The Situation in Biological Science

I

THE development of industry in the U.S.S.R. has been so rapid and so striking that there has been a tendency to regard it as the characteristic feature of the developing Soviet economy. Especially in England, with our overwhelmingly industrial economy, are we apt to forget that the Soviet industrial development rests on and demands a parallel development in agriculture to provide the food for the growing industrial population. The progress from Socialism to Communism calls forth even greater demands on both industry and agriculture, if "to each according to his work" is to change into "to each according to his needs."

One way in which the young Soviet state sought to assist this development of agriculture was to give the science of genetics full opportunity to show its value in practice. Under Vavilov—generally considered a first-class geneticist and administrator—a vast nation-wide system of experiment stations was set up, ample funds were provided and every possible support was given. We now see that in face of this unprecedented opportunity, genetics failed. The decision has now been taken to replace the old Mendelian-Morganist genetics by the new Michurinist genetics. The importance of this book[1] is that it shows how and why this decision was arrived at; the object of this review is to show why it is important to read and study the book, to try to help towards an understanding of the decision, to try to expose the absurdity, if not downright wickedness of the picture of a dictatorial decision, imposed on scientists by politicians; my task is not to justify the decision or otherwise—that will be the task of the future historian.

In his agrarian studies, Lenin never tired of exposing the fallacy of the bourgeois "law of diminishing returns." Russian agricultural scientists, clearly influenced by Lenin's writings, have been at pains to show by concrete examples that the so-called "law" is an error, due to a failure to appreciate the interaction of qualitatively different factors (see, for example, V. E. Williams, *Principles of Agriculture*, now available in English translation). If this is so, then the possibilities of advance in agricultural production are, in principle, unlimited and the whole Malthusian doctrine falls to the

[1] *The Situation in Biological Science*. (Proceedings of the Lenin Academy of Agricultural Science of the U.S.S.R. July 31–August 7, 1948). (Collet's 9s 6d.)

ground. The contrast between this confident Soviet outlook and the prophets of woe, especially in America, who see the only hope of survival of the human race in famine, pestilence and atom bombs to remove "surplus" people, is probably the clearest example of the influence of society on scientists.

What is important to our argument is the importance of integrating the advances in agricultural technique: the erroneous "law" of diminishing returns rests on a too mechanical analysis, considering the action of factors one at a time accurately enough but failing to see how they interact. Conversely, the way to avoid the operation of this restrictive "law" is through planned, all-round improvement so that no factor is held back in producing its full effect because other factors are becoming limiting. Herein lies one of the essential differences between Socialist development and capitalist growth.

It is this concept of planned, all-round improvement which is at the heart of the *travopolye* system, based on the work of Russian soil scientists and plant physiologists, two fields of study in which Russia has long held a leading place. Briefly, it consists in the use of sown grasses and legumes to provide forage and improve soil structure, cultivation with the right implements and at the right times to maintain the structure, correct use of crop rotations, of stock, of fertilisers, of shelter belts and so on. It bears some resemblance to the British practice of ley farming but is far less one-sided in that neither the sown grasses nor any other feature is regarded as the pivot or keystone: the central feature of the *travopolye* system is the integration of all features so that the maximum return is obtained from the labour expended. Clearly this is a system peculiarly appropriate for a Socialist country with collective agriculture. The breath-taking scope of the great shelter-belt programme gives an indication of the incalculable advances which it is destined to produce. The Tennessee Valley Authority is the nearest thing the capitalist world has produced, but even it is the exception which proves the rule that planned advance is in principle impossible under capitalism. Its very success was enough to evoke organised opposition and kill the Mississippi scheme, which might have been comparable with the Soviet programme for Don and Volga. A more typical capitalist effort is the groundnut fiasco.

Another factor in this drive to increase productivity, a factor which occupies a special place, is the Soviet people, incomparably the most valuable asset of the Union of Soviet Socialist Republics.

In Stalin's words, "cadres decide everything." The Soviet worker is not merely an item on a balance sheet, selling his labour power for a capitalist to exploit. He is a living, human being actively and consciously building Communism, a new civilisation. He has to know where he is going, to understand and participate in the technical and scientific advances involved in that progress.

The first important point to note about the book is that all these aspects are covered by it. They are important in themselves, but particularly important if the new trend in biological science is to be understood. In the discussion at theLenin Academy of Agricultural Sciences, Soviet workers, administrators and scientists discussed all these aspects with the utmost freedom and we have the opportunity of studying the discussion in an extremely good translation.

The second important point about the book is that the exposition and elaboration of the Michurinist approach to the problems of heredity and development, given by Academy President T. D. Lysenko and many others, are not merely clear, uncompromising and unambiguous, but are related to the aspects we have briefly indicated and to many other more immediately practical aspects of agriculture as well as to biological science in general, both bourgeois and Soviet. It is clear from Lysenko's definition of heredity as the capacity to require definite conditions for development, that the interrelations of heredity and environment have the central place in Michurinist biology and it becomes clear as the discussion continues that here is its great strength. On the basis of this theory, Soviet workers of all kinds testify, their understanding of the qualitative features of plants and animals has been deepened and extended and their control of them correspondingly increased. Formal genetics, on the other hand, shows how to handle differences in breeding work but fails to develop this understanding of the differences themselves, especially if one asks how they are integrated in the living organisms, inseparable, while it is growing and developing, from its environment.

It would be unprofitable in this review to elaborate the theoretical differences between Michurinism and Mendelism. The former is developing so rapidly that a detailed comparison might be out of date before it was completed. The latter, if we may judge by a comparison of the 1939 and 1948 International Congresses, is badly bogged down at present, but does nevertheless contain the internal contradictions which may make its further advance possible. The most important theoretical difference between the two theories is the refusal of the Michurinists to accept a hard and fast distinction between genotype and phenotype, leading to their acceptance of the inheritance of adaptive changes and of graft hybridisation. The important practical difference lies in the emphasis on studying the organism's development in relation to the environment. The book shows very clearly how much more appropriate this method is for the struggle towards a new Soviet agriculture. The concept of Mendelian genetics as a general theory of breeding equally valid for all higher organisms with sexual reproduction, regardless of the special features of those organisms, is well adapted to the needs of specialist research workers and, especially, of scientific bureaucrats. Even in capitalist countries its weaknesses become more evident in proportion as practical improvements are sought, because here the qualitative features of the organism become all-important. In a socialist country, with radically different concepts of labour and of the relation between theory and practice, events have shown this approach to be quite inadequate.

These ideas may sound controversial to the English reader, but the book shows that they are no longer controversial in the U.S.S.R. Nobody taking part in the discussion was concerned to defend formal genetics. What was controversial there was whether the two trends could continue side by side, with the Mendel-Morganist approach predominating in the universities and some research institutes, the Michurinist approach dominant in other research institutes and on the collective farms. A quite casual perusal of the book is enough to show that such a situation could not last without the most harmful effects on the unity of theory and practice. It also shows how Soviet scientists, administrators and workers *themselves* decided to end it. Remembering that while the discussion was proceeding the reports of it were filling the columns of Soviet newspapers, we are forced, if we are still capable of facing facts, to conclude that this was an outstanding example of democracy in science.

When we turn from these general considerations to the more special aspects of the discussion, we find equally strong reasons why everybody concerned in any way with the science of biology should study the book. I can only point to some of them. Much food for thought is provided by the striking similarity between stockbreeding methods in the U.S.S.R. and in Britain. Plant-breeders will find the discussion of the application of Michurin's methods and principles to agricultural crops most stimulating. We

note again certain basic similarities between Soviet and capitalist plant breeding, but also certain new methods. We seem to note some reluctance on the part of plant breeders to take part in the discussion, as though some of them were not yet fully convinced. The rye-breeder, Dolgushin, however, made a very illuminating contribution which very concisely demonstrates certain weaknesses of the Mendelian approach.

On the question of evolutionary theory, the report is again very stimulating. For example there is so drastic a re-evaluation of the significance of Lamarck that from now on it will no longer be possible to damn a theory with the simple label, "Lamarckism." Marxist students of evolution (and no serious Marxist can afford to neglect evolution) will find much to ponder concerning the dialectic relationship between the organism and environment in development, in heredity and in evolution. Other sides of biological science are covered by various speakers.

To sum up, the report gives a clear, instructive and stimulating account of a most fundamental turning point in the history of Soviet science and possibly of world science. It is essentially a human picture, built up by the protagonists themselves in their own words; their individual characteristics, failings, strong points, animosities, humour are all there, adding to the fascination of the book and effectively disposing of the "dull-uniformity-of-Socialism" type of propaganda. Any account of geneticists stricken with terror will henceforward bring only ridicule to its inventors. Its main value is for the general reader and consists in the light it throws on Soviet society in general and on the advance of Soviet agriculture and Soviet culture in particular. Biologists will find it an intensely, almost painfully, stimulating book and will be driven by it to re-examine their own work. Of the biologists, those directly concerned with practical application will find the book of especial value, for whether they accept the Michurinist trend eagerly or maintain reservations, the work reported here and the new methods of approach cannot be ignored.

J. L. Fyfe.

II

It would take a long review to do justice to this book. It covers a lot of ground; problems of animal and plant breeding, the principles of rotational cropping, the correct use of fertilisers, cytology, cell-biochemistry and the theory of the gene all receive attention. But it is not so much the breadth of the field covered in discussion that is remarkable as the breadth of outlook shown by the participants. We are frequently over-specialised in this country and it is unusual and stimulating to read the speeches of people who are trying to understand nature, and the practical problems of the control of nature, in all their true complexity.

The polemical vigour may be unpalatable to some, but it would not have appeared out of place to an English intellectual of the eighteenth century. In any case, the polemical style in no way conceals the fact that theoretical issues of the greatest importance to the future of biological science are involved.

Though the discussion was allowed to develop in a broad field, one theme was of special importance—the attack on the theory of the gene. In an intervention, Lysenko protests when Professor I. M. Polyakov takes up the views of Lysenko on intra-specific competition—". . . the question of intra-specific competition is not only a second-rate but even third-rate question in our controversy . . . the issue is . . . the significance of environment for the organism, the evolution of variability." So, although many intriguing problems are raised, this review will concern itself only with the criticism of the theoretical basis of genetics as we know it.

Considerable variation in detail may be detected between the theoretical views of leading geneticists but there is fairly general agreement nowadays on certain basic principles. Put briefly and doubtless rather crudely, these are as follows. The likenesses between parent and offspring are determined by the distribution from parent to offspring of certain genetic material. This material is particulate, the particles being known as genes, which are, in the main, arranged in linear order on certain well-defined organs in the nucleus of the cell—the chromosomes. It is considered that these genes, nucleoprotein in chemical nature, owe their specific properties to their specific chemical constitution. Occasionally a gene may change, by an apparently random process known as mutation, and this change may be reflected, in the offspring receiving this changed gene, in a changed physiological or morphological character. Consequently the inherited characters of an organism depend primarily on the nature of the genes passed to it on the chromosomes of the gametes involved in the sexual reproductive processes of its parents. Some of the earlier Mendelians regarded a given gene as rigidly determining a certain character but it has now for some time been recognised that, in the development of an organism, the genes it has received interact with one another and with the products of environmental conditions, to produce the characters of the mature organism. Thus a gene may express itself differently under different circumstances. But, as the American geneticist Muller has been at pains to make clear in his recent Pilgrim Trust Lecture on "The Gene" (*Proc. Roy. Soc.*, (B) 134, 1, 1947), these interactions are of *gene effects* only, the genes in the process of self-reproduction and passage from parent to offspring remaining independent of one another and of environmental conditions. This rigid distinction between phenotype and genotype, this belief in the insulation of the gene from its environment, is the aspect of genetical theory attacked by the Michurinists.

Their theoretical attack is very weighty and must surely make anyone stop to think. All scientific investigation of recent years, above all in the field of biology, has emphasised the inter-connectedness of phenomena and the importance of *processes*. For example, the nature of the vegetation in any given situation, and the historical changes in the vegetation, are the consequence of multifold effects of organisms upon one another, of mutual interactions between organisms and soil conditions, of mutual interactions between organisms and climate, and so on. Or again, in the study of cell-metabolism, one may for convenience separate the processes taking place under such categories as respiration and nitrogen metabolism, or one may distinguish between processes of synthesis and processes of degradation, but the real picture is one of great complexity, all these processes being linked in a web of reactions, so that in fact the molecular groupings composing the protein of the cell are never the same from one moment to the next. But the gene, we are asked to believe, is unique in the whole natural world in that, though admittedly chemically reactive, it is isolated from this flux and, unlike everything else around it in the cell, is utterly unaffected in its essential properties by all surrounding processes and changes. The effects of the gene may interact with the effects produced by environmental change, but the gene itself is an unalterable and stationary rock in a raging sea of change and motion. The Michurinists say that they cannot believe in such a situation; it is, they say, an undialectical conception quite out of accord with all our knowledge of nature. Now that it is pointed out to us, it is difficult to disagree.

The Michurinists' criticism of the gene theory was based on doubts aroused by experimental observations. It is obvious from the book that a wealth of significant experimental work exists, well known to all the participants in the discussion. Unfortunately we know little of the details of these experiments and all we get is a series of fascinating glimpses. Nevertheless it is possible to give some idea of the kind of work on which their criticism has been based. The present writer confines his attention to the botanical examples, this being the field most familiar to him.

There is first of all the evidence from vegetative hybridisation. Apparently there are now many examples of hereditary changes induced in either stock or scion after grafting procedures. No answer to demonstrations of such experiments was made by the "orthodox" geneticists attending the conference. It is difficult to find any reason for rejecting these results except that they fail to agree with preconceived theories and that is not a good reason. I. I. Prezent tells an amusing story of the passers-by who leaned over the fence round the plantations of the Timiryazev Academy and picked and ate the fruit from some tomato plants. Unfortunately, these originated from flowers of tomato grafted on *Datura stramonium* stocks; the capacity to synthesise poisonous alkaloids had been transmitted to the "tomatoes" and the passers-by finished their experiments in hospital. The proof of the pudding is in the eating!

Then there is the work on "training" plants by exposing them, over several generations, to new environmental conditions at certain stages of their development. Lysenko and other speakers describe experiments in which a spring wheat, characterised by low resistance to winter conditions, was changed by such a process of training into a winter wheat, characterised by resistance to winter conditions and failure to form ears if sown in spring. This startling change, in which a hard, *durum*, 20-chromosome wheat was transformed into a soft, *vulgare*, 42-chromosome wheat, was discontinuous, without the formation of intermediates. This experimental claim has caused much astonishment and even ribaldry in this country; the kindest critics have suggested that the stocks of wheat used in the first place were mixed, less kind critics that the result was faked. Time will show who is right; meanwhile, an equally astonishing change will be discussed below, which has been observed in laboratories both in England and America.

In addition to providing their own experimental evidence that characters may be inherited in a non-Mendelian way, in circumstances where the chromosomes are unlikely to intervene, and that

with suitable experimental methods (contrasting remarkably with some of the methods used by geneticists to increase the mutation rate) adaptive changes may be induced in an organism and transmitted to offspring, the Michurinists point with effect to data obtained by workers in other countries. Much of the apparent solidity of the gene theory is based on the close parallels said to exist between the behaviour of the chromosomes during meiosis and the segregation and distribution of inherited characters; I. I. Prezent quotes with effect the damaging blows at the chromosome theory recently made by the American cytologists E. C. Jeffry and F. Schrader (*Science*, October 3rd, 1947; *ibid.*, February 13th, 1948). Again, several contributors mention the growing number of cases of non-Mendelian inheritance which are nowadays explained by various subsidiary hypotheses to the classical gene theory. They pointed out, however, that the theoretical explanations evolved by geneticists to account for those facts, being based on a variant of the gene theory, were quite distinct from Michurinism.

In conclusion it is interesting to consider certain recent work carried out in this country, not in the main field of genetical research, which has a bearing on the points at issue. In recent years biochemists have directed much attention to micro-organisms; there is every reason to believe that their fundamental processes of cell-metabolism are comparable with those of higher plants and animals and they are very convenient working materials. Geneticists, too, are devoting more and more attention to them. Recently, work on adaptation to drugs has achieved prominence, partly because of its obvious practical significance. The fact is, that if a population of bacteria is grown in the presence of a sub-lethal dose of a drug, a measure of resistance frequently develops and by increasing the dose of the drug in steps a strain of the organism may be obtained which is highly resistant to the drug.

E. F. Gale (*J. Gen. Microbiol.*, 3, 127, 1949) has recently published some work on adaptation of *Staphylococcus aureus* to penicillin. Penicillin is a specific drug affecting certain bacteria in very low concentrations and others scarcely at all. By and large, the penicillin-sensitive organisms possess certain characteristic staining reactions (so-called *Gram-positive*) and, for growth and multiplication, have to be supplied with a variety of amino-acids, being unable to synthesise them for themselves; on the other hand *gram-negative* organisms which do not show the staining reaction and are nutritionally non-exacting, are generally resistant to penicillin. Gale, in the process of training his *Staphylococcus aureus* (which is a Gram-positive, nutritionally exacting, spherical organism) to grow in the presence of ever-increasing concentrations of penicillin, found that at a certain stage a discontinuous change took place, and his organism had become Gram-negative, nutritionally non-exacting, and rod-shaped! Any systematic bacteriologist would agree that this is a change of far greater magnitude then Lysenko's change of a spring wheat into a winter wheat.

There are roughly two ways of interpreting the body of knowledge of bacterial training, including the specific case described. Michurinists would postulate a direct action of the drug on the organisation of the cell, producing a heritable adaptive response. Mendelian geneticists postulate a simple selection of chance mutations involving several genes, but all they have been able to do to support this view is to show that, with certain accessory hypotheses, the observations *could* be explained on such a basis. Professor Sir Cyril Hinshelwood, a physical chemist at Oxford who has been responsible for much valuable work on the kinetics of drug-adaptation in bacteria, discussing this phenomenon of training and its explanation, says:

> "*With suitable auxiliary assumptions* [my italics—P. W. B.] some form of the selection hypothesis can be made to account for nearly all the facts; but it is because these auxiliary assumptions themselves appear to increase in arbitrariness and complexity as one proceeds, that one concludes by declining the main thesis as improbable" (C. N. Hinshelwood, *Chemical Kinetics of the Bacterial Cell*, Oxford, 1946).

He then proceeds to offer a much more simple explanation based on "direct action of the new environment in causing (*a*) the operation of alternative modes of growth, (*b*) the quantitative increase of certain parts of the cell-material, (*c*) the quantitative modification in the texture and configuration of certain parts of the cell-material, (*d*) a mode of cell-division likely to favour growth in the new environment." This point of view, unorthodox though it may be, is supported by a mass of experimental evidence. The analogy with the views of the Michurinists in an analogous field is striking. Further, Hinshelwood's criticism of the over-elaboration of Mendelian explanations of training is essentially similar to that made by N. V. Turbin in the Soviet discussions, dealing with current genetical explanations of non-Mendelian inheritance:

> "The appearance of these new ideas, of the new hypotheses of Morganist genetics, is in itself striking evidence that some of the prominent adherents of this theory of genetics, who up till now have ignored the facts obtained by Michurinists and which undermine their theory, are themselves coming up against such facts more and more often, but they are incapable of breaking away from the fundamental pseudoscientific dogma of Mendelist-Morganist genetics, from the theory of a hereditary substance; they are incapable of drawing correct conclusions from these facts. These scientists are trying to save the bankrupt metaphysical dogma about a hereditary substance *by means of various supplementary hypotheses*." [My italics—P. W. B.]

Both Hinshelwood, in his book, and Turbin, in the Soviet discussions, call attention to the numerous accessory hypotheses needed by the Mendelians to account for certain biological observations. Hinshelwood's explanation of bacterial training is essentially the same as the Michurinist explanation of "training" of higher plants. If, by calling attention to this parallel, the present writer has helped to convince readers that the Michurinists have a serious scientific case, he will be satisfied. The book under review is at present the best entry into Michurinist literature.

P. W. Brian.

NOTE

In his article "In Defence of Genetics," Professor Haldane writes: "I am much more convinced that collective farming is superior to capitalist farming than that Soviet breeding practice excels our own. If, of course, they can produce more wheat per acre, or more milk per year from a cow of given weight, than the best British or Danish farms, I shall have to change this opinion."

In *Soviet Weekly* of July 28th it is reported that the top yield now obtained from the branched wheat being grown over an area of 1,000 acres or more in Moscow Region is 80 cwt. per acre. This compares with the highest-ever yield of the capitalist world which was 65·2 cwt. per acre in New Zealand. The highest-ever yield in Britain was 53·5 cwt. per acre obtained in Kent.

Secondly, the Kostroma cow bred in the Karavayevo State Farm mentioned by V. A. Shaumyan during the discussions at the Lenin Academy of Agricultural Sciences, yielded 16,262 litres of milk in one year. This compares with the best British Fresian which yielded in 1947 a little over 14,000 litres. The fat content of the British Fresian's milk was 4·76 per cent. The fat content of the Kostroma cow's milk is said to be over 4 per cent.

A last point to note is that the high yield cows of this Kostroma breed have a milking life of anything from 15 to 20 years.

Maurice Cornforth.