REVIEW OF H. FRAENKEL-CONRAT, THE GENETIC CODE OF A VIRUS

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The Genetic Code of a Virus
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The first hint of the existence of viruses came in 1892, when the Russian bacteriologist D. Ivanovsky found that he could infect healthy tobacco plants with a filtrate obtained from extracts of diseased plants passed through a porcelain filter that screened out all bacteria. Knowledge about the tobacco mosaic virus has increased until at present some 200 mutant forms are known and it has been shown that the RNA code is made up of a helix of 6400 nucleotide subunits. This is more than was expected by those who are trying to decipher the "genetic code" of this virus. Although the nucleotides are of only four kinds, their arrangement is complex beyond the expectation of the researchers. The RNA molecule bears the genetic code for synthesizing the 158 amino acid subunits found in the protein coat of the virus, and also for synthesizing various enzymes.

It was found that nitrous acid brings about the replacement of the amino group of some of the nucleotides with the hydroxyl group, and in doing so produces mutant forms, some of which match previously known mutants. These mutants were studied in an effort to discover the arrangements of the nucleotides associated with the synthesis of certain proteins. It became evident that this situation also is more complex than expected.

In this article the Darwinian term *natural selection* is used in two different ways, just as it is in other evolutionary literature. It is said that the most frequently occurring exchanges of amino acids in the shell are probably not the result of mutations occurring preferentially at these sites, a more likely explanation being that they are observed most frequently because they do the least harm to the organism. Thus they are preserved by "natural selection" and are comparable to the natural selection observed by Kettlewell in industrialized areas of England, where dark moths are increasing in number and light moths are decreasing because the birds can see the light colored moths more easily as they sit in the daytime on the darkened trunks of the trees. As the birds eat more of the light moths, they decrease in number and the camouflaged dark moths increase. It is admitted that the difference between the dark and light moths can be due to a single mutant gene. On the other hand, it is assumed that the protein coat of the virus developed through natural selection. This is an altogether different matter, and it is comparable to the problem of how moths evolved from something which was not a moth. Incidentally the light colored moth still persists showing inefficiency of natural selection even in this classical case after 100 years of industrialization and resulting smog.

As in the case with other creatures, most mutations found in this virus are deleterious. As usual when discussing this phenomenon in other creatures, it is said in connection with this virus that natural selection has done such a good job in evolving a good protein coat for the virus that it is rather to be expected that any mutation would be detrimental and would reduce the viability of the virus. Various enzymes are able to partially digest the protein coat of this virus. Thus one of them digests or chops off the amino acid threonine from the carboxyl (COOH) end of the protein chain. The first mutant studied made the virus so much more susceptible to the enzyme digestion that three instead of only one amino acid could be clipped off by it, thus making the virus distinctly less viable.

A few generations ago biologists accepted a combination of Darwinian natural selection and the de Vriesian mutations as the basis of evolution. Later it was realized that living creatures are too complex to have come about in this way, and it was admitted that the mechanism of evolution was not known. Now, although so much progress has been made in the study of the hereditary mechanism that the scientists write hopefully of "cracking the genetic code" and of "genetic surgery," they have, for want of anything better, returned to accepting the formerly rejected combination of mutations and natural selection as the basis of evolution.