Genes and Our Evolving World

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There are two basic approaches to any phenomenon. First, is it a fact?—has it actually happened? In the case of evolution, paleontology and comparative anatomy tackle this problem. Second, granted that the phenomenon is indeed a fact, why does it necessarily happen the way it does? Ecology and genetics are concerned with the causality involved in evolution. The current stage of learning would indicate that mutations in genes are at least partially the cause of evolution. Since our understanding of mutation remains somewhat vague, there is an accompanying vagueness in evolutionary theory. This, however, does not justify the opinion that evolution is the product of chance only. Merely because we do not yet fully know the chain of causality in mutations does not destroy the possibility of such causality. And, in fact, the continuous striving after more knowledge about mutations indicates that the scientist does not really accept the notion of chance as the sole factor involved.

Evolution is an equivocal term. It has been defined as "any series of changes in which the nature of each step depends on what has preceded." If this series of changes occurs in living things over a period of many generations, it is organic evolution. But even this organic evolution tends to be equivocated. The General Theory of evolution is that "all the living forms in the world have arisen from a single source which itself came from an inorganic form." The evidence in support of such a theory is far from overwhelming. The fact that our modern taxonomic classification of organic matter indicates a branching pattern lends support to the notion of a single source. It is taken as a basic assumption that spontaneous generation occurred and that it occurred only once. However, no scientific proof can be offered for the evolutionary step from non-living to living.

The Special Theory of evolution states that animals can be observed over the course of time to undergo changes by which new species are formed. The evidence for this Special Theory is relatively conclusive. Scientists can observe the development of new species in nature and in controlled experimentation. Dozens of species of birds have evolved from the honey creepers of Hawaii.

There seems to be a third sense of organic evolution found—at least implicitly, but very commonly—in the literature. This is an evolution of races, or subspecies, or varieties. If changes occur over successive generations without, however, producing animals sufficiently different to be classified as distinct species, then we have "race evolution." (A species can be defined as a group of closely related, structurally and functionally similar organisms, which in nature interbreed with one another, but which do not interbreed with organisms of other groups.) At least six varieties of the golden whistler are found in the Solomon Islands. Varying environment has led to birds with quite different color markings—but of one species. Such evidence of "race evolution" is profuse.

We must not be trapped by this equivocation of "organic evolution." An author may offer page after page of evidence for "race evolution" without thereby proving the General Theory.

> Of course one can say that the small observable changes in modern species may be the sort of thing that leads to all the major changes, but what right have we to make such an extrapolation? . . . A blind acceptance of such a view may in fact be closing our eyes to as yet undiscovered factors which may remain undiscovered for many years if we believe that the answer has already been found.[1]

In the remainder of this article I shall not be concerned with the General Theory unless I indicate otherwise. It would seem that any proof of this theory is impossible due to a lack of evidence. Rather, I wish to expose a genetic interpretation of "race evolution" and of Special Evolution.

Charles Darwin observed a very large number of plants and animals and noted that organisms in adjacent localities were often related closely—but with certain distinctions. He postulated that these organisms had evolved due to varying demands of the environment. There was a "natural selection" of those organisms most suited to the environment. These selected parents begot offspring of similar features. Hence the honey creepers have evolved such that one species has long bills to suck nectar, others have beaks suited to a diet of seeds and berries, others have a sharp bill to probe for insects and a final species must wrench at hard wood to find burrowing insects. The fact that such traits are passed on to the offspring should raise questions. After all, if one bird happened to have one eye pecked out, its children were nevertheless born with two eyes. There was needed an intrinsic physical basis for such propagated changes. Mendel provided this basis with his famous theory of genes.

In every body cell there are threads of matter known as chromosomes. Each species has its own peculiar number of chromosones per cell, and this number remains constant from generation to generation. Each chromosone is in turn made up of tiny genes which are now known to be the cause of the particular manner in which the organism develops. One gene regulates the process of development of a particular area or organ of the organism and any given organ is actually influenced by a large number of genes. (This could be exemplified by considering the task of building a house. One man—a gene, in this example—does the plumbing; another man—a second gene—plasters the walls; and so on throughout the house. So each man may produce an effect over a large part of the finished house. Now consider just the finished kitchen—an organ in the organism. It has been determined in its appearance by plasterer, plumber, carpenter, painter, etc. If one man does a poor job, several rooms may be inferior. Likewise, one inferior room may be due to the shoddy work of one craftsman only, or to the combined "efforts" of several.)

This is important when we try to understand mutations. If a mutation happens in a gene of widespread influence, the resulting phenotypic alteration will be pronounced; perhaps this leads to new species. (Note: the phenotype refers to the physical appearance of the individual plant or animal—e.g., tall, green, rough leaves, etc.) On the other hand, mutations of less influential genes may cause a new race—or perhaps only a negligible change. An interesting example of the former is found in mice. It had been observed that the mutation of one gene produced mice with short tails. However, when both parents contributed such a mutated gene the offspring was a monster that died before birth. Closer examination revealed that the tail, legs, and whole hind section were defective. The mutant gene had given rise to an imperfect notochord (an early stage of the backbone). This parallels the example given above of building a house. We saw that one craftsman may leave his mark on a large section of the finished house. So also here the mutation affected the growth and development of one entire area; it did not merely determine one minute feature of the baby mouse.

In reproduction there is the possibility of a great variety of gene combinations. We usually think of each individual having two complementary genes designed for the same task. These may occur as mixtures or pure dominants, recessives, etc. The number of possible combinations of all genes in the individual is staggering. For instance, if any organism has 1000 genes (a most conservative estimate in the case of man) and there are only two variations of each gene (again, conservative), then there would be $2^{1,000}$ possible different gene combinations! Nevertheless, such a vast source of variety would not give rise to new species; it would not be the cause of evolution. In the case of man, this variety can be imagined if we consider the marked differences between a white European, a Negro, and a Japanese—with the infinite number of slight modifications in between. Yet all these men are of one species. This is in accord with the Hardy-Weinberg law which states: "If mating is random, if mutations do not occur, and if the population is large, the gene frequencies in a population remain constant from generation to generation."

The importance of working with a large population is evident from the laws of probability. Consider the oft-used example of flipping a coin. If I flip it only seven or eight times, the heads-tails ratio may deviate seriously from a equal one-to-one chance. However, when I test the coin in a great number of trials, the laws of probability will be obeyed. In the case of genes, if only a small population is involved, certain genes may easily disappear due to the chance character of mating. This genetic drift might tend to cause some phenotypes to disappear, but it would not lead to evolution.

A second demand of the Hardy-Weinberg law is that mating be random. It is easy to see that if one mates organisms having only a pair of dominant genes (we are here considering just one gene), the recessive gene would not appear in the second generation, even though members (not mated) of the first generation had these recessive genes. Again, some phenotypes will become extinct, but this is not evolution.

The remaining condition is that mutations should not occur. When mutations do occur, we find evidence for the causality of evolution. First we should say a few words about what we mean by mutation.

A mutation is any stable, inheritable change in the basic genetic system with which every cell is equipped. In the normal process of cell division and reproduction a duplicate copy is made from the original cell. The process as found in the reproductive cells (germ cells) differs from that found in all the other cells of the body (somatic cells). Evolution does not derive from any mutations in the somatic cells since such mutated genes cannot be passed on to offspring; it is only mutation in the germ cell which interest us. There are several possibilities in mutation. Pieces of chromosomes may be inverted, lost, or fused with another whole chromosome; whole chromosomes may be lost or added. Certain plants sometimes double or triple their normal chromosome number. However, these chromosome mutations are not as common as point mutations, which imply an actual change in the identity of one or more genes on the chromosome.

A major problem in genetics and evolution is finding the cause of mutations. For some time it has been thought that radiation was the prime cause of mutation. In 1927 H. J. Muller discovered that radiation would induce mutations in the fruit fly *Drosophila* and that these same mutations occurred spontaneously in nature. L. J. Stadler made similar discoveries in his work with plants. Of course, it was suggested that natural radiation was causing the spontaneous mutations. However, there is not sufficient natural radiation for this. In the case of *Drosophila* the amount of radiation required for the observed mutation rate is about twelve hundred times the radiation available during the 12-day interval from egg to adult of the *Drosophila.*

Mutations can be induced by ionizing radiation, ultraviolet radiation, and by high temperatures. None of these cause mutation in a specific gene. However, it has been found that some chemical mutagens (chemicals causing mutations) do tend to be specific. It has been suggested that perhaps certain types of food contain chemicals causing the "spontaneous" mutations of nature. Recently much has been written of a so-called genetic code. The evidence presented by F. H. C. Crick in *Scientific American* (October, 1966) is conclusively in favor of such a code. Certain chemicals (adanine, guanine, cytosine, and thymine) are arranged in a different order in different genes; they form a definite "code," depending upon the order or arrangement. This code directs functions of the body by determining what proteins will be formed by the body. If this order or code is altered, the message to the body will also be altered. The code can be changed by merely inserting one extra chemical into the arrangement; the possibilities for mutations are evident. In fact, if man could begin to change this code by treating the individual with specific chemicals, we could hope to cause whatever mutations we desire. We could perhaps develop the "ideal" ear of corn, or "ideal" beef cattle, or the "perfect" man!

So we see that mutations in genes are a necessary requirement for the phenotypic changes of evolution. We should show here how Darwin's natural selection is easily compatible with, and essential to, our understanding. Once a mutation has occurred we find offspring differing from parents and from other offspring. There seems to be universal agreement that the majority of mutations are not good for the organism. The very fact that the plant or animal has reached such a high degree of specialization in organs would lead us to predict that it would be improbable that a new mutation will give more desirable traits. However, there are cases in which the mutation is beneficial to the organism. At any rate, natural selection must determine whether the mutant offspring is to survive.

Can we say then that genetics offers an explanation of the causality? Yes, and no. First, why do I say no? The nature of mutations is not yet totally understood. There has not yet been found any regularity of predictability in natural spontaneous mutation. This might lead the modern scientist to attribute the process to chance; I would rather think that there is a cause operating, but we do not yet have sufficient information to identify the causality. Mutations cause evolution, but until mutations are understood, evolution cannot be truly understood. Still there is a sense in which genetics does explain evolution. Several examples have been given in this paper showing how mutations cause a new phenotype. However, I again warn that such evidence for "race evolution" and specific evolution should not be taken as conclusive of general evolution.

FOOTNOTE

[1] G. A. Kerkut. *Implications of Evolution* (New York, 1960), Pergamon Press. p. 154.