HEREDITY

East and West

Lysenko and World Science

BY JULIAN HUXLEY

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LYSENKO AND WORLD SCIENCE

Henry Schuman · New York

Preface

MY REASON for writing this book is that I believe in science and the scientific method as indispensable tools for human advance. I found so much misapprehension, even among professional scientists, about the controversy over Soviet genetics that I volunteered to write an article on the subject for the British scientific weekly, *Nature,* pointing out what seemed to me to be the major issues involved. While engaged on this, I received a letter from Mr. Henry Schuman asking whether I would undertake the writing of a short book on the subject, and it seemed well worth while to utilize the material I had already digested, by amplifying it in book form.

I must confess that the task has been much more arduous than I anticipated, and has involved the consideration of various general questions, in addition to the actual Lysenko controversy. I can only hope that the result will be of some use in clarifying the problem of the role of science and the scientific method in world civilization, as well as the issues of the controversy itself.

I have for many years been professionally concerned with genetics and evolution, from my school days forty-five years ago when I had to master elementary Mendelism for my

scholarship examination, through the period when I was responsible for the teaching of genetics in various universities, to the present decade when I set out to write a comprehensive book on evolution, including its genetical basis. I have done my best to popularize genetics and evolutionary science, notably in collaboration with H. G. and G. P. Wells in *The Science of Life;* and for the last three years I have been professionally concerned, as Director-General of UNESCO, with science as an international activity. I had the unusual opportunity of hearing Lysenko lecture and of a conversation with him, in 1945, and have now read all the main documents concerning the recent genetics controversy in the U.S.S.R.

I at first imagined that there must be something in Lysenko's claims. However, the more I heard and read, the clearer it became that Lysenko and his followers are not scientific in any proper sense of the word—they do not adhere to recognized scientific method, or employ normal scientific precautions, or publish their results in a way which renders their scientific evaluation possible. They move in a different world of ideas from that of professional scientists, and do not carry on discussion in a scientific way. Michurinism, as their form of genetics is called, is largely based on ancient superstitions which the advance of scientific knowledge has now left behind; in any event, it is less a branch of science comprising a basis of facts, than a branch of ideology, a doctrine which its proponents seek to impose upon facts. I have tried to convey this by direct quotations from their published utterances and writings.

Meanwhile Lysenko's alleged results are suspect because of his faulty methods. It may be that he has made some new discoveries; but that we cannot know until his experi-

ments have been repeated with proper scientific precautions.

The next question was, why had Lysenko won his battle, how was it possible for the Academy of Sciences to have lent its scientific authority to the suppression of an entire branch of science? The conclusion is inescapable that this has been done on ideological grounds, under political pressure, although the precise reasons why political and ideological pressure has been so forcibly exerted are not altogether clear.

In any event, it speedily became clear that the major issue at stake was not the truth or falsity of Lysenko's claims, but the overriding of science by ideological and political authority.

The Communist Party has officially pronounced that Michurinism is scientifically true and Mendelism scientifically untrue. It has divided science into Soviet science, which is good and right, and bourgeois science, which must be combated by all Soviet scientists. Such a course of action, in my view and that of the overwhelming majority of scientists, is impermissible. To follow it is to destroy the necessary autonomy and unity of science as a major human activity. This repudiation of the validity of science and scientific method is a denial of that freedom of the intellect which we fondly imagined had been laboriously won during the past three or four centuries. This point too I have substantiated wherever possible by actual quotations.

I was finally then led to a consideration of the relations between science and society in other countries and at other periods. It is clear that science is often in conflict with society or with powerful groups or vested interests in society. Sometimes science seems to threaten social stability, at others to run counter to the dominant aims of society. The problem is

how to reconcile the autonomy of science with the needs of society as a whole. It is not always easy; but it must be done if we are to enjoy the benefits which science alone can bring to society.

It is with such considerations in mind that I have written the following pages. If I criticize the actions or utterances of Soviet individuals or organizations, it is not on account of any political bias, but because I believe that they are wrong or inexpedient. As a matter of fact, I have been very appreciative of the efforts and achievements of the U.S.S.R., especially since my first visit to that country in 1932. But appreciation does not exclude criticism; and as a scientist and a believer in internationalism, I cannot help being critical of many aspects of the genetics controversy.

Many colleagues have helped me in preparing this book: I should like especially to thank Prof. H. J. Muller, Prof. Eric Ashby, and Dr. Cyril Darlington. I must also thank Mr. John Langdon-Davies for letting me see advance proofs of his interesting book *Russia Puts the Clock Back*, which treats of the same controversy, but from a slightly different angle.

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The Controversy: Its Nature and History

Most people are now aware that something has recently happened to science in the U.S.S.R., and that this something is quite important. But there is still a great deal of misapprehension on the subject, not merely as regards specific points, but as to what the dispute is really about, and what are the essential issues involved.

This is not surprising, for the whole controversy has been obscured by a fog of misunderstanding, largely resulting from the emotional smoke screen that seems inevitably to envelop any issue concerning the U.S.S.R. Red-baiters have used it as a convenient new stick to beat the Russians with. Communists talk of the resistance of bourgeois science to new ideas. Upholders of free enterprise say "see what happens to science under planning." Believers in state planning point to the necessity for some generally accepted doctrine, including scientific doctrine, to unify society. Pink sympathizers, while avoiding the main issue, make excuses for the Russians' action, or point to the fact that science in Western countries does not enjoy complete freedom. Libertarians let their indignation get the better of them, and confuse the rightness or wrongness of Lysenko's theories with

the rightness or wrongness of the drastic methods used to defeat his opponents. Too often, the upholders of one view are ignorant of the different atmosphere of ideas inhabited by their antagonists, and invective has too often taken the place of argument.

The best way to begin dispelling this fog of misunderstanding will be to explain the basis of the controversy and to give the history of what has happened. Later, the main issues involved can be defined; and finally the whole controversy discussed in relation to its general social and intellectual background.

The controversy, then, primarily concerns that branch of science known as genetics. Genetics in the restricted sense deals with the way the inherited characteristics of organisms —plants and animals and human beings—are transmitted from one generation to the next. But here we have to do with genetics in the extended sense of evolutionary genetics, which deals also with the way in which organisms change their inherited characteristics in the course of many generations. Such an extension is natural and inevitable, for evolution clearly depends on heredity: the methods by which the visible characters of organisms are transmitted from one generation to the next must to a considerable extent determine the methods by which they change in the course of many generations.

The two rival systems are usually called neo-Mendelism on the one hand, and Michurinism on the other.* In a later

* Neo-Mendelism as generally used applies only to genetics in the restricted sense, of transmission, while neo-Darwinism is used to cover evolutionary change arising from Mendelism plus natural selection. Most Western scientists actually use the general phrase "evolutionary genetics" instead of neo-Darwinism. But the fact that the Russians have propounded a wholly different system of genetics makes it necessary to use a distinct term in dis-

chapter, I shall give a more extended description and analysis of neo-Mendelism and Michurinism from the point of view of their scientific validity. Here I shall confine myself to a brief sketch of their fundamental characteristics, and some points concerning their historical development.

Neo-Mendelism is a generalized extension of the discovery by the Abbé Mendel, over eighty years ago, that when different kinds of peas were crossed, certain of their characters retained their distinctiveness in later generations without any trace of dilution or blending, and behaved as if they were transmitted by some kind of definite unit or particle in the reproductive cells—i.e., that the material basis of their heredity was particulate.

Neo-Mendelism is the general science of particulate heredity. It has demonstrated that the hereditary units postulated by Mendel do actually exist. We now call them *genes,* and define or describe them as self-reproducing units of living matter. Each kind of gene may exist in a number of different forms, called *allels* (or alleles). The genetic difference between tallness and dwarfness in Mendel's peas was due to difference between two allels of the same kind of gene.

But it has gone much further: it has discovered that in all types of organisms so far investigated—insects, flowering plants, birds, crustacea, many protozoa, fungi, mammals (including man) ferns, etc.—there exists a material basis for inheritance, a special organ of heredity. This

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cussing the controversial issues, and I shall for the present stick to *neo-Mendelism.* Eventually I shall have occasion to point out that the two systems have quite different natures: neo-Mendelian (neo-Darwinian) genetics is a *branch of science,* while Michurinism is primarily a *doctrine* which its adherents are attempting to impose on scientific fact.

is constituted by the total assemblage of genes (which in higher animals, must amount to several thousand different kinds). Furthermore, the genes are arranged in a definite linear order within the cell-organs called chromosomes; * their number is also kept constant (usually two of each kind of gene in each cell). The whole system is thus extremely complex and very highly organized—as we would expect if it has to discharge the varied and delicate functions demanded of an organ of heredity.

What are generally called the laws of heredity, including Mendel's original two laws, are really laws concerning the distribution of different genes from one generation to the next: they are all explicable on the basis of facts concerning the maneuvers and behavior of the chromosomes in cell-division and reproduction, which can be observed through the miscroscope.

The chromosomes are thus a distributing mechanism in heredity. The organ of heredity has other functions to perform, notably to influence and regulate the processes of development, whereby the egg or spore develops into the adult animal or plant. For instance, certain differences between a pug-dog and a greyhound, or between a typical Negro and a typical white man, must somehow depend on the influence of the genes concerned on the processes leading to the development of the face and skull. This regulating or controlling

* It has recently been discovered that a small portion of hereditary transmission is sometimes effected by something other than the ordinary genes in the chromosomes; but this "something" appears also to be particulate, in the shape of super-molecules or other self-reproducing units in the general protoplasm (cytoplasm) of the reproductive cells. These units have been called *plasmagenes*. They appear to differ from ordinary genes mainly in the fact that, since they are not arranged in single file within the chromosomes, an indefinite instead of a fixed number of them can be present in each cell, and their distribution cannot be orderly and regular like that of ordinary genes.

function of the organ of heredity is a much more complicated subject than its distributive function, and much more difficult to investigate. Science is still only making a beginning with it. But facts about it are being discovered (e.g., that many genes affect the *rate* of developmental processes), and we can look forward to reaching various general laws and principles within a few decades. However, the extent of our ignorance must not be allowed to obscure the achievements already made by neo-Mendelian genetics. And its chief achievement is the discovery of the physical basis of heredity. There does exist a specific organ of heredity, as there are specific organs of digestion, or of bodily movement; and it is just as distinct and separate from other organs as are the stomach or the skeletal muscles, although, being microscopic, it is not so obvious.

This discovery of the organ of heredity and of the fact that it is built up out of genes is as important as was the discovery of molecules and the fact that they are built up out of atoms.

Outside the U.S.S.R., neo-Mendelism is usually equated with genetics, since all but a negligible few of Western geneticists (and, up till last year, a considerable number of Soviet geneticists) have become satisfied that the machinery of heredity is wholly (or, to be on the safe side, almost wholly) particulate.

Neo-Mendelism is the science of variation as well as of heredity. It has established, in the first place, that the visible variation of organisms (for instance variation in human skin-color or in the size of pigs) can be separated into two components of basically different origin—those which are due to differences in the hereditary constitution and those

which are not. The latter we call *modifications*. Modifications are of two somewhat distinct sorts, the one due to differences in environment, such as the darker skin-color of white men who have been exposed to plenty of sun, the other due to differences in habits or activity, such as the greater muscular development that comes with heavy work. But all modifications have this in common, that in the first instance they affect the individual body and its organs, and not the reproductive cells.

In the second place, neo-Mendelism has established that the variations originating in the hereditary constitution are due to *mutations*. A mutation is a change of measurable extent in the constitution—either a change in quality of a single gene, or a change in quantity due to the addition or subtraction of whole genes, sections of chromosomes, whole chromosomes, or whole chromosome-sets. A small part of this sort of variation, as it exists at any one moment, is due to fresh mutations, but most of it is due to old mutations (giving rise to mutant genes which have then become stored in the hereditary constitution), and to the combination of mutated genes with each other and with unmutated genes. The existing difference between a natural blonde and a natural brunette depends on a difference in a few kinds of genes, blondes and brunettes possessing different allels of these genes. But it is of mutational origin, due to some of the original allels having mutated into slightly different ones; and this holds good even though the blonde, through modifications acquired by intensive sun-bathing, might become as dark as the brunette.

Here I must diverge a moment to clear up a common misunderstanding, that neo-Mendelism denies any influence to

the environment. On the contrary, it starts from the principle, solidly established by fifty years of research, that all characters of adult organisms are always the result of the interaction of heredity and environment. The hereditary constitution (the genes) is a chemical system which reacts with its environment during development to produce certain results. Alter either, and the end-result may alter.

For instance, there are breeds of fowls which breed true for yellow legs and others which breed true for white legs. This difference is due to differences between the allels of a single gene, as is shown by crossing the two types and breeding a second generation, when yellow and white "segregate" in the typical 3 : 1 Mendelian ratio. But this only holds good if they are fed on a normal diet. If they are given only white maize, birds of the normally yellow-legged breed will have white legs. To show yellow, their genes have to interact with a chemical substance found in yellow maize (and also in green vegetables), but not in white maize. Or again, dwarfness in pea plants may be due to bad conditions, *or* to a single gene: only experiment can decide which, in any particular instance.

The situation is in principle similar to what happens with lifeless chemical substances, though much more complicated in detail. For instance, the hydrocarbon octane (well known in octane fuel) differs from heptane merely by having 8 carbon and 18 hydrogen atoms instead of 7 and 16 respectively. It "reacts with its environment" differently, in that it boils at a higher temperature when heated. But the precise temperature depends on other conditions in the environment, notably pressure. At a reduced pressure, octane will boil at the same temperature as heptane will at normal atmospheric pressure.

In genetics, the complexity of the interaction is at its greatest in regard to human mental characters. The actual degree of intellectual attainment, for instance, is always in part—sometimes in large part—due to opportunity and education; but it also depends in part on genetic make-up. If you cannot get figs from thistles, you also cannot get good figs without good environment.

Of all the problems which genetics faces, one of its first tasks is to try to disentangle differences due to environment from differences due to heredity. In many cases, this can only be done by experiment (or to a certain extent by mathematical analysis).

Mutations are in general produced either as a spontaneous rearrangement of the structure of a gene, or as the result of some agency such as X-rays, ultra-violet radiation, or certain chemical substances acting on the gene. In all cases (with a few possible exceptions), the change produced by a mutation bears no special relation to the agency producing it. Thus a well-known mutation changing red to white eyes in fruit-flies is not produced by anything to do with vision, but by X-rays (or other agencies) hitting a particular gene and producing a rearrangement of its atomic structure and turning it into a new allel. Furthermore, although there are normally two representatives of each kind of gene in each cell (sometimes both the same allel, sometimes two different allels), only one mutates at any one time: the fact that both do not mutate together thus seems to rule out any idea that mutation is due to the effect of general conditions, and to confirm that it depends on agencies capable of acting on the atomic structure of single genes.

Neo-Mendelism has also established that, at least in the great majority of cases, and possibly always, modifications

are not inherited. Whether a woman had grown brown by constant sun-bathing or had kept out of the sun and stayed very blonde, would make no difference to the skin-color of her children.

This being so, it follows that neither the effects of use or disuse or of alterations in the conditions of the environment can normally play any direct role in evolution. Evolution consists in a change in the hereditary constitution, and neo-Mendelism in the extended sense has established that this is brought about by natural selection favoring the possessors of certain genes and certain mutations as against others, thus producing a differential survival of certain types. The black skin of Negroes is thus not due to the accumulation of the effects of tanning by the sun over many generations, but to the natural selection, in tropical regions, of those individuals who are naturally darker-skinned owing to their hereditary constitution. Selection will favor these, since their black pigment prevents the undue amount of ultra-violet in the tropical sunlight from penetrating the skin and damaging the underlying tissues. Even a very small selective advantage in each generation will produce large changes in evolution over a period of time which is, biologically speaking, quite short.

Evolution is normally adaptive, in the sense that the animals and plants which it produces are adjusted, often with astonishing delicacy, to their environment and their conditions of life. Adaptation is apparently purposeful; but one of the major achievements of modern biology has been to show that the purpose is apparent only, and that adaptation can be accounted for on a scientific basis, as the automatic result of mutation and selection, operating over many genera-

tions. In a similar way, physical science, largely as the result of Newton's work in the seventeenth century, showed that the orderly movements of the heavenly bodies, which at first sight seemed to demand divine guidance, can be accounted for on a purely scientific basis, as the automatic result of the force of gravity.

Organisms are thus closely related to their environments. But the relation is not an immediate one: the environment does not affect the hereditary constitution directly. It is an indirect one, mediated through the complicated and lengthy process of natural selection causing differential survival of better-adapted variants.

The theory and system of heredity that we call neo-Mendelism thus grades into the theory and system of evolution that we call neo-Darwinism. Or we might perhaps say that neo-Darwinism is neo-Mendelism plus natural selection.

The controversy cannot be properly understood unless we bear in mind some of the salient facts about the history of neo-Mendelism as well as its present stage of development. Mendel published his results on peas in the 1860's, but they remained virtually unnoticed until 1900, when they were brought to light, confirmed, and extended to other organisms, notably by De Vries and Bateson.

When I began studying biology at Oxford in 1906, the main issue in genetics was whether Mendelian inheritance (i.e., by self-reproducing particles) applied only to a restricted range of characters and organisms, or whether it was general. By about 1910, however, it had become evident that Mendelian inheritance was general.

Meanwhile, by 1901, Sutton had pointed out that various facts of Mendelian inheritance could be at once explained if Mendel's unit-factors, or genes as we now call them, were