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## Breaching the Walls

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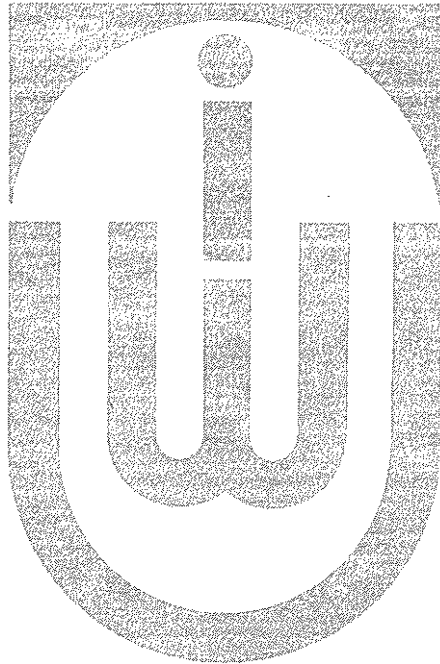
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# BREACHING THE WALLS

by Dr. Wendell W. Hess



THE CENTURY CLUB  
ILLINOIS WESLEYAN UNIVERSITY  
Bloomington, Illinois

*Address by Professor Wendell W. Hess  
on the occasion of the  
Century Club Dinner  
held on May 6, 1969  
Memorial Center*

*Dr. Hess had been chosen by the faculty  
as recipient of the  
Century Club Award for 1969*

## BREACHING THE WALLS

Dr. Wendell Hess

There exists in this country a large and growing audience deeply interested in the problems that are either caused by or solved by the discoveries and applications of science and technology. The problems involved, and the opportunities for facing them successfully, are enormous--they demand public discussion. Some of our college students would say that we are galloping toward disaster. I shall endeavor to place the responsibilities for consideration of these problems and opportunities on both the total society and on the scientific community--academic and non-academic.

Tonight I should like to step beyond my particular discipline of chemistry and share with you some thoughts concerning the role of natural science in today's complex society.

Let me begin by making a very arbitrary division of science into two classifications--big science and little science. I shall choose the term big science to mean those endeavors in which society has a very large stake both in the effect upon society and the cost to society. Examples of big science might be such scientific projects as the space program under the auspices of the National Aeronautics and Space Administration (NASA) or the field of nuclear energy under the direction of the Atomic Energy Commission (AEC). Both of these very large and complex agencies are instruments of the federal government, deriving their support and direction from our tax dollars. I could also include the Department of Defense, which maintains a large scientific force, as being another example of big science. At least 10 billion dollars per year is spent for military research and development. We as a society have delegated the responsibility of national defense to our federal government; therefore, we have little, if any, direct voice in Defense Department decisions. An unusual exception has been the recent

widespread discussions of the proposed antiballistic missile (ABM) defense system, an issue in which we have a large stake and should rightfully express our opinions. The possibilities of public choice and influence of other big science interests are not generally so restricted. It is with this concern that I shall direct my attention in this presentation.

The decision to expand and accelerate greatly our efforts in space exploration was largely a political choice which the late President Kennedy set as a national goal. You will recall that he set 1970 as a target date to land U.S. astronauts on the moon. This decision was an attempt to enhance our national prestige. We might ask: would the conquest of cancer as a killer disease enhance our national prestige more than beating the Russians to the moon? Another question might be: which is of higher priority--winning the race to the moon or making available in abundance from sea water fresh water, which ultimately can be used to produce food. Desalinization is a technological problem not unlike the moon race except perhaps in the glamour aspect. Much of the earth which is presently barren could be made into highly productive and habitable land if fresh water were readily available.

Big science is mission-oriented science. In order that it be successful it must perform both basic, or pure, science and applied science or technology. In some cases the balance between the two is not initially clear. Any mission-oriented science will have what we may call "spin-off"; that is, knowledge and products become available which were not primary to the mission. Many examples of spin-off could be cited from our space exploration or from our developments in nuclear energy. Who would deny the effect of the Telstar communication system or the use of Cobalt-60, a radioactive isotope, to treat cancer and other medical problems?

We can see that value judgments are involved in the pursuit of big

science. Who will make these judgments? It is my sincere hope that an informed, interested society will decide the necessary priorities.

Little science as contrasted to big science is the pursuit of basic research, usually within a narrow discipline, by scientists not usually mission-oriented. They may or may not be primarily concerned with the effect of their work on society. The scientific problem may be undertaken by a single individual or a small group of scientists. Relative to mission-oriented big science, the expenditure of such scientists is very small. However, when one considers all such scientific studies throughout our nation, the total expenditure is found to be sizable. For many years the cost of such research was borne primarily by private capital from such sources as universities, business corporations, and philanthropic foundations. Immediately after World War II it became apparent to Congress that our little science needed financial help. In 1950 the National Science Foundation (NSF) was created to serve as a dispensing agency of tax dollars for the pursuit of basic research. This agency function was and still is administered primarily by scientists for scientists. It was felt that people within the profession would be most competent to evaluate scientific proposals and to make best use of the funds available which are appropriated by Congress. In my judgment, this undertaking has been tremendously successful. The very concept of justification for support to a peer group causes the scientist to give serious consideration to what he proposes to investigate. In addition, it creates a healthy competition to gain funding and hence maintains a high standard of excellence within all scientific disciplines which may be funded by the National Science Foundation.

Many people have recognized this and consequently other agencies patterned along these lines have been created to support the arts and humanities. The social sciences have been receiving increasing support from NSF. As the merit

of such programs becomes more widely recognized, I am confident that additional tax dollars will be allocated in order to provide better balance with science funding. Research is expensive in any discipline, especially in time and money. Because of equipment costs necessary to pursue scientific research, it will become increasingly costly even for little science.

Unlike some national science policies practiced by other countries, our concept of funding little science provides a balance in pure research and it is from this balance that we will profit in the future. Generally speaking, research and development decisions in the Soviet Union are much more highly centralized than in our country. Modern weapons, aerospace, and nuclear energy are all areas of spectacular Soviet success in recent years. These successes are reflections of Soviet science policy toward mission-oriented big science. Uneven growth has occurred in other areas, such as computers and chemicals. Part of the answer for this uneven growth is inadequacy of funding for pure research in areas not mission-oriented.

As science grows, its demands on our society's resources grow. The growth and pursuit of science will be limited by what we are willing to allocate. Choices of what is to be investigated must be made among different fields of science. As these choices become necessary, the role and responsibility of society becomes more apparent. Dr. Alvin Weinberg, director of Oak Ridge National Laboratory, has suggested that the criteria for scientific choice can be divided into two kinds: internal and external.

Internal criteria are generated within the scientific field itself and answer the question, How well is the science done? External criteria are generated outside the scientific field and answer the question, Why pursue this particular science? Though both are important, I think the external criteria are the more important as far as the question of large-scale public support of science is concerned. 1

Dr. Weinberg suggests that society can recognize three external criteria: technological merit, scientific merit, and social merit. With some questions

we have little trouble in making value judgments. Adequate defense, more food, less sickness and disease are rather uncontroversial. Perhaps the most difficult question is national prestige, to which I referred earlier. "Whether or not a given achievement confers prestige probably depends as much on the publicity that accompanies the achievement as it does on its intrinsic value",<sup>2</sup> according to Dr. Weinberg.

An example of a recent policy decision which may involve national prestige is the Weston Accelerator. Representative Emilio Daddario spoke about this topic recently. He said:

You may be, and probably are, much interested in the "policy" machinations which resulted in a decision to go forward with this highly publicized, highly expensive, bit of big science. I am too. But I must confess I do not know what they were.<sup>3</sup>

Big science can be an advantage in the solution of many of our pressing modern-day problems. Among other things, it can be used as an effective instrument of international cooperation: a \$500 million scientific venture can necessitate international cooperation. The most expensive of all scientific or quasi-scientific enterprises, the exploration of space, is from this viewpoint one of the best suited instruments for international cooperation. The new exciting field of oceanography with tremendous scientific and technological potentials is another prime example of a scientific undertaking of tremendous cost which could benefit by a cooperative venture. It is the role and responsibility of society to speak for the desirability and necessity of international cooperative efforts in such endeavors.

We have arbitrarily divided science into two classifications--big and little--for our discussion, and have attempted to show where each has a significant place in our society. Let us now turn our attention to some problems presently requiring value judgments and priorities.



Fred Singer, Deputy Assistant Secretary of the Interior, recently expressed an opinion worthy of our consideration. He said:

Our greatest concern must be with our own planet. Here we face the danger that large-scale engineering projects which give us a short-term gain may carry with them long-term ecological consequences which are distinctly harmful."<sup>4</sup>

This expression was recently echoed in our city by Professor Barry Commoner, an eminent scientist greatly disturbed by our undesirable ecological consequences commonly referred to as pollution. It is my opinion that as a society we must make sure that our concern with the environment will keep pace with our technical capabilities. Human activities, not necessarily scientific, whether by neglect--or by accident--or by intent--are constantly damaging the environment. Subtle, as well as more obvious, changes are taking place in our atmosphere and oceans with far-reaching but little-understood effects. One of the most important results of our space and planetary exploration may well be a better scientific understanding of the workings of our own planet.

Two problems concerning our planet, which will require the help of big science, and which must be solved as rapidly as possible, are the questions of peace and population.

Some may argue that these two questions are closely related and that in order to control population, peace is not possible. This is simply to say that war is a major factor in controlling population. Thomas Malthus developed the theory that population grows faster than do the means of subsistence. Science in the western world has been able to forestall the consequences of Malthus' dilemma by creating abundance, and in the United States, the problem-laden affluent society. The problem of population control is a problem of society and its solution can be found only by a society.

Science can and does make available certain controls, but the problem of population control is not simply a scientific question. Neither is it strictly a religious nor a philosophical question. I think rather that it becomes essentially a political question having far-reaching scientific, religious, and philosophical implications. It may well be that the question of peace is in essentially the same category. Science has made available awesome weapons of war which may be used by a society but the question of war is not a scientific question. Again a value judgment exists as to the direction that science should properly take.

Science's impact on our society and indeed upon our planet has become the overriding concern of some of our most influential senators and scientists. Senator Edmund Muskie recently introduced a bill to establish a Senate Select Committee on Technology and the Human Environment. This committee would be a central forum to study and debate the future impact of scientific and technological change--its benefits and hazards--on population, communities, and industries. It would consist of three members from each of the standing committees of Congress concerned with the individual and his environment. Senator Muskie states:

We are caught up in a gigantic technological revolution. This can only accelerate in the years ahead, touching on every phase of man's life, his thinking, and his environment. Yet, we--at least in the Senate--don't know all that is going on, what lies ahead, and what our policies of controlling science and technology should be. As legislators, we must understand the new technology and its application to solving human problems. But, also as legislators, we have a duty to find out the risks involved and devise some kind of early warning system to prevent serious injury to the individual and his environment.<sup>5</sup>

This bill has received wide support and the only disagreements are relatively minor and concern such matters as organization and structure of the

committee and its area of responsibility.

A prominent scientist has this to say:

The choices between alternative technologies and their effects are essentially political choices. That is, they involve choices between competing and conflicting interests and scales of value, and, therefore, can only be resolved as part of the political process. The United States Congress is the body designed to debate and resolve such conflicts, and is the only body that can do so.<sup>6</sup>

These remarks were spoken by Dr. Harvey Brooks, Dean of Engineering and Applied Physics at Harvard. Dr. Brooks goes on to say that technical expertise and professional judgment are important in predicting the social and environmental consequences of various courses of action. The final choice is a choice among consequences that can be predicted with only a limited degree of probability. This is the function of the political forum.

Dr. Brooks adds:

Our choice is not between controlled technological progress and abandonment of technology as a tool of human aspiration. Our problem is to discipline our mastery of nature and of society so that man can live in harmony both with nature and with his own human nature. This means not less but more--and more sophisticated--science and technology.<sup>7</sup>

This entire idea of environmental change is not really new. Man has for centuries caused major changes in his environment, often making it so intolerable that he must leave--as nomadic herders do. But now in this century we must fashion our technology so that we can live in equilibrium with the environment which we help to control and create. Dr. Herbert Simon, another scientist, sees the problem as:

Decisions which employ modern technology and that have effects which science can anticipate are made by millions of people. Hence, intelligence about technology, to be effective, must be widely distributed; there must be a wide diffusion of discussion and understanding of modern technology and its implications.<sup>8</sup>

A second dilemma which arises with the population problem is that of increasing social complexity. When the population density increases in a given location, the number of contacts between people also increases and life becomes more complicated. One has more ideas, social contacts increase, personal interactions increase. Mass information dissemination imposes all of these stimuli upon us. Our ability to absorb sensory impressions grows slowly; each person merely can know less of what there is to know; thus he interacts less efficiently with the rest of society. We each grasp for a speciality in order to overcome this problem. For example, even in a liberal arts college, professors become so specialized that they may lose sight of what is common among them. College teaching is a profession, yet we become specialists within a rather narrow academic discipline and do not feel capable of teaching outside that discipline. Many other professions tend to become highly specialized in this manner. Consider the practice of medicine, in which one finds innumerable specialities. I, and I suspect most of you, have wished for a return to "normalcy" in which we would be able to assimilate a larger fraction of knowledge, but there is no immediate prospect for a solution to this dilemma.

Our future will be a struggle between increasing population on the one hand, and dwindling resources of energy and inability to cope with complexity on the other.

What are we currently doing to help solve these problems? Today we live in the middle of two major scientific revolutions which are addressing themselves to the problems of energy and information--both directly related to the overriding problem of population.

The energy revolution is not new, but its successes within the past few decades have been extraordinary. The ability to harness nuclear energy has made it scientifically possible to meet the energy requirements of the

world for the indefinite future. The question remaining to be solved is simply one of economics. We must have not only tremendous quantities of energy, but we must have cheap energy in order to have a "world set free" as imagined by H. G. Wells.<sup>9</sup> With cheap energy we can convert common materials into the necessities of life. Nitrogen from the atmosphere can be converted into nitrate fertilizer and ultimately into food. Sea water can be converted into fresh water for irrigation to produce foods; coal and petroleum can be converted into man-made fibers for clothing and shelter. In short, we must produce enough energy to convert rock, sea, and air into useful commodities. Big science and little science continue their struggle to unlock from nature the secret of fusion which can supply our planet with an inexhaustible supply of energy.

It is my personal belief that science, in concert with society, can and will continue to provide the subsistence necessary to support the increasing population.

Very briefly turning to the information revolution, we find rapid and steady progress being made to help solve the problem of imbalance between the individual's capacity to assimilate information and the proliferation of information. To live effectively is to live with adequate information. Dr. Norbert Wiener called this the cybernetic revolution and identified several aspects of it. The problem is complex and involves the areas of automation, digital computation, efficient communication, and identification of information. This specialization, which has become apparent in most people's lives, is causing a reaction in American society. I see healthy signs that an emergence of generalists is beginning to occur in science. These people spend their time reviewing and compacting literature for their specialist colleagues. Teachers of undergraduate science are of necessity becoming generalists and must be capable of extracting from current scientific

research within their disciplines the material deemed to be important for both the student aspiring to become a scientist and the student who must become aware of the role of science in his profession and in his society. This is no small task and has awesome responsibilities associated with it. Actually, it can be compared, I think, with some generalists who have been operating within our society for a long time. Is not the editor of any newspaper a generalist responsible for assimilating the news and presenting in a manageable form that which he deems important to his readers? The revolution in technology of information and communication helps the generalist maintain sensitive touch with society. Many highly competent science editors are writing for the benefit of the non-scientific community. John Lear for The Saturday Review and Walter S. Sullivan for The New York Times are examples of science editors who are not only competent scientists but also have great literary skills. Much need exists for people with these abilities and I am hopeful that more students will consider this field as a worthwhile profession.

The computer with its fantastic memory and speed will be a technological tool to aid the generalist in his job. Computer science and its potential for serving humanity is just now becoming apparent.

Biochemists and molecular biologists are beginning to focus their efforts on information. Evidence is accumulating that the human brain itself has certain elements that resemble a computer and that certain types of molecules are the essential memory elements. I imagine that most of you are aware of some of the research that is being performed on memory studies. The research is not presently conclusive and more must be performed before the answers are obtained. It is not idle speculation, however, that many of the mechanisms of the brain will be elucidated within a short period of time and that from this knowledge will come ways to improve the efficiency of our own brains. If we can make both our computers and ourselves more clever, we

may be able to overcome this problem of complexity.

You are probably thinking by now: he surely paints a rosy picture of things to come, but what about all of the new problems which will continue to be created in our search for solutions to some of our current problems? Problems of varied kinds have always resulted from scientific and technological advances. Society has been distressed in its thinking and activities ever since Galileo, Darwin and Newton formulated their theories concerning our planet. The bomb and pollution are both modern day products of an advancing technological world and they present problems not previously present. We have been affected by these problems and have voiced a great deal of distress. This is as it should be! Big science will continue to interact very directly with its society and hence we are forced into a role of active participation. All of us must become better informed and concerned about the big science that we support and must therefore take some initiative to gain this information. Concerned scientists cannot speak effectively within an apathetic or hostile atmosphere. We simply cannot afford to let walls rise which retard communication between society and the scientific community. These walls must be breached! In short, we cannot have the two cultures as defined by C. P. Snow.

Great achievements often carry with them the seeds of future failures. Repeated success breeds overconfidence and unwillingness to persist in the hard measures that have led to excellence. Prolonged enjoyment of excellence brings indifference and even contempt for it. I am afraid that some of these tendencies of human nature can be seen in current attitudes toward science and technology. Apollo 8 and 9 tend to make us say: "If we can do that, we can do anything." It is not true that given the goal and the money, technology can accomplish any and all tasks. We as a society must be capable of defining our goals in a realistic manner and of realizing that positive

achievements will not inevitably result, especially if the knowledge is abused.

I wish to conclude these remarks by indicating that the scientific community has not been active enough in preventing this loss of communication between itself and its society. Dr. John Bailer, one of our truly great chemists, has expressed this concern very adequately:<sup>10</sup>

Scientists as a group have consistently refused to accept responsibility for the management or control of the discoveries which they have made, or of the consequences of such discoveries. There has recently been some change in this attitude. During World War I, the chemical profession was criticized by many people for its work in devising poison gases; during World War II, similar criticisms were expressed because of our part in the development of the bomb. In both cases the scientific fraternity shrugged off the criticism with the statement, "We seek only to unravel the secrets of nature. If the world elects to turn our discoveries to evil uses, that is not our responsibility.

This attitude is superficial and cannot be justified. We have created a scientific world and we are quick to accept the credit for the benefits which have resulted. Can we, then, logically disregard the problems which our work has created? Is science content to provide a family with an electric refrigerator and a TV set, and simultaneously, to allow technological advancement to plunge that family into unemployment, with its concomitant frustration and bitterness?

We are not only scientists; we are also citizens. The social problems which have been raised by scientific discovery will be harder to solve than the scientific problems which created them. Can we rightfully turn our backs on these social problems because they are not in our sphere of special interest or training? Do we have a right to open Pandora's box, and then run away from it? I think not.. We have created a world of science; we must teach our fellow men to live happily in it.



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4. Fred Singer, Time, March 7, 1969, p. 10.
5. Chemical and Engineering News, March 24, 1969, p. 42.
6. Ibid.
7. Ibid.
8. Ibid., p. 43.
9. H. G. Wells, The World Set Free: A Story of Mankind (New York: Dutton & Co., 1914).
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This lecture is the tenth in a series prepared by Illinois Wesleyan University faculty members for presentation at the annual Century Club dinner. Mr. Donald M. Freese, immediate past president of the club, was Master of Ceremonies. Mr. Joseph Meyers paid a beautiful tribute to Miss Elizabeth Oggel, who is retiring after twenty-four years of faithful service to Wesleyan. Honoring Dr. Wayne Wantland and Oliver R. Luerrsen, Dr. Eckley presented the twenty-five year award watches. Wesleyan's School of Music presented excerpts from "Carmen."

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