THE PHYSICAL BASIS OF HEREDITY

CHAPTER I

INTRODUCTION

THAT the fundamental aspects of heredity should have turned out to be so extraordinarily simple supports us in the hope that nature may, after all, be entirely approachable. Her much-advertised inscrutability has once more been found to be an illusion due to our ignorance. This is encouraging, for, if the world in which we live were as complicated as some of our friends would have us believe we might well despair that biology could ever become an exact science. Personally I have no sympathy with the statement that "the problem of the method of evolution is one which the biologist finds it impossible to leave alone, although the longer he works at it, the farther its solution fades into the distance." On the contrary, the evidence of recent years and the methods by means of which this evidence is obtained have already in a reasonably short time brought us nearer to a solution of some of the important problems of evolution than seemed possible only a few years ago. That new problems and developments have arisen in the course of the work—as they are bound to do in any progressive science, as they do in chemistry and in physics for example—goes without saying, but only a spirit of obscurantism could pretend that progress of this kind means that we see the solution of our problem fading away into the distance.

Mendel left his conclusions in the form of two general laws that may be called the law of segregation and the law of independent assortment of the genes. They rest on numerical data, and are therefore quantitative and can be turned into mathematical form wherever it seems desirable. But though the statements were exact, they were left without any suggestion as to how the processes involved take place in the living organism. Even a purely *mathematical formulation of the principles of segregation* and of free assortment would hardly satisfy the botanist and zoölogist for long. Inevitably search would be made for the place, the time, and the means by which segregation and assortment take place, and attempts would sooner or later be made to correlate these processes with the remarkable and unique changes that take place in the germ-cells. Sutton, in 1902, was the first to point out clearly how the chromosomal mechanism, then known, supplied the necessary mechanism to account for Mendel's two laws.

The knowledge to which Sutton appealed, had been accumulating between the years 1865, when Mendel's work was published, and 1900, when its importance became generally known. An account of the chromosomal mechanism may be deferred, but I have spoken of it here in order to call attention to a point rarely appreciated, namely, that the acceptance of this mechanism at once leads to the logical conclusion that Mendel's discovery of segregation applies not only to hybrids, but also to normal processes that are taking place at all times in all animals and plants, whether hybrids or not. In consequence we find that we are dealing with a principle that concerns the actual composition of the material that carries one generation over to the next.

Segregation and independent assortment were the two fundamental principles of heredity discovered by Mendel. Since 1900, four other principles have been added. These are known as linkage, the linear order of the genes, interference, and the limitation of the linkage groups. In the same sense in which in the physical sciences it is customary to call the fundamental generalizations of the science the "laws" of that science, so we may call the foregoing generalizations, the six laws of heredity known to us at present. Despite the fact that the use of this word "law" has been much abused in popular biological writing we need not apologize for using it here, because the postulates in question have been established by the same scientific procedure that chemists and physicists make use of, viz., by deductions from quantitative data. Excepting for the sixth law they can be stated independently of the chromosomal mechanism, but on the other hand they are also the necessary outcome of that mechanism.

The theory of the constitution of the germ-plasm, to which Mendel's discoveries led him, not only failed to receive any recognition for fifty years, but the principle of particulate inheritance to which it appeals has met with a curious reception even in our own time, leading a recent writer to state that particulate theories in general "do not help us in any way to solve any of the fundamental problems of biology," and another writer to affirm that if the chromatin of the sperm is "pictured" as composed of individual units that represent "some specific unit-characters of the adult," then we should expect it to be extremely complex, "more complex indeed than any chromatin in the body, since it is supposed to represent them all," but "as a matter of fact chemical examination shows the chromatin in the fish sperm to be the simplest found anywhere." Were our knowledge of the chemistry of the "chromatin" as advanced as these very positive statements might lead one to suppose, the objection raised might appear to be serious, but there is no evidence in favor of the statement that the sperm-chromatin should be expected to be more complex than the same chromatin in the cells of the embryo or adult. And even were it different in the germ-tract and soma the criticism would miss its mark, because heredity deals with the constitution of the chromatin of the germ-tract and not with that of the soma. Until physiological chemists are in position to furnish more complete information concerning the composition of the chromosomes, or more illuminating criticism of the situation as it exists, we need not, I think, be over-much troubled by such views so long as we handle our own data in a manner consonant with the recognized methods of scientific procedure.

Other critics object for one reason or another to all attempts to treat the problem of heredity from the standpoint of the factorial hypothesis. It has been said, for instance, that since the postulated genetic factors are not known chemical substances the assumption that they are such bodies is presumptuous, and gives a false analogy with chemical processes. Such critics claim that the procedure is at best only a kind of symbolism. Again, it has been said, that the factorial hypothesis is not a real scientific hypothesis, for it merely restates its facts in terms of factors, and then by juggling with numbers pretends that something is being explained. It has been argued that Mendelian phenomena relate to unnatural conditions and that they have nothing to do with the normal process of heredity in evolution that takes place in "nature." It has been objected that such a hypothesis assumes that genetic factors are fixed and stable in the same sense that molecules are stable, and that no such hard lines are to be found in the organic world. And finally it has been urged that the hypothesis rests on discontinuous variation which, it is said, does not exist.

If the implications in any or in all of these objections were true, the attempt to explain the traditional problem of heredity by the factorial hypothesis would appear fantastic in the extreme. An attempt will be made in the following chapters to present the evidence on which our present views concerning heredity rest, in the hope that an understanding of this evidence will go far towards removing these *a priori* objections, and will show that they have no real foundation in fact.