THE IMPACT OF SCIENCE IN A DEMOCRACY

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The comments of Dr. Norman D. Levine last year in his presidential address, "The Woes of a Biologist"; my involvement with the Illinois Sesquicentennial Commission; and my responsibilities as Director of the Illinois State Museum: all have combined to make me very aware of the multiplicity of problems involved in the understanding and communications of scientific knowledge.

I realize that, as members of an interdisciplinary organization such as the Academy of Science, you are cognizant of the problems of communication between scientists, that you are more or less involved both in the infinite minutiae of specialization and the consolidating gap-closing effect of interdependency and interrelationship among all the facets of mathematics, physics, chemistry, biology, and social sciences.

Because of the complexity of this oneness of the sciences, most major scientific projects are performed today not by individuals but by teams — sometimes referred to as "big science" — whether they be as spectacular and concentrated as the recent heart transplant operations or of a more common occurrence, such as, an archaeological exploration with a working organization of anthropologists — combining archaeologist, physical anthropologist, ceramics analyst, identification laboratory for faunal remains, identification laboratory for floral remains, and a laboratory for Carbon-14 analysis, to name but the most obvious. Not only is this exhaustive exploration of prehistoric sites becoming infinitely more complex, but in the last thirty years, there has been a complete change from a search for archaeological sites to explore to the realization that there is more information to be obtained in Illinois alone than there is manpower or funds for the work. Unfortunately, the physical development of our State — urban development, highway expansion, strip mining, reservoir impoundments, and industrial plant expansion — will destroy the major portions of this material within the next twenty years. A similar explosion in the search for knowledge and in the need for trained manpower is occurring in every one of your fields.

The march of scientific discovery has been a major factor in changing the way of life for mankind upon this earth. Today the proliferation of new knowledge progresses at an uncomprehensible r a t e. However, the impact of any new disclosure on our existence follows or comes after

a very considerable time lag between the period of discovery and the period of implementation. Seldom does a breakthrough from discovery to mass use move as rapidly as did Dr. Salk's discovery of the polio vaccine. The dramatic impact and outstanding results were triggered, of course, by the great need of both the medical profession and the public, supported by full cooperation of mass media communications. This is an example of the techniques of science applied to the solving of a problem of great public concern, but even this project suffered a great emotional and technological setback when the breakdown of techniques in one company laboratory resulted in the spread of a dangerous polio virus.

Basic scientific research does not mean the search for a product of immediate practical use. More commonly, it is simply the search for knowledge: the statement of a problem, the search of the literature, the finding of answers to the unknown facets of knowledge, evaluating the discoveries and publishing the results. The new knowledge added to the total fabric must then be disseminated.

Just a very few years ago a dedicated scholar could set out, as did Sir Francis Bacon, to make all knowledge his; and, egotistical as the objective may seem, Bacon did study and understand the great mass of known recorded knowledge of his time. Imagine a man today becoming an authority on the entire aspect of the science to which he is dedicated, even with the mass assimilating aids that computerization has put at our disposal.

We, as individuals, are increasingly faced with the growing problem expressed in the cliché of "knowing more and more about less and less until we are in danger of knowing everything about nothing." In reality the converse is true.

As I have come to know many of you as individuals and have sat in meetings where your counsel is sought and given, I have come to have great respect for the breadth of your knowledge and the diversity of your interests. Most of the scientists I have come to know, particularly those of you who carry great responsibility as well as having earned stature in your chosen field of science, have proved to be extremely interesting people with a great variety of interests and social skill. Apparently, the ability to communicate with others is a necessary adjunct to scientific recognition. Certainly it is important to the dissemination of scientific knowledge.

As the director of an important science museum dedicated to the preservation of materials and dissemination of knowledge to the public, standing in that tenuous realm between the exploding mass of knowledge and the layman's comprehension (and each of us is a layman when we move out of our particular specialty), I am both challenged and appalled by the problems of interpretation which face us.

In the difficult field of biological interpretation, the task does not seem as great to me as in that of archaeology, probably because the biological sciences have a broader base of generally understood knowledge which has been more stable over a longer period of time; yet much of

what was taught to us a generation ago as fundamental knowledge we now know is "not necessarily so." When we move into a field such as American archaeology, we find that the whole field of knowledge is in such a tremendous state of flux that even our own staff working on the same or closely related projects may have differences of opinion in interpretation — so basic that our interpretive program of exhibits is least developed in the field where we are most deeply committed in essential research.

The exhilaration in the accumulation of knowledge is but a part of the over-stimulation of our senses. Just think how the merchandising fields compete for our every attention and how often they use a clever sort of pseudoscience to rake in our dollars; how often an actor in lab coat with some staged, scientific background of instruments, equipment, or library gives a pronouncement on the special qualities of a medicinal treatment or gasoline ingredient. They recognize the respected position of science but tend to break down its image by trading on its reputation of integrity until the source of the image becomes threatened.

It behooves those of us working in the fields of both basic research and applied science to be doubly careful of our responsibilities. Lest we too become pseudoauthoritarian, we should be most careful of our pronouncements when we move out of our own fields of knowledge into those areas where our emotions, beliefs, and statements are those of a layman and not of a practicing scientist. Here we must so carefully avoid using our positions of prestige and our claims of academic freedom to make authoritative statements which may be destructive and prejudiced. We have so much to defend in areas where we know our ground that we must not weaken our position by injudicious pronouncements and crusades where our prejudices are showing.

The lack of understanding between scientists is not as serious as is the problem of the scientists' communications with those who are completely outside the realm of science. This dilemma creates a major problem and responsibility, especially in a democracy. The acceptance of new concepts by the scientific community, and the solutions of the engineering problems of mass production, are simple and direct as compared to the processes of changing viewpoints and policy by an electorate.

Have you ever stopped to think how many things taught as facts to us as students are no longer considered correct or of as simple a solution? Then consider that the average adult voter has this same background of misinformation but with no opportunity to update it.

We face water pollution on a scale of which we never dreamed. Fertilizers designed for the production of increased foods to sustain a terrifying growth in world population are polluting our water supplies more insidiously than are organic wastes. Chemists are proposing solutions! But will the citizenry understand these proposals and approve the necessary expenditure of billions of dollars to safeguard our waters for the survival of the human population

and of the biotic community? We no longer talk of pollution as meaning only filthy *water*. We are also greatly concerned that the delicate balance of oxygen production by photosynthesis and oxygen consumption is being seriously threatened by the machines and processes of our modern world. Pollution is taking place not only in water and air but in the soil itself.

The consumption of our resources is accelerating at an alarming rate with crude wide-spectrum harvesting — and, at best, only partial use. Rapidly we are learning that many of the unwanted or wantonly destroyed by-products are more valuable than the prime product itself. Sometimes we are fortunate that the by-products are still available in the piles of waste dumps; but all too often they have been discarded as useless pollutants of our environment.

How often the "practical" manufacturer, engineer, or other consumer has overridden the "conservationist," labeling him as an emotionalist or an impractical dreamer, only to learn in a generation or less that the conservator was more practical than the immediate consumer.

I would not for a moment suggest that we should build no bridges, dams, or roads; plow no fields; cut no trees; spray no insects; devise no new uses of our resources. But I would suggest that the immediate dollar return on a project which consumes or alters our habitat can be, and often is, ultimately more costly to the public than it was profitable to the individual harvester.

In reality, in all this habitat destruction, we tend to forget that it is our own habitat which we are altering at such an alarming rate; and that we are biological creatures living in and depending on biotic factors, no matter how mechanized, commercialized, and synthesized our civilization becomes. Yet, with every struggle to preserve our natural world, the battle lines usually appear to be drawn between the "practical realist" and the "impractical dreamer" in almost direct inversion to the long-term human needs.

As a nation, we need to be conscious of the changing demands of technology on our available resources. Let me illustrate: The American Indian in Illinois made use of very few resources, and he used them very directly. He was dependent on cherts to produce projectile points and sharp-edged cutting and scraping tools, on clay for soft-fired pottery for containers, and on bone and horn for tools. For food he used native game and plants. Only the more recent Indian cultures cultivated corn, amaranth, squash, and beans for food.

Let us follow some of man's changing demands on the geological resources alone. Under French supervision, the Indians who had mined only chert were taught to mine galena. Under French supervision, they smelted the ore in crude earthen smelters, separating the lead which was then transported to Canada for shot to use against the British in the French and Indian War. The British at Jamestown processed wood into charcoal and used it to melt the local sand for producing blown glass. In early times, man harnessed water power to operate lumber and flour mills; later, coal and oil became

sources of energy. The mineral resources harvested in Illinois last year amounted to $500,000,000. In 500 years Illinois has moved from a Stone Age of agriculture through an agricultural economy, an industrial economy, and into a technological economy.

Agriculturally, we are one of the world's leading producers of food. Our land is still a major resource, but we employ less than ten per cent of our manpower to work the land. Five hundred years ago, a single Indian woman planted, cultivated, harvested, stored, and cooked corn, serving her family a simple corn bread as did every other Indian woman of her culture. Two hundred years ago, a few more people were involved in the processing and distribution of the grain, and even in the time of our grandparents most of the bread was still baked at home. By 1935, half of the population had moved from the farms into manufacturing and service tasks. Today, ninety per cent of our people live in urban and suburban America. Economists tell us that we have moved from the Industrial to the Technological Age.

Change in our Technological Age is so rapid that job obsolescence is now the rule. The average worker must retrain for new jobs two, three, and four times during his working career. Even those in specialized scientific and professional fields must keep in constant touch with new findings in their expanding fields to avoid obsolescence. One cannot help but wonder at the rate of depreciation of so many college educations — sometimes expressed as the "half life" of a college degree. Today we face a serious dual responsibility: First, to maintain our respective professional competence through almost constant study and retraining; and, secondly, the constant and appalling task of bringing before the rest of the population a sufficient understanding of this expanding knowledge so that it may be used to insure not only our survival but also the survival of our way of life.

We have heard the alarming reports on the aging of Lake Michigan. In fact, there is no longer a single major stream that is not seriously altered by pollution and silt. Now added to sewage pollution is industrial pollution, fertilizer and insecticide pollution and now thermal pollution by both conventional and atomic plants.

Illinois, though not unique among industrial states, contributes to this pollution not only in the Great Lakes but also through the Mississippi drainage and, thereby, to the Gulf of Mexico. Here, as in other parts of the world, conditions on the continental shelf are apparently becoming less suitable for freeing oxygen by photosynthesis. This, at the very time when our world population and its expanding use of fossil fuels is consuming oxygen at a rate that, according to Dr. Lamont C. Cole, Professor of Zoology at Cornell University, is approaching dangerous levels.

Whether this frightening point of imbalance between CO_2 and O_2 comes in our lifetime or in that of our childrens' children, we nevertheless face a major scientific problem. It will require not only that solutions be found but that the im-

plementation of those solutions be undertaken by governments with the full support and cooperation of their people. Furthermore, these solutions must be undertaken while we still have our wits about us — not in a stupefying low oxygen atmosphere!

I cannot help but remember the strange effect that flying above 12,000 feet had on us in those World War II planes without pressurized cabins. I remember that problems were so simple of solution in the high rarefied atmosphere; but the answers were so often wrong. Yes, we took our "trips" before the days of psychodelic drugs.

I recall the story of the veteran Pan American navigator who was lost on a flight from South America to Ascension Island on a cloudy night. He requested his captain to fly above the clouds for a few minutes so that he could get a fix on the stars. As they broke clear above 16,000 feet, the navigator became enthralled by the beautiful sky; but after returning below the 10,000-feet level to adequate oxygen, he suddenly realized that he had completely forgotten to shoot the stars for the much-needed fix. Such was the effect of an inadequate oxygen supply on one of the world's most skillful veteran navigators.

I hope we act before we enter a world of daydreams — act not with scorn of that "stupid" public but with the realization that we as members of the scientific community have not completed our task unless we have helped to implement the application indicated by our findings. Even pure science has a dual responsibility: To exemplify the utmost in absolute integrity and to implement the indicated programs, particularly as they apply to our world and its survival. We are no longer allowed the luxury of hiding our findings for posterity behind secret codes and systems—as did Leonardo da Vinci in order to escape burning at the stake. We are fortunate to live in a world that believes in the miracles of science. We must not lose our advantage to the pseudoscientists and the opportunists by default!!

We must exert our every influence in the clarification and support of significant laws and resolutions so that the citizenry will be sufficiently informed to understand and elect the road not only to survival but to a richer, fuller life. This requires, first, interpreting the answers to the problem of world use of resources; and, second, motivating the public to want these solutions. Our role has always been broader than discovery and recording. Like it or not, we also must merchandise our product rather than depend solely on the huckster.

Vocabulary is one of the greatest barriers between the specialist and the public. Every field of science, trade or profession has its own vernacular, a combination of technology and verbal shorthand. When we seek to explain an idea to others, we must in the main use their vocabulary in speaking or writing. In the museum field, this is a most difficult challenge facing museum curators: expressing a complex idea in simple understandable language and in a straightforward, noncondescending manner when preparing a label, writing a popular article, or appearing on television. I suggest that communication with the non-

scientists is a major problem and a responsibility of the entire scientific community.

Recently I received a most appropriate communication from John H. Melvin, President of the Academy Conference of the American Association for the Advancement of Science, in which he reported on a request for a National Science Foundation grant to set up a workshop conference for editors of the forty-four state and local academies. The major problem being considered is the analysis of current publications of the various academies. In most cases these publications account for over one-half of each academy's budget. The majority of the members prefer to publish their most significant reports in the journals of their respective disciplines, for comparatively few of the academy journals are abstracted in the principal abstract sources. We are fortunate that the *Transactions of the Illinois State Academy of Science* is so widely abstracted. For this we owe a debt to both our authors and our editors. Yet, lest we get too smug, our journal really reflects the publication policies of the 40's and 50's.

As Dr. Robert E. Gordon, Secretary of the Council of Biology Editors, expressed it before the Academy Conference in 1966: "While the general role of the Academy has moved from its pre-1940 monotypic function as a major forum for the discussion of original research in all fields to a mid-1960 polytypic function — perhaps best summed up in the words 'educational catalyst' — I strongly suspect that the publication practices of the majority, through neglect, still attempt to reflect the pre-1940 picture. A reconciliation of these aspects, in those organizations where it is needed, would not only serve to enhance the publication activities and image of the Academy, but also would contribute in a very substantial way to the resolution of major problems facing the whole scientific community."

Perhaps we should devote at least one session of each section at our Annual Meeting to a panel type discussion which would bring some major facet of discovery or thought from the national picture as an updating forum for those members who could not attend their respective national forums. This would help to better establish our local lines of communication, and it would, I feel, improve the drawing power of our Academy.

The next logical step would seem to be to break the tradition of publishing only new research in our *Transactions* and, perhaps, to expand the "News and Notes" to include important world-wide developments in the various scientific fields.

As we improve the flow and modernize the functions of our communications, we will not only benefit but we will also become more articulate locally. I firmly believe that the single most important key to public understanding is better, broader, more general improvement of our internal communication. Let us, among ourselves, consciously reverse the trend of never finding that elusive "something" we so often feel is lacking at these important gatherings. Let us establish that necessary

communication with the fascinating frontiers of our work — in order to rekindle the *spark,* the *challenge,* and the *enthusiasm* that drew us originally to this intriguing world of science. Let us then use our enthusiasm to stimulate a renewed interest and understanding of this important realm of public understanding of science! Then and *only* then will *we,* as portions of the scientific community, be making *our* contribution to the necessary understanding of the world of science in a democracy!