

**THE RELATION OF MENDELISM  
TO MUTATION AND EVOLUTION**

W. E. CASTLE

Bussey Institution

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## THE RELATION OF MENDELISM TO MUTATION AND EVOLUTION

W. E. CASTLE

Bussey Institution

IT HAS BEEN GENERALLY ASSUMED that Mendel's law of heredity affords a complete explanation of the facts of inheritance. But the characters which conform with Mendel's law, as Mendel understood it, involving dominance and segregation in 3:1 ratios, are comparatively few. They also relate to the more superficial, less important and most recently evolved characters of organisms. Very frequently they consist in the loss of some characteristic of the normal individual and so may be regarded as monstrous or defect variations. The English geneticists have been inclined to regard all Mendelian characters as due to loss variations, but this extreme position is scarcely tenable. Nevertheless, very few Mendelizing variations have a survival value equal or superior to that of the forms from which they have sprung. It is, therefore, probably the fate of most Mendelizing mutations to perish under natural conditions without contributing to racial evolution. But under domestication they are frequently preserved and incorporated in domestic races, if they happen to please man's fancy, which they sometimes do, just because they are distinctive.

The Mendelizing characters of domestic mammals consist very largely of color mutations, such as albinism (an all-white condition), or spotting, or a change from a complex gray and protectively colored coat to a simple black, brown or yellow coat. Other Mendelian mutations involve a change in the length of the hair or the hair slope. The hair may even practically disappear, as in the Mexican hairless dog, due to a Mendelizing dominant character.

Aside from their utility as breed trade -marks, color variations have little value in animal husbandry. The really valuable characters are those affecting size, proportions, rapidity of growth, milk yield,

butter-fat content of the milk, wool production in sheep and fecundity, especially in swine and poultry. So far as differences exist between breeds in these important characters they are not typically Mendelian in inheritance but blending. There is neither dominance nor segregation in recognizable Mendelian ratios when such differences exist between the races crossed. Are they, then, Mendelian? For, if they are not, Mendel's law can not be regarded as the fundamental law of heredity. Very likely they are Mendelian. That is the current interpretation which I see no reason to reject until a better explanation can be substituted for it. (1) It is supposed that in the inheritance of blending characters, genetic units (genes) are concerned which are not subject to the law of dominance. Such absence of dominance is known to occur in cases which are otherwise simple and Mendelian in character. (2) It is further supposed that blending characters depend upon the action of more than one gene, usually of numerous genes located in different chromosome pairs, so that they are independent of each other in transmission. The result is that complete segregation is a rare event. (3) It is supposed also that some of the genes on which blending characters depend are more important than others in determining the varying grades of expression of the character. Besides major, there are also minor or modifying factors. Such modifying factors are known to be operative in the inheritance of characters simply Mendelian, but varying slightly in expression.

The important outstanding question concerning evolution is: How do new variations arise? The most popular present-day answer to the question is by mutation. This answer, when first given by DeVries was thought to involve sudden large changes made simultaneously in many characters of the organism giving rise from the start to distinct specific types. This sort of mutation does indeed occur in at least several groups of plants and the mechanism of it is now understood, as a result of the investigations of Gates and others on the evening primroses, of Harrison and others on the roses, and of Blakeslee on the jimson-weed. Such mutation involves variation in the germ cell through duplication of whole chromosomes or through the loss of whole chromosomes, involving as they do simultaneous changes in all characters which have genetic representation in the particular chromosomes duplicated or lost. This kind of mutation can not be regarded as a satisfactory general explanation of the origin of species, the thing which DeVries had in mind when he proposed the theory because comparatively few species differ from each other by whole chromosomes, or are incapable of interbreeding even if they do.

The current theory of mutation, which we owe largely to Morgan, is a theory of evolution by mutation in single genes, not in whole

chromosomes. It assumes that changes in single genes occur spontaneously without any as yet known external causes; that change in one gene does not necessarily involve change in any other gene and is usually not attended by it. Each gene mutation will obviously have to stand the test of natural selection and will consequently either be eliminated or will be added to the genetic complex of a surviving race. Intensive study of any species of animal usually reveals the occurrence within it of gene mutations with appreciable frequency. Students of *Drosophila* have calculated a rate for it in that species. A state of genetic flux may therefore be assumed to be the normal condition in an organism, which assumption corresponds exactly with the view of Darwin that heritable variation is ever present as material for natural selection to act upon. The contrary assumption made in the popular pure line doctrine is quite unsupported by recent critical experimental investigations as well as by the whole science of paleontology.

If each gene, as is apparently the case, is subject to independent mutation, it follows that a blending character, which by hypothesis depends on the joint action of many independent genes, will vary only gradually, since mutation in a gene at a time will produce only minor changes. Mutation in such cases will not be mutation at all except in name, but will consist of a gradual change in the direction favored by selection, again exactly the view of Darwin concerning the usual course of evolution.

The net result of our inventory is to show that Darwin was substantially right in his views concerning the nature of variation and the results of selection, and that the mutationists have lost their case except in so far as they have succeeded in attaching a new name to an old idea.

But we have acquired in Mendel's law a fundamental explanatory principle applicable to all heredity. Yet we must not expect simple three to one ratios to be found in all cases of inheritance or even in any considerable part of them. For only newly evolved characters will conform with it, such as are as yet represented only in a single gene in a single chromosome pair. Older, better established characters, those which characterize the species (rather than a variety), the genus or the class, will have become rooted in many or all chromosomes, and consequently in crosses with other species, genera or classes (when possible) will give a blended result.