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the aid of scientific thinking as used in physics and chemistry.

We must regard biological applications which rest on partial knowledge of life as irresponsible. Of course, scientists who practice these applications are not aware of acting irresponsibly. On the contrary, they work with a maximum of conscientiousness possible within the framework of their partial science. However, scientific applications which have even a chance of inflicting general damage on life in the future cannot be justified from the ethical point of view.

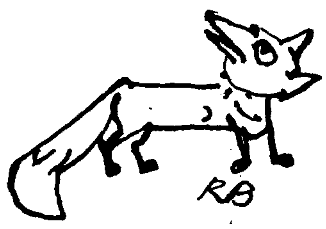
The root of this irresponsibility lies in the fact that *the part is taken for the whole*. We suggest that the thesis on which this irresponsibility is based—namely, that life is nothing but a complicated case of physics and chemistry—is itself immoral.

The lack of appreciation of the limits of present scientific knowledge of life has direct and very dangerous consequences for the position of man in our world picture. It leads to identification of man with a complicated physico-chemical mechanism, and this, in turn, to devaluation of all that is genuinely human. A mechanism is amoral; "mechanization" of life, be it conscious or unconscious, is bound to lead to destruction of all ethics. If we consider life in general and the freedom of the individual in particular as positive values, we are forced to consider the mechanistic-materialistic concept of life as immoral.

• *A NEW SCIENTIFIC ETHIC*

Let us return to our original subject. It should now be clear that we need nothing more urgently than a new ethics, adapted to the present scientific possibilities of human action. It will not be easy to develop it. We cannot imagine a scientist, philosopher, lawyer, or theologian sitting down at his desk and composing a new moral code. Rather, the creation of a new ethics must be a development comparable to a great scientific discovery, or to the creation of a masterpiece of art. That moral creation is possible is shown by the example of Albert Schweitzer and his thesis of "respect for all life." On the other hand, we cannot afford to do nothing and wait for this creation. A few points can be outlined even now:

In the first place, a main requirement is to recognize that the main body of present scientific activity concerns only one aspect of nature—the material—and cannot be regarded as providing a full grasp of reality. As we have seen, this *totum pro parte* is at the root of the present ethical chaos. The purpose of this article was to awaken the consciousness of scientists to this limitation. The next step should not be too difficult. There are enough people, including some scientists, who possess a highly developed conscience. As soon as it has become common knowledge that, for example, a true and complete knowledge of life processes does not yet exist, this conscience will direct research into more healthy directions (in the literal as well as in the figurative sense). One chief point of new scientific ethics will have to be respect for life, which is not yet explored, and respect for free human personality. It is to be hoped that in the course of time, new lines of scientific ethics will develop; without them, mankind will stumble from catastrophe to catastrophe.



WHEN SCIENTISTS TESTIFY

AMITAI ETZIONI

It was a warm afternoon in June 1963; the Senate Committee on Aeronautical and Space Sciences was listening to a distinguished American scientist's testimony on the merits of our space program. Senator Margaret Chase Smith of Maine reported that she had read a newspaper story about another potential Russian "first." The Russians, she reported, were planning to build "a power station on the moon which could beam electricity to the earth in the form of a thin ray of light energy." What are we doing, she asked.

On the stand was Professor Polykarp Kusch, chairman of the department of physics at Columbia University and holder of a Nobel Prize. His eyes twinkled as he cleared his throat and said briefly, "I am sorry, it would take me more time than I have at my disposal now." The chairman, not easily distracted, asked if Dr. Kusch would be willing to send in a written comment. Yes, said Dr. Kusch, he would.

In his written comment, which contained all of ten lines, Professor Kusch explained dryly that converting the solar energy that reaches the moon into a light or radio beam, sending it to the earth, and then reconverting it to useful energy on earth would result in such a great loss of energy that collecting the same solar energy on earth would "almost certainly yield at least as much energy, area for area, as collection of energy on the moon, with an incredibly smaller engineering effort."

Senator Smith and her colleagues on the Committee and in the Senate were thus faced with a typical predicament, the need to make a decision on a matter about which they know extremely little. There is not even one member of the Senate who can, by any definition of the term, be called a qualified scientist. This means that the Senators must base their decisions on expert testimony. But who evaluates the experts? Have not experts been wrong before—and in a big way? What is the Senate to do if two—or more—scientists disagree?

Senator Smith surely realizes that if

she asks enough scientists about her lunar power plant, she will find at least one eminent researcher who is all in favor of snatching this "first" from the Russians and at least one who is violently opposed. What is the Senate to do then—bring in more experts, have them take a vote, agreeing to follow the advice of the majority of the experts? Will every expert have one vote, or should votes be weighted according to years of experience, number of degrees, and the times each man has been right in the past?

The question is, of course, much more serious than whether the U.S. ought to have energy loaded moonbeams as an aid in its earthly contest with the USSR. The federal budget of research and development has doubled every two years for the last decade, reaching the level of 15 billion dollars for fiscal year 1963. More than two-thirds of all American research and development is now federally financed, and every third graduate student—the scientist of tomorrow—holds a federal fellowship, has a federal loan, or works as a research assistant on some federally financed project.

Until recently, the Congress did not pry into this mushrooming federal research and development empire. It almost automatically approved bills submitted to it by the President, trimming a little or adding a little. In 1962, the National Science Foundation requested $358 million, $322.5 were appropriated; the Atomic Energy Commission asked for $3.2 billion and got $3.1; the National Bureau of Standards requested $30 million, received $27.5. But, in 1963, Congress became more actively concerned about the loss of its traditional powers to scrutinize the spending of the executive branch. It even cut $0.6 billions from the $5.7 requested by Nasa, and appointed a committee to "research the researchers," under the chairmanship of Carl Elliott (D, Indiana).

• CONFLICT OF INTERESTS

A major technique of Congress in gaining an understanding of government science and technology is hearings. This legislative instrument is not free from flaws when employed in other areas of the Congressional work; when it comes to probing science, there are special defects.

One problem might be called "scientific conflict of interests." Congress is accustomed to dealing with interest and pressure groups; it uses their partisan statements to bring out the various sides of an issue. By taking testimony from both labor and business, exporters and importers, small farmers and big farmers, Congress guards against being swayed by any one view. As long as all the major interest groups are represented, the "cause" represented by each expert is clearly identified, and when a committee's staff has done some digging of its own, Congressmen can pretty well understand the issues and can form an independent judgment.

But when scientists testify as scientists, Congress expects them to act not as an interest group but as disinterested experts, evaluating issues on their scientific merits, as Professor Kusch did when he dispassionately buried the power plant on the moon. With scientists, Congressmen let down their political guard; since scientists are not expected to have axes to grind, which specific axes they do have is not widely known on the Hill.

• *FACTORS AFFECTING TESTIMONY*

It should not be a complete surprise that scientists have feelings and interests of their own, which occasionally affect their testimony. Take, for instance, the moon race. The Senate Committee on Aeronautics and Space Sciences, in two days of hearings on June 10 and 11, 1963, heard the testimony of ten distinguished American scientists on the wisdom and value of our rushing a man to the moon. Seven of these scientists favored the lunar tour, two had reservations, and one was strongly opposed. The Committee, as its summary report shows, was left with the distinct impression that the overwhelming majority of American scientists favors the present lunar race. But were these ten scientists representative of the American scientific community? No, indeed—most of them belong to a very special subgroup of scientists—those who are deeply involved with the space race and who benefit from it in one way or another through financial and administrative ties with the space agency (Nasa). Compare these figures with a poll made by *Science*, the publication of the American Association for the Advancement of Science: out of 113 scientists not involved in Nasa's work, all but three expressed their dissatisfaction with the haste-and-waste moon-or-bust race.

The factors affecting the testimony of a scientist are complex and quite different from those that might bias an expert testifying for the Chamber of Commerce or the AFL-CIO—biases that Congress is familiar with and has learned to recognize. The scientist rarely seeks to advance his own pecuniary interest, or that of his subgroup. His potential gains are indirect and sometimes intangible, making them less easy to identify—such as the advancing of the branch of science with which he identifies or keeping a prestigious chair on a prestigious research board set up by the Administration. The following exchange vividly illustrates the kind of slant Congress looks for and the kind that exists.

Dr. Colin S. Pittendrigh, an eminent biologist from Princeton University, was on the stand. The exchange of pleasantries and introductory comments had just ended, and the professor launched into his testimony, stating that he was in favor of the moon program, and that "I have no vested interest in the space program, in the sense that the main line of my professional work will be very little affected by how this program develops."

The Chairman: "Doctor, I will have to stop you just for a second because I read a newspaper story—I do not remember who wrote it—saying that of the ten scientists who will testify, all but one have a direct financial interest in the space program. Do you have a direct financial interest in the space program?"

Dr. Pittendrigh: "I am not quite sure what financial means in this context. I do not own shares in an aircraft company, no."

The Chairman: "Well, the reporter says that most of you do have."

Dr. Pittendrigh: "I really do not understand."

Fortunately for the Chairman, Senator Clifton Anderson, and his fellow Senators, the director of the Committee's staff did understand and was able to explain the chairman's question to Professor Pittendrigh.

Mr. Di Luzio: "Government contracts with yourself personally or the institutions with which you are associated."

Dr. Pittendrigh: "Oh, yes, indeed, I do receive funds from the Space Administration for part of my work, that is true."

The same, it turned out, was true of most of the witnesses. Dr. Martin Schwarzschild, Eugene Higgins Professor of Astronomy at Princeton, cast much light on the nature and extent of his ties to the program about which he was testifying. He opened: "I could not be more personally involved than I am. I am an astronomer. That automatically makes me strongly involved, and I belong to a small astronomical observatory in Princeton, where space research is the main topic. Emotionally, that sets the scene for me. On the more financial side, I am responsible for what you probably consider a very small project; for me, it is a very big one." Other witnesses declared a similar involvement—or their positions and testimony indicated such an involvement.

Traditionally, those who need the service of a professional but are unable to judge the disinterested nature of his advice are protected by the professional code of ethics; thus, doctors and lawyers watch each other, so that their special knowledge and skills are not used to the disadvantage of the client. Of course, the code is occasionally violated, but the forces that support it can by and large keep it effective. But in situations such as giving testimony, when the scientist becomes, in effect, a practitioner and science a profession, the scientist is guided by no similarly organized professional code of ethics. Thus, it is not considered unethical for an astronomer, whose career, secretary, travel funds, status on the campus, and professional interests are deeply affected by Nasa grants, to testify on behalf of the space program, without even volunteering the nature of his involvement, ties, and interest. It is urgent that the American Association for the Advancement of Science and the professional associations devise a code of behavior, including either full voluntary disclosure of all such vested interests, or forbidding scientists to testify on behalf of programs in which they have other than scientific interests.

• *LACK OF INFORMATION*

Even deeper misunderstandings arise from habits of congressional committees to put before an expert on one subject questions that require expertise in another, or questions that are political and moral in nature and about which a scientist knows no more than the next man. Some scientists conscientiously avoid answering such questions, others leap at them without reservations.

For example, Senator Stuart Symington asked Dr. Pittendrigh, "Do you think from the standpoint of national survival or national security that the space program is important from the standpoint of our future security?" Dr. Pittendrigh sensibly explained that he could answer this question only from the viewpoint of a biologist, and that from this vantage point "the space program seems to me to have very little bearing on security matters, except insofar as a manned station or stations in space may have military significance." Then he correctly added: "Now, that question would first have to be answered by military strategists, not by me."

However, other witnesses were less restrained. Dr. Lloyd V. Berkner, president of the Graduate Research Center of the Southwest (and formerly in other public and administrative positions), felt no inhibitions in stating that there is "a whole spectrum of potentials [for a military space program] —early warning reconnaissance, surveillance, intelligence, electromagnetic warfare, and interception, inspection, and destruction of unfriendly missiles and satellites." Some of these systems are already in operation, but others are highly controversial; experts have raised questions on technical feasibility, political consequences, and strategic necessity. But administrator Berkner simply pushed all these considerations aside, as if he had researched these matters and his considered scientific judgment had led him to believe in their feasibility and desirability.

• *EXTENT OF EXPERTISE*

It is clearly up to congressmen to determine to what extent a witness is sharing with them his scientific findings and expect judgment, and to what extent he is expounding positions he holds for emotional or political reasons, positions on which he is no more "expert" than the next guy and on which there is as much consensus among scientists as there is among congressmen.

It might be all too obvious that astronomers, physicists, and biologists are hardly military strategists or experts on missile systems, but it seems to be less evident that in sociological and psychological questions these eminent natural scientists are equally out of their depth—although everyone considers himself an expert on these subjects. Thus, although some scientists disqualified themselves on matters of national security, they were far less reluctant to testify concerning the vigor of the American society and the ways in which it moves and reacts, probably assuming that it is enough to be an American to have an expert opinion on this subject.

Testimony on the effects of the rapid pace of our space explorations illustrates this point. The space agency is reluctant to admit that our rush—which costs hundreds of millions of dollars and forces many short cuts, including the weakening of the scientific aspects of the program—is due to our desire to beat the Russians to the moon. Nasa feels quite accurately that it is not dignified for the U.S. to enter a race just because another power has made (or is believed to have made) that goal an object of a propaganda campaign. The *rush* to the moon (not to be confused with the general program of space exploration or nonmanned flights) must therefore be explained by other considerations. It seems that a desire to justify the moon race led some natural scientists, friends of Nasa, to stray in their testimonies into the depths of the social sciences.

• *PACE OF ACCOMPLISHMENT*

Dr. Harold C. Urey is a professor of chemistry at large, at the University of California; his studies of isotopes and paleotemperatures and his discovery of deuterium apparently qualify him to tell the highest legislative body of this country why American industry, administrators, and engineers have entered the space race and why our psyche is friendly to space. While he was quite frank to state that "The reasons for the speed [of the moon race] lie outside the range of scientific considerations, and I think perhaps I am not in a good position to judge them," he nevertheless rose to the occasion. He stated, "The industrial companies, the scientists, the engineers, and the administrators cannot be attracted to this work unless some certain rate of accomplishment rewards them for the work," adding that the real reason for undertaking the space program is an innate characteristic of human beings, namely, some curious "drive to try to do what might be thought to be impossible."

In fact, industrial economists do not consider the pace of "accomplishment" as important as Dr. Urey indicates. They are more interested in the rate of profit, which attracts industries to the competition for a place in space—a profit that can be kept quite high, even if the space race is slowed down by half. As for "innate characteristics," psychologists gave up the search for them long ago and no one has yet discovered a drive to do the impossible, in space or on earth. It is somewhat difficult to believe that we came under the spell of this universal drive precisely on October 5, 1957—before the Russians orbited Sputnik our drive to explore space was quite controlled.

Dr. Martin Schwarzchild, of Princeton University, is an international authority on astrophysics and observational astronomy; he has explored heat convection in the solar atmosphere and the structure and evolution of stars. Although this impressive background does not seem to make him a social scientist, this fact did not prevent him from making some rather dogmatic statements about the structure and evolution of the American society and the ways it responds to challenges. Like most of the natural scientists who testified, Dr. Schwarzchild holds to a stimulus-response theory that is allegedly applicable to biology and still has some followers in psychology, but has long been defunct in sociology and political science. Dr. Schwarzchild and other natural scientists believe that the more you exact from a system, the more potential it has, because the initial stimulus pushes the system to higher levels of performance. The race to the moon is suposedly such a stimulus for America. It puts a strain on our resources, on our scientific facilities, our school system, and our federal research and development budget, but this very strain is "invigorating," "energizing," and "stimulating;" it makes for better schools and more scientists, with the net effect that we can race to the moon and still be in a better position to meet all our other needs.

• *MANPOWER PROBLEMS*

Natural scientists tend to ignore that in socio-political systems—unlike physical or biological ones—a conscious effort of the system is necessary if a given stimulus is to have an impact, and that counterefforts can neutralize this impact; as much depends on the deliberate efforts of the system into which a stimulus is introduced as on the nature of the stimulus and its magnitude. For example, the draining of engineers and scientists to the space mills does not by itself create more school buildings and college teachers—somebody must appropriate the necessary funds to expand these facilities at the necessary scale and pace. Similarly, the monumental expansion of space research will probably accelerate the growth of astronomy, but whether it stimulates or stifles other sciences depends on how much unused talent the society has, and the degree to which this unused talent is recruited and trained. The utilization of this reserve of talent depends, in part, on our willingness to lower racial and class barriers in offering opportunities for education and employment. But there is little in the moon race that promises to "stimulate" Southern cooperation in these matters. In short, positive response and productive adaptation of societies to stimuli is a highly complex and far from automatic matter, contrary to what is implied in the misleading analogy from natural science.

• *SANDBAGGING*

Since almost none of the natural scientists on the stand had training or professional experience with manpower statistics, the structure of educational systems, the questions of social lead time (the necessity to start training now scientists whose work will be needed in the late seventies), or a thorough knowledge of how societies respond to pressures, it is no wonder that the natural scientists—although they freely discussed socio-economic matters—did not have any data to support their statements. Dr Schwarzchild, for instance, felt that a touchdown on the moon in six to eight years, preferably sooner, was right for "sparking the whole nation to new levels of vitality," but we never learned how he arrived at this figure. Similarly, neither he nor any other scientist testifying provided any figures to support their confident claims that by taking more than 42,000 engineers and scientists to work in the space mills, we stimulate the graduation of considerably more, enough to fill the gap. Theoretically, we may be affluent enough to afford to race to the moon and everything else at the same time, but the fact is that Nasa's budget alone is six times larger than our total basic research budget; while we race deeper into space, we cut back other important earth projects, such as penetrating the earth crust (project Mohole). In 1963, 87 per cent of federal R and D went to defense, space, and atomic energy and only 13 per cent to all the rest—social, medical, international, and other earth sciences included. And Congress, which gave Nasa four thousand fellowships to attract students into space-related sciences, failed to approve federal aid to education to expand other fields of graduate study, to expand and improve undergraduate and high school teaching, or to increase the supply of graduate students in earth and space sciences.

It is unfortunate that Senate Committees, like the Aeronautics and Space Sciences Committee, when reviewing these questions, take the word of those directly involved in space sciences and do not invite even one manpower expert, educator, or social scientist. If Congress is to learn more about the impact of science, it will have to learn to call on those who study the impact of scientific developments on society as well as on those who create the scientific impact.

"Whenever a scientist goes to Washington regularly," a student of congressional hearings explained to me, "more than he educates Congress about science, he learns the way of politics. He lures the Congressmen into his corner, and then sandbags them." "Sandbagging," it seems, includes much more than baffling the uninitiated Senators with facts and equations they do not understand about the intricacies of modern science; the technique also involves being less than completely open about vested interests of scientists, testifying on matters quite outside the range of one's expertise, and appealing to such vague images and notions as "innate qualities" and "stimulating the nation," which sound informative but are not. The Congress had better get a sandscreen and the scientists had better curtail their sandbagging; billions of dollars and the quality of our democratic decisionmaking process are at stage.