A Molecular Messiah: The New Gospel in Genetics?

R. C. Lewontin

I am under 40, have for a long time been considered a brash Young Turk, thoroughly enjoyed *Dr. Strangelove*, am not offended by jokes about religion or motherhood, and once had a manuscript returned to me by one of the more imaginative editors of a scientific journal because the manuscript was too flippant. Nobody has *ever* accused me of being a stuffed shirt. Nevertheless, I am offended by Franklin Stahl's book, **The Mechanics of Inheritance** (Prentice-Hall, Englewood Cliffs, N.J., 1964. 185 pp. Illus. $4.95), the first volume in the new series, The Foundations of Modern Genetics, edited by Sigmund R. Suskind and Philip E. Hartman. I am so put off by Stahl's adolescent *hubris* that it is difficult for me to evaluate the substantive contribution he is trying to make.

In the preface the phrase "Mendelian genetics" is used with a footnote stating that "Mendelian" is an "adjective referring to the nineteenth century Austrian who established most of the ideas this book aims to elucidate." On page 2 is a double photograph, supposedly to provide a stereoscopic view, of two cells of *Escherichia coli in copulo*. We are informed in the caption that one cell "is being pestered to death by bacteriophage particles" and that permission to reproduce the photograph "was secured from *Erotica*." Pretty hot stuff, eh? Figure 3.1 is an electron micrograph of a part of a DNA molecule which, we are told, is "20 A° wide and terribly long." Stahl missed up here. Surely he meant "tewwibwy wong." On page 77 is a set of diagrams of chromosomes in mitosis with instructions as follows: "You can't see the chromatids in interphase; color them invisible." "Reflect upon the wonders of the Nuclear Age while you color the nonradioactive chromatids yellow. Quickly." Feeling a slight touch of nausea? Well, I won't go on.

Stahl does deserve our praise for his attempt to write about the mechanics of inheritance in a way that takes into account the recent advances in molecular genetics. It is certain that we need a text which assimilates molecular studies into genetics rather than simply relates them. However, Stahl, in common with many enthusiasts, has mistaken the tail for the dog. It is vital that we understand the Aristotelian distinction between efficient and final cause in biology. The molecular configurations of living organisms are the efficient causes of biological phenomena but not their final causes. That is, except in a trivial sense, the laws of genetics are not the result of the structure of DNA, but rather DNA has been chosen by natural selection from among an immense variety of molecules precisely because it fits the requirements of an evolved genetic system. DNA is only the tactic adopted in the course of working out an evolutionary strategy. That is why some organisms can get on without it.

The confusion of cause and effect colors the approach of the book as a whole. There is far too much emphasis on the unique problems of bacteriophage and bacterial genetics. The bacterial-viral system is an extremely interesting case of a host-parasite relationship, and the unravelling of its complexities has occupied some very intelligent and able people. Nevertheless, the real contribution made to genetics by the study of these organisms has not been the analysis of their unique properties, but the properties that they share with the rest of the living world. After all, bacteria are not *intrinsically* more interesting than pigs, only easier to understand.

There is a somewhat Procrustean air about much of the discussion, a result of the author's excessive enthusiasm for the smallest possible organisms. Only such an enthusiasm or some form of scientific "payola" can explain the curious choice of *Chlamydomonas* as the example in the discussion of the relationship between genetic segregation and the observable facts of meiosis. As Stahl himself admits in a footnote, the cytology of *Chlamydomonas* is nasty, and the detailed description of meiosis is not really that of *Chlamydomonas*, after all, but of salamanders. Moreover, the choice of *Chlamydomonas* cannot be defended on genetic grounds, since it does not give ordered tetrads as does *Neurospora*. It is the existence of the ordered tetrad in *Neurospora* that has provided the neatest parallel between genetic segregation and meiosis yet. Stahl never mentions it, nor does he discuss the fundamental importance of the mapping of centromeres.

One of the most important and interesting problems in the mechanics of inheritance is the mechanism of crossing over. Remarkably little attention is given to the evidence on this question, and Stahl fails completely to weigh the importance of evidence on this question from *Neurospora* and attached X chromosomes in *Drosophila*.

The book contains three sections devoted to mathematical formulations. The first, on the rate of accumulation of mutants in a bacterial colony growing exponentially, is nowhere referred to again and seems out of place in the book. The second, on a so-called "mapping function," goes to some trouble to derive a mapping function on the assumption of no interference in order to show that there really is interference. But interference can be demonstrated and calculated without any mapping functions at all, and the mapping function approach provides only a semblance of sophistication without making any contribution to understanding. Finally, there is considerable algebra and hidden calculus involved in the section on recombination in viruses, again to no great purpose, since it is applicable only to phage.

Now a minor point or two. The reader may get the erroneous impression from reading the caption that the fimbriae on the bacterium in fig. 1.1 are bacteriophage. It is not true, as stated on page 83, that "chiasmata give the appearance of having resulted from breakage, exchange and reunion." Chiasmata are, alas, completely ambiguous

The reviewer, a geneticist, is professor of biology at the University of Rochester, Rochester, New York.

in their appearance and interpretation. Lastly, it is not true (p. 157) that $p = \frac{1}{2}$ in the Gaussian distribution. As N grows large, all binomial distributions approach the normal if p is held fixed. This is a common error.

I have reflected a long while on what general implication can be drawn from the fact that a first-class scientist finds it necessary to relegate Mendel to a footnote and to describe A. H. Sturtevant's beautiful paper on the linear arrangement of genes in *Drosophila* as "a great little paper." I think the key to the problem is in the fact that Stahl puts "nineteenth century" in the lower case but uses capitals for the "Nuclear Age." There is implied a rejection of the past and the preaching of a new gospel in genetics, the gospel of a molecular Messiah. In the very first paragraph of the preface Stahl tells us that "old texts, then, must go to the shelf (not the wastebaskets, please) and new ones to the students desk tops." And he is right. Genetics *is* a dynamic and changing science, but what Stahl fails to see is that there is no break with the past, but a building on it—or perhaps he does see it and that is what disturbs him. I almost get the impression that Stahl wishes there were no continuity with the past because that continuity in some way detracts from the accomplishments of the present. I find support for this uncharitable point of view in little turns of phrase, the most revealing of which are repeated references to experiments done and papers published "in the late 1950's" or "in the 1960's" when, what is meant is simply "in 1958" and "in 1963."

Stahl is looking at genetics not from the perspective of 1964 but from that of 2064 when men will refer to the golden age of the "1960's" as we now speak of the *Cinquecento*. This pseudo-historical style shows pretty clearly that, although other texts may go on the shelf, Stahl's has been written for the ages. Moreover, it is the history of a new movement, of a revolution, that is being written. It is a new testament in which the miracle of the fish and the loaves is a case of semiconservative replication. Yet, for all that, the very great contribution that microbial genetics has made to our understanding of the molecular tactics of evolution, does not entitle Stahl to be condescending to Mendel or contemptuous of the intellectual level of his readers.

Nuclear Chemistry

Nuclear Chemistry and Its Applications. M. Haïssinsky. Translated from the French edition (Paris, 1957) by D. G. Tuck. Addison-Wesley, Reading, Mass., 1964. xiv + 834 pp. Illus. $22.50.

Since the discovery of radioactivity, chemists have contributed greatly to the investigation and explanation of radioactivity, nuclear structure and reactions, and the interaction of radiations with matter. They have also shown how nuclear and isotopic effects can provide unique research tools in all branches of science and technology.

In this volume, which is a translation of his 1957 treatise, Moïse Haïssinsky has set out to provide an integrated description of this history, of the fundamentals of nuclear science, and of its manifold applications. His is not a popular or superficial account, but a thoroughly professional description within the space limitations set by the extremely broad range of subject matter. Haïssinsky is eminently well qualified to do this. In his early years he worked with Marie Curie and with Irène and Frédéric Joliot-Curie. For several decades he has been associated with the famous Institut du Radium, in Paris, as a leader of the French school of nuclear and radiochemistry. It is welcome news that his 1957 reference work, *La Chimie Nucléaire et ses Applications*, an impressively clear and concise summary of an enormous scientific literature, is now available in this excellent translation by Dennis G. Tuck of Nottingham University.

The first six chapters provide a concise description of the history of this science, of the fundamental particles, of nuclei, and of the spontaneous and artificial transmutation of nuclei including nuclear fission. Two chapters review the natural radioelements and the synthetic transuranium elements. There is a chapter on isotope effects, and one on geochemical, geological, and astrophysical applications of radioactivity. One chapter reviews the dissipation of energy of radiations in matter. Several chapters constitute a compact review of various aspects of radiation chemistry, radiation effects, "hot atom" effects, and related topics. Another group covers radioactive tracers and their application to a variety of chemical studies. The final chapters deal with biological, medical, technological, and industrial applications of isotopic tracers. It is impossible in this bare-bones summary to convey a real idea of the detailed contents of this volume.

It is inevitable in a work of such wide scope that the specialist will find limited coverage of his own field. Nonetheless, he should find this volume valuable for a discussion of the origins of his specialty and of its position in the context of the whole science. It should also serve him as a useful encyclopedia of possibly pertinent information in related fields. It is also inevitable that in a translation of a 1957 work dealing with fields under vigorous investigation some important recent developments are not considered. These defects do not detract greatly from the usefulness of Haïssinsky's book as a comprehensive, well-organized, reference work.

As a final note, this volume can be recommended to those university departments of chemistry that are debating the importance of inaugurating a program in nuclear chemistry.

EARL K. HYDE
Lawrence Radiation Laboratory, University of California, Berkeley

Medical Care in England

Trends in the National Health Service. James Farndale, Ed. Pergamon, London; Macmillan, New York, 1964. xiv + 423 pp. Illus. $15.

The practice of producing a book by inducing a number of authors to write short essays on single aspects of a complex problem seems to be growing. In this book, described by its editor as a "form of stocktaking and also a self-examination," some 36 authors have contributed chapters on subjects as diverse as planning, financing, medical-legal problems, nursing education, and ambulance service operations in England's National Health Service.

It is quite clear that no one is going to push himself very hard to write an essay for someone else's book. It is almost a foregone conclusion that results will be routine. Since a routine performance by some contributors is bound to be better than that of others, the book is a mixed bag. An introductory essay by Arthur Blankensop, a parliamentary secretary to the Ministry of Health during the early days of the