UNDERSTANDING SCIENCE
IN THE SPACE AGE

A National Symposium

DISCUSSIONS AND ADDRESSES

Fiftieth Anniversary
1912-1962

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Understanding Science In The Space Age

A National Symposium

Sponsored by

The Industries of Rochester, the Rochester Museum of Arts and Sciences and the Rochester Museum Association

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Why Do We Need To Understand Science In The Space Age?

We live in an age in which research and development are affecting the lives of all of us, yet the average citizen knows very little of these dynamic forces.

Business and professional men and women, parents, teachers, workers in industrial plants, engineers, and others are *all* concerned with the various ways in which science can be made understandable to them, to their children and to the people of the world.

In these pages sixteen scientists, writers, educators, industrialists and museum administrators evaluate and discuss the ways in which education, industry, museums and the mass media can contribute to an understanding of science today.

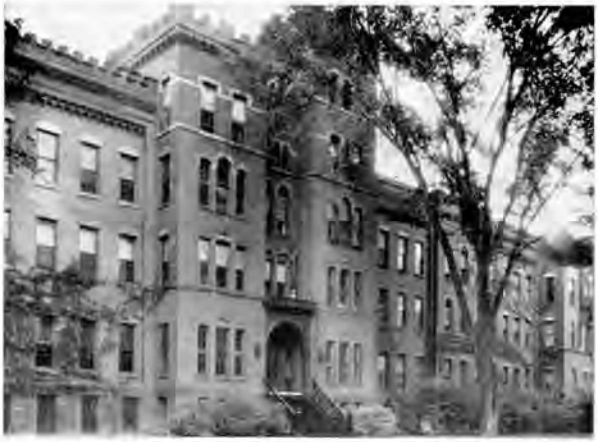
Fifty Museum Years 1912-1962

by W. Stephen Thomas, Director
Rochester Museum of Arts and Sciences

FIFTY YEARS of Rochester Museum of Arts and Sciences accomplishment which we observed in the fall of 1962 represents a notably useful period of service as treasure house of cultural and scientific objects, research institute and community educational center.

The first period, 1912-1925, was the era of struggling growth and development. Conceived by Mayor Hiram Edgerton who sought a progressive, civic use for the building in Edgerton Park, the Museum was at first a collection of heterogeneous objects without force or purpose. Still, its two early curators, Robert T. Webster and, later, Edward D. Putnam who served for 12 years, struggled to acquire worthy collections and exhibits. Arthur C. Parker's appointment as director late in 1924 was the most significant event of the period. Equally notable was the reorganization of the Museum in January, 1925 by city law under a Board of Museum Commissioners. From that action emerged the plan that led the Museum to become a forceful community agency for research and education.

An era of professionalization for its staff and the development of citizen support are characteristics of the second period, 1926-1936. Because of a nation-wide business depression, the Museum budget was threatened with a slash late in 1932, which, if undertaken, would have forced it out of operation. Fortunately, private citizens and groups came to its aid.



PROLOGUE OF THE PAST
Edgerton Park Building—
Home of the Rochester
Museum of Arts &
Sciences from 1912 to 1942.

PROPHECY OF THE FUTURE: SCIENCE CENTER comprising Bausch Hall of Science and History (center); Building of Physical Sciences and Planetarium (right); Industrial Wing (left); Auditorium (left rear).

With the support of Dr. John R. Williams, Sr. and others, the Rochester Museum Association was established and the budget cut was restored. In 1934, Dr. Williams became Chairman of the Board and served until 1961. His dynamic leadership and his support of Dr. Parker had much to do with the Museum's subsequent success. It was during this period that the Museum became a highly successful laboratory of museology which attracted national attention.

Planning and establishment of the organization in a new building typified the years from 1936-1946. Director Parker's stimulation of wide public interest in a new structure bore fruit in 1940. In that year, Edward Bausch contributed the money and land for the modern Bausch Hall of Science and History at East Avenue and Goodman Street. The edifice was open to the public in May 1942. After Dr. Parker's resignation late in 1945, W. Stephen Thomas was appointed director in January 1946.

The years 1946-1956 were marked by the enlargement of community services and completion of many new permanent exhibits. The high spot of this epoch came in 1955 with the acquisition of six additional acres with money raised by the Rochester Museum Association. Our final and fifth period, 1956-1962 has been marked by plans for a Science Center or complex of buildings including a museum of the physical sciences, planetarium, industrial wing and auditorium. When this scheme can be carried out, the Museum will be launched on its next fifty years as a preserver of the records of material culture, as a leader in research and investigation, and in serving as the focus for popular education in science.

Foreword

by Dr. Nisson A. Finkelstein, Vice-President for Research and Engineering, General Dynamics/Electronics and Chairman, Steering Committee of the Symposium

On September 26, the Rochester Museum of Arts and Sciences celebrated its Fiftieth Anniversary. The Museum has contributed fifty years of good service manifested in many ways to the Rochester community and surrounding areas. It was felt, however, that this anniversary should be marked by more than a recounting of past activities, past accomplishments, past glories. It should look forward to a greater contribution by the Museum in the future to the community and to the nation.

It was in this manner that the concept arose of a symposium treating some major problem of broad interest. We chose to look at the problem of "Understanding Science in the Space Age." Our plan was to attack this problem not in terms of science education or in terms of understanding science and technology from a restricted technical point of view, but rather to discuss science relative to its broad impact on the lives of all of us, our society, our economics, and our politics. It would be presumptuous indeed to anticipate a "solution" to such a diffuse and all-encompassing problem, but it was our hope that this symposium might lend some insights into the nature of the problem and possibly point to areas deserving of further study and discussion.

The format of the symposium included four panels in the afternoon on the contribution of mass media to understanding science, the contribution of education, the contribution of industry and the contribution of museums. A distinguished group of chairmen and participants were invited to fill these panels. The panel on mass media was chaired by Mr. Donald J. Dunham, president-elect, National Association of Science Writers. Participating along with Mr. Dunham were Dr. Watson Davis of *Science Service;* Mr. Gerard Piel of *The Scientific American;* and Miss Mildred Spencer of the *Buffalo Evening News.* The panel on the museum was chaired by Dr. James M. Brown, III, director of Corning Glass Center. Participating along with Dr. Brown were Dr. James A. Oliver of the American Museum of Natural History; Mr. D. M. MacMaster of the Museum of Science and Industry; and Dr. M. Graham Netting of the Carnegie Museum. The panel on education was chaired by Dr. McCrea Hazlett, Provost, University of Rochester. Participating along with Dr. Hazlett were Dr. Robert L. Springer, superintendent of Rochester Schools; Rev. Joseph B. Dorsey of St. John Fisher College; and Prof. Philip Morrison of Cornell University. The panel on industry was chaired by Dr. Cyril J. Staud, vice-president in charge of research, Eastman Kodak Company. Participating along with Dr. Staud were Dr. John C. Fisher of General Electric Company; Dr. John C. R. Kelly of Westinghouse Laboratories; and Dr. John N. Shive of Bell Telephone Laboratories. In each of these panels, discussion from the floor was invited toward the end and some lively interchanges took place.

DISCUSSION PANEL ON CONTRIBUTIONS OF INDUSTRY
From left to right: Dr. John N. Shive, Dr. John C. R. Kelly, Dr. John C. Fisher, Dr. Cyril J. Staud, Chairman

During the evening, brief summations were presented by each of the panel chairmen concerning the discussions in their respective panels and these were followed by addresses given by Dr. M. Graham Netting, director of Carnegie Museum, Pittsburgh, Pennsylvania, and Mr. Gerard Piel, Publisher, *The Scientific American*.

Our ambitions for the symposium were modest: To spotlight an area of great concern to all citizens of this country and, for that matter, to all of western civilization; to stimulate discussion; to develop insight. It was our further hope that this one-day gathering might lead to an expanded use of the museum as an educational tool of great strength and diversity.

There is a great investment in facilities and people and knowledge in the Rochester Museum as in all museums. While the financial analysts keep us aware of the capital investment in facilities, the much greater investment in ideas and in people defies balance sheet analysis. This investment can be effectively exploited by all of us in developing the minds and the spirits of all our residents, young and old.

All too many of us look upon the Museum as a place to take school classes on tour and our own children on a rainy weekend afternoon. While the Museum is one of the oldest educational institutions in the world, we have much to do to bring its full impact to bear on the educational needs of our society. To accomplish this is an opportunity and responsibility. Those of us who worked in preparing the Fiftieth Anniversary symposium hope that it served to manifest some of the opportunities. We are confident that the community will rise to accept the responsibilities that go with them. This could lead to a second fifty years more brilliant than the first.

PARTICIPANTS AT THE EVENING SESSION OF THE SYMPOSIUM.
Front row from left: Donald J. Dunham, President, National Association of Science Writers; James M. Brown, III, Director, The Corning Glass Center; Dr. McCrea Hazlett, Provost, University of Rochester; Dr. Cyril J. Staud, Vice-President in Charge of Research, Eastman Kodak Co.; Dr. M. Graham Netting, Director, The Carnegie Museum; Gerard Piel, Publisher, The Scientific American; George R. Williams, President, Rochester Museum Association.

First National Symposium, Sept. 26, 1962

Address of Welcome by George R. Williams, *President, Rochester Museum Association*

IT IS A PLEASURE to welcome all of you to this happy and significant occasion. I am glad to say that, in addition to school teachers, research scientists and professors, there are as well in our audience a number of housewives, students, businessmen, office workers, industrialists, and others of our varied Rochester public. We have visitors from several states and Canada.

We have chosen this first national symposium on "Understanding Science in the Space Age," as a time of celebration and dedication. The celebration is the 50th Anniversary of the founding of our Museum and also the 108th birthday of our good friend, Edward Bausch. For our second 50 years, we dedicate ourselves to an ever increasing usefulness to our community through the broadening of our scientific horizons. We hope that our symposium today will produce some guideposts for our future.

The Rochester Museum of Arts and Sciences had rather humble beginnings in an old building in Edgerton Park, where it was housed with the Rochester Historical Society and a branch of the Rochester Public Library. For its first twelve years, the Museum was a heterogeneous collection of history, anthropology, and assorted items, including firearms and coins. In

1924, Dr. Arthur C. Parker came as museum director. Dr. Parker took over a small and impoverished Municipal Museum and shaped its growth into a model community museum for the world devoted to the anthropology, biology, culture history, and industrial arts of western New York. For seventeen years he and his staff used the inadequate first building as an experimental laboratory for museum techniques. The Museum increased its scope of usefulness, added important services to the schools and to hobby clubs, and affected the lives of thousands of citizens.

In February, 1940, the late Edward Bausch generously donated the land and money to build a model Museum. The present building, Bausch Hall of Science and History, opened in 1942, has been a model of its type for community museums. Many delegations of architects, museum directors and trustees, have come from all over the world to study its facilities, as well as its program of service. The director and members of the staff have been called upon as consultants in this country and abroad.

As we begin our 51st year, we look forward to a new science center designed to give the significant achievements of the past decade the broadest possible appeal and interpretation. This new science center will incorporate a planetarium with accompanying exhibits, a building devoted to industrial and scientific developments of our western New York community, and an auditorium building which would be available for scientific meetings and educational lectures. This is an ambitious program—but let me say that we have already acquired the necessary land and the plans for construction are well along. With the generous support of our citizens we hope the dream will materialize.

The Rochester Museum Association, which co-sponsors the event of the symposium, is indebted to the sixteen industries of Rochester which have so generously provided the funds for this symposium. We are honored to have the principal executive officers of these firms here this evening. We wish, also, to acknowledge the untiring efforts of the Steering Committee which has labored for many months under the able guidance of Dr. Nisson A. Finkelstein, vice-president for research and engineering at General Dynamics/Electronics.

Program of Symposium

AFTERNOON PROGRAM

Panel Discussions

MASS MEDIA—2:00 pm-3:30 pm (newspapers, magazines, films, radio, and television)

Chairman:

DONALD J. DUNHAM
President-Elect, National Association of Science Writers

Panel:

Watson Davis
Director, *Science Service*

Gerard Piel
Publisher, *The Scientific American*

Miss Mildred Spencer
Buffalo Evening News

MUSEUM 2:00 pm-3:30 pm

Chairman:

JAMES M. BROWN, III
Director, Corning Glass Center

Panel:

James A. Oliver
Director, American Museum of Natural History, New York City

D. M. MacMaster
Director, Museum of Science and Industry, Chicago, Ill.

M. Graham Netting
Director, Carnegie Museum, Pittsburgh, Pa.

EDUCATION 3:45 pm-5:15 pm

Chairman:

McCREA HAZLETT
Provost, University of Rochester

Panel:

Robert L. Springer
Superintendent of Rochester Schools

Rev. Joseph B. Dorsey, C.S.B.
Dean of Studies, St. John Fisher College

Philip Morrison
Professor of Physics, Cornell University

INDUSTRY 3:45 pm-5:15 pm

Chairman:

CYRIL J. STAUD
Vice-President in Charge of Research, Eastman Kodak Company

Panel:

John C. Fisher
Physicist, General Electric Company

John C. R. Kelly
Westinghouse Laboratories
Pittsburgh, Pa.

John N. Shive
Director, Education and Training, Bell Telephone Laboratories

EVENING PROGRAM

Greeting . . . W. Stephen Thomas, Director, Rochester Museum of Arts and Sciences

Welcome . . . . George R. Williams, President, Rochester Museum Association

Introduction . . . Nisson A. Finkelstein, Vice-President for Research and Engineering, General Dynamics/Electronics and Chairman, Steering Committee of the Symposium

Summary of Mass Media Panel . . . . by Donald J. Dunham, Chairman

Summary of Museum Panel . . . . by James M. Brown, III, Chairman

Summary of Education Panel . . . . by McCrea Hazlett, Chairman

Summary of Industry Panel . . . . by Cyril J. Staud, Chairman

Addresses . . . . *Museums—Launching Pads for Scientists*
M. Graham Netting, Director, Carnegie Museum, Pittsburgh, Pa.

Understanding Science in the Space Age
Gerard Piel, Publisher, *The Scientific American*

Summary of Panel Discussions on Contributions of Mass Media to Understanding Science in the Space Age

by **Donald J. Dunham, Panel Chairman**

Panel: Dr. Watson Davis, Director, Science Service; Donald J. Dunham, President, National Association of Science Writers; Gerard Piel, Publisher, The Scientific American; Miss Mildred Spencer, Buffalo Evening News.

THE MASS MEDIA SECTION ran about 15 minutes overtime when it got involved in some trenchant questions both within the panel and from the floor.

Miss Mildred Spencer, medical writer for the *Buffalo Evening News* and producer of TV and radio medical shows; Dr. Watson Davis, director of *Science Service*, and Dr. Gerard Piel, publisher of the *Scientific American*, were on the panel and I served as moderator.

Miss Spencer reported splendid cooperation from every doctor who has been approached to appear on her show over a period of years. It has been demonstrated, she maintained, that the show is good for medicine and good for the public, the people who watch or listen. Miss Spencer reported that some in the audience accept what they hear on TV as gospel despite what their own doctor may tell them. She noted that doctors often have difficulty in communicating to a lay audience on TV because they have no middleman, the science writer, as middleman or interpreter.

She has discovered no special problems in the science writing field because she is a woman and says the rewards are rich in satisfactions in this area of the profession, even as they are for men.

Dr. Davis emphasized the importance of the mass media in helping people keep informed on science, saying it probably is even more important than the schools. He believes that the mass media does a relatively good job in this field but that it should strive to do better.

He assailed newspapers that defend or even inflict pseudo-science on its readers, such as columns on astrology, organic gardening, etc. He called for more courage by newspapers in crusading for public health needs such as fluoridation, immunizations, etc. He fears a new program of pseudo-anthropological justification for debasing the Negro and perhaps an epidemic of Carsonitis—campaigns against insecticides—without which we probably would starve.

He urged courses in science for adults such as we have fashioned for youngsters. He asserted that adolescents and children today are most sophisticated in science and far outstrip their parents in their understanding of it.

Dr. Piel argued that we fall far short of the ideals of the founding fathers of this great country. They believed all citizens should share in its culture for their own happiness and for a more effective society, to let the individual attain his greatest promise and fulfillment.

The advances of science, Dr. Piel said, have left behind the cozy world of old. It is a very different and far larger world, with a complexity that is intimidating. There is a great gulf, he said, between the body of science and its understanding by the common citizen.

The major task, as he sees it, is up to the schools. We of this generation, he added, should be written off. The real failure has been that the education system for several decades did not provide an education comparable to that given by the 18th century society.

Piel defended the press in many respects but said it still fails to cover science in its significant advances as such, covering them only through their practical applications. The press should cover science as a human activity, a method, an aspect of our culture and a rational process, he insisted. It is fundamental to our values that there be a dedication to reason and truth as criteria of science.

Both he and Miss Spencer and also the moderator defended the press against charges of slanting the news. But Dr. Piel continued with a blistering attack on Government bureaucrats who habitually stamp everything top secret and feed to the public only such information and handouts as they feel the public should have. It also might be added that too many Washington correspondents today are content to subsist on only government handouts without digging for facts on their own.

The moderator noted that in a democracy the people must make the decisions. And that virtually every policy-making decision of every cabinet member and department today in some way or other impinges on science. Defense and State certainly do; Interior, Health Education and Welfare, Justice, Agriculture—all in some way touch science.

Thus it becomes obvious, that to have a knowledgeable citizenry, we must educate our people in scientific terms, purposes, meaning and methods.

Earlier the moderator noted that the National Association of Science Writers also is vitally interested in this question of popular understanding of science and more and better coverage of science news. As a result, it has taken several major steps to try to help implement this program.

Summary of Panel Discussions on Contributions of Education to Understanding Science in the Space Age

by Dr. McCrea Hazlett, Panel Chairman

Panel: Rev. Joseph B. Dorsey, C.S.B. Dean of Studies, St. John Fisher College; Dr. McCrea Hazlett, Provost, University of Rochester; Dr. Philip Morrison, Professor of Physics, Cornell University; Dr. Robert L. Springer, Superintendent of Rochester Schools.

I HAVE NOT BEEN ASKED to do this but as a representative of the University of Rochester, I would like to take a moment to bring the greetings of the University to the Rochester Museum on the occasion of its 50th Anniversary.

Dr. Finkelstein alluded to the fact that this was a loaded panel in the sense that two of us are right out of the humanistic tradition. Of the other two members, one is an active scientist. Dr. Springer is extremely active and extremely able, but I don't think even he would claim at the moment to be a scientist. It will surprise none of you therefore to learn that this panel spent approximately half of its time talking about the humanities. The most interesting thing that was said about science education on this panel was said by implication which is that in its very nature the developments in modern science have got the humanists worried. We discussed, for instance, the whole question of traditionalism versus newness in society. We agreed humanists devoted themselves to the preservation of a traditionalist society. But the developments of science have been so broad, so pervasive that even those of us completely encased in the Ivory Tower have become worried about the future of the study of the humanities and have begun to explore in a very meaningful way new devices for such study. I think this is symptomatic of the pervasiveness within institutions of education, of the new science.

Beyond this we discussed the general question of how education disseminates information and knowledge about science. We felt that this restricted us to talking about the preparation of the non-professional—the student who is going into business administration who may have certain requirements or wish to take certain work in science; the student who is majoring in literature and so on. I started out by suggesting that I felt professional scientists were not really interested in the teaching of science for the non-professional scientist. They said they were, but if one divided up their time one found that this was not borne out by their activities. All three of my colleagues disagreed. The argument was that in fact this had been true, that the gap between science education in the elementary schools, the secondary schools, the lower years of college and the actual state of science was now being closed and that this was not a major problem. We concurred that there is a difference between the preparation, the teaching of science to the pre-professional scientist and the teaching of science to the student who is not going to become a scientist. The point made here was that one loses the need for complete coverage. One's needs, however, gains the crying need to present the student with a wide variety of scientific problems and their solutions. The argument was further presented that textbook science is in all fields equally ineffectual. That laboratory work—the exposure of the student to the raw materials, whether it be the universe or a work of art or a societal situation—is an absolutely necessary qualification to effective education at whatever level.

Thank you very much.

Summary of Panel Discussions on Contributions of the Museum to Understanding Science in the Space Age

by James M. Brown III, Panel Chairman

Panel: James M. Brown, III, Director, Corning Glass Center, Corning, N.Y.; D. M. MacMaster, Director, Museum of Science and Industry, Chicago, Ill.; Dr. M. Graham Netting, Director, Carnegie Museum, Pittsburgh, Pa.; Dr. James A. Oliver, Director, American Museum of Natural History, N.Y.C.

Our discussion began with the observation that of all money donated by corporate foundations only 1% of this found its way into museums.

The panel asked itself consequently if, indeed, museums really *were* educational institutions. Although there may perhaps have been some doubt about this in the past, it was emphatically decided that they are educational institutions today—particularly because in recent years museums have been *interpreting* to the public the *meaning* and *origin* of the objects bequeathed to us by past collectors. Further, it was generally felt that museums in this country are considerably ahead of their counterparts in Europe. No longer, generally speaking, are we benumbed by the soulless stares of a thousand trilobites but rather—through demonstrators, dioramas, audio and visual techniques, the visitor becomes involved in a *planned scientific* teaching experience. The science museum today is, in itself, a superior "teaching machine."

The point was made again and again that the unique and greatest strength of a museum lies in its collections and it is through explaining the why and how of these three dimensional objects that the museum leads its visitors to a greater understanding.

In addition to the planned interpretive teaching experience, certain other contributions to greater understanding and intellectual growth were noted:

1. Net additions to the corpus of human knowledge made by researchers on museum staffs and the publication thereof.
2. There is no age limit to participation in the museum experience—the gateway to science is open so that interest may develop at any level.
3. T.V. programs, publications, lectures, films, nature walks, and school programs lead to a greater understanding of the forces that shape us and shape our world.

Finally, problems of science museums were agreed to be in the areas of money, expansion and trained people.

Summary of Panel Discussions on Contributions of Industry to Understanding Science in the Space Age

by **Dr. Cyril J. Staud, Panel Chairman**

Panel: Dr. John C. Fisher, Physicist, General Electric Co.; Dr. John C. R. Kelly, Jr., Westinghouse Research Laboratories; Dr. John N. Shive, Director, Education and Training Center, Bell Telephone Laboratories; Dr. Cyril J. Staud, Vice-President in Charge of Research, Eastman Kodak Company.

THE FOLLOWING is a summary of the presentations made by the members of the Industry Panel:

After introducing the panel members, the moderator gave a brief review of the rise of industrial research. The need for investigations in fundamental science by industrial research organizations was outlined, and the group of Nobel prize winners from industrial research laboratories was mentioned.

The publication of scientific results from industrial research laboratories was brought out. The interpretation of these results for the general public was outlined through the various media.

In addition, it was mentioned that industrial research laboratories provide sponsored programs, arrange for visits to laboratories by those interested, and supply speakers for many different groups who have occasional interest in the general field of science.

Also, the relation of industrial research organizations to museums was brought out in connection with financial assistance, help in preparing scientific exhibits, and supply of products exemplifying the results of technology.

The moderator closed with a statement on the importance of an understanding of the fundamentals of science to those concerned with other fields.

Dr. John Fisher of the General Electric Laboratories in Schenectady indicated that industry contributes to an understanding of some aspects of science through new products and materials. In this way, the user vicariously is taught some aspects of science. He pointed out that in driving an automobile some portions of the field of mechanics must be understood—acceleration, deceleration, and centrifugal force as an automobile turns a corner too rapidly.

For the private plane pilot, some knowledge of aerodynamics must be learned if the private plane is to remain in the air and, more particularly, land safely.

In electricity, Dr. Fisher pointed out that some knowledge of the subject is gained through the use of electric lamps, electric motors, and the telephone. He mentioned that the phenomenon of resonance is learned in tuning a TV or radio set.

Dr. John Kelly of the Westinghouse Laboratories felt impelled to criticize industry, in connection with the understanding of science, from the standpoint that what he termed advertising "chaff" appeared widely in newspapers, on the radio and on TV. He felt that a more rigid code of advertising ethics was required. He felt that greater scientific and technical accuracy should be maintained.

Dr. Kelly then went on to describe some specific experiments which were being conducted at Pittsburgh in getting teachers into industrial research laboratories and presenting to them, by means of lectures and demonstrations, some of the most recent developments in science and in technology. This would include work which had not as yet been published but had reached the point where it had definite implications for those teaching science in schools and universities.

In addition, he mentioned that a selected group of some 250 students from Allegheny County each year were brought to an industrial research laboratory, given lectures and demonstrations, and then subjected to an examination and grades assigned. He pointed out that the schools were cooperating very well in this program.

Finally, Dr. John Shive of the Bell Telephone Laboratories discussed the new physics courses which were now being introduced in the schools, particularly in the East. These courses have been evolved by a cooperative effort between high school, college teachers and those working in industry. About an equal number of academic and industrial laboratories members constituted the group. He stated that similar work is being done leading toward new types of courses in chemistry and mathematics.

Dr. Shive then turned his attention to the public relations aspects of industrial research laboratories in helping others in the understanding of science, and mentioned the "Mr. Wizard" and "Mr. Sun" TV presentations which had been well received and had, in his opinion, definite significance. He also pointed out that science teachers obtain cooperation from those in industry in connection with any matter in which the industrial research laboratories can be of assistance.

Dr. Shive then went on to discuss the need for the development of a new attitude on the part of the public toward science. In his opinion, knowledge should not be confused with science, and an understanding of the use of facts through the scientific method was of much more widespread and general importance. He felt that cooperation between those concerned with education and members of the staffs of industrial organizations would be beneficial toward this objective and would probably increase in the future.

The discussion was wide ranging, and many members of the audience participated by asking pertinent questions and offering interesting comments. It was necessary to terminate the discussion because of the time allotted for the panel rather than any dearth of questions from the audience.

At the conclusion of the session, Mr. Curtis of the Rochester school system expressed his gratitude for the assistance that had been rendered by industrial research laboratories to those concerned with education. This, of course, was much appreciated by the members of the panel.

Museums—Launching Pads for Scientists

by **Dr. M. Graham Netting, Director, The Carnegie Museum, Pittsburgh, Pa.**

ANNIVERSARIES in a colleague's institution are enjoyable; in one's own they are a nightmare of checking invitation lists, arranging ceremonies and putting the finishing touches on the newest exhibits five minutes before the first guests arrive. I have survived such ordeals so I not only congratulate the Rochester Museum of Arts and Sciences upon its fiftieth anniversary, but also commend Director Thomas and his staff upon having thus far survived it. If they nap during my remarks I shall use no lecturer's tricks to spoil their relaxation.

It is, more seriously, a pleasure to come to the city of Bausch and Lomb and Eastman Kodak, two firms that have served science so well, and to the locale of Ward's Natural Science Establishment, which has been so intimately associated with the rise of natural history museums in North America, to participate in paying tribute to a scientific institution whose accomplishments are widely known and highly regarded in the museum profession.

The Rochester Museum is but half a century old, but its lineage antedates the dawn of history. Millenia before photography, optics, or taxidermy the first men or pre-men garnered bright shells or puzzling objects that caused them to wrinkle their low brows. Collecting and curiosity were the precursors of museums and of science, although science has grown so sophisticated that symbols have largely replaced objects. Ontogeny again recapitulates phylogeny as curious youngsters marvel at objects before they learn symbols.

The oldest museum—although not so named—according to Ruthven (1931: 41), was located in Ur, the home of Abraham, three thousand years ago. The word "museum" derives from temples of the Muses, located in the Grecian groves of Helicon and Parnassus. And the Muses, as this intellectual audience will recall, were the daughters of Zeus and Memory—certainly potent sponsors for any institution. The first real science museum was the Alexandrian Museum which, with its associated Library, influenced the ancient world for seven centuries. The Museum apparently preceded the Library for the first director of the former left his collection of books as the nucleus of the latter. George Sarton's "A History of Science" includes an excellent description of the role of Ptolemaios I in founding the Museum and in bringing Straton of Lampsacos to Alexandria to tutor his son, Ptolemaios II. Straton subsequently became the second director of the Museum which flowered into an important scientific institution under his leadership and with the backing of his former pupil. I cannot quote at length from Sarton, as I should like to do, but one statement in his discussion (1959:29) is too significant to be omitted. In emphasizing that the Ptolemies were typically Greek, he states:

> They were Greek enough to realize that prosperity without art and science is worthless and contemptible.

The first "modern" (in quotes) museum was the Ashmolean Museum at Oxford, founded in 1667. Mrs. Netting and I made a pilgrimage there last year, primarily, I must admit, to meet Charles Elton, the great ecologist, but secondarily to pay homage to an object lesson for all museum administrators. Almost a century after its founding—but still long ago—a hot-shot executive decided that a house cleaning at the Ashmolean was indicated—a custom of new directors even today. A dusty, and probably badly mounted, dodo was consigned to the trash fire from which the head and one foot were surreptitiously saved by a curator at the risk of his job. These remnants of probably the only dodo ever stuffed, and already extinct when it was discarded, are a prized exhibit in an elderly case under the iron and glass roof of the Ashmolean's main hall today (Ley, 1941:200).

From the third century B.C., true museums have had two principal functions: to increase knowledge and to disseminate knowledge. In our own days, a third function has been added, namely, to serve the community—a worthy and desirable addition, but one that further complicates the proper balancing of competing programs. It is entirely possible for a museum to be a great center of learning without developing the third function of community service to all. The tragedy of many contemporary museums, however, is that they have become so engrossed with disseminating canned knowledge and with catering to the community that they have subordinated or omitted entirely the first function, increase of knowledge, and have become sterile as museums and unworthy of the proud title, even though they may flourish as community centers.

Increase of knowledge on the part of museums requires two things. The first prerequisite is collections. Museums are essentially the only institutions that assemble and preserve for the future actual objects of the natural world or of human culture. They are—in this sense—the originators of visual education; and the possession of vast collections of real objects becomes increasingly important in a world which devotes so much attention to duplicating. Aline B. Saarinen in an excellent discussion of museums, published in the *New York Times* a few years ago (Oct. 7, 1956; Magazine, p. 48), stressed this uniqueness of museum collections:

> Within its walls are the tangible evidences of the great works of man and God. In a world swamped with propaganda and selling, in an age of reproductions, facsimiles, the second hand, the summarized and the simplified, the truth of objects in museums becomes sacrosanct. What they contain is the first hand, the undistorted, the

original. Moreover, in the face of mass media, mass pressures and mass thinking, they provide the opportunity for the truth of the free, private, individual and independent experience.

> I believe the major function of the museum is to keep faith with that truth in terms of quality and in terms of fact. And I believe the public must learn to respect, judge and allocate tax support, for museums as citadels of truth and institutions which *actively* inspire and aid intellectual development, rather than demand that they forfeit their uniqueness and, in order to show big attendance records, become carnivals and community centers.*

Although they are the memory of things past, the source of newer knowledge, and the foundation of future exhibits, collections alone are not enough, and a collection of objects—no matter how precious—does not create a museum. Otherwise, a parts dealer might call his establishment an automobile museum. Collections are mere warehouse accumulations without scholars to muse over them, and an institution that merely accumulates and exhibits objects, is not a spring of living thought. A museum must have scientists studying its collections if it is to be a vital force in its community and worthy of admission to the confraternity of museums. Donald K. Crowdis, the brilliant and witty director of the Nova Scotia Museum of Science, stated categorically in an address at a museum convention a few years ago:

> Research and education are requisites if the name museum is to be used. Passing on the discoveries of others, looking it up in a book, are mere coasting. The persons doing so tend to accept what is written as true.

In this historic preamble I have used nineteenth century nomenclature. Now I move toward the Space Age by switching from the Smithsonian Institution's hallowed "for the increase and diffusion of knowledge among men" to the contemporary but less felicitous terms "research and communication." The two basic functions of museums remain constant; only the words describing them have changed.

I could expatiate at length, and usually do, upon the importance to society of research in museums, but we are gathered to discuss "Understanding Science in the Space Age" and I must accelerate to the discussion of communication. When I drag in research in the remarks that follow it will be to belabor the point that museums and their scientists are as inextricably involved in promoting the understanding of science as they are essential in the advancement of science.

Tremendous advances have been made in the publishing field. Children's science books are now available in bewildering variety, possibly half of them written accurately as well as entertainingly, and the majority excellently illustrated. I can recall—as a book reviewer in the 1930's—deploring the backwardness of American publishers in not issuing inexpensive paperbacks, either reprints of expensive or out-of-print titles, or original serious works. There is no longer cause for such complaint, as every drugstore and airport

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evidence. The number of magazines in the natural history and science field has multiplied greatly, and the quality has shown marked improvement. This flowering of publications has been tremendously helpful in two respects: first, adults interested in learning the rudiments of a subject can now turn to children's books which offer the best introduction to many fields of knowledge. Secondly, children who have been fired with an interest can progress at their own learning speed to more and more advanced and readily available references. Teen-agers have far greater capacity for learning than many have recognized and make excellent use of "adult" publications. Obviously, few are equipped to read and to comprehend every article in *Science*, the *Quarterly Review of Biology*, or the *Scientific American*, but for that matter I hasten to confess my own inability to understand all contributions that appear in such media.

Museum scientists have authored many of the popular books and articles. A host of others incorporate results of museum research or illustrative material drawn from museum exhibits or photo files. Finally, a goodly portion of the flood of new children's books or popular science volumes are reviewed by museum staff members for factual accuracy before they go on sale at museum shops.

Concurrently, museums generally have been engaged in extensive rehabilitation of their exhibits to make them more attractive and educationally effective. Progress has not been at jet speed for the task is formidable, funds limited and staffs too small. My own museum, not one of the largest in the country, has over two acres of exhibit halls and almost 10,000 individual items included in over 650 separate displays. (The total collections amount to about 6 million specimens.) The magnitude of the task does not account fully for delays in modernizing presentation; lack of imagination on the part of museum personnel has been a contributing factor. Some scientists have shuddered before the ghost of popularization, feeling that they would be censured by their colleagues if they attempted to sugar-coat knowledge. Administrators have worried about possible loss of dignity in their staid old institutions if they approved dramatic or completely realistic displays or permitted levity or humor to creep into the presentation of serious matters. I take sharp issue with these hangovers from the past. Both the scientist clinging to priestcraft and the administrator clothed in dignity reflect concern over what other adults may think of the museum. Museum galleries should be places where learning is fun, and if children find them so the parents will share their regard for the institution.

My great concern is whether the museum is doing its utmost to open new vistas to curious children, to fire the rockets of youthful imagination. We oldsters are far less important then we like to think. Russia, we are told, is opening museums—and good ones—in hundreds of towns and cities to educate youth, even though the elderly wear shoddy clothes. I have scant patience with the numbers game played by many institutions. It is not the size of the attendance figure that counts, but how many young, active minds find sufficient stimulation to make repeated visits. Most museums do not practice age discrimination in their galleries. Timid youngsters who may feel restricted to the Children's Room in a library may view every exhibit in a museum and read every label—and may have the time and fortitude to do so.

A child's first introduction to a museum often comes in the course of what museologists have come to term "snake tours." Half-a-dozen bus loads of children from a distant community suddenly arrive at the museum without advance warning and with no arrangements for guides. The leader of the party then starts on a complete tour, followed by a sinuous line of several hundred children, two abreast, weaving past exhibits at slow walking speed, but without pauses that might delay departure for the next stop on the day's grueling tour! All that can be hoped from such visits is that most of the youngsters learn that there is such an institution as a museum and that some of them, at least, will be sufficiently intrigued to persuade their parents to bring them again for more leisurely viewing. Children fortunate enough to live within easier access to museums may come more frequently by themselves or accompanied by parents. If exhibits are well presented and varied some will appeal to almost any youngster. The importance of these early experiences in visual education has persuaded me that museums must experiment with methods of presentation. We are badly in need of co-operative research programs involving psychologists as well as exhibit personnel. Few studies of visitor motivation and exhibit impact have been made. I have often wondered how many repeat visits in later years may have been made by the four-year-old girl who exclaimed to her nursery school teacher on entering our Dinosaur Hall for the first time, "I've never been in a place like this before and I don't think I will ever be in a place like this again!" Lacking psychological studies as guide lines each museum director evolves pet theories that he expounds *ad nauseum*. I am no exception.

I believe that every museum exhibit should engender a sense of wonder or teach something or combine the two. Visitors may marvel at the size of a dinosaur or be entranced by the beauty of a large habitat group that gives them a picture of plants, animals, and scenery from a part of the world they may never visit. Most of the exhibits cannot be of such magnitude, however, and must be simple presentations in which the actual objects serve to illustrate the story presented by a label. Viewed from this aspect labels become critically important. Every museum worker is conscious of this importance, but in actual practice too many exhibits are built and then labeled. The story line should be developed first and then the illustrative materials selected.

I have been a great proponent of the importance of headlines, and some of my colleagues may believe that I over-emphasize this point. The most carefully written label, however, means nothing unless the visitor can be persuaded to stop to read it, and a catchy title may accomplish this. We have a complete mount of one of the smaller dinosaurs which the paleontologists believe may not have been adult at the time of death. For years this was labeled *Camarasaurus lentus* Marsh. It is now introduced in large letters as "Teen-age Dinosaur." The scientific name is retained, and explained, as an essential part of the label but not given top billing. An exhibit of stream bank protection is labeled: "A Sound Bank Is A Good Investment."

If the headline has functioned properly, lighting, format, and content of the label become important in holding the visitor's attention. Parenthetically, I might say that every installed label should be approved as to type size and placement by a middle-aged staff member wearing bifocals—an essential overlooked in the Science Pavilion at the Seattle World's Fair.

I believe that labels written by scientists who have developed writing skills are superior to those produced by trained writers lacking technical knowledge. The principles of good writing are the same in every field, but a plenitude of exact, small things makes writing interesting and the scientist has the advantage of having an over-supply of facts competing for inclusion. He must, however, train himself to use his home vocabulary rather than his laboratory one. Many a botanist who has plants with *stems* on his lawn at home invariably writes "petiole" when he composes a label. Long ago someone defined an ecologist as a person who invariably calls a spade a "geotome." On the other hand, only a person familiar with shrews is apt to describe one of these active beasties, as one of our staff did, as having "a face that looked like it had just emerged from a pencil sharpener."

Scientific fact can be presented entertainingly and largely in non-technical terms without loss of substance. In the course of labeling a panel devoted to the life zones of the sea we found that every technical term could be translated into ordinary English except "photosynthetic zone," for which we could find no simpler alternative. In such instances there should be no hesitancy about using the big word. Much of the delight of learning has been ripped from elementary textbooks by using vocabulary lists and deleting words unfamiliar to the average student. Children love to learn the scientific names of dinosaurs or new words to confound their parents, and we have no hesitancy in using the right word even though it may be generally unfamiliar. We hold that a label written for an intelligent twelve-year-old can be comprehended by most adults.

I have emphasized exhibits and labels because they are our show windows to the public of all ages and only our galleries influence every visitor. They are only a first contact, happily, for many youngsters. We hope that the most curious will join classes or clubs, or will have burning questions that only the specialists can answer. Universities have great scientists and scholars, but only the most aggressive ten-year-old can find a professor in the rabbit warrens of a great university. In museums, however, inquisitive youngsters with scientific interests can take their problems directly to curators, at least in present-day museums. It was not always so.

One of our country's great museologists, Dr. Robert C. Miller, Director of the California Academy of Sciences, grew up in western Pennsylvania. He spent many Saturdays roaming the exhibit halls at Carnegie Museum and longed to penetrate the laboratories which in those days had "No admittance" emblazoned on their doors in gold leaf. Happily many brash youngsters entered anyway and were welcomed by the friendly although cloistered curators. Bob Miller was not one of these and he told me only recently that he vowed to make access to scientists easier if he ever had anything to do with a museum. After some years as a university professor the opportunity came. After becoming Director of the Academy he established a Junior Curators program, one of the oldest and most successful in North America. High school age junior scientists in this program carry out creditable research projects and issue their own mimeographed reports. Dozens of the leading professors and research workers on the West Coast are alumni of this program so even closed laboratories at Carnegie forty years ago started a chain reaction that has been educationally productive.

Science clubs are well organized and potent educational forces in most museums. Even if they do not carry students on to the level of independent research, as I think they should, they may have far-reaching results. For example, some twelve years ago a scenic woodland of about one hundred acres, in a bend of the Youghiogheny River at Ohiopyle, Pennsylvania, was threatened with exploitation. The late Charles F. Chubb and I approached the late Edgar J. Kaufmann, a department store executive and civic leader and he gave $37,500 anonymously to the newly organized Western Pennsylvania Conservancy to save the tract. Other donors and foundations have followed his fine example and the Conservancy now owns 4,500 acres of rugged mountain scenery surrounding the original parcel, the core area of what we hope may become a future state park three times as large. Some years after his gift I asked Mr. Kaufmann why he had responded so immediately and generously. He told me that in the early years of Carnegie Museum, he had been one of 32 youthful members of the Andrew Carnegie Naturalist Club, organized by a taxidermist, F. S. Webster—who has been called the father of museum habitat groups. Mr. Kaufmann went on to say that this club had been "a most wonderful thing," and that in later years he had succeeded in tracing all but four of his fellow members. The interest in nature aroused by this museum experience flowered years later into gifts to the Museum, support of conservation projects, and related benefactions kept so secret that the full extent of his generosity may never be recognized.

The case of Mr. Kaufman is an example of one of the most important services of museums and one almost impossible to document fully. An impressive number of today's leading scientists, physicians, educators and professional men collected plants or animals in their youth, haunted the galleries of the nearest museum, participated in nature programs sponsored by a museum, or learned under a scientist's tutelage that drudgery is as much a part of science as the thrill of discovery.

Everyone knows what schools do, even though they may dispute about how the teaching should be done. The complex educational role of museums is less fully appreciated. Many visitors have observed school classes trailing a museum instructor and have perhaps recognized subconsciously that some nugget of information about the natural world may initiate a ripple of interest that will expand in a youngster's consciousness and turn him toward a scientific career. Few visitors, however, imagine the magnitude of the over-all educational contribution made by museums. Museums, in a very real sense, educate educators. Every science museum with an active research program produces technical studies that are new contributions to knowledge, the basis for fresh exhibits, and source material for the textbooks that will be written tomorrow. Museum staffs make a further important contribution through popular articles, public lectures, and radio and TV programs, which vastly speed the process of communicating new ideas in science to both teachers and the public. At Carnegie Museum this has been particularly well exemplified in local archeology. In eleven years, 1950 through 1960, two or three staff archeologists, ably assisted by amateurs they trained, located over a thousand Indian sites in the Upper Ohio Valley in an area previously almost a blank spot in the geography of modern archeology, produced one book and 197 technical and popular articles, gave 477 lectures, radio and TV talks, and were the source of 456 press notices or articles. The total educational impact of such communications cannot be evaluated fully, but the role of the museum in discovering and disseminating makes a big splash in the pool of knowledge.

In 1951 I became worried over the question of whether our scientific publications were making a good or a bad impression upon trustees to whom they were sent as a matter of courtesy and editors to whom they were sent in the hope of favorable publicity. A business man might well question the advisability of spending money upon research after receiving a paper entitled "Notes on the Fresh-Water Snail *Leptoxis* (*Mudalia*) *carinata* (Bruguière)." We began attaching a half-page popular summary, mimeographed on colored stock, to each technical publication sent to trustees, donors, and communications media. This innovation has proved highly successful. Trustees take greater interest in research results and newspapers, radio and television stations frequently take note of them. The summary for the paper with the unstimulating title given above actually resulted in a laudatory editorial in a leading Pittsburgh newspaper. This popular summary may be worth including in its entirety:

> "Life is most unfair at times. An eastern freshwater snail is so variable that it has been given 15 different scientific names since 1792, but it has never received a common name! This snail was described and redescribed largely because its shell spine erodes in a fashion which prevents accurate measurement and customary statistical analysis. Mr. Parodiz solved the problem by devising a diagrammatic triangle of variations. Using this new technique he studied 1168 specimens from 52 localities from New York to North Carolina and proved that they all belonged to the same species.
>
> "Establishing correct names for the often puzzling freshwater snails is important, although unexciting. These inconspicuous animals are increasingly useful as indicators of the extent of water pollution, and endless confusion results if they crawl along stream bottoms masquerading under different aliases.
>
> "Additional copies of this publication may be obtained from Carnegie Museum, Pittsburgh 13, Pa., for $0.40 each."

Museums have problems of communication with their neighbors as well as with the public at large. Several generations ago most Americans had either a rural background or had been subject to rural influences in the course of visiting relatives who had not yet moved to the city. To a growing extent this is no longer true and we have the problem of introducing nature to a population that has been increasingly urbanized. I have noted two outside influences that arouse interest in science. Frequently parents visit the museum for source material when their children begin to display curiosity about living things. Another motivation, and a very powerful one, occurs when urban people acquire a vacation spot in the country or move from the city to a suburban property. Some of these migrants become intent upon eliminating most forms of wildlife, such as moles in the lawn, so that their new habitat environment becomes as sterile and devoid of interesting creatures as the city streets from whence they came. More typically, however, the freshman squire becomes intrigued by the plants and animals that occur on his property and are, in a sense, his wards. Shortly after Carnegie Museum acquired its field station, Powdermill Nature Reserve, a 1,500-acre research area in the Ligonier Valley, we recognized the desirability of making some return to the local community that we had deprived of tax income on these lands. A series of mimeographed educational releases was instituted to acquaint our neighbors with some of the current discoveries being made. A mimeograph machine has many advantages in the modern world, although I sometimes feel inundated by the flood of paper coming from efficient public relations offices of agencies and corporations. Since we are understaffed and own only one mimeograph machine for all museum needs, we are not likely to overproduce releases. In fact, since the first Powdermill mailing in early 1957 only forty-one educational releases and eight somewhat lengthier research reports have been distributed, but our mailing list—built up mainly by request of interested persons—has climbed to over 400, including limited distribution to other museums operating similar preserves. A further advantage of the mimeographed release is that scientists in general do not regard it as publication and, in consequence, are willing to offer interim reports that are too incomplete for formal publication. Our releases list the plants and animals being found on the Reserve in the course of inventorying our biological resources there. We also endeavor to treat timely topics, such as tent caterpillar ecology one spring when this moth caterpillar was particularly evident in our countryside. Virtually all releases are intermediate between a newspaper story and a technical article. People will read more scientific information if it applies specifically to their own neighborhood. The finest testimonial came from a hardware dealer in the nearest town who asked if he might have duplicate copies mailed because his clerks picked up the release on arrival and it was not immediately available to take home to his wife. In most instances, however, this difficulty is obviated by mailing the releases to home addresses so that they may fall into the hands of children as well as adults.

At this fiftieth anniversary of a museum that was interpreting science long before the Space Age dawned let us keep firmly in mind that new fields of science rest upon old foundations. All the science museums in America spend annually only a fraction of what is expended upon space programs, yet the museums are actually the launching pads for scientists of tomorrow. If we fail to support museums adequately and the Russians multiply theirs our space biology directly, and the other scientific endeavors collaterally, will inevitably misfire and fizzle and lag behind. Science has grown so complex that motivation and learning must begin in early years on nature walk or at a sky show or when a child first comprehends that the massive dinosaurs disappeared utterly because they did not adapt to changing conditions.

It is impossible to estimate how many scientists and how many community leaders with understanding of science the Rochester Museum of Arts and Sciences has orbited successfully during its first fifty years. The community it has supplied with such wealth of scientific talent should recognize its obligation to the Rochester Museum for this educational propulsion, and it should give of its prosperity to finance the accelerated launchings demanded by the space age.

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EVENING SPEAKERS AT THE SCIENCE SYMPOSIUM
From left to right: Dr. Nisson A. Finkelstein, Gerard Piel, Dr. M. Graham Netting, and George R. Williams.

Understanding Science in the Space Age A National Symposium

by Gerard Piel, Publisher, *The Scientific American*

THE KEY TO UNDERSTANDING science in the Space Age is to learn the distinction between science and science fiction. Here in Rochester—where your industries are concerned with the more primary functions of our industrial civilization—you may not have had opportunity to make first hand acquaintance with the marvels of the Space Age. Those of us who have come here from the world outside, especially those who have had recent occasion to visit Florida or Southern California, can testify to you that rumor has not improved upon reality. The gigantic rockets, the awesome discharge of violence that propels them and the intricate systems that navigate them—all make fact of fiction. And no matter how unbelievable the Space Age machines, the people of the Space Age are no less improbable.

By way of illustration, let me reconstruct for you an event, symbolic of this period, reported in *The New York Times* just two weeks ago. The President of the United States has arrived at the George Catlett Marshall Space Flight Center at Huntsville, Alabama, in the course of his photographic visitation to the nation's space facilities. He is ushered into the office of Dr. Wernher von Braun. There the *Times* reported:

"As Dr. von Braun, director of the center, was showing Mr. Kennedy a small model of the advanced Saturn C-5 rocket, which will be used for the lunar shot, he turned to the President and said: 'This is the vehicle which is designed to fulfill your promise to put a man on the moon by the end of this decade.'

"He hesitated a second, then said: 'By God, we'll do it.' "

Now the real-life President, who has committed some $30 billion of other people's money to this lunar enterprise, must have taken some reassurance from the manly declamation of his space captain. But, I imagine, he must have found greater reassurance during the course of that day in the sight of an actual Mercury Atlas rocket poised on its launching pad in preparation for the six-orbit flight of Commander Walter M. Schirra and in the breathless drama of a count-down for the next day's launching of a Titan II, the booster that is to place two astronauts on orbit in the womb of the Gemini space capsule. And the President probably felt that prospects were even brighter when he was brought into the presence of a full-scale mock-up of the F-1 rocket engine, five of which clustered in a single booster will start the lunar explorers on their voyage, hopefully to return.

For the President and the electorate, however, this day of promise and anticipation was marred by a curious episode that took place a little later as the presidential party made its way through the Saturn assembly plant. According to the *Times*, the procession was brought to a halt and: "President Kennedy stood by, obviously somewhat nettled, as Dr. Jerome B. Wiesner, his principal science adviser, engaged in an argument with Dr. Wernher von Braun, director of the Marshall Space Flight Center, over the best way to reach the moon.

"Dr. Wiesner, according to those who overheard the discussion, disagreed with the method favored by the National Aeronautics and Space Administration and Dr. von Braun. Under this plan, a lunar 'bug' with two men in it would be detached from the parent capsule while in orbit around the moon, and would descend to the lunar surface.

"One man would remain in the parent capsule. Later, the bug would take off from the moon and rendezvous with the circling parent capsule. The bug would be abandoned before the capsule returned to earth.

"Dr. Wiesner is understood to favor a method that was earlier agreed on and then discarded. Under this method, a lunar rocket would be formed by a rendezvous of parts orbiting the earth. It would blast off from the parking orbit and land on the moon. Later it would take off and return to earth again."

Now the practiced reader of space fiction will see immediately the logic of this episode. It supplies the element of human conflict that is so necessary to lend drama to the otherwise inexorable performance of machines. On the other hand, the President's discomfiture is also deserving of sympathetic consideration. Men of affairs are often exposed to anxiety by the ambivalence and uncertainty of their "thing" men. The engineer or scientist always tries to hedge and qualify what must be in the end a clean-cut decision; he has second thoughts: he squeezes design changes into the last minute. This kind of behavior costs money and, worse yet, it stalls the forward march of great enterprises. Somehow technical experts fail to comprehend the larger context. On occasions such as this, when they are so heedless as to conduct their disputations in the presence of reporters, their preoccupation with their narrow technical concerns can be downright embarrassing.

The rest of us must nonetheless be grateful for this episode. Here, in a casual argument between two of the principal scientific policy-makers of our Government, we gain a giddy insight into the virtuosity with which man may now summon and manipulate the forces of nature. The episode gives us still another insight: into the "closed politics," as C. P. Snow has called it, by which an increasing number of decisions are taken in our increasingly complex world. Decisions issuing from contests of brain and will conducted in private behind closed doors and frequently under the cloak of military secrecy deploy the human and material resources of the entire nation. They may one day commit our lives as well as our fortunes, without prior notice or consultation. Yet the advocate of open politics is hard put to show how these decisions might be made otherwise: so very few of us are qualified by talent or training to contribute to the deliberations from which they come.

What is more, the brief history of the Space Age would suggest that something has gone wrong with the traditional decision-making machinery of our Government. The attempt to put a man on the moon by the end of this decade was undertaken in broad daylight. It is true that the proposal originated in secret as an imagination-capturing venture of a young new Administration. But the Administration had to enlist the approval of the Congress and of the electorate by something approaching the open procedures prescribed by our Constitution. Yet the sense of this decision to go off to the moon remains as obscure as the argument between Wiesner and von Braun about how to get there.

The motives that ruled the public deliberation on the project had little relevance to its inherent values. Project Apollo was undertaken before all else as a ploy in the Cold War—the Russians may yet beat us to the moon. It is thus a para-military enterprise; by brandishing their missiles out in space the two Great Powers seek to enhance the credibility of their deterrents. Next, one must mention the economic compulsion; this gains ascending importance as military expenditures yield a diminishing stimulus to the economy. The last and least of the motives was the increase in human knowledge that a successful round-trip may yield.

Now it is impossible to put a price on the things we may learn from a visit to the moon, and the scientific motive may be taken as sufficient. Disturbing questions must nonetheless be asked. It is, for example, a moral as well as a technical and financial question whether we should send men instead of robots to the moon. We must also ask: Why in a decade? Finally, we ought to examine the order of priority which we have assigned to the pressing demands on the capacities and resources of our country.

These are questions on which the public can and ought to be consulted and to which public discussion may bring wisdom and humanity. The same may be said even of the highly technical issue that divided Wiesner and von Braun. For one of the two routes to the moon is the safer, while the other promises an earlier launching. It is easy to guess which route has been chosen by the method of closed politics, and it is likely that open politics would choose the other.

Citizenship in the Space Age, therefore, calls for wary discount of the marvels of science fiction. Some people think they have a clear-cut test; the space feats of the Soviet Union, they say, are fiction. The Russians simply faked the "beeps," forged those photographs of the far side of the moon and generated the TV picture of Nicolayev lounging in his space cabin by straight-forward electronics. A closed society is, of course, vulnerable to such charges. The logic of this line of argument, however, requires us to believe that the Russians are incompetent in space and at the same time incomparable masters of the techniques of mass communication. Carried just a step further, it throws our own space feats in doubt. How do we know the entire space pageant is not a gigantic hoax—an optical illusion created by a conspiracy of the press, the radio and television through which the rest of us have been sharing vicariously, at third hand, in this latest adventure of mankind?

How, in this age of fact made fiction, do we know what we think we know? Most of us are ready enough with our knowledge, especially those of us who have had the privilege of higher education. Ask your well-informed contemporary, and he will freely render an acceptable account of modern cosmology: our earth is an undistinguished (except for our presence on it) planet of an undistinguished star located in an undistinguished region of an undistinguished galaxy in—he will not fail to add—an expanding universe. Then ask him how he comes to know all this. He will doubtless lead off with the observation that the rising and the setting of the sun shows our earth to be turning on its axis as it travels on its orbit around the sun. His assurance on these points will be dampened, however, when you remind him that men as intelligent as ourselves have watched the sun rise and set for more than 25,000 years and, until very recently, held that the sun revolved around the earth. In the end, it will turn out that he grew up knowing these things, learning them by parental instruction, in school and from books; he knows what he knows because someone told him it was so. His knowledge, in sum, rests upon the same foundations of authority and faith as that of ancient and primitive man.

In some ways the typical cosmology of the ancient or the primitive man is more honorable and simplistic. As to that portion of the universe which he beholds with his own eyes, he makes no complicated correction of what he sees. The earth is flat and stationary and it is roofed over by the revolving hemispheric dome of the firmament. This was the cosmos of the Bible and of Homer. At different times and places it has been variously embellished by legends taken on faith. So long as men were bound to the soil, the sun played the central life-giving role in the mythologies that illuminated the all-encompassing mystery. The moon, by coincidence of the menstrual and the lunar cycles, was most commonly assigned jurisdiction over fertility. In the cosmology of ancient Greece, the universe outside the celestial dome was filled with fire that shone through the tiny windows of the stars. In the cosmology of the medieval fathers, fire was infernal, not celestial, and it roared in the bowels of the earth; the still deeper depths of hell were locked in eternal ice. From one age to the next, the masses of men were acquainted with these marvels through the offices of their prophets, priests and philosophers. These learned and inspired teachers came by their knowledge in turn through vision or revelation or other ecstasy of the imagination.

The question of how we know what we know today is rightly framed in the context of cosmology. Astronomy is historically the first of the sciences because the firmament was the realm of nature first susceptible of precise and repeated observation and measurement. The straight lines described by rays of light made possible the exact measurement of angles; the repetition, from day to day and year to year, of the sidereal cycle made it possible for different men at different times and places to make the same measurements and compare their results.

Early in history, one can discern the divergence of science from other methods of philosophy. Observation and measurement engage the imagination in external reality. The results achieved by this method make a difference. Each observation, as it is made and verified, leaves its mark indelibly upon the world. Step by step, nature is transformed in the eyes of man. With measurement there comes prediction and, with prediction, control. The method is accumulative and, over time, the rate of accumulation speeds up; this is because each addition to knowledge proposes new questions that no one would have thought to ask before.

As early as the 6th Century B.C., for example, it had been observed that the wheeling of the sky turned the constellation of the Great Bear around the Pole Star when observed from the latitude of Greece and carried it below the horizon when observed from Egypt. To Anaximander this observation suggested an ingenious amendment of the Homeric cosmology: the surface of the earth was curved in the north-south direction, that is the flat earth became a cylinder. The Pythagoreans, in their commitment to esthetic values, warped the cylinder into the more "perfect" shape of a sphere. But they also had another set of observations to account for—the shadows cast by the earth upon the moon—and they had sufficient sophistication in geometry to interpret what they saw. In the 3rd Century B.C., with the sphericity of the earth established, Eratosthenes was able to undertake the measurement of its size. He observed that a stick of a measured length stuck upright in the sand Syene, on the upper Nile, cast no shadow at noon on the day of the summer solstice. At the same hour on this day in Alexandria a stick of the same length cast a shadow of a length that showed the sun to be at an angle of 7° 12′ from the vertical at that latitude. From this observation and calculation, plus a sufficiently exact measurement of the distance from Syene to Alexandria supplied by professional runners, Eratosthenes was able to measure the diameter of the earth with an error of only one part in one thousand—within 70 miles of the modern equatorial diameter of 7927 miles.

Measurements of this kind supply the decisive test of knowledge in modern times, and they distinguish much of what we know from the knowledge carried in the heads of our forebears. Most of the knowledge of most of us still comes to us by hearsay. We can take confidence in this kind of knowledge, however, because we know that it rests upon observation and measurement made by experiments that have been repeated more than once; experiments that we ourselves could perform, had we the time, the tools, the wit and the inclination; experiments that we can perform, in any case, in our heads. When we accept the authority of a scientist we do so in the assurance that his peers will expose him if he ventures into fraud.

Though the experiment is thus decisive to knowing, it is the imagination that drives the expansion of knowledge. The act of the imagination that explains the latest experiment and proposes the next one is the creative act in science. By such an act Copernicus placed the sun at the center of the universe. The imaginative quality of this bold stroke is revealed as much in the errors that it contained as in its essential rightness. Moved by esthetic considerations to picture the planetary orbits as circles, Copernicus found it necessary to distort his model of the solar system. He made the sun the center of the earth's orbit, but he had to postulate another point, "K," as the center of the circular orbits of the five other planets, in order to account for their peculiar apparent motion against the background of the stars.

To Kepler, this complication in the Copernican model presented a challenge. He was able to eliminate point K and bring all the planets into revolution around the sun through a recalculation of the data that showed the orbits of the planets to be in varying degrees elliptical. But Kepler was almost as much an astrologer as astronomer. He also undertook to explain the distances between the planets and the sun by boxing their orbits in the succession of five regular solids and later by the no less extravagant notion that the planetary motions obeyed the laws of musical harmony.

Galileo brought this first century of modern astronomy to fruition in his discovery of the universal presence of gravity. In this powerful abstraction he comprehended at once the swinging of a pendulum and the motion of the planets on their orbits. In his *Dialogue on a New Science*, which he wrote in his seventies under house arrest for his advocacy of the Copernican heresy, he describes how he undertook to measure the acceleration of gravity acting at the earth's surface on a falling body. He "diluted" gravity, as he put it, by interposing an inclined plane; he was thus able to measure the slower motion of a rolling, instead of falling, ball. From a critical reading of his account of this experiment, however, historians of science today have developed the strong suspicion that Galileo never really performed it. His results are so perfect that it must have been a thought experiment, performed in his imagination!

In the great world systems of Newton and of Einstein, the imagination bridges the void between the few, isolated and remote corners of the universe that men have taped and measured and brings them into orderly relationship with one another and with regions still unexplored. Engineers who employ these systems and scientists who seek to extend them take assurance from their beauty as well as from their demonstrated power. The Greek esthetic prevails in science. Hypotheses and theories must have the elegance of simplicity and the symmetry that balances equations.

The ultimate contemporary proof of the power of this method of philosophy is, I suppose, our arrival in the Space Age. One may say, at least, that the ideas of Copernicus, Kepler, Galileo and their successors have now been popularized on a scale appropriate to their grandeur. Men have repeated the experiment that placed the moon on orbit and have adorned the sun itself with new satellites.

The triumphs of space technology involve, of course, much else in addition to celestial mechanics. The Promethean theft of Galileo and Newton placed the universal laws of motion at man's disposal on earth. Physics has triumphantly invaded every realm of natural philosophy. The daring ventures into the depths of space now in preparation invoke the deep and diverse knowledge of the nature of matter and the forces of nature, of life processes and even of human perceptions and behavior that no single human mind as yet has comprehended.

A true understanding of science in the Space Age would show that much else is possible. Others have computed the number of universities, of steel mills, dams and acres of irrigated land that could be created by applying a different order of priority to the treasure and talent now lavished upon space ventures—and on the war-making capacity to which they are incidental.

By this tragically round-about reasoning, if by no other, we should at last be able to persuade ourselves that we can make this earth a fit habitation for our species.

We must come to this understanding soon. Our increasing numbers, the progressive wasting of our resources and the overhanging threat of weapons of mass destruction compel us now to come to terms with one another and with our natural environment. There are already eight barren planets on orbit around the sun.