times to re-appraisal."[9] This reconstruction takes place when the individual attains to a fuller knowledge of ethical reality, when the present ideal qualities no longer satisfy and function: then a new ideal quality for the value becomes imperative and the individual by projecting himself establishes new forms, new qualities, new contents to his values which thereby become essentially ideal.

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REVIEWS AND ABSTRACTS OF LITERATURE

The Physical Basis of Heredity. THOMAS HUNT MORGAN. Philadelphia: J. B. Lippincott Company. 1919.

Biology has in recent years been tugging at the leading-strings that have tied it to the older descriptive method, and has made an effort to break loose and to walk in the ways of the experimental and exact sciences. This effort has been most strikingly successful in the field of heredity, where the research of the past twenty years has revealed definite mathematical laws and a physical mechanism by which these laws may be explained. A particular interest, therefore, attaches to the present volume, which gives an account of the work that has cleared up the question of heredity—a question that had previously been one of the most difficult and complex that biology has to deal with.

The work of Mendel in 1865 showed that there are in the organism discrete hereditary units which are transmitted in definite ways from generation to generation. Since the rediscovery of Mendel's laws in 1900, it has been found that the entire hereditary complex is a mosaic of such units. The hereditary factors are located in the chromosomes, which are small rod-shaped bodies in the cell nucleus; within each chromosome the factors are arranged in a linear series. The method of distribution of the factors can be summed up in several laws or generalizations of heredity, on the basis of which it is possible to predict with mathematical exactitude the results of any particular mating. These laws are, however, merely another way of stating that the hereditary factors are located in linear series in the chromosomes. Thus the laws of heredity, while experimentally established beyond question, may be derived as corollaries of the known biological mechanism by which the chromosomes are divided and distributed.

Conversely, from the behavior of the hereditary factors, it is possible to deduce the behavior of the chromosomes, and even to map out the topography of each chromosome and to show the relative loca-

[9] Dewey: *Studies in Logical Theory*, p. 298.

tion of the hereditary factors within it. The organism is thus disclosed as a collection of at least hundreds, and possibly of several thousands, of independent self-perpetuating units, which are literally the heritage of each species. It is by the interaction of these factors with each other and with the environment that the organism is built up. But, although we know how the factors are distributed in heredity, we do not yet know how they interact to produce the organism. The solution of the embryological problem waits for a fuller knowledge of the intermediate stages between the factors and the characters which result from them.

It has also been shown that sex is a character inherited as definitely as any other. Sex differences have been traced to differences in the chromosome mechanism, one of the sexes possessing a chromosome not found in the other. The sex of the offspring thus depends on whether or not it receives the extra chromosome.

These discoveries have not only disclosed the mechanism of heredity; they have whittled away a large part of the mystery that had surrounded the question of the method of evolution.

It is obvious that if Mendelian units comprise the heritage of a species, changes in the species must be due to changes in the Mendelian factors. The fruit fly, *Drosophila,* which has been bred in the Columbia laboratory for ten years, is a particularly favorable organism for the study of such changes or mutations, since a new generation can be obtained every ten days. So far there have been found over three hundred mutants, from each of which a distinct race has been isolated. All of these races are descended from wild flies; each differs from the wild type in a single hereditary factor, and yet each race is entirely distinct. By combining the different mutant characters the biologists can obtain a fly which differs widely from the original type.

The study of these mutations has settled the question of continuous versus discontinuous variation. It has shown that variation is, in deVries's sense, discontinuous; that each change, or mutation, is sudden, definite and stable. But the change, while sudden, is not necessarily large; it may be, and frequently is, minute. So that by the piling up of such minute changes we may get continuous variation in Darwin's sense.

It must have been by the accumulation of such changes or mutations—sometimes large, sometimes small—that species have become differentiated in nature. The truth of this is further indicated by the fact that in several cases differences between species have been proved to be due to differences in one or more Mendelian factors. Presumably, therefore, the differences must have arisen in the same way as those found in the laboratory, that is, by mutation. If this is so, the biologist need not content himself with viewing the panorama of evolution respectfully from the distance of the ages; he can actually observe the process going on in his laboratory.

The next step is to induce mutations experimentally, but this has not yet been done. We know exactly what it is that changes, but we do not yet know how the change is brought about.

Although the mutation theory in the form first proposed by deVries was backed largely by evidence which he had obtained regarding sudden changes in the evening primrose, it now appears that the changes he observed were probably not alterations in the hereditary factors themselves, but consisted merely in the formation of new combinations of old factors, taking place in a peculiar way which has since been duplicated in *Drosophila* experiments. Nevertheless, the work on *Drosophila* places it beyond doubt that real changes in hereditary factors, or mutations, do occur, even though the so-called mutations in deVries's evening primrose are probably not valid examples of the process.

It is a curious fact that Mendel's original discovery, which laid the foundation for all the recent work in heredity, aroused no interest during his lifetime. Most biologists were then engaged in comparing the structures of organisms, in speculating on transitional forms, and seeking these intermediate forms among living or fossil animals and plants, or in their own imaginations. While this gave a plausible moving picture of the successive stages of evolution, it told us nothing of the mechanism which brought the stages about. Paradoxically enough, it was the turning away from the historical method that threw light on the method of biological history; for only with the shifting of the center of interest from the descriptive and historical to the mechanical and experimental mode of procedure was Mendel's discovery appreciated and a particulate theory of heredity developed. This theory has explained the mechanism of heredity and sex determination; it has all but solved the question of what evolutionary change is; and it has enabled the biologist to analyze the structure of living matter by a method which, like the astronomer's analysis of the constitution of the stars, is none the less precise because it does not treat the unknown with chemical reagents.

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Inbreeding and Outbreeding: Their Genetic and Sociological Significance. EDWARD M. EAST and DONALD F. JONES. Philadelphia and London: J. B. Lippincott & Company. 1919.

Whether close inbreeding causes deterioration of the race and cross-breeding re-invigorates it, is a question that has long been dis-