surface tension, agglutination, permeability, etc., in their biological applications is

rapidly expanding. The field of general physiology is indeed a rich one and from it are being gained conceptions of the most fundamental character.

The last field of endeavor to be mentioned here is a very new one indeed. It has long been known that certain organs of the body produce substances that are discharged into the blood stream directly and are known as internal secretions or hormones. It is now realized that the production of hormones is much more common than had formerly been dreamed, and their study is the object of the newest member of the biological family, Endocrinology. Although the endocrine organs do not constitute a system in the ordinary sense of the term organ system, they are a source of chemical control of body process that is of the most far reaching importance. Certain hormones are secreted by organs which have no other functions than their production, while others are the results of the activity of special cells imbedded in such organs as the pancreas and the reproductive organs, of which physiologically they form no part. Still other hormones are without doubt produced and utilized within the body of single cells. One of the common examples of the hormones is the thyroid gland, the general effect of which is to regulate the rate of oxidation in the body. As an example of the nicety of control and adjustment within an organism which depends upon production of hormones, "it may be mentioned that the thyroid gland itself is subject to regulating stimuli reaching it through the nervous system as well as by a hormone derived from the pituitary body which is another endocrine gland situated in conjunction with the lower part of the brain," (Woodruff). Investigations of hormones and their part in influencing the activities of the body are now affording insights into mechanisms which in many cases were not even suspected.

If from a consideration of these chief lines of its activity one were to attempt to characterize in a word the modern zoological point of view, he might say that it is an attempt to apply the experimental method to the animal kingdom and the re-interpret vital phenomena in the terms of the new knowledge thus gained. An illustration of this tendency and at the same time a prediction of future problems for the investigator is the growing field of experimental ecology; that is, the relations of an organism to its environments, and the experimental study of the causes and effects, which underlie these relationships and adaptations. While descriptive and speculative zoology represent merely stages in the progress of the science when viewed from the experimental standpoint, they

assume a new and fascinating interest in the march of science toward an ultimate goal of exact knowledge.

VII. UNILATERAL INHERITANCE IN BRUCHUS

J. K. Breitenbecher

From the Zoological Laboratory of the University of Oklahoma.

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Any person who has observed living things knows that there exists in nearly every animal as well as in man a harmonious relation of functions due to a duplication of structures. Almost every animal manifests symmetry and nearly all are bilaterally symmetrical with the exception of Echinoderms which show a radical type adapted from a bilateral. Bilateral symmetry is found in all vertebrates and nearly all invertebrates. Often, however, one discovers a few organs which are asymmetrical such as the heart, pancreas, etc., i. e., all organs do not manifest symmetry.

In *Bruchus*, the insect which we use for our studies, bilateral symmetry is manifested by duplication of appendages, wings, and other structure, as well as spots, patterns, and colors. *Bruchus* has two black spots bilaterally located on each elytrum. From this culture there appeared on October 23, 1922, an abnormal female insect having a right elytrum red spotted, instead of the usual black spots. The first thought was that this unilateral character was a mosaic and due to a somatic mutation. But the offspring from this mosaic proved that the character was inherited, and it is the object of this paper to discuss briefly the problem concerned.

Symmetry has always been a question for scientific debate. Prof. Child whose idol is the "axial gradient theory" maintains that symmetry is determined by differences in metabolic rates. That region of the reproductive cell or part of an organism having the highest rate of metabolism becomes the animal pole. As this rate decreases posteriorly development continues in that direction until polarity is determined. He believes that differences in a metabolic gradient toward the periphery causes bilaterality. In contrast to this idea nearly all embryologists interpret polarity as being pre-shadowed in the cytoplasm of the egg previous to fertilization. This is no doubt true for *Bruchus* since all insects manifest polarity while the eggs are still in the ovary.

In the frog, as in all animals, bilateral symmetry appears soon after fertilization. Certain animals, especially snails, show a reversion from the normal type of symmetry. In *Bruchus* we also discover that the asymmetrical trait under our observation may be the reverse from normal due possibly to a different mutation.