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SOME IMPLICATIONS OF SCIENCE FOR OUR SPACE AGE SOCIETY

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For the past several years, my vork has led me into the history, the ociology, and the philosophy of sci-nce, in consequence of which my orizons have expanded beyond the iological sciences to embrace the hysical sciences, including astron-omy. My remarks will be in keeping vith my current orientation to sci-nce, which centers about the in-eraction of science and society, a topic zealously pursued by James B. Conant (1947) at the close of World War II. This generation of scientists has been privileged to witness the second great impact of science upon society, inaugurated by the explosion of the first atomic device, and enormously catalyzed by the launching of the first sputnik. Parallels have been drawn with events and forces that characterized the first major impact of science upon society in the 16th and 17th centuries (de Santillana, 1955).

We have witnessed the equally significent impact of society upon science, manifested originally as concern for the consequences of nuclear warfare and anxiety for the effects of radioactive fallout from nuclear test explosions.

The Space Age burst upon us in October, 1957, when the Soviet Union, supposedly a backward country, launched the first artificial satellite. The Western nations were shocked by this wholly unexpected achievement, for supposedly Soviet science had not progressed very far beyond the days of Mendeleef and Pavlov. In my hand is a copy of the *Moscow News* for July 29, 1957, purchased in Moscow on that date. On page seven, under the banner line, "What Scientists Dream About", is a statement entitled "We Must Dream", by Academician A. N. Nesmeyanov, President of the Soviet Academy of Sciences. His second paragraph ended with the sentence:

> "I like the idea of catching a glimpse of the 21st century and of trying to imagine on the basis of advanced science how ideas born today will become reality tomorrow."

I make no apologies for my lack of insight. As did others, I failed to make the transition from the 21st to the 20th century as I read his next paragraph:

> "Soon our planet, the earth, will have a second satellite, this time one created by human hands. This tiny and short-lived laboratory will send us messages over a distance of several hundred kilometres by means of radio waves, keeping us informed about the mysteries of the ionosphere and cosmic rays. The human intellect, will and labour will create this artificial cosmic body and send it moving along its celestial orbit. The technical difficulties which stood in the way of solving this gigantic problem have been surmounted by our scientists. The machinery which will help carry out this bold experiment has already been built."

It is of interest to contrast the impact of science upon two different societies in the first year of the Space Age. The ability of Soviet scientists and technicians to launch three satellites produced a severe and sweeping reaction in the United States which found expression in the fear that Soviet education represented a sinister challenge to our system of education. This worked to advantage in compelling us to develop concern for the nature and quality of our education, and in forcing us into a realistic appraisal of our schools and their products. As charges and counter-charges were hurled regarding the worth of our education, American success in developing hydrogen weapons caused the Russians to be seized with the acute fear that the United States might launch upon the Soviet Union at any moment a widespread and devastating attack with hydrogen weapons. History will say how this impact of American science and technology upon Soviet society influenced the Soviet government in the consequent conduct of its international relations.

For our part, we accepted three assumptions regarding the merits of science education in the Soviet Union:

1. Science education in the Soviet ten-year schools (corresponding to our twelve years) was vastly superior to American science education.
2. The obvious superiority of Soviet science and technology could be traced directly to the superior program of Soviet science education.

3. The source of Russia's scientists, mathematicians, and engineers was the science classrooms of the ten-year schools, whose single severe curriculum emphasized mathematics and science, especially physics.

It was to check the validity of these assumptions that I returned to the Soviet Union in 1958. Time does not permit analysis of the Soviet system of education nor the science program of the Soviet ten-year schools. Ultimately I came to these conclusions, which in general have been confirmed by others who studied Soviet science education in both 1958 and 1959:

1. Great stress is laid upon biology, which apparently includes agronomy and agriculture. However, it is difficult to say how much biological theory is taught and to what extent the courses serve for teaching practical agriculture.
2. Biology teachers in the ten-year schools gave indication of possessing little more than an elementary knowledge of biology, soils, and agriculture.
3. Physics receives greatest emphasis among the sciences. Again it is difficult to determine how much theory is taught and to what extent the course is given over to the applications of physical theory in industry.
4. The physics teachers of the ten-year schools seemed to know their subject thoroughly, could discuss it intelligently, and gave evidence of insight into its significance.
5. Chemistry plays second fiddle to biology, physics, and mathematics.
6. Theory is sacrificed for application in the science program of the Soviet ten-year schools, the teachers giving theory a "lick and a promise" in order to concentrate on the technological and agricultural applications.
7. Students in the ten-year schools apparently are prodded to think in terms of industry and agriculture rather than theoretical science.

At the university level my observations were confined to the biological sciences, including radiation biology. Again I will summarize my impressions. There appeared to be ample opportunity for the serious study of biological phenomena and the conduct of significant research. The laboratory equipment and the teaching facilities in the classrooms seemed adequate. The academic problems and decisions confronting Soviet faculty members were amazingly similar to those facing members of American university faculties. The students went about their work in much the same way as do our students. Emphasis seemed to be shifting rapidly from taxonomy to experimental biology. Work in progress at the university level appeared to be of good quality. It should be added that the foregoing comments may not apply to those areas of biology dominated by the thinking of Lysenko.

A topic of more fundamental significance than the achievements of Soviet science education at either the ten-year school level or the university level is the motives which operate to direct Soviet students into careers in science, mathematics, or engineering, a topic which Soviet educators were quite willing to discuss. Four factors appear to impel Soviet students to seek such careers:

1. The desire to escape the labor force—the element of greatest concern to Soviet educational and governmental authorities.
2. The desire to escape being drafted into the Soviet army.
3. The desire to avoid political risk.
4. The desire to better oneself, i.e., to rise to a higher social level, to increase one's prestige, and to improve one's purchasing power. In discussions with Soviet young people of university age, this motive was most often expressed.

Contrast this motivation with the factors that seem to operate in the

United States. In June, 1959, speaking to the newly constituted Business Advisory Committee of the Illinois Junior Academy of Science, Professor Lee J. Cronbach of the University of Illinois gave a penetrating analysis of the factors involved in the choice of science or engineering as a career by American students. Cronbach pointed to studies of the careers of American scientists, mathematicians, and engineers which indicate that it is not the work in the science class that moves the student to choose such a career. True, the student learns the principles and sees them demonstrated in the laboratory experiments of the formal science courses. Cronbach suggested that the two most significant motives contributing to the development of a creative scientist, mathematician, or engineer are the opportunity to work on a problem on one's own and the opportunity to express one's scientific intellect. Seemingly such motivation was absent among the Soviet young people with whom I spoke, although undoubtedly these factors had operated among the older generation of Soviet scientists.

What has been said thus far regarding Soviet science education is no longer new to the scientific world, for in the past three years there has been an overwhelming number of similar observations from a variety of observers. I have attempted to cite one example of the effect of science and technology upon society, and to trace some side effects which are apparent in the science education of two different cultures.

Since we have contrasted the motivations of the potential scientists, let us consider briefly the status of the career scientist in the Soviet Union and in America. In the past forty-three years, the Soviet Union has been occupied with war and the recovery from war for twenty of those years. The net progress of that nation has come about in the remaining twenty-three years. This is an extremely rapid rate of advancement, and it continues at an accelerating pace. The Soviet people credit their progress to their system of education and the contributions of their scientists. One has only to talk with Russians for a short time to discover the esteem in which they hold the professional scientist. To whatever extent they exist in Russia, the good things of life have come from the contributions of the scientist to Soviet technology, and the promise of the future is bright! The scientist occupies the top social stratum jointly with the educator and the bureaucrat, enjoying special privileges apart from his wages, and the enormous respect of Soviet society.

With the advent of the Space Age in 1957, the American scientist was catapulted to heights of respect he had never known, and some elements in our population were moved to call upon him to rescue us from almost certain defeat and disgrace. This was a startling experience for the scientist, who recalled vividly the early 1950's and the growing movement of anti-intellectualism which in part was comprised of growing hostility to the scientist. In those years the delayed wave of recoil against the use of the atom bomb, and the fear that the scientist might create a mechanism which would destroy the world or at least contaminate it to such an extent that life could not survive, did little to enhance the standing of the scientist. Still another reason for increasing hostility to the scientist was, to quote P. W. Bridgman (1959, pp. 283-291), the "general resentment against the necessity for revising the social outlook imposed by modern general technological improvement."

I admit to pessimism in my conviction, shared with Professor Bridgman, that there has been not a reversal, but merely a respite in the growing tide of anti-intellectualism. The hysteria that followed the onset of the sputniks has faded. The prospects for peace seem slowly to improve with time. Much of the earlier fear of war in the near future is being dissipated in the belief that the nations of the earth know full well that nuclear warfare will be accompanied by destruction of both the aggressor and the victim.

In the first year of the Space Age, we exhibited great concern for the quality of our education and advocated modification of the curriculum to encourage more students to seek careers in science, mathematics, and engineering. The emergency seems to be ending. We are doing better in putting our satellites into orbit, and the public is no longer persuaded that we need an improved education. True, our educators have become geared to the significance of science, and the intelligentsia are still willing to make some sacrifices that we may step up our education. But the rank and file of the population is beginning to think once again in terms of the three R's and of educational facilities geared to the first quarter of the 20th century.

Our society has paid lip service to the worth of intellectual activity, but in reality our respect for intellectual excellence has never been high, and our practices have fallen short of whatever ideals we may have professed. One of the yardsticks of the interest of society in intellectual endeavors has been the value placed upon the teaching profession. There are still too many people in our communities who relegate the teacher to a low rung on the social ladder, who are convinced that teachers are paid enough or are over-paid, and who question the attempts to make the teaching career more attractive considering that teachers work but nine months of the year and have Christmas vacation in addition. Our complex society has developed at a rapid pace in step with our population increase, resulting in a demand for teachers which cannot be satisfied. But our college students have too often considered the low prestige and general social esteem of the teacher and have chosen other careers.

Earlier I quoted Professor Bridgman to the effect that the nonscientific portion of our population generally resents the fact that their social outlook must be revised because of the rapidity with which our modern technology has advanced. To rephrase his point, our science, engineering, and technology have developed more rapidly than has society been able to assimilate these developments. I quote from the statement by President Eisenhower's Science Advisory Committee, issued

May 24, 1959, entitled *Education for the Age of Science* (Chapter II, p. 3):

"There is much reason to expect that such developments will continue, and will indeed accelerate. There is no way to turn back the clock or to turn off scientific advance. There will be no international moratorium on science or technology. The people of the United States, on the most practical grounds, must accept and support these propositions. By ignoring them, or by fostering them only with reserve, they could doom their nation to unnecessary weakness and backwardness in a world where other nations are not so foolish. Alfred North Whitehead said in 1916:

"'In the conditions of modern life the rule is absolute: The race which does not value trained intelligence is doomed. Not all your heroism, not all your social charm, not all your wit, not all your victories on land or at sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have moved forward yet one more step, and there will be no appeal from the judgment which will then be pronounced on the uneducated.'

"This is even more forcibly apparent in 1959 than it was in 1916. It follows that we must educate more, and especially we must educate better, scientists and engineers. But this is not enough. We must have trained specialists in many fields. Even then we would not be successful if, having such specialists, the American people were merely to applaud and reward them for their contributions while still thinking of them as useful strangers, dimly understood and more feared than admired. Hence, we must also cultivate a widespread dedication to and respect for learning in all fields, and a deep understanding between the public and the experts."

One aspect of the attempt to rectify anti-intellectualism falls within my experience. For a dozen years I have taught a general education course in science, with subject-matter content. No attempt is made to survey the sciences as a whole or a particular science. Fundamental principles selected from physics, astronomy, chemistry, and biology are analyzed against a historical setting to discover how the scientist attacks a problem, what he actually does in the course of research, how he thinks through a problem, and what impact his ideas and discoveries have upon the main streams of society. The course is constructed upon the premise that the future acceptance of science and the scientist by society depends upon the understanding and and appreciation of the role of science and scientists in modern life by the lay public. The influence of Conant in the development of the course is evident. In dealing with students who too often are antagonistic not only to laboratory science courses, but to the idea of science, I have come to believe, quite aside from Dr. Conant's arguments, that we can educate the future business man, homemaker, farmer, government official, artist, professional person, and teacher to the understanding of the nature and value of science, and to the conviction that science must continue to thrive.

It is the obligation of the scientist, whether teacher or researcher, to convey to the non-scientist an understanding and appreciation of the value of science, whether he do it informally among his friends and acquaintances who are laymen in science, or teach a laboratory science course, or teach a general education course in science. By this means perhaps the fear of the threat of science to society can gradually be erased. We might take the process one step farther and insure that the future career scientist, busily assimilating scientific knowledge at the undergraduate or graduate level, be granted the opportunity to gain greater insight into the heritage of the scientist, to consider how the fundamental concepts with which he works have come to be, and to examine the struggles of science and scientist against the forces of ignorance and prejudice. Perhaps I am saying that we need enlightened scientists rather than intellectually nimble technicians.

In the absence of an understanding of the nature of science, the non-scientist tends to the view that the problem is of easy solution if only the scientist would concern himself with some values. The non-scientist finds it strange that the mind which can conceive a theory, formulate a concept, or make a discovery, should not possess the wisdom to scrutinize his contribution and assess its potential for the common good and for evil purposes. One need only peruse our better journals and the editorial pages to discover the pressure for the scientist to concern himself with values. Of course the scientist subscribes to the value of the human being, to the value of knowledge and wisdom. The non-scientist is quite oblivious of the questions, which values are significant in the probe of nature? Who shall set the values? Shall society impose upon science the responsibility for deciding not only the procedures, but the goals? To satisfy the non-scientist's desire that nothing unpleasant be derived from science, the scientist must foresee the future effect of his discoveries as he makes them and decide to what use they will be put. This can but lead to the curtailment of intellectual inquiry. Orientation of research toward the view that the scientist must assume responsibility for the future use or mis-use of his contribution will soon result in the tendency toward development of innocuous scientific trivia.

Having stated that we cannot foresee the future, I put the question, whither science? What is man's hope for the future? Space research is intriguing, glamorous, exotic, and newsworthy, but I doubt that it will be the major factor in the future betterment of man's welfare.

Assuming a rather wide margin of possible error, I suggest that insofar as our material life is concerned, man's hope for the future lies in the development of nuclear energy. I cannot tell you whether nuclear energy will create a world far better than that which we know today, nor whether nuclear warfare will destroy the earth. I have a greater concern. Suppose we be optimistic and assume that nuclear warfare will be averted. If we come to the day when we have more leisure time than work, when every man possesses that portion of the world's goods he desires, and our every wish is met, how will man's mind and personality react? Will our society be able to keep pace with the increasing rate at which science is accelerating? Will man himself be able to maintain such a pace?

A few of the volumes published coincidentally with the Darwin Centenary attempted to deal with the future of man. Garrett Hardin (1959) expresses optimism and puts the premium upon individuality in a world becoming more and more dedicated to conformity. Jean Rostand (1959, p. 98) concludes that man is on his own, "with no obligation except towards himself, with no law to obey except his own, and with no values to revere except those of his own making.'' Panel discussions involving the great and the near great of science have attempted to deal with the future of man. The consensus is that we want the best which life may have to offer, but there is a decided lack of comment on how to improve man or how to go about insuring the future for man. John G. Kemeny (1959, p. 262) closes our discussion by saying that

> "No development of Science alone will solve our great problems. Even if we give Man all the means of achieving whatever goals he chooses, the final choice still rests with him. Science can but hope to present him with the alternatives clearly outlined, free from emotional slogans, free from superstitious misrepresentations. But beyond this, Science cannot tell Man what is right and what is wrong. All the progress Science can make throughout human history will be wasted if Man fails to answer the eternal question correctly."

I cannot promise you the answers today for any of the questions I have raised, but I am reasonably certain that as the increasing complexity of our civilization gives rise to new tensions and new problems, the future of man depends upon his willingness to meet his problems head-on, his courage to take responsibility for decisions, and the wisdom with which he attempts to plan his destiny.

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