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# The Microbiologist and His Times[1]

S. E. LURIA

*Department of Biology, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139*

The title of this essay, "The Microbiologist and His Times," is paraphrased from that of a famous lecture by my favorite writer, Albert Camus, entitled "The Artist and His Times." It may seem rash on my part to substitute "Microbiologist" for "Artist" since the social and ethical problems of the microbiologist, which I am going to discuss, are probably of less cosmic import than those of the artist. Yet, an analogy does exist.

Camus in his lecture raised the basic question of the role of the artist, and in fact of every intellectual, within the world of his own time. Camus' thesis was that the role of the artist is always conditioned by the society that he lives in; that even the most extreme choices open to the artist—withdrawal into the ivory tower, or passive acceptance of the values predominant in his society—are themselves forms of social activity; and, finally, that the true role of the artist is neither to reject nor to accept society as it is, but to express the striving of man, within that society, toward a creative understanding of himself and of his humanity.

Thus, the issue that Camus raises is that of responsibility, that is, the recognition of the consequences and implications of one's activities and the willingness to face up to them. It is on the responsibilities that face us as microbiologists at the present time that I wish to comment in this brief essay. I shall discuss two such areas of responsibility, the first one narrowly professional, the other more broadly social.

The first problem I wish to consider is the responsibility of the microbiologist as a biologist. This question arises today because the structure of biology as a science has been radically altered by the rise of molecular biology, and in that development microbiology has walked to the center of the biological stage. The basic discoveries of Beadle and Tatum, of Avery, of Hershey, of Benzer, and of Nirenberg, to mention only a few of the great moments of modern biology, were all rooted in the fertile soil of microbiology.

It is true that molecular biology in its modern form is the successful outcome of the convergence of two branches of biology—genetics and biochemistry—neither of which was microbiological in its origins. But it is also true that such convergence could have been successful only within microbiology. The great discoveries, such as the nucleic acid nature of the genes, the structure of DNA, and the structure, function, and regulation of the genetic code, could be clarified only by working with bacteria and bacteriophage, because only here the geneticist and the biochemist had the opportunity to deal with the same materials at a common operational level.

And this opportunity was not accidental; it was rooted in the very history of bacteriology. For it is the traditional way of the bacteriologist to deal with bacterial cells both as organisms and as chemical factories. Because of the practical roots of his science, in medicine, in agriculture, and in the fermentation industry, the bacteriologist has long been accustomed to ask mainly questions of "How"—how does it cause disease? how does it ferment? how does it fix carbon dioxide?—rather than the traditional questions of natural history —whence? how come? and even what for?

In fact, the bacteriologist has always been closer to biochemistry than the zoologist or the botanist. Even more important, I think, is that within microbiology there has never been created the disciplinary dichotomy between the biochemist on the one hand, and the morphologist, taxonomist, and ecologist on the other hand, as has traditionally been the case in other areas of biology. Bacterial physiologists have always been actively concerned with the physiological role of biochemical reactions in those vital processes that affect the structure and the mode of life of microorganisms. Thus, the contributions of microbiologists to biochemistry and to molecular biology have in a certain sense come about naturally. They have been related in an almost spontaneous way to the traditional pursuits of the bacteriologist, be it analyzing a pattern of fermentation or tracing the mode of action of a chemotherapeutic agent.

I do not want to give the impression that I am boasting about the achievements of microbiology. I only wish to make the point that the present role of our science is forcing upon microbiologists an increased position of leadership within the field of biology, both educationally and organizationally. This does not mean claiming for microbiology any "manifest destiny" to run the bio-

[1] Based on the Presidential Address delivered in Detroit on 4 May 1968 at the 68th Annual Meeting of the American Society for Microbiology.

logical show, but simply recognizing that an understanding of microbiology is at least as central today to a sound biological and scientific education as is an understanding of zoology and botany. Already in many schools, including my own, we are teaching courses of general biology in which the central focus is on the microbe as a cellular prototype. We are witnessing also a tendency to revise the institutional framework of biological instruction and to create life-science departments in which microbiology assumes prominent and even central roles.

This increased educational responsibility is inevitably coupled with another one, which we may call a public-relations responsibility. At the moment we are faced in this country with a mood of slowing down the expansion of fundamental research in general and of biological research in particular, in the name of illusory demands that scientists concentrate on immediate practical goals. If the valid claims of fundamental biological research to a continued and expanded support are to be presented effectively, few groups can do so better than microbiologists, who can point to the remarkable contributions of their science to the recent advances in molecular biology and to the successes of chemotherapy and preventive medicine.

If this is so, it is reasonable to ask whether we microbiologists, as a group, are fully prepared to assume our due share of responsibility. My concern is whether the tradition of practicality, which has permitted us to avoid the split between purely academic activities and strictly applied ones, may not prove a hindrance to the fulfillment of the task of championing the rightful role of basic research. Microbiologists seem to have suffered themselves at times from a mild case of anti-intellectualism, or at least of hyperpracticality—almost as though research without immediate practical goals were something of a sinful luxury, an attitude which, by the way, is not unique to our group and, in fact, is deeply rooted in the Puritan tradition of this country. I may cite, for example, the tolerant skepticism with which bacterial genetics was received among microbiologists in the early 1940's, at a time when it was eagerly seized upon by geneticists. For many years, in fact, bacterial genetics flourished more in departments of zoology or biology than among card-carrying bacteriologists.

As we microbiologists assume a more active role within the life sciences, I think we should be careful to avoid both extremes of emphasis. We must, of course, stress the tangible benefits to be expected from both fundamental and applied aspects of biological science, but, at the same time, we must insist on the value of science per se, as an intellectual activity. Art and science are the activities that fulfill the human needs of men, as distinct from the animal needs for survival and for physical well-being, which practical activities aim at satisfying. One might say that the true aim of art and of science is to make human life more meaningful, rather than only more enjoyable or less fraught with sorrow.

This brings me to the second area of responsibility that I wish to discuss, that of the social consequences of scientific activity. It is painfully clear that the findings of science can all too easily be employed, not to enrich the human experience but to render it more painful. The march of science generates a technology that can be applied to dehumanizing goals as well as to humanizing ones. In fact, the destructive applications of science are often much easier to achieve than the constructive ones.

The obvious example, of course, is the application of science to warfare; the development of nuclear energy and nuclear weapons is the clearest case history. But other social dangers may be contemplated.

For example, the current advances in molecular genetics suggest that it may become possible, in a not too distant future, to carry out what has been called genetic surgery—the specific directed alteration of genes in the germinal cell line, possibly by means of viruses or other subcellular agents of genetic transfer like those recently discovered in bacteria. Ultimately, of course, such techniques may find beneficial uses in animal breeding, in medicine, or even in human eugenics; however, it may unfortunately prove easier to turn genetic surgery to weaponeering, or even to degrading the genetic quality of entire populations. We may soon have to face the potential danger, indeed the nightmare, of a "Brave New World" based on genetic surgery rather than on Pavlovian or hormonal conditioning like the one imagined by Aldous Huxley. It is important for biologists to be aware of these possibilities, so that they will call them to the attention of the public and help society reach wise decisions as to relative priorities in the uses of science and its products.

Thus, the issue of the social implications of scientific technology raises the related issue of the responsibility of scientists to concern themselves with the possible uses to which their findings may be put.

For a microbiologist, one important question is that of his relation to research on germ warfare. There are valid arguments in favor of research on defensive measures against germ warfare. There are also serious arguments that can be advanced both for and against the actual preparation of biological weapons. The attitude of many laymen

as well as that of some microbiologists, including myself, is strongly influenced by the emotional recognition that biological warfare implies a deliberate effort, to quote from a recent article by John Edsall in *Scientist and Citizen*, "to invert the achievements of modern public health in order to produce epidemics that would devastate enemy armies and civilian populations."

The decision as to whether or not to work on biological warfare research, and on war-related research in general, is bound to be a personal one. Consciousness of the difficult issues involved dictates the utmost restraint in making value judgments concerning either those who do carry out such research or those who wish to disassociate themselves from it.

As for scientific organizations, such as the American Society for Microbiology, the question of association with warfare-related research, especially of a classified nature, raises what seem to me to be different and simpler issues. I personally believe that such association is undesirable because it is not fully consonant with the stated purpose of an open-membership scientific organization.

For many years, the ASM has maintained a friendly association with the Biological Laboratories of the U.S. Army Chemical Corps at Fort Detrick, an association formally sanctioned in 1955 with the appointment of an Advisory Committee to the Fort Detrick laboratories. Despite the many valuable contributions to microbiological science made by those laboratories, many people, including myself, have doubted the wisdom of this consultative function of the Society to a classified program of government research.

This year, prior to the Detroit meeting, the Advisory Committee to Fort Detrick unanimously recommended that the Committee be discontinued. The grounds for this recommendation were purely technical, concerning the limited effectiveness of the Committee, and did not in any way express any adverse judgment on the work of the Fort Detrick laboratories on either technical or ethical grounds. The Council Policy Committee and the Council of the Society unanimously approved the recommendation that the Committee be discontinued.

This decision, reached on purely technical grounds, also relieves our Society of a function that in my opinion was not germane to its primary concern with open, unclassified scientific activities. Scientific advice on problems of classified research, for the Fort Detrick laboratories as well as for other agencies of the U.S. Government, should best be provided by individual consultants or through government-chartered agencies such as the National Academy of Sciences—National Research Council.

In concluding these remarks, let me return to the theme of the responsibility of the microbiologist for the intellectual and social consequences of his work. I think we may accept, as a common goal, the achievement of a society in which science will flourish, both as a liberating intellectual activity and as the source of a beneficial technology. What this goal implies, as a minimal requirement, is a society intellectually and institutionally preadapted to assimilate the advances of science and ready to put them to fruitful purposes rather than to selfish or destructive uses. For us scientists, aware of the awesome powers and of the bountiful opportunities that science places at the disposal of mankind, the question of individual responsibility might be formulated in the following way: What can I personally do to see to it that society will be so informed and so organized that it can derive the maximum benefit from the fruits of science?

The answer to this question rests with each of us.