DOCUMENT RESUME

ED 266 029 SE 046 412

TITLE	The Role of the Research Museums. Science Policy Study--Hearings Volume 2. Hearing before the Task Force on Science Policy of the Committee on Science and Technology, House of Representatives, Ninety-Ninth Congress, First Session (April 17, 1985). No. 56.
INSTITUTION	Congress of the U.S., Washington, D.C. House Committee on Science and Technology.
PUB DATE	86
NOTE	177p.; Several pages containing small and light type may not reproduce well. For other volumes in this series, see SE 046 411, SE 046 413, and SE 046 419-420.
PUB TYPE	Legal/Legislative/Regulatory Materials (090)
EDRS PRICE	MF01/PC08 Plus Postage.
DESCRIPTORS	*Exhibits; Hearings; Higher Education; *Institutional Role; *Museums; *Science Education; Sciences; *Scientific Research
IDENTIFIERS	Congress 99th; *Science Policy

ABSTRACT

Various issues related to the role of scientific research at American museums were addressed during these hearings. The hearings include the testimony and prepared statement of Robert McCormick Adams (Secretary, Smithsonian Institution) and questions and answers for the record. These questions focus on such areas as the extent to which museums have dual responsibilities for research and public education, how non-university institutions handle the financial burdens of housing and maintaining newly acquired collections, and how achievements of natural history museums contribute to the public good. Also included is a panel discussion and prepared statements by the panelists representing the Associated Natural Science Institutions: Thomas Peter Bennett; Thomas D. Nicholson; George M. Davis; John E. McCosker; and John W. Fitzpatrick. Appended materials included a science policy report of the American Museum of Natural History and descriptions of the Associated Natural Science Institutions (The Academy of Natural Sciences of Philadelphia, Field Museum of Natural History, The Natural History Museum of Los Angeles County, American Museum of Natural History, and The California Academy of Sciences). (JN)

Science Policy Study—Hearings Volume 2
THE ROLE OF THE RESEARCH MUSEUMS

HEARING

BEFORE THE

TASK FORCE ON SCIENCE POLICY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

FIRST SESSION

APRIL 17, 1985

[No. 56]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE

54-939 O WASHINGTON : 1986

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
GEORGE E BROWN, JR, California
JAMES H SCHEUER, New York
MARILYN LLOYD, Tennessee
TIMOTHY E WIRTH, Colorado
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ROBERT A. YOUNG, Missouri
HAROLD L VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California
MICHAEL A. ANDREWS, Texas
BUDDY MACKAY, Florida **
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G TORRICELLI, New Jersey
FREDERICK C BOUCHER, Virginia
TERRY BRUCE, Illinois
RICHARD H STALLINGS, Idaho
BART GORDON, Tennessee
JAMES A TRAFICANT, JR, Ohio

MANUEL LUJAN, JR, New Mexico *
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, JR, Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
SHERWOOD L BOEHLERT, New York
TOM LEWIS, Florida
DON RITTER, Pennsylvania
SID W. MORRISON, Washington
RON PACKARD, California
JAN MEYERS, Kansas
ROBERT C. SMITH, New Hampshire
PAUL B. HENRY, Michigan
HARRIS W. FAWELL, Illinois
WILLIAM W COBEY, JR., North Carolina
JOE BARTON, Texas
D FRENCH SLAUGHTER, JR, Virginia
DAVID S MONSON, Utah

HAROLD P. HANSON, *Executive Director*
ROBERT C. KETCHAM, *General Counsel*
REGINA A. DAVIS, *Chief Clerk*
JOYCE GROSS FRIEWALD, *Republican Staff Director*

SCIENCE POLICY TASK FORCE

DON FUQUA, Florida, *Chairman*

GEORGE E BROWN, JR, California
TIMOTHY E WIRTH, Colorado
DOUG WALGEN, Pennsylvania
HAROLD L VOLKMER, Missouri
STAN LUNDINE, New York
NORMAN Y MINETA, California
HARRY M. REID, Nevada
FREDERICK C BOUCHER, Virginia
RICHARD H STALLINGS, Idaho

MANUEL LUJAN, JR., New Mexico
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBERNNER, JR., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
SHERWOOD L BOEHLERT, New York
TOM LEWIS, Florida
SID W. MORRISON, Washington
RON PACKARD, California

*Ranking Republican Member.
**Serving on Committee on the Budget for 99th Congress.

CONTENTS

WITNESSES

THE ROLE OF THE RESEARCH MUSEUMS

WEDNESDAY, APRIL 17, 1985

House of Representatives,
Committee on Science and Technology,
Task Force on Science Policy,
Washington, DC.

The task force met, pursuant to notice, at 9:39 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the task force) presiding.

Mr. Fuqua. The task force will come to order.

Today the task force will begin its regular hearings on various aspects of American science policy. During February and March, we conducted a series of minihearings which were held more or less weekly. These were focused on the general topic of the goals and objectives of national science policy, and they served to give us a useful overview and a good preparation for the hearings on the individual, more specific topics which we begin today.

The research activities carried out at American museums are perhaps less well recognized and less clearly understood than research done at universities, in Government laboratories, and in industry. Yet, in certain disciplines, especially in many of the social sciences, museum-based research is highly important.

Such research is frequently based on extensive collections of artifacts which are the reason for the existence of the museums in the first place. The large collections are, however, expensive to develop and maintain. In that sense, they are not unlike other aspects of big science which also require extensive facilities and demand high operating costs.

Collection-based research is undergoing much change, all of which may not be for the better. Some universities are phasing out such research, and that raises questions about the disposition of their collections, about the divorce from graduate education, and about the future supply of scholars in certain fields.

Before we call our first witness, we will place opening statements of any members who so desire into the record at this point.

[The prepared opening statement of Mr. Lujan follows:]

Opening Remarks of Hon. Manuel Lujan, Jr., Science Policy Task Force

Today's meeting on the role of the scientific research museums begins our task force's more formal and directed hearing schedule. Over the past two months, the task force has received overview briefings on the goals and purpose of U.S. science policy from five distinguished individuals. Dr George Pimentel of Berkeley, Dr. Alex Roland of Duke University, Dr John Foster of TRW, Dr. James Wyngaarden of the NIH and Dr Lewis Branscomb of IBM. We owe these individuals a vote of thanks for providing us with both a broad review of past and present U.S. science policy as well as identifying some interesting areas for continuing attention throughout our study.

Our focus today is on one aspect of the U.S. scientific establishment which is familiar to most of us although not necessarily for its unique role in research. The scientific research museums have a distinguished reputation and through their collections contribute to scholarly pursuits in selected fields of science. How their capabilities fit into the overall picture of U.S. research activity is of interest today, as well as the composition of, and future requirements for, financial support of the museums' research programs Also of interest are the procedures which the museums use in selecting which research activities to pursue and how these may differ from those of, for example, the research universities.

I would like to join Chairman Fuqua in welcoming today's witnesses. I look forward to their testimony.

Mr. FUQUA. To discuss these important subjects, we are very fortunate to have with us today a number of distinguished leaders from American research museums. The first of our witnesses is Dr. Robert McCormack Adams, the Secretary of the Smithsonian Institution.

Dr. Adams came to his present position only last September after an outstanding academic career, principally at the University of Chicago. Since coming to Washington, he has expressed a particular interest in the strengthening of the Smithsonian's research activities.

We welcome him to the task force for his discussion on the future role of research museums and the role of the Federal Government in their development. Dr. Adams, we are pleased to have you today.

STATEMENT OF DR. ROBERT McCORMACK ADAMS, THE SECRETARY, THE SMITHSONIAN INSTITUTION, WASHINGTON, DC

Dr ADAMS. Mr. Chairman, it is, of course, a great pleasure to be here. I welcome the opportunity to appear before the Task Force and to participate in your examination of Federal science policy.

I have submitted a somewhat longer statement than I would propose to begin with today before submitting to your questioning.

Mr. FUQUA. We will make the prepared statement at part of the record, and if you wish to summarize, that will be fine.

Dr. ADAMS. Thank you.

I believe that the research enterprise of the United States can be thought of as a house, the foundations of which are securely anchored by the building blocks of scientific inquiry pursued in universities, industrial laboratories, the Federal establishment, and museums.

I do regret, by the way, that the term "museums" does not appear, as far as I can find it, at least, in the initial agenda that was published for the work of the Committee. I think that the museum component is indeed one of the anchors of the foundation of that house.

While the role of museum research is clearly of most interest to you today, my analogy is nonetheless purposeful in stressing the interdependence of these activities. If any of the blocks were allowed to crack or crumble, the essential structure of the entire research house would be weakened and in jeopardy.

It is only recently that I have moved from an academic setting, with which I have been associated for decades, to the Smithsonian, the charter of which commits it to aims similar to those proclaimed in the mottoes of many universities—the increase and diffusion of knowledge. Not unnaturally, I find myself thinking about the distinctive features of museum-based research, especially as it compares with research in universities.

First and most importantly, museums are built around collections. In order for the study of collections to be made meaningful, museums staffs include individuals who are competent in, and who give attention to, the means of classification by which alone those collections can be reduced to intelligible order. Systematics—the proper identification and classification of organisms and their evolutionary and ecological relationships—is essential to museum-derived knowledge.

Second, because systematics research tends to require large collections, museums tend to be preoccupied with collections and their management. On the whole, therefore, museums have been less involved in the laboratory-based or experimental approaches that characterize universities, although this is now changing.

Third, since museum research is collections-based, museums often pursue a different balance of strengths than that which characterizes universities. A single museum with anything approaching the universalistic aspirations of at least a few of the great universities is an absurdity. The Smithsonian probably goes as far in this direction as any institution in the world; and, significantly, it does so by loosely linking together no less than 14 highly diverse, physically as well as professionally, distinct units.

Museum collections, and the exhibits representing them, have many of the qualities of capital investments. Prudently assembled, they can almost endlessly repay further study from viewpoints beyond the imagination of those originally responsible for them. The prudence, of course, is difficult to maintain over time.

The factors I have just mentioned would seem to limit the research effectiveness of museums. But there are other, more positive considerations.

First, the broad, voluntary, and unselected character of a museum's audience somewhat counterbalances the narrowing effects of concentrating on specialized collections. Visitors' questions, not to speak of the prior need to make exhibits intelligible, encourage a dialog reaching far beyond the stratified circles to which most academic faculties confine themselves.

Second, accompanying museums' direct dependence on the public and lack of selectivity with regard to their audience are gratifying opportunities to respond to national needs and problems that are beyond the reach of universities. There are many practical demonstrations that museums offer constructive supplements and alternatives to the deteriorating environment of many ordinary classrooms, and are a means to mobilizing creative effort and accomplishing genuine learning.

Turning more directly to research in museums and its relationship to the seemingly more competitive world of university research, it is worth noting that work in universities is typically tied to the relatively narrow tolerances and priorities of the peer review systems of the national foundations, institutes and endowments; that in museums is less so. Hence, museums are particularly suitable as a base for long-term undertakings, the priorities for which would shift through time as they were perceived in relation to a field of competing proposals at a single moment in time.

Similarly, the tendency within museums for a preoccupation with systematics to lead to isolation and corresponding theoretical weakness, has a matching strength: modern ecological problems underscore the need for more, not less, systematics.

Take what can only be described as an approaching world crisis of tropical deforestation. These forests are biologically the richest of the Earth's environments. A proliferation of species is now being found in them that far exceeds earlier estimates. This suggests that we may need to alter evolutionary views concentrating on the differential survival of variably endowed individuals within a species, and to give greater emphasis to processes of interspecies competition. Fundamental to any such research effort must be a securely established basis of species identification, classification, and relationships, the only source for which today is the great natural history museum collections.

Collections remain the raison d'etre of museums and form a precious resource for science which must be nurtured and maintained. Our knowledge of the natural world derives in large measure from studies of the collections. As new insights and technologies are developed, collections are reexamined and more information is gleaned. Hence, we should not think of collections as stagnant, but rather as dynamic assemblages of the natural world which grow in value over time. The Smithsonian's collection of eggshells has been crucial to understanding the impact of pesticides on the size, growth rates, and sustainable populations of birds, while our fish collections, which date from the 1880's, have provided important evidence of significantly higher concentrations of methyl mercury in fish in the 1970's. Furthermore, in addition to our own scientific staff at the National Museum of Natural History are scientists from organizations such as the Department of Agriculture, the Fish and Wildlife Service, the U.S. Geological Survey, and the National Institutes of Health, who work daily with our collections on issues associated with the missions of their respective agencies.

The collections in American museums have been called a "biological/physical national bureau of standards," the baseline upon which all branches of science can draw. Continuation and fulfillment of this daunting task require sustained financial support to conserve existing collections properly, to acquire new collections, and to provide thoroughly trained personnel with proper equipment for the vital process of documentation. Constant attention must be paid to these efforts so that our stewardship for future generations is not called into question.

Museums overlap with universities, industrial laboratories, and Federal science efforts along the single continuum of research activity in the United States. Doubtless we can find better ways to share tasks or divide responsibilities all along that continuum, so as to improve not only our interaction, but also the overall effectiveness of our combined effort. The first step is to recognize that there is a high degree of complementarity to the entire research enterprise and that all four of its components are necessary if that enterprise as a whole is to meet the increasing demands we are making of it.

Thank you, Mr. Chairman.
[The prepared statement of Dr. Adams follows:]

STATEMENT BY

ROBERT McCORMICK ADAMS

SECRETARY

SMITHSONIAN INSTITUTION

BEFORE THE

TASK FORCE ON SCIENCE POLICY

COMMITTEE ON SCIENCE AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

WASHINGTON, D. C.

APRIL 17, 1985

Thank you, Mr. Chairman.

I appreciate the opportunity to appear before the Task Force today, to participate in your review of Federal science policy, and to talk specifically about museum-based research.

The research enterprise of the United States can be thought of as a house, the foundations of which are securely anchored by the building blocks of scientific inquiry pursued in universities, industrial laboratories, the Federal establishment, and museums. While the role of museum research is clearly of most interest to you today, my analogy is nonetheless purposeful in stressing the interdependence of these activities: if any of the blocks were allowed to crack or crumble, the essential structure of the entire research house would be weakened and in jeopardy.

Beyond the interdependency of and the similarities between the various research sectors in the United States, there are, of course, crucial differences that can usefully be examined and unique roles, such as those performed by museums, to consider. It is only recently that I have moved from an academic setting, with which I have been associated for decades, to the Smithsonian, the charter of which commits it to aims similar to those proclaimed in the mottoes of many universities: the increase and diffusion of knowledge. Not unnaturally, I find myself thinking about the distinctive features of museum-based research, especially as it compares with research in universities.

* First and most importantly, museums are built around <u>collections</u>. In order for the study of collections to be made meaningful, museum staffs include individuals who are competent in, and who give attention to, the means of classification by which alone those collections can be reduced to intelligible order. Systematics - the proper identification and classificiation of organisms and their evolutionary and ecological relationships - is essential to museum-derived knowledge.

* Because systematics research tends to require large collections, museums tend to be preoccupied with collections and their management. On the whole, therefore, museums have been less involved with laboratory-based or experimental approaches, although this is changing. Museums have always emphasized working in the field - the living laboratory - with both observational and manipulative studies. Museum departments of biology are likely to have descriptive titles reflecting the organic character of their collections, basically subdivisions of botany and zoology, even though their research may be theoretical, experimental, and multidisciplinary in thrust. In universities such taxonomic titles have largely disappeared or become more generalized, reflecting subordinate components in a more thematically unified approach to the field at many alternative levels of analysis.

* Since museum research is collections-based, museums often pursue a difference balance of strengths than that which characterizes universities. True, there are some more-or-less

'natural' units, such as perhaps Modern Art or Natural History, within which bodies of method, theory, and data are so widely shared that real eminence is difficult to achieve on a narrower basis. But contrariwise, a single museum with anything approaching the universalistic aspirations of at least a few great universities is an absurdity. The Smithsonian probably goes as far in this direction as any institution in the world, and, significantly, it does so by loosely linking together no less than fourteen highly diverse, physically as well as professionally distinct units.

* Museum collections, and the exhibits representing them, have many of the qualities of capital investments. Prudently assembled, they can almost endlessly repay further study from viewpoints beyond the imagination of those initially responsible for them. But such prudence is difficult to maintain uniformly over a long period of time. And even when it is, the sheer mass and importance of major collections tends to perpetuate existing divisions of specialization and, perhaps, to slow responses to newly opened fields of knowledge.

These factors would seem to limit the research effectiveness of museums, but there are other, more positive considerations:

* First, the broad, voluntary, and un-selected character of a museum's audience somewhat counterbalances the narrowing effects of concentrating on specialized collections. Visitors' questions, not to speak of the prior need to make exhibits intelligible, encourage a dialogue reaching far beyond the stratified circles to which most academic faculties confine

themselves. Museum exhibits, let me emphasize, need not be frozen and didactic. They can genuinely involve at least some members of the public in their improvement and even in their initial design. They can even involve exciting voyages of quasi-research discovery that transform the understanding of those creating them as much as those viewing them.

* Secondly, accompanying museums' direct dependence on the public and lack of selectivity with regard to their audience are gratifying opportunities to respond to national needs and problems that are beyond the reach of universities. Museums must, for example, creatively interpret currently intensified demands for public participation, and for a multitude of individual choices. With a quarter of the annual increase in our population now being a product of massively renewed immigration, museum exhibits must somehow reflect the re-emergence of cultural pluralism. Or consider one of our most serious national problems, growing inadequacy in many districts of provisions for public primary and secondary schooling. Focused particularly on cities, this inadequacy has tended to deprive the most disadvantaged part of our population of real opportunities for literacy of all forms, even as our proclaimed entry into an "Information Age" makes such literacy ever more necessary for their own, and our society's, survival. There are many practical demonstrations that museums offer constructive supplements and alternatives to the deteriorating environment of many ordinary classrooms, as a route to mobilizing creative effort and accomplishing genuine learning.

* Turning more directly to research in museums and its relationship to the seemingly more competitive world of university research, there are some obvious and positive elements that are worth consideration. Work in universities is typically tied to the relatively narrow tolerances and priorities of the peer review systems of the national foundations, institutes, and endowments; that in museums is significantly less so. Hence museums are particularly suitable as a base for long-term or high-risk research projects. The necessarily delayed or uncertain payoffs of such projects cannot correspond to the restrictive terms of granting cycles. They aim instead at slowly cumulative increases in knowledge, or at going beyond safe bets to test unpopular ideas that, if correct, would have important consequences. I am proud to include the Smithsonian among the museums that at times have quite consciously taken this last approach.

* Similarly, the tendency within museums for a preoccupation with systematics and descriptive approaches to lead to isolation and corresponding theoretical weakness, has a matching strength: modern ecological problems underscore the need for more, not less, systematics. Take what can only be described as an approaching world-crisis of tropical deforestation. These forests are biologically the richest of the earth's environments. A proliferation of species is now being found in them that far exceeds earlier estimates. This suggests that we may need to alter evolutionary views concentrating on the differential survival of variably endowed individuals within a species, and to

give greater emphasis to processes of inter-species competition. But fundamental to any such research effort must be a securely established basis of species identification, classification, and relationships. And the only source for that today is to be found in the great natural history museum collections.

While an unfortunate public perception of museums as large, dimly-lit buildings where researchers hunch over lab benches examining microscopic details of insects, fish, or skeletal remains may, indeed, persist, the fact is that today there is a new breed of museum researchers who are trained in modern methods of science and take an interdisciplinary view of the natural world. Systematics is certainly the root of this endeavor. Moreover, it is no longer an end in itself, but rather a starting point for the substantiation of modern ecological principles and evolutionary theory.

Collections remain the raison d'etre of museums and form a precious resource for science which must be nurtured and maintained. Our knowledge of the natural world derives in large measure from studies of the collections. As new insights and technologies are developed, collections are re-examined and more information is gleaned. Hence, we should not think of collections as stagnant, but rather as dynamic assemblages of the natural world which grow in value over time. The Smithsonian's collection of egg shells has been crucial to understanding the impact of pesticides on the size, growth rates, and sustainable [illegible] of birds, while our fish collection, which dates from [illegible] importa[illegible] significantly higher concentrations of methyl mercury in fish in the 1970s. It is worth noting here that, in addition to our own scientific staff, also assigned to the National Museum of Natural History are scientists from organizations such as the Department of Agriciulture, the Fish and Wildlife Service, the U. S. Geological Survey, the National Marine Fisheries Service, and the National Institutes of Health who work daily with the collections on issues associated with the missions and goals of their representative agencies.

Increasingly museum efforts have taken on an applied bent. Many of the Smithsonian's marine biologists at the National Museum of Natural History and its field stations in Belize and the eastern Caribbean are working on the ecosystems of coral reefs and on the primary productivity of the oceans. This research offers the possibility of developing renewable resources and sustainable yields to meet the economic and nutritional needs of the people of that region. As another example, one of the Museum's botantists has provided critical pollen analysis to assistant in answering questions about the composition and origin of yellow rain in Southeast Asia.

Across the Mall at our National Air and Space Museum the System Disc Retrieval (SDR) was developed to meet the problem of compact information storage. Applicable far beyond the museum field, it is a wonderful example of the synergy of museum and industrial research.

Obviously I can only deal with the constraints and opportunities that museums offer for research in the most general terms. There are important differences from subject area to subject area, as well as from institution to institution. However, I would like to share with you a final example from my own discipline. Evolving standards and traditions of inquiry in anthropology and archaeology are leading them away from concentrating on the formal, macroscopically observable properties of individual objects. The science moves instead toward the internal properties, contexts, and associations of objects in collections -- features that will never be evident to the casual museum visitor. Context, in particular, is of critical importance. This explains why archaeologists have taken leadership in efforts to prevent the illicit international movement and sale of antiquities, since that traffic, by its nature, conceals or destroys information on context.

Scientific advance in this area involves steadily improving precision in recording and interpreting temporal and spatial associations and modes of deposition or preservation. Manufacturing debris may be at least as important as the object itself. A used and broken specimen may permit dimensions of understanding that a perfect, unused specimen cannot. A poor copy or duplicate, of little interest to an art historian, may provide vital clues to the ways in which commodities were produced and circulated. Physico-chemical analysis can reveal sources of raw materials, modes of preparation and patterns of use. All of these details are frankly more significant as scholarly objectives than the display of the object itself. Exhibits become correspondingly more difficult to explain and mount, and attention shifts from individual works of art or craftsmanship to the representation of entire social systems in large, carefully sampled, collections of which little will ever go on exhibit.

The collections in American museums have been called a "biological/physical national bureau of standards," the baseline upon which all branches of science can draw. Continuation and fulfillment of this daunting task require sustained financial support to conserve existing collections properly, to acquire new collections, and to provide thoroughly trained personnel with proper equipment for the vital process of documentation. Constant attention must be paid to these efforts so that our stewardship for future generations is not called into question.

Museums are sister institutions to universities in the enhancement and communication of knowledge. They both overlap extensively with the industrial laboratories and the Federal science efforts along the single continuum of research activity in the United States. Doubtless we can find better ways to share [illegible] responsibilities all along that continuum, so as to improve not only our interaction, but also the overall effectiveness of our combined efforts. The first step is to [illegible] there is a high degree of complementarity, to [illegible] all four of its components [illegible] necessary [illegible] the [illegible]

DISCUSSION

Mr. FUQUA. Thank you very much, Dr. Adams.

I recall that one evening I was going into the Smithsonian Museum of Natural History to visit with some scientists there and to speak with them, and they carried me back through the stacks of all the botany collections that they had, particularly some of the leaves.

I was very interested. Many of them went back several decades. I was very interested at that time in what change had developed in the same species of leaves in different parts of the world, and there had been some changes—they were explained to me—but a very good baseline to begin to understand over a long period of time, and I think it is very fundamental to the things that we are all interested in, whether it is crossbreeding that was taking place, or the effects of the environment, or weather conditions or whatever that may have caused that, which leads me to a question. How do you see a payoff back to the public in museum-type research versus the more university-oriented research?

Dr. ADAMS. Well, I spoke of the mission-oriented agencies who already are working, and have for many years worked, side by side with the staff of the Smithsonian, directly employing the Smithsonian collections. I think that is a fine illustration of what the payoffs are.

If one is concerned with the damage that is done to this country's agricultural output from various kinds of infestations, be it boll weevils or Mediterranean fruit flies or whatever, one has to deal fundamentally with that insect population, and one has to work with the systematic collections that are available only in the Smithsonian and a few other of the great natural history museums in order to make those identifications.

Moreover, this is not a problem that can be confined to the continental United States. Unfortunately, bugs don't observe international frontiers, and the truth of the matter is that most of the serious crop pests that we have encountered are tropical in origin. One needs to have going right along with the work on problems within the United States a more fundamental study of the nature of the insect populations of the great tropical regions to our south.

Mr. FUQUA. By the way, in your beginning remarks, you mentioned that the word "museum" did not appear in our task force. That will be corrected in our final report, I can assure you.

Dr. ADAMS. Thank you.

Mr. FUQUA. It was not an intentional oversight.

How have the changes in Federal policy toward science in recent years affected the museum research, if at all?

Dr. ADAMS. Mr. Chairman, my impression is that changes in Federal science policy have not been primarily directed at museums and have not primarily affected them.

My own association with the Smithsonian is recent enough that I am not sure I have a long-term view that would be accurate on that point, and I probably should refrain from going further.

Museums obviously have, for the most part, been able to benefit from the growth in research funding in the national foundations. I might say that that does not apply to the Smithsonian, which is not able to draw on funds from the national foundations under ordinary circumstances. But certainly, for the museums which have been the beneficiaries of research funding coming from that source, my impression is that they have benefited less from it than have the universities, but there certainly has been some benefit from that source.

Mr. FUQUA. How could we make it better? How could we get better research looking at it from our perspective for the public good, by what programs for supporting or helping or fostering basic research in museums?

Dr. ADAMS. My impression would be that the most serious problem is one that requires national recognition of the importance of those systematic collections. Whether this needs to be involved in legislation, I am not clear.

I think that if one looks across the country at the tendency in recent years for people who would have been trained in systematic fields to move into other aspects of biology, for example, priorities have been given to the field of biology at the cellular, and molecular, and genetic level which obviously have seen enormous explosive breakthroughs that are of great importance, but that somehow there hasn't been recognition of the need to maintain balanced strength across all of biology, and that the most critical thing would be to reestablish that sense of balancing our priorities. Whether this calls for legislation, I am not clear.

Mr. FUQUA. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

One of the principal areas where you have shown an interest in your science policy studies, particularly at the museum, is in areas where you have blended private funding with public funding. Would you describe for us the general funding mechanism of the institution, and particularly break it down into public and private funding and where those come from?

Dr. ADAMS. The Smithsonian budget is composed of a primary component in the form of appropriated Federal funds amounting to about two-thirds of the annual Smithsonian budget. The other third is from private sources and is composed of a number of elements.

It would include income from funds that have been given to form the Smithsonian endowment. It would include income from a number of the Smithsonian's private enterprises, the magazine *Smithsonian,* the stores that are operated in our museums, the sale of books and other objects by mail, by catalogue. It also includes private grants and contracts from private foundations for carrying on research.

There is also a component of support from Federal foundations in some areas as, for example, in areas where collections are of critical importance and where that has been recognized.

Mr. PACKARD. Is there very much of your funding that is targeted to specific projects or research activities?

Dr. ADAMS. There is some, both on the private side and the Federal side. I think there probably will be more if I look at the way our budgets are developing.

I think there is considerable interest in the Congress and, I might add, also, in our own museums, in developing project areas that can be specifically identified, and described and in trying to introduce these as line items in the Federal budget or as items to attract private funding just as well. I think this is a way, in fact, of making the museum research more accountable in the sense that the descriptions of it become a matter of public record.

Mr. PACKARD. In your testimony, you mentioned that you have seen a shift from simply collecting artifacts and museum pieces to more of a research-oriented structure. Would you elaborate on that and describe not only how you have seen that transition taken but whether you see it increasing in the future? Will a greater portion of your moneys go toward research and so forth?

Dr. ADAMS. I can illustrate that in a number of ways, but let me begin by saying that collections themselves consisting of individual plant specimens, or animal, or insect, or fish specimens, as the case may be, were the initial form that museum collections took, more or less as they were haphazardly brought in by volunteers or by people sent out from museums. The complexities of the material collected have been more and more widely recognized, and it is now understood that you need specimens at different stages of growth, for example, or under different conditions of diet. You need field observations that associate the behavior of specimens with the physiological characteristics if you are fully to understand the patterns of difference between them. The result of all of this has been that the amount of field work connected with the collecting of really useful materials for identification and to serve as standards for future classification has steadily increased.

The Assistant Secretary for Science of the Smithsonian Institution, Dr. David Challiner, who is with me today, made the observation to me last week that there were more of the Smithsonian research scientists who were concerned with collections who were now involved with field work than at any time in the past, and I think that certainly has been one important change. Another has been that one has to deal increasingly with aspects of microstructure, with features which are determinant of genetic and evolutionary differences that can only be observed with electron microscopes. Or, again, important studies that have come out of molecular biology and that involve the differentiation of species as measured by differences in proteins require laboratory facilities on a much more extensive scale than would have been the case in the past.

I think it is precisely the growing complexity of the subject that drives us in the direction both of more extensive laboratory work and more extensive field work, and I think that is a trend which is understandable if you look at the way in which biology has developed over the last generation or so, and one has to anticipate that will continue in the future.

Mr. PACKARD. One of the misconceptions that many Americans, myself included before I came here, have of the Smithsonian is that it is Washington-based, and most of the facilities are what you see down in the, old Smithsonian Institution. I don't know the figures, but I think you have literally hundreds of buildings and facilities throughout the country and buildings throughout the Washington area besides this concentrated area. Are the research aspects concentrated here in the hub of what most people perceive as being the Smithsonian Institution, or do you find that it has branched out into all of your facilities?

Dr. ADAMS. Well, in fact, the research is carried on all over the world. We have done a recent tabulation of the current work of the Smithsonian, and we find that there are activities underway in something like 113 countries There are research bases in many of those cases, although they may consist of no more than rented facilities or quite temporary facilities. On the other hand, we do have a major research base for the pursuit of studies in tropical marine and terrestrial biology in Panama, a very important installation called the Smithsonian Tropical Research Institute.

Dr. PACKARD. Do some of the foreign countries support and assist in the funding, private funding, of your research?

Mr. ADAMS. There is no case known to me at the moment in which we have direct assistance from foreign countries in funding, but we have many forms of important collaboration that have in fact financial value, have real financial value in terms of availability of land and other such considerations, that operate very widely. And certainly we are very closely involved with foreign scientists in many of these cases.

But the further point I want to make is that while the greater number of the Smithsonian research staff are primarily located here in Washington, they are carrying on field work, they are going overseas for their field work, into many other countries as well, so that one has to look at their pattern of activity and not simply their place of permanent residence.

Mr. PACKARD. Thank you very much.

Mr. BROWN [acting chairman]. Thank you.

Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman.

Dr. Adams, that is certainly a different picture of museums than I have always had. As a matter of fact, you mentioned that, unfortunately, the public perception is dimly lit buildings where researchers hunch over laboratories examining microscopic details of insects and that sort of thing. I didn't even know they did that. You know, my impression of a museum is you go there to see some valuable paintings or old bones, and out West we have covered wagons, and wheels, and those kinds of things, and indeed, perhaps the capsule from an Apollo flight.

What do you do besides show us those things that were prominent in history? You have mentioned the marine biology research that you do. What other kinds of research is the Smithsonian involved in?

Dr. ADAMS. Well, let me take a slight aside, if I may, Mr. Lujan, before coming to what I think is the thrust of your question.

Take the question of our insect collections. There is really only a very small corner of the Smithsonian that is devoted to insects. There is a living zoo that you will find in the Natural History Museum. They don't lend themselves well to public exhibit; most of them are just too small.

The Smithsonian insect collection numbers on the order of 30 million specimens. It is comparable only to the collection of the British Museum. It needs to be that large to serve as the standard of reference that can in fact be used by people who are either concerned with the fundamental science of insects or evolution or who are concerned with various kinds of mission-oriented problems that are connected with insects. So here is a vast collection which is not at all seen by the public. This is a case where the tip of the iceberg is indeed a very, very small, small tip.

But I might go on further to say that, large as that collection is, it doesn't begin to approach the adequacy that people in the field now believe will be necessary as our understanding has grown about the number of different species of insects there are in the world. That number is now estimated to be on the order of 30 million, and I can tell you that our collections do not include only one example of each insect.

Mr. LUJAN. Well, I will look at museums a lot differently now. You know, when I go to an aquarium or something like that and some fish glow in the dark, I think, "How pretty," you know, and walk away from it.

Dr. ADAMS. Let me shift to the more general thrust of your question.

I haven't even mentioned an area of very important Smithsonian work and one that comes more directly to the question of some of your old wagon wheels and so on. Conservation is a rapidly expanding field where much more is possible; much more is understood than was true some years ago. The Smithsonian has a Conservation Analytical Laboratory where fundamental work is going on on how to conserve our specimens that otherwise might very well continue to deteriorate even while they are being kept. So very important work needs to go forward on the conservation of paper, and textiles, and ancient metals, and many other materials which are subject to continuing deterioration under museum auspices, which obviously we would like very much to avoid. That would be another example of an area where there simply must be further work if we are to keep what we have.

Mr. LUJAN. To digress from that area of it, you mentioned statements about the international cooperation and those sorts of things. I know that in other areas which we have jurisdiction over, international cooperation is becoming even more and more important, one, because of the budget constraints in our other committees, and in fusion work, and space work, we are looking for moneys from other countries.

But beyond that, there is kind of a welding together of our allies and our adversaries, as a matter of fact. That could be, it seems to me, a natural, the type of work that you do and the international Smithsonian has, that everybody would be falling all over themselves to do some cooperative work with the Smithsonian. Is that a heavy thrust on the part of the Smithsonian to bring in other nations to share in that research, perhaps not just from a financial standpoint but from the standpoint of solidification or breakthroughs?

One of the things that I am thinking of, for example, in the space business, we sit in Geneva talking about arms control, and while that may seem way off over there, the big question is verification and inspection. Yet when the Soviets decide to go into the commercial satellite business, the companies say, "Hey, we've got to get in there and make sure what you're putting into that satellite, that it is launched properly, all of those things," and the Soviets are saying, "Sure, you can come in"—probably the first breakthrough into inspection.

That is why I view this whole international cooperation as really a plus beyond just the monetary. My question is: Is there a big push on the part of the Smithsonian, a sustained push, to bring other nations in to share in that research?

Dr. ADAMS. Mr. Lujan, I think I could fairly say that the general orientation you have just described is the one that primarily led me to take this position and come to Washington. It is precisely that aspect of the Smithsonian's potential and of what I see as the growing need for world cooperation in science that led me to come here. Let me briefly illustrate with two further projects that are currently underway. First of all, we have studies underway through the Air and Space Museum in West Africa on processes of desertification that involve the use of the Landsat space imagery for checking the progress of desertification and steps that are taken to try to hold this in check. Those studies inevitably open up possibilities for land management that would never be recognized by the countries in question and which they could never become familiar with except through access to our specialists, our technology, working directly with them in the field. I think it is an important world problem, and it is one to which we can make a real contribution and are now trying to do so.

Take another one which illustrates the complexity of international patterns that frequently crop up. We have had a study underway in Panama for some time now on the variability of species within test plots of tropical rain forests. We find in Panama that something on the order of 50 percent more species will occur within a single half square kilometer of trees than occur in all of the Eastern United States. That raises all kinds of questions about the ecology of a tropical rain forest that are not well understood. Now studies have begun in Malaysia, on the other side of the world, which carry that much further still and illustrate perhaps twice as many species occurring in test plots over there.

Clearly, one needs to have some framework in which people who are working on problems of tropical biology, for example, are able to come together, whether they are dealing with the Amazon or whether they are dealing with Southeast Asia or whatever, and we believe that the Smithsonian offers one of the sort of rare institutional opportunities in the world for bringing people together who are working on problems of this kind and allowing them to check their findings with one another, to become cognizant of differences in method and differences in theory, quite possibly to have access to more advanced equipment than they would in their own countries.

I think all those things are within reach, and I think all of them are more likely to proceed from a museum base than they will from any other base.

Mr. LUJAN. Very good. Thank you very much.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Brown?

Mr. BROWN. Dr. Adams, I would like to add my voice to the welcome I am sure the chairman has already given you. I do not think you have been before the Science and Technology Committee before, and you may have more opportunities in the future. It is a great pleasure to see you here and to recognize that you are starting out on a career which I hope will last as long as your predecessor's and make as large a contribution to the progress of our Nation.

Of course, he sometimes ran into trouble because his scientific interests took him to far fields. You are not still interested in Middle Eastern archeology, are you? [Laughter.]

Dr. ADAMS. I would say that if conditions reemerged in that part of the world that permitted me to do some further work, I would certainly try to do so. They do not show much sign of helping me along in the near term.

Mr. BROWN. I particularly appreciate your emphasis upon the research capabilities and contribution of the natural science museums. I think, of course, that we have to keep in perspective that that is only a part of the overall role of the museums; that in addition to the natural science, you have the art, the history, the various other things which fall within different purviews in science strictly.

I don't think this committee has really fully appreciated that large research contribution that you make. I hope—and I am sure it will—that your presentation this morning will help to change that.

I want to raise just one question. Generally speaking, in the previous concerns of this committee, we have looked upon the natural science museums as a part of our process of public education in science. We have seen that role as being an extremely important role. To some degree, we have funded that through the National Science Foundation.

I am interested in having you comment about that role and the degree to which, in addition to the education that occurs when the public goes through the museums and sees and thinks about the material there, if you have considered a somewhat broader role comparable, we will say, to what a university does when it engages in teaching and publication, or in the land-grant college systems which we are familiar with, where you have teaching, publication, extension, in which the effort is made to take the results of the research out to the public.

I would like to have you comment on that because it has not—I have not perceived that the natural science museums or museums in general have put as much emphasis on that as they might, and if we are looking at a rapidly changing society in which science is more and more important, and in which a scientifically literate public is more and more important, then I think we have to use every resource to attain that literacy. The museums, I have always felt, are a very important part of that mechanism of public education.

Dr. ADAMS. I think I would share those sentiments completely, Mr. Brown. First, with regard to the educational component at the level of future specialist, which is only one component of your question, I should say that this has been for many years held by the Smithsonian as one of its very important functions.

We do support predoctoral fellows, postdoctoral fellows, people coming in as interns while still in the course of their college careers, I might say with a special emphasis on identifying minority interns.

We do regard that as a very important part of the program of research that the Smithsonian carries on. That has been growing in recent years, and I think it will continue to grow.

Research is, frankly, best done with a mix of individuals. Some research, of course, will always go on by single investigators, but much of it is best done with a mix in which there may be a senior investigator and several assistants or people collaborating from different fields coming in for varying lengths of time to learn new skills that they will add to their repertoire when they go back to their home universities.

So that is an area where the Smithsonian has already been very active and will do more. I might say we have done most of it with private funding rather than with Federal funding.

With regard to the outreach question, I think it might be a fair criticism that we haven't done as much with traveling exhibits that were drawn from our scientific materials as we should, although there have been a number that were prepared by the Air and Space Museum. That may very well be an area where we should do more.

There is a major activity of the Smithsonian called the traveling exhibit service, which at any one time will have more than 100 exhibits moving around the country, moving in response to requests by other museums for loan exhibits for varying periods of time. It is true, as I say, that not enough of those probably have been connected with the field of science education.

I might say that the Smithsonian is now making steps toward the very early development of a joint program with the National Academy of Sciences in the field of science education, so this is something that we propose to become very active in within the near future.

Mr. BROWN. Well, I hope you will. It is a very important function but, of course, one which you have to keep in proper balance.

I think we have kept you long enough this morning, Dr. Adams. We appreciate your being here very much and look forward to future opportunities.

Mr. LUJAN. Thank you very much Dr. Adams.

Dr. ADAMS. Thank you.

[Answers to questions asked of Dr. Adams follow:]

SMITHSONIAN INSTITUTION
Washington, D.C. 20560
U.S.A.

October 17, 1985

Honorable Don Fuqua
Chairman
Committee on Science and Technology
U. S. House of Representatives
Washington. D. C. 20515

Dear Mr. Chairman:

Thank you very much for your letter of September 17 and for the opportunity to provide additional information on science in museums.

In developing the enclosed responses to your questions I have had the benefit of considerable insight and assistance from my colleagues at the Smithsonian's National Museum of Natural History. They and I will be glad to be of whatever additional service we can to you, the Task Force, and the Committee.

Sincerely,

Robert McC. Adams
Secretary

Enclosures

Question 1

1.1 How have the research contributions of natural history museums changed since World War II?

Natural history museums, as scientific institutions at large, have undergone a virtual revolution since World War II, making unprecedented growth with quantum jumps in the size and diversity of staff and in the scale and scope of programs. The result has been a major revitalization of traditional research disciplines and the birth and rapid development of a whole new array of scientific enquiries and applications. In general, the museums have been driven by the same forces that have been driving the universities, not only because both are dealing with the same ultimate questions but also because the museum scientists and technical staff have been trained almost exclusively by the universities.

Museum budgets, even allowing for inflation, have grown dramatically in the post-World War II years. The scientific staffs are much better trained and more professional. In the past it was fairly typical for curators to come up through the museum ranks as apprentices, often without ever obtaining post-graduate degrees. This trend has died out rapidly since World War II, and today scientists and other scholars rarely are hired by museums if they do not already possess a doctorate. Furthermore, the level of education of the technical support staff has been rising steadily. Today many hold a bachelor's degree, and masters' and doctors' degrees are becoming more common. Scientific and technical staff specialization has grown enormously as well, until today's natural history museum is a complex, university-like research organization that is a far cry from the museums of the past. Because of the growth and diversification of support staffs, museum scientists have been freed from much routine curation and are able to concentrate on research.

The consequence of all of this growth and change has been great change in quantity, quality, and character of scientific research output.

Biological research by museum scientists has undergone an historic shift in emphasis away from a purely descriptive approach focussed largely on the taxonomy (identification, description, nomenclature, classification) of organisms, to a much more dynamic, evolutionary approach, concerned with biological systematics in the broadest sense, which goes beyond description and classification and attempts to explain the origin and evolution of the diversity of life on earth by tracing the history of lineages (phylogenetic systematics) and elucidating relationships among modern organisms. Since 1945, systematics research has branched out greatly to incorporate ecological, biogeographical, behavioral, ultrastructural, cytological, genetic, functional, and many other perspectives and methodological approaches. Indeed, the whole evolutionary framework of modern biology is a product in large part of research in natural history museums since World War II, with such museum-associated influential biologists as Niles Eldredge, Stephen J. Gould, Willi Hennig, Ernst Mayr, Peter H. Raven, George Gaylord Simpson, and Edward O. Wilson leading the way.

Museums have been a major source of innovation and creativity in paleobiology since World War II. Such major contributors as George Gaylord Simpson have not sought inspiration from the university but rather the universities have sought inspiration from them.

The field of anthropology has witnessed a growing awareness of the importance of museum objects, both for basic and applied research. Today, anthropological collections are being studied by more scientists, both from inside and from outside museums, than in 1945.

Museum-based meteorite research has entered a much more interpretative era, leading to a much broader and deeper understanding of our planetary system. In 1945, meteorites were a small side issue. Now meteorite research, which depends on museum collections, is mainstream planetary science. Meteorites provided crucial background data for lunar rock studies prior to the lunar landings. Meteorites and lunar rocks together have increased greatly our understanding of the planetary system and have made some old ideas untenable.

Research methods also have undergone radical changes since 1945. There has been enormous growth in interdisciplinary studies and large collaborative projects, as in planetary science or in studying ecological and evolutionary relationships. Collaboration also has been crucial in large oceanographic and terrestrial surveys of faunas and floras and in ecosystem research. At the Smithsonian, for example, the pacesetting Caribbean Coral Reef Ecosystem program would be impossible without wide, interdisciplinary collaboration.

The explosive postwar growth of civilian air travel has greatly expanded opportunities for fieldwork, especially abroad. As a result, natural history museums have broadened their geographic scope greatly, and today a much larger proportion of research is actually conducted in the field than in 1945. In many cases, it no longer is considered acceptable to base a study entirely on preserved specimens. The major consequence of easy, relatively inexpensive travel has been the large expansion of research in the tropics.

World War II triggered a revolution in technology that continues to revolutionize research in natural history museums as everywhere. SCUBA diving, deep-sea submersibles, underwater photography, electron microscopy, aerial photography, color photography, advanced light microscopy, molecular biology, and computer technology, especially the recent advent of the personal computer and word processor---these are some of the numerous important technological advances during the postwar period that have continued to have a profound effect on research in natural science museums. High technology has come to museums in a big way. Computers have opened vast new opportunities for analysis and data storage and retrieval. The Scanning Electron Microscope has revolutionized the study of morphology and structure, bringing a whole new dimension to virtually every area of collection-based research. Because of such new technology, we now can learn more from our existing collections than ever before, and most collection-based fields of research have been rejuvenated repeatedly by technological advances since 1945.

Thanks to computers and the rapid development of methods of quantitative and statistical analysis since World War II, today's research is far more quantitative than in the past.

In sum, research in natural history museums today is vastly more complicated and specialized than before World War II, and most museum scientists are highly trained specialists.

Finally, natural history museums have undergone significant changes in research philosophy and perspective. Of particular note is the shift toward much greater concern for the value and relevance of the research contributions. Most striking is the blossoming of a conservation conscience. Ever-increasing concern for the environment has led to ever-greater involvement by museum scientists in research related to habitats and biotas threatened with destruction and specie threatened with extinction. Concern for the tropics, especially the rapidly disappearing tropical rainforests, has reached the proportion of a scientific crusade.

1.2 In what direction are they now headed?

In general, natural history museums are not likely to see any dramatic shift in direction in the foreseeable future but are likely to continue to intensify and sharpen the trends already underway as described in 1.1. As always, basic research will be emphasized, but increasingly, attention will be given to the relevance and practical applications of the research, especially in a world of disappearing habitats and species. Working with limited budgets, museums will struggle to keep abreast of current technology and methodology.

Natural history museums, vis-a-vis universities, are fast becoming the keepers of knowledge about the biota—plants and animals—of the earth. They will be the primary centers of the future for the study of biological diversity. With their large collections and their taxonomic specialists who study whole organisms, they alone will have the documentation and the expertise to deal with the many kinds of plants and animals in the world.

Overwhelmingly, the basic biological research will focus on the tropics and on reconstructing evolutionary history. There will be more vigorous efforts to explore; to conduct biotic surveys and inventories; to record and document habitats and species; and to save voucher specimens of the biota and samples of natural phenomena. Organismic biology will continue to be the main focus, but increasing attention will be given to evolutionary and ecological relationships and processes in order to develop a deeper understanding of the world's ecosystems and global environmental problems.

Anthropology scholars will use museum collections to locate specimens among them that are sufficiently well documented in time and space as to become markers for studies of past events and conditions. In physical anthropology, sample size and documentation are emerging as most important criteria for research. Overall, however, anthropological research will continue to deal broadly with cultural diversity and change, much as biological diversity is being studied.

Multidisciplinary and collaborative approaches and projects are sure to increase. The use of biochemical methods to study evolutionary biology clearly is growing.

Museums, by virtue of their need to handle large collections and other data bases, will make major contributions to the development of tools and methods for data management and use.

In the final analysis, natural history museum research will continue to be distinctive primarily because it is collection-based. This feature is, indeed, the sine qua non of a museum as compared to a university. If there will be any threat to museums such as ours, it will be the perennial temptation to succumb to the fads and bandwagon fields constantly being spawned in universities, where they have important short-term, if not also long-term, teaching value. There also will be the risk of placing too much emphasis on popular subjects, rediscovery, and practical applications.

In the realm of applied research, natural history museums will face ever-growing demands to serve as identification centers for ecological and environmental studies and to produce basic identification manuals for scientific and lay users. Indeed, as public awareness of the natural world and its problems grows, there is an ever-greater demand for authoritative popular pubications on plants and animals. Museums can be expected to be called upon to meet these needs more and more in the future as, increasingly, they become the last strongholds for organismic biology.

1.3 In your view, have the contributions of museums to basic research climbed or fallen off since 1945?

Without question, the contributions of natural history museums have increased greatly and steadily across the board since 1945, at least in absolute number. Given the explosive expansion of universities in the post-World War II period, it is difficult to say whether museum contributions have increased in relative number. Furthermore, the relative importance of a body of scientific contributions must be judged in the context of the state of the science overall at the time when the contributions were made. Viewed in these terms, it is difficult to judge the relative importance of today's greater number of contributions as compared with the relative importance of museum contributions in 1945. Surely one must conclude, however, that museum contributions to our knowledge of biological diversity are ever climbing in relative significance, as more and more universities largely forsake organismic biology.

Growth in museum contributions stems from two causes. First, staff and program size has expanded greatly, as already detailed, because of improved funding that has derived from an increasingly greater national public awareness of worldwide technological advances and from general public concern about threats to habitats and biotas and the need for environmental protection. The advent of household television and many excellent series on nature has had a profound influence on the public mind, and this in turn has placed new pressures on natural history museums. The concerns arising from this awareness have been responsible for the major thrust in studying endangered species shared by many museums. The Smithsonian, for example, played a key role in getting efforts started to study endangered plant species.

Second, the increasing professionalism of museum scientific staffs since 1945 has put museum scientists into much more direct competition with university scientists. This has placed increasing emphasis on publication, so that today's museum scientist lives more or less by the same "publish-or-perish" rule that long has governed university scientists. As a consequence of publication pressures, the quantity and rate of publication from natural history museums has been on a steady rise.

An unfortunate side effect is that the pressures of publication have a tendency to discourage the substantial, long-term monographic research efforts that are the hallmark of good collection-based studies in favor of the short, fast publications that can be produced more easily in university laboratories. The rise of the grant system in science also has tended to force researchers to look for fast results and to publish shorter papers more often.

1.4 How can this be accounted for?

The growth of museum contributions to basic research since 1945 can be attributed to a number of factors. Principally, it is due to steady staff and program expansion that has come about for a variety of reasons. To a large extent, perhaps, research in museums has been the beneficiary of the general expansion of federal funding for research in the postwar years, spurred by such extrinsic forces as the launching of "Sputnik" and the establishment of the National Science Foundation. The explosive growth of concern about the environment, triggered initially by such ecological disasters as the spread of DDT in the food chain, also has brought a clamor for more ecological research. Museums have played direct roles in solving many of these problems, as in studying the impact of DDT on the thickness of shells in bird-egg collections or in assaying mercury content in the flesh of fish collected long before the "mercury scare" in the tuna industry. Thus, museums have often demonstrated their direct benefit, and this has enhanced their ability to increase their budgets. The public now often makes a direct connection between environmental problems and the value of museum collections and research.

Advances in technology and instrumentation also have had a large bearing on the increase of museum productivity, as already discussed.

Public awareness of museums generally is higher by many orders of magnitude today than in 1945. The Smithsonian's National Museum of Natural History now attracts about 6 million visitors a year, and its public educational activities are at an all-time high. All of this interest translates into more public understanding and support, which in turn affects federal financing positively.

Finally, a not insignificant factor is the much higher professionalism of today's museum scientists and supporting staffs. The gradual introduction of the university "publish-or-perish" value system has had a dramatic effect on attitude and productivity. Freed from many of their former curatorial duties by highly professional support staff, today's curators are more scientist and less curator than they were in 1945. Much of this change has come about in the last 20 years. Furthermore, with museum scientists mingling far more today with their university peers in their disciplines, peer pressure has pushed productivity up. Added to this is the general use now in museums of promotion evaluation systems based largely on publication of original research.

Question 2

2.1 What areas of science seem most promising from the perspective of the research museum?

All areas of science within the scope of the research museum are appropriate, and certainly research should continue in today's areas of strength. Although collection-based fields should continue to dominate, especially as more and more universities divest themselves of collections and collection-based researchers, such areas as cultural anthropology should continue to benefit from the perspectives of scholars in museums. Any research requiring collections of preservable specimens or objects and high-level curation along with modern scientific description and classification must be done in museums, whether free-standing or associated with universities. Some of the many museum disciplines that will always be specimen-dependent are evolutionary biology and biological systematics, biogeography, conservation biology, physical anthropology, some fields of cultural anthropology, paleontology, meteorite studies, volcanology, mineralogy, petrology, and sedimentology.

In the broadest terms, the perspectives of the research natural history museum can be summarized as centering on the concern for a threatened biosphere. Increasingly, museums will have to themselves the task of salvaging primary information on the diversity, evolution, and adaptation of the world's biota and of its disappearing cultures. Museum repositories will serve not only museum scholars but scholars everywhere who will need samples of natural biological or cultural diversity from time and space that they could not themselves ever have assembled.

Museums must play an even larger role in discovering and assessing the earth's natural resources before it is too late and in guiding the protection and wise use of these resources. Researchers in museums possess special expertise and insights on these resources. Biological inventories and baseline ecological and evolutionary studies will be needed on an ever larger scale.

The museum should continue to provide the environment for stable support for long-term studies and large, multi-disciplinary collaborative projects that traditionally have been difficult to sustain in the university environment where research is conducted mainly in short, grant-supported bursts. Museums also are best suited for supporting the extensive fieldwork that is essential to the study of natural systems, and for maintaining the collections and other data bases needed for long-term studies, such as the Smithsonian's Volcano Reference File.

Among the many priorities for the future that museum biologists might name, none ranks higher than the study of tropical biotas and ecosystems. A crisis mood exists, calling for fast measures to study--and if at all possible stem--the catastrophic disappearance of tropical ecosystems and their plants and animals before it is too late. This will require fast work just to do the elementary tasks of discovering and describing the unknown species. First priority should be placed on threatened or endangered floras and faunas. Even in such well-known parts of the world as temperate North America, however, there is an urgent need for a continental survey of the fauna and flora, which is why our National Museum of Natural History has begun to project a National Biological Survey as one of its priorities for future research support.

Museum biologists also find much promise in the newer, biochemical methods for studying the chemical and molecular relationships of organisms.

Paleontologists are turning more and more to the study of extinction events in the history of life, and paleochemistry, coupled with biochemical analyses of extant organisms, is coming to the fore. Museum scientists are taking part in these new thrusts, but the museum must help to protect organismic biology from being totally dominated by high-tech research. Museum paleobiologists, working with collections, are on the threshhold of obtaining more precise measurements of rates of morphological change through time that will answer much-debated questions of the tempo and mode of evolution.

In physical anthropology, research museums with their skeletal collections hold promise in the study of major aspects of human health, such as longevity, fertility, nutrition (growth of key areas of skeleton, study of trace elements in bone), and physiology (bony evidence of fighting, genetic mixture, migration). This work is done with skeletal samples from different geographic regions or over an historical time sequence. Bone studies also can yield data about diseases relevant to current world health problems, e.g., the anemia related to malaria or to schistosomiasis. Finally, the study of physical remains continues to be an ever more potent tool in crime solving (forensic anthropology), and the demand for such research from the FBI and many state and local law enforcement agencies is growing steadily.

In cultural anthropology, material collections hold increasing promise for research on preservation and conservation technologies and art-related problems.

Finally, research museums have an increasing opportunity and responsibility to train researchers in other countries, especially in Third World countries, and to develop closer working relationships and partnerships with foreign scientists for the tasks that lie ahead, particularly in the tropics.

The ultimate challenge to research museums everywhere is to use their vast collections to the best advantage to support meaningful worldwide environmental protection, the development of biomedical resources from plants and animals, and the effective and wise exploitation of all of the earth's terrestrial and marine natural resources, but especially food resources.

2.2 What basic research priorities can be identified for the next few decades?

The basic priorities for the next few decades are implicit in the promising areas and priorities already discussed in 2.1. The question becomes one of relative urgency.

Certainly, the highest priority must be given to studying vanishing or threatened ecosystems and cultures and to understanding life in the sea, especially the deep sea. For many museum biologists, biological inventories and baseline studies of plant and animal relationships are the No. 1 priority for the foreseeable future. This is especially urgent in the tropics, but there also is an urgent need for a general survey of the flora and fauna of our own continent, given the pace at which habitats and ecosystems are being perturbed, fragmented, or destroyed.

An implicit corollary to this basic research priority is the priority to apply such research to national and international needs on an urgent basis, especially to the ever greater problems of environmental protection and conservation. Research on endangered tropical habitats and biotas, for instance, should lead to the conservation, perhaps on a sustainable-yield basis, of these habitats and faunas and floras. This introduces the relatively new and rapidly growing research field of "conservation biology" or "restoration ecology," as it is sometimes called.

Urgent new biological inventory and collecting will make all the more urgent the need to enlarge and modernize collection storage and maintanance systems at museums and to train the necessary specialists to identify and classify the vast numbers of organisms. This latter need will be especially critical for insects and other invertebrates. The United States, for example, has but one researcher studying the economically important free-living soil and freshwater nematodes and only two studying marine nematodes, one of whom is at the Smithaonian.

In planetary science, the greatest urgency for museums is to collect and conduct research on meteorites.

Museum anthropologists see a critical need to conduct interdisciplinary studies in archeology, human origins, and cultures in relation to the environmental context before the evidence disappears through ever more massive human disturbance. Tropical and arctic environments are proving to be especially fragile, labile, and subject to massive interference, and work is needed urgently in these regions.

There also is a critical need to study manuscript linguistic collections and linguistic aspects of ethnographic and historical writings, while native speakers of the languages in question who are conversant with the earlier ways of life are still alive. In many cases (most American Indian and Australian groups, for example) the languages are on the verge of extinction. The Smithsonian has a large collection of American Indian manuscripts, and museums in general provide a good environment for the curation and study of such materials.

2.3 Within the limited federal resources available, what role should the natural science institutions play?

Obviously, natural science museums have the time-honored functions of collecting, documenting, storing, studying and exhibiting plant and animal specimens, archeological and other anthropological objects, and such other natural history objects as fossils and meteorites. Vast collections already exist; they are unique and must be curated and studied for the benefit of present and future generations. In time of financial stress, proper curation of the collections should come first but not to exclusion of the very research and public exhibition that justify their existence.

One might summarize by saying that natural science museums have always played and should continue to play a leading role in (1) public science education, (2) stimulation and training young scholars in natural science careers, (3) conduct of basic research, and (4) maintenance and expansion of reference collections for the use of the entire community of natural scientists.

Collection-based research and public education largely through exhibits constitute the very raison d'etre of natural science museums, and a reasonable balance must be maintained between them. A museum that tries to educate the public without a base of active research soon loses its inspiration, originality, and wellspring of fresh knowledge that keep the exhibits, lectures, and other outreach activities vital and in tune with the state of science generally. By the same token. a research museum that does not maintain an active, up-to-date exhibit and public education program based on its research loses it public support and its right to claim tax or philanthropic underwriting.

In short, natural science institutions should continue to fulfill their historic role to the maximum extent possible with the limited federal resources that are likely to be available. To an ever increasing extent, it may be necessary to appeal directly to the private sector for contributions and endowments to keep up the time-honored functions and at the same time stay current with developments in science at large, but federal resources should always be concentrated on those functions, such as collection maintenance, that never can be supported adequately by private funding. The most difficult task is to stay current with capital investment in modern technology and equipment (including computers) to make leading-edge research possible.

The one type of research that surely must continue, because it remains vital to many practical areas of society even while universities are scaling it back and phasing it out, is biological systematics—the organismic study of the origin, diversity, and evolution of organic life on earth. By comparison with such Big Science areas as space science, astronomy, or high energy physics, systematics is a cheap science that surely our society can continue to afford.

2.4 <u>What effects have recent developments in high technology had on the conduct of museum-based scientific research?</u>

As already discussed in 1.1, research in museums has been revolutionized in numerous ways by technological advances since World War II. Indeed, the revolution mirrors what has taken place in the same or comparable fields in universities, and over the years there has been little if any time lag between the introduction of new technology to universities and its introduction to museums. This stands to reason because the museum's scientists come from the universities. The only limitation has been the limitation of funding, already discussed in 2.3 University scientists often are able to acquire major new equipment with grants that are not as available or easy to justify in the non-teaching environment of museums.

Museum research has been revolutionized especially by high-tech analytical instruments and methods. Electron microscopy and computers, in particular, have opened frontiers of study never imagined before. As scanning electron microscopy has revolutionized the study of surface structure, transmission electron microscopy has advanced the study of internal structure. Many other kinds of instruments could be enumerated, a partial list of which is given in 1.1.

Probably the single most important technological advance in the post-World War II period is the computer and its impact on data handling and information storage and retrieval. Perhaps the most exciting aspects of this are the recent developments in small computers, which even have revolutionized manuscript preparation and publication. For persons whose research ideally requires huge collections of specimens--e.g., tens or hundreds of thousands of insects--and associated data, the computer now makes it feasible to build and process such large data bases.

Computers also make it possible to inventory and track large museum collections, such as the more than 30 million specimens in the Smithsonian's National Museum of Natural History. This has improved access to many Smithsonian collections remarkably. Also, collection inventories can be sent easily to researchers elsewhere. Museums, because of their collection needs, have a much greater potential than universities for developing new methods of dealing with large amounts of specimen or object data. Computers also are being used for linguistic analysis of texts and to process census and village survey data. The development of small, portable computers has made it possible to take the computer into the field to enter data directly, thereby cutting out the age-old time-consuming step of first taking field notes and then later transcribing them. Computers also have had a profound impact on almost all aspects of library science and management. Library resources are becoming increasingly more accessible, especially with the rapid development of on-line bibliographic search services.

Theoretical frontiers also have been advanced by the computer in many fields, as, for example, in the development of the quantitative school of systematics known as "numerical taxonomy" and in the more recent development of the field of "cladistics," to hypothesize and test proposed evolutionary lineages. These new disciplines depend largely on the power of the computer to process large data sets, especially metrices. Finally, computers are now being used for pattern recognition to develop automatic analysis and identification systems.

Radiography and other high-tech analytical techniques have revolutionized physical anthropology, archeology, and ethnology. New biochemical instrumentation and methodology have introduced a variety of molecular techniques to many branches of natural history, including even paleobiology, and as a result theoretical frontiers are being advanced in anthropology and evolutionary biology.

High technology has increased the cost of research dramatically, straining the already limited budgets. The equipment requires large capital outlays, and additional technical help usually is needed. Often whole new units, as, for example, computing centers or special laboratories, must be established, equipped, staffed, and maintained. Service contracts alone can take a big bite out of an annual budget. Often additional staff training is required.

Question 3

3.1 <u>To what extent are the museums' dual responsibilities for research and public education (or, in the language of the Smithsonian bequest, "...the increase and diffusion of knowledge") comparable to the universities' dual responsibilities for research and teaching?</u>

In broad terms the dual responsibilities are comparable in that both university researchers and museum researchers are responsible for conducting independent programs of original research that, when published, will contribute to knowledge and for translating their findings into terms that can be passed along to laypersons, be they students, aspiring scholars, or the general public. There are significant differences in emphases, approaches, and audiences, however, when one looks beyond the superficial similiarities.

In many ways, the relationship is much more formal, open, and direct in universities, where a researcher routinely meets classes and advises students and the institution exists to teach students, pass along research findings and methods to the next generation of scholars, and grant degrees. The audience is rather narrowly constituted as a largely undergraduate student body of limited age-range and known educational achievement. The university exercises strong control over audience selection. Public education in museums is often a complex of activities with ill-defined boundaries, and the museum can exercise little or no control over its primary audience, the visitors to the exhibits, lectures, and other public events. Museums attract visitors of all ages and all educational and economic backgrounds and especially large groups of school-age children. The goals of university students are reasonably predictable when compared with the goals of the public served by museums. For this reason, educational programming at museums is largely a shot in the dark, far more unmanageable than in universities. It has to be packaged and offered primarily according to principles of entertainment and marketing rather than in straight-forward manner for its educational value and intent. University students, by-and-large, are there because they have a specific educational goal, whereas the museum's public often wants to be entertained first and educated second and has no specific educational goal.

Museum researchers, therefore, find their public educational role to be relatively indirect, through publications, exhibits, and perhaps a certain amount of lecturing. The responsibility for the scientific and technical accuracy of exhibits and exhibited-related material and for popular publications is just as serious, however, as for scholarly publications. In addition to their roles in mass education, museum researchers often teach courses in local universities, train undergraduate interns, guide graduate students, and advise and collaborate with postdoctoral researchers. In this respect their role is quite analogous to that of the university researcher, except that they seldom have direct control over a graduate student in the manner of a professor. Contrariwise, many university researchers also may do a significant amount of popular lecturing, writing, and even advising for exhibits. Thus, in many individual cases there are close convergences between the museum curator and the university professor. Overall, however, the professor usually does more formal teaching than the curator, and the curator does more informal instructing.

The respective research responsibilities of the professor and the curator are far more comparable than their educational responsibilitie Probably the main difference is one of emphasis. Most universities exist primarily to educate, and in those institutions the first responsibility of a professor is to teach; research often must be done in marginal time. Research museums, particularly, the large ones such as the Smithsonian, exist to do research (increase knowledge), and the first responsibility of a curator is to do research; educational activities except for the publication of scholarly papers and books, often must be done in marginal time. Curators also have the added responsibility of curating collections, because the museum has the public trust to conserve collections regardless of their interest to a particular curator. Generally, the larger the university, the greater the emphasis on research, and this applies as well to museums.

Both uni. rsity and museum researchers face the same scramble to divide their time and resources between research and service and to acquire research funds for travel, fieldwork, equipping laboratories, hiring assistants, and contracting for services.

In the end, it is a matter of perspective, and surely university and museum researchers have more in common than they have differences. Museums and universities largely complement each other both in research and education. In terms of education, they address largely different audiences. In terms of research, museums, as bastions of collection-based organismic research, are able to provide certain kinds of specialized training and produce certain kinds of research that have become more and more difficult for universities to deliver.

3.2 What should museums do to ensure that this relationship between research and public education is kept in proper balance, with each function supporting the other?

The right balance begins with an enlightened administrative view, and the key to this is to hire leaders who understand the need for balance and are committed to maintaining it. The leaders must in turn be provided with adequate funding to maintain both functions at a balanced and fully professional level. Central to a proper balance is staffing, which must include a good mix of researchers, exhibits specialists, and educational outreach personnel. Scientists and other research scholars should serve in conspicuous roles in public educational programming.

The researchers are pivotal to success, because their training, experience, and attitude can make or break an exhibit and public education program. New curators must be indoctrinated in exhibits and education, and these functions should make up a significant component of their duties. Above all, the reward system for the research curators must acknowledge and compensate them for exhibit and other educational work and also provide them with adequate career incentives if their continued participation in this function is to be ensured.

There is no formula by which the proper balance can be determined. It is a matter of museum objectives and priorities and of being able and willing to respond to needs. It clearly is not a matter of an even split, if that were possible. What would be right for one museum might be wrong for another. In general, the smaller the museum, the smaller will be the research program, and vice versa. If research museums are to retain public interest and suppport, they must not ignore exhibits and public outreach and must make every effort to keep exhibits current and relevant. If, on the other hand, research is short-changed, the museum will soon lose its wellspring of originality, authenticity, and inspiration to produce state-of-the-art exhibits that portray for the public the latest knowledge of science and culture and use the museum's own collections to best advantage.

A museum's budget provides an important measure of the balance of responsibilities. If either research or public education is getting only marginal dollars, the museum's responsibilities can hardly be said to be balanced. Because of the growing public interest in museums generally, most museums have not really caught up with the demands for public outreach through exhibits, programming, and publication.

Question 4

4.1 It has been noted that there is a trend toward transfer of collections from universities to non-university institutions such as museums. What is the basic cause of this?

There are two main causes. The basic cause is scientific and technological change and the inevitable emphasis on the latest trends in universities. The field of biology has shifted heavily in the last few decades away from whole organism studies to biochemical and experimental research at the molecular level, and this has brought about a long-term, irreversible de-emphasis of natural history and organismic biology in university biology departments generally. As support for organismic programs has decreesed, professors and students no longer are hired or attracted, and sooner or later the programs collapse. Collections that once were a necessity in many if not most biology courses, suddenly are needed in few if any courses, and they become an expensive luxury, even if they are only stored and not curated. Thus the second main cause, which derives from the first, is that many universities no longer can afford to maintain collections once collection-based organismic biology has been abandoned. Often little or no attempt has been made to maintain a balanced program of organismic and molecular biology.

Collections take a multi-generational commitment of space, personnel, facilities, and supplies, and a stable source of funding is required. These costs must be borne by the institution and usually are not recov -able on a reliable basis from research grants. For many university researchers, short-term grants are the lifeblood, and they get little or no institutional support apart from their salaries. The universities exist largely to train undergraduates for which elaborate collections are seldom needed, and the universities support only those laboratories and other facilities that are essential to the teaching program. Except in those cases where universities still have large graduate programs in organismic biology, collections are nonessential and not cost-effective. Furthermore, universities are unable to pay for the extensive fieldwork required to build and maintain strong collections of broad scope.

One other important factor is the grant system of funding. Grant support obviously goes to what is perceived to be cutting-edge research, and as organismic biology has declined so has direct and indirect grant support for collections. This downward trend has continued for many years, although in recent years the National Science Foundation, through its Biological Research Resources program, has reversed this trend for the time being, at least, for many mid-sized and large universities, by giving them one-shot grants for equipment, facilities, and/or technical assistance. In addition, it has provided major, continuing support for a number of the largest university collections deemed to be of national importance.

This last point emphasizes the continuing significance of university museums, and one should not dichotomize universities and museums artificislly. The best university museums are vital members of the research museum community.

4.2 <u>How do the non-university institutions handle the financial burdens of housing and maintaining such newly acquired collections?</u>

This is a matter of continuing and growing concern. For the most part, these new collections must be housed and maintained with existing budgets, but as the number of orphan collections grows the financial burden becomes more acute. The answers depend on many factors, not the least of which is the size of the absorbed collection, and vary from museum to museum. In every case, the institution has to set rigorous priorities and goals in order to be able to live within its budget even while taking on greater collection management responsibility.

Lack of space for housing causes the greatest difficulty. Where space exists, routine maintenance often can be provided at little or no extra cost once the acquired collection is consolidated with the existing collection. Because of their deep commitment to maintaining priceless collections for posterity, museums make every effort to absorb orphan collections and have become ingenious in finding ways to compact storage and obtain support for the actual transfer process. Sometimes the National Science Foundation and other federal agencies have provided support to enable consolidation. Private donations and corporate grants also have been used. Some non-federal museums have begun to charge for certain services they provide. Despite some very creative efforts by museums, the bottom line is that there is no satisfactory solution to the financial burdens of orphan collections.

4.3 Are there any instances where collections have been dispersed or otherwise been lost to scholarly work?

Many collections of varying sizes have fallen into disuse and been allowed to deteriorate or be destroyed by insect pests for lack of curatorial staff and support, especially in small institutions (museums and universities), in private hands, and even in some federal agencies. This applies to kinds of collections, including archeological collections, that have sat in basements and warehouses without ever being properly catalogued and until their labels have been lost or eroded away. Frequently, university scientists simply never find time and the minimal support needed to curate their collections sufficiently to ensure their survival and use. There are also the famous cases of collections lost or destroyed during World War II.

Some of the most celebrated cases of collection dispersal or loss involve some of the biggest names among universities. Recently, Princeton University dispersed its fossil collection because it is phasing out paleontology, as did Yale University earlier. Catholic University is selling its plant collection (herbarium) in parts to the highest bidders. Johns Hopkins University is said to have taken parts of its plant collections to the Baltimore Dump some years ago. A classic case of a university museum disposing of a collection of important materials is the sale in 1979 by Harvard University to private collectors of its American Indian portraits by Henry Inman. Princeton, Johns Hopkins, and the University of Virginia are a few of the many institutions where mineral collections have been dispersed or otherwise despoiled for lack of interest or curation. Many other cases on a lesser scale could be enumerated.

4.4 <u>Are there, conversely, significant cases where universities have made an affirmative commitment to the continued maintenance of important collections?</u>

Yes, there are many examples of universities that continue a strong commitment to collections, especially since the National Science Foundation has been providing regular grant support to major university collections deemed of national importance. Although the inexorable trend is away from university commitment to collections, at present university collections are in a good state of health overall, and commitment is still more the rule than the exception. The cases of dispersal or loss tend to get a lot of negative publicity, particularly when prominent institutions are involved. In fact, the post-World War II years have seen a boom in collection building at many rising universities, but many of these collections are the passing fancies of enterprising individuals and are living on borrowed time. This portends a much greater crisis of orphan collections in the years ahead.

Among the institutions that have made positive commitments in recent years to maintain some or all of their long-standing collections are Cornell University, Harvard University, Ohio State University, Tulane University, Yale University, and the Universities of California (Berkeley and Davis), Connecticut, Illinois, Kansas, and Michigan.

4.5 Are there any signs of a counter-trend, that is, cases where universities have decided to initiate or expand collection-based research?

As explained in 4.4, the postwar years have seen a boom in collection building at many universities, but this surely is largely a passing phase because the whole trend of science and the severe economics of collection maintenance militete against long-term commitments, except where there is an overriding application. A key factor in the boom has been the National Science Foundation. It has supported extensive fieldwork, which generates collections, and collection maintenance equipment and assistance. Also, the rush to explore the tropics before it is too late has created a salvage environment. Furthermore, the last generation of organismic biologists is still in charge in many universities. Possibly, the pendulum will swing part-way back again, and there are some signs of this, especially among the ever-growing ranks of students of the tropics.

Question 5

5.1 Why should public funds be expended for basic research in museums to any significant extent?

As was pointed out in my testimony before the Task Force in April, 1985, museums constitute one of the four main building blocks of the research enterprise in the United States. If the museums were to quit conducting basic research, major scientific and other scholarly needs of the country would not be met. Universities and museums are pursuing largely different goals and fulfilling different needs in the nation's research agenda, as already discussed under previous questions (see especially 1.1); therefore, their respective roles are highly complementary, even while they have much scholarly tradition and interest in common. Museum research differs only in kind, not in value or quality. Ultimately, the justification for doing basic research in museums is the justification for doing basic research in universities or anywhere.

Museums, as guardians of vast collections, are fast becoming the last bastion of basic research that depends on the study of specimens and objects--plant, animal, and mineral specimens and archeological and recent artifacts of material culture. In the biological realm, museums, as explained earlier, have become the last stronghold for organismic and evolutionary biology and thus the keepers of expertise and knowledge about the earth's plants and animals. Slowly but surely natural history museums are becoming the chief source of knowledge about the world's biological diversity and thus for understanding the biosphere. Only collection-oriented research can lead to understanding such as yet unanswered questions as how many species there are, how many and which ones are endangered, and what are the causes of their decline. In fact, there is a whole class of research questions, anthropological and geological as well as biological, that can only be addressed where there are comparative collections. The specimens and objects are vouchers for information about the natural and cultural environment of the earth and sometimes document extinct parts of the environment. Without natural history museums, their collections, and the research based on them, disciplines such as ecology, ethnology, forestry, and wildlife biology would be merely disconnected, useless observations lacking in descriptive, classificatory, or predictive power.

Universities and museums not only share interests and complement each other but also often work together closely in a mutually beneficial or symbiotic way so that the end result is better research.

Such a fruitful partnership is illustrated by the nation's Antarctic program, where Smithsonian and other museum scientists have collaborated with university scientists to recover and study meteorites and to study the famous lichens (plants) that grow inside rocks.

The overwhelming majority of collections made by museums--probably more than 99% in large museums--are made in the first place for the purpose of supporting current or future research. Very few specimens and objects, relatively speaking, are collected expressly or only for display.

As indicated earlier, a museum's exhibits and public programming are kept vital through research. If basic research were discontinued, the museum's exhibits would be transformed rapidly into nothing more than second-rate public-relations displays. In fact, with more support for basic research on existing collections, museums could bring a new vitality to its exhibits, especially in the realm of anthropology, and produce fine showcases of stored-collection wealth for touring as well as for permanent, local displays.

The research wealth of collections is never fully tapped at any one time in history. It may take years for the right perspectives and technologies to come along before even the questions can be asked. This is well illustrated by the history of studying animal bones. Thirty years ago, Near Eastern archeologists did not save animal bones from their excavations. Today there is a rapidly developing specialization called zooarcheology in which scholars study faunal remains recovered in digs to determine not only parameters of the environment, but also ancient economic strategies in animal breeding, raising, and butchering, as well as questions of diet and nutrition.

Of paramount significance are the scientific tomes and authoritative popular publications of lasting value produced by museum scholars, which at the end-point form the basis for much practical application and popular benefit. Principal among these are the monographs, books, manuals, and field guides that constitute the foundations for the identification of plants and animals. Museum scientists also provide identification services directly to other scientists and the public. Without the identification enterprise, sustained only by constant basic research, numerous applied sciences from agriculture, medicine, and pest management to conservation, fisheries, and wildlife management could not function. Every report of the UNESCO International Humid Tropic Committee has emphasized, for example, that the greatest bottleneck for ecological research (including epidemiology) is lack of adequate taxonomy and taxonomists to provide identifications and understanding of relationships and biogeography. The problems of human disease control can only be conquered after careful study of the disease-causing organisms, and much of the primary research for this comes out of museums.

Plants and animals have long been exploited by man to improve his well-being. How many more species are there in our environment yet to be studied that may offer other exploitable features? This question is especially relevant as man stands at the threshold of genetic engineering where possibilities may be limited only by the genetic material that he finds in the natural environment.

Surely it is crucial to know the life forms with which we share this planet and which infringe on our individual lives in essential but variable degree; museums play an indispensable role in generating this knowledge.

5.2 Realistically, isn't most leading-edge scientific research being conducted in universities and medical centers?

This is a highly debated question, and the answer depends on perspective, philosophy, and opinion. At the least, the answer is quite relative.

Any research that increases knowledge is, by definition, at the leading edge of some facet of science. All components of science have their "leading edges." Some frontiers of science are more excitement-generating or headline-grabbing than others, but the popular press often sensationalizes, even fantasizes, "leading-edge" research advances. Today's sensational leading-edges are in molecular biology and genetic engineering. If these are the fields one has in mind, then, "yes," the leading-edge research is being done in universities and medical centers. The answor is "yes" also if one defines "leading-edge" research only as that directly affecting human health, such as cancer research. But the quality of medical research often depends ultimately on the quality of knowledge about the underlying organisms for hich the "leading-edge" work may be taking place in museums. If sh_er quantity of research output is the measure, the answer also is "yes," becsuse for every research museum there are dozens of universities with many more researchers. If the quality of museum research tends to be lower on the average, it is only because most museums are not primarily research museums and are staffed not by research scientists but by collection managers and curators, whose research, if any, may be little more than descriptions of collections. The quality of research coming from the best scientista in the best research museums is fully comparable to the best from universities, which have their share of mediocre scientists doing less than "leading-edge" work.

In fact, as pointed out earlier, it is telling that some of the most influential thinkers in all of modern biology, such as Ernst Mayr, Willie Henning, George Gaylord Simpson, Stephen J. Gould, Edward O. Wilson, and Niles Eldredge, have been directly associated with natural history museums. Furthermore, the prestigious MacArthur Prize was just awarded in 1985 to Peter H. Raven, long a renowned collection-oriented and museum-based scientist. Just as Charles

Darwin developed his theory of evolution from museum collections, so today's leading evolutionary theorists, such as Gould and Eldredge, are museum scientists.

Museum science has its share of "leading-edges" even if they are not as flashy as, say, genetic engineering, and much museum science is basic to so-called "leading-edge" research elsewhere. Science is more than engineering; it is more than taking organisms apart to see how they work. Good science is synthetic—it takes data from disparate fields, welds them together into new and more powerful theories, and then subjects these theories to exacting empirical tests. The theory of evolution is the most synthetic theory in the whole of biological science, and, as already noted, the foremost researchers in evolutionary biology of this century have come out of museums. An eminent evolutionary biologist has said, "Evolution is the context in which everything else makes sense." The study of evolution and the synthesis of biological facts from all scientific fields are largely the responsibility of museum researchers. Molecular biologists study "trees," and museum researchers--systematists--study "forests." Both need each other.

Anthropology, as a theoretical discipline, was established first in museums, including the Smithsonian. The shift to more sociological, structuralist, and symbolic perspectives in the 20th century took place for the most part outside museums, but a movement is underway back to more materialist perspectives. Museums will continue to play a central role in this movement and also in the creation of a synthesis of diverse fields such as anthropology, sociology, and art history that is currently taking place. George Stocking, a university-based historian of anthropology, has predicted that anthropology will become increasingly museum-oriented in the future.

"Leading-edge" research also is being done in museums in the use of computers to capture and process morphological data (morphometrics) and to store and retrieve data in a large-database environment.

Museums, as already discussed, are doing "leading-edge" work on meteorites. This is true as well for work on volcanoes.

The ultimate area of "leading-edge" contributions by museums is in the realm of research and synthesis dealing with the diversity of life on earth, already discussed at length in previous questions. The Global 2000 report tells in dramatic way the scale of such problems as tropical deforestation, which will require the kind of approaches to organisms, populations, biotas, habitats, and ecosystems that have characterized museum science. Natural history museums are committed to the study of the most complex systems of the world, living systems. Organismal science is far ahead of "high-tech" science in the conceptual nature of the questions. Museums are major centers for research in such conceptual fields as phylogeny, biogeography, systematics, tropical and marine ecosystems, human cultures, and, indeed, evolutionary theory in general, as already stated. Finally, museums are virtually the only sources of expertise and basic data on many small groups of plants and animals, such as the lichens, unique symbiotic plants which are proving to be key organisms for the biomonitoring of acid rain and other forms of air pollution.

A few other perspectives are important here. Museums provide a much better environment for research on the large questions that require long-term study, because museum scientists often are not as tied to the short-term grant mode of funding. Many university researchers are so busy with teaching and grant-getting that they have limited time for long-term creative research.

Finally, the question, as asked, implies that only "leading-edge" research should be funded. Basic and foundational research, whether or not it meets the public's notion of "leading-edge," is constantly needed. Less flashy research is just as important, whether or not it is perceived to be "leading-edge" research. If it is only of background or foundational value now, it may prove pivotal on the frontlines in tomorrow's research environment.

In sum, university and museum research are complementary and interdependent, and together the efforts have a synergistic effect. In terms of dollars spent, the museum research enterprise is far less costly than the university research enterprise.

5.3 Within the overall framework of scientific achievements in the United States, what have natural science museums contributed, and what is the relationship between the independent natural science institutions and the universities?

This question has been covered rather thoroughly already by answers to 5.2 and other earlier questions. However, few points can be added.

Indisputable testimony to the many basic contributions of natural science museums to science in the United States is to be found in the rich annals of such institutions as the Academy of Natural Sciences, American Museum of Natural History, California Academy of Sciences, Field Museum of Natural History, Missouri Botanical Garden, New York Botanical Garden, and the Smithsonian Institution. It is abundantly clear from the record that we would know very little about the plants and animals of the earth today if these and many other great museums had not existed, because even the many studies of faunas and floras that have been done in universities over the years have been based upon use of collections held by museums.

Perhaps the most basic contribution of natural science museums, therefore, has been their central role in elaborating the catalog of nature, living and fossil, and in holding in trust for the whole community of science the millions of specimens and objects that document this catalog.

Museums have contributed enormously to the exploration of the world by mounting countless field expeditions over the years to all parts of the globe, often taking university scientists along. The contribution of fieldwork has been especially important to anthropology as well as to biology. The centrality of museum contributions to elaborating evolutionary biology and deciphering and describing the patterns of organic diversity has already been discussed in detail.

Recently, natural science museums have been leading the way in large, multidisciplinary, multi-year studies of tropical and marine ecosystems. Museum-led studies with submersibles have made remarkable discoveries in deep-sea plant and animal life. The sea-vent studies are especially noteworthy in this respect.

As for the relationship between universities and independent natural science institutions, there is no general rule--just long years of cooperation and collaboration in a spirit of collegiality and common interest. As stated above, university scientists often use museum collections, usually by borrowing them, and thus museum collections are in effect lending libraries. Universities often draw upon the educational opportunities of the independent museums by sending undergraduate and graduate students to the museums to study under museum scientists. Curators frequently are extramural members of doctoral committees and often teach advanced courses in local colleges and universities. Some universities work out formal cooperative training agreements with museums. Professors frequently spend periods of days or months to a year working at museums, while curators sometimes spend a semester or a year teaching and doing research at a university. There also is regular staff interchange, with curators being hired from the teaching ranks of universities and vice versa.

In the end, although there are few written rules, the relationship works to the mutual benefit of everyone. The unwritten but accepted division of res nsibility and labor makes it possible for the universities to emphasize the more experimental aspects of science, which may be more glamorous, trendy, and easier to fund with grants, leaving the museums to concentrate on the more descriptive and traditional organismic aspects, which, though essential, may be less fashionable and require stable, long-term funding. A fair measure of both kinds of research continues to be done in both places, however.

<u>Question 6</u>

6.1 <u>How do the achievements of natural history museums contribute to the public good?</u>

Much of what might be said here is implicit if not explicit in the answers that have already been given. Whatever is done by natural history museums in the first instance for science ultimately has a ripple effect to a. segments of society, with secondary and tertiary public benefits that often cannot be predicted from the basic research. Many payoffs are quite serendipitous.

Millions of people visit natural history museums every year, with some 6 million visiting the National Museum of Natural History alone. Obviously, creative exhibits are a key to public visitation. The visitors benefit each in his or her own way, and the sum total is an awesome, mass educational experience. Many visitors come back again and again, especially when there are major changing exhibits, such as are scheduled in Natural History's Evans Gallery. Added to the exhibits are the numerous lectures, seminars, workshops, classes, and field trips conducted for the public by every major natural history museum.

The museums also reach out to the public, and for the Smithsonian the outreach is a vast panoply of activities for a national, even international, audience, including the Resident and National Associates' programs; the traveling exhibition service (SITES); Smithsonian World and other Smithsonian television programs; Smithsonian magazine; the Smithsonian Press, with its large and growing library of authoritative popular and semi-technical books such as the one just published on the ferns of the United States; and innumerable lectures and appearances by individual curators and other scientific staff.

Just begun is the new National Science Resource Center, a joint project with the National Academy of Sciences, which will concentrate initially on improving the quality of science education in the nation's elementary schools. In the fall of 1986, in another joint effort with the Academy, the Smithsonian will sponsor a forum on biological diversity expressly for the public. Museum scientists are constantly serving as consultants or advisors on matters of science to persons, organizations, and agencies in and out of government at local, state, and federal levels. The total amount of assistance being rendered to the public by museum scientists in any one year would be truly staggering if recorded in one place.

All of this speaks to the methods of dissemination, but what of the substance?

As keepers of the catalog of nature, natural science museums play a key role in popularizing knowledge of plants and animals and making the public aware of the natural world and man's place in it, thereby enriching the lives of the people. This is a necessary first step to developing environmental awareness among the public at large. Museums have been playing a large part in educating the public to the major environmental issues of our time, including such massive problems as species extinction, tropical deforestation, and the general loss of biological diversity. Indeed, getting across the concept and significance of biological diversity is itself a daunting task for all scientists. Without knowledge of the organisms, environmental impacts cannot be assessed. Museum scientists contribute greatly to the whole enterprise of environmental assessment by providing identification services, field guides and manuals, and other technical advice and assistance. Many museum scientists have prepared or contributed directly to environmental impact statements and have given expert testimony before courts and governing boards.

During World War II, only museums contained the information and the expertise necessary for the search and procurement of certain strategic materials, e.g., quinine, rubber substitutes, balsa, certain minerals, or for the study of certain important parasites. More recently, museum collections provided the bird-egg specimens for studying the consequences of DDT buildup in the food chain and the fish specimens for studying historical patterns of mercury uptake by tuna.

As long as there is a need to know the names and identities of plants, animals, fossils, minerals, and anthropological objects, there will be a need for museum scientists. Apart from plain human curiosity, the needs are legion. Pest control, biomedical experiments, ecological analysis, park management, forestry, fishery biology, disease control, conservation and environmental protection, space science, natural-products chemistry, oil exploration, law enforcement--these are some of the many areas of human endeavor and welfare requiring the service of museum taxonomists or other specialists in some manner.

6.2 How do they contribute to the advancement of modern science?

This question has been covered rather thoroughly in the proceeding answers. In summary, Museums can continue to make several major contributions to the advancement of science at large:

(1) Systematic biologists are the keepers of the keys to the taxonomic system of naming and classifying organisms, and this is the universal reference system needed by every branch of science that deals in any way with organisms. Museums employ a large, ever-growing proportion of the national pool of systematists.

(2) Museums provide the essential service of curating and holding in trust for all science the bulk of the collections upon which the study of the earth's biota, minerals and rocks, and material culture depends.

(3) Museums play a key role in documenting extant and fossil forms of life, in analyzing their history and evolutionary relations, and in elaborating evolutionary theory. Museums, consequently, are a major and growing force in whole-organism biology and soon will become the last stronghold.

(4) Museums hold baseline data for studies of environmental change and are leading the way in confronting the problems of massive habitat destruction, ecosystem disruption, species extinction, and depletion of biotic diversity, especially in the tropics.

(5) Museum anthropologists are leaders in documenting cultural diversity and in addressing the problems of disappearing cultures.

(6) Finally, in a general sense, museums will continue to provide the resources and environment for long-term research projects with broad representation of experts in many disciplines, thus continuing to complement the more trendy short-lived programs of most universities, which are funded by short-term grants. Museums alone, if properly funded, have the capacity to undertake massive national efforts, like the proposed "National Biological Survey," and major international salvage and conservation efforts.

6.3 <u>What kind of payoff could federal investment in research and development at national science institutions generate?</u>

6.4 <u>Are there spillovers from achievements of natural science institutions into other areas of the economy?</u>

Federal investment at national science institutions, apart from enhancing existing efforts and increasing their individual payoffs, could make a whole new scale of scientific endeavor possible, which would hold enormous promise for large payoffs.

In the first place, more stable funding is needed just to sustain vital existing efforts and to guarantee better and safer care for, and better access to, the nation's millions of stored treasures.

In the second place, there is an urgent need to begin certain large, new programs to explore for new sources of energy and to develop new sources of food and medicine from naturally occurring plants and animals. Large-scale, integrated surveys and inventories could lead to a much better understanding and wiser management of the nation's biological resources and marine fisheries and other ocean resources. A National Biological Survey would provide precise knowledge on the existing fauna and flora of North America and the seriousness of the existing environmental threats, such as acid rain and habitat destruction and fragmentation.

The world's diverse biota, especially in the tropics, constitutes a natural laboratory, with an amazing inventory of chemicals and compounds useful to humankind. No one knows better than pharmaceutical companies, who invest billions each year in screening wild plants and animals for useful properties. Their applied research is entirely dependent on basic taxonomic and evolutionary research in museums for identification, interpretation, and strategic guidance. It has been estimated that the flora of Southeast Asia alone could generate 10 billion in plant-derived medicinals a year. Museum research is a sine qua non in that equation. Greater investment in such basic exploration is certain to payoff.

Natural science institutions already are playing a key role in developing the scientific undergirding for aquaculture, e.g., crayfish and shrimp farming, and sea-farming, including a Smithsonian project in the Caribbean Ocean. New investments here may pay off by increasing world food supplies with new sources.

Finally, our very future depends on the preservation of biological diversity and may hinge critically on the future of the tropics. Massive efforts in conservation biology or restoration ecology will be needed, but much basic research must first be done. It clearly is in the best interests of the United States to invest in major training and research programs to address these problems.

Question 7

7.1 Are there areas of federal policy other than financial support that should address the needs of science museums?

In general, federal policy should recognize more explicitly the enormous research and educational functions of science museums that flow from their curatorial-research staffs, behind-the-scenes collections, and service functions to the national and international community of scholars who are dependent on collection-based research in anthropology, geology, and systematic biology. Increased federal funding for science museums as a partial subsidy of their service functions in research and education would be a proper way for the federal government to recognize the invaluable and unique resources of science museums.

Legislation directed toward environmental protection generates a need for taxonomic expertise and often results in collections made during environmental impact studies (e.g., BLM collections). Storage of voucher collections and provision of taxonomic expertise are a drain on museum facilities that can only be made up by increased funding.

Federal policy should provide for involvement of natural history museums in all activities that include the study and collection of animals from their natural environments--such collections should become the property of museums who can exercise an option to preserve them for posterity.

There are many areas of federal policy other than funding that affect museum research. One example currently in the news is the attempt by the Bureau of Land Management to promulgate rules regarding the collection of fossils and artifacts on federal lands. They seem to refuse to listen to expert opinion and repeatedly publish rules that later must be rescinded. Museum researchers require free, unencumbered access to public lands, for purposes of retrieving significant scientific specimens or data, through elimination of the restrictions imposed by the Bureau of Land Management.

The laws governing importation of objects from foreign countries (museum research is worldwide) can impact enormously and often quite adversely on the free flow of scientific specimens and thus impede scientific study. Less cumbersome regulations affecting the interstate and international exchange of scientific specimens, whether biological, anthropological, or geological, would enhance international cooperative efforts while still safe-guarding concerns over national interests in endangered species of plants and animals and artifacts of indigenous past civilizations

Museums need support for field work and related research efforts to broaden their abilities to explore our own wilderness areas and to permit cooperative research efforts with other research institutions on a worldwide basis. If, for example, a "National Biological Survey" or major new programs in arctic, tropical, marine or other ecosystems are to be established, major support and perhaps specific new legislation will be required.

Education of school children and of undergraduate and graduate students needs to be strengthened at science museums.

Existing programs within U.S. AID could be better coordinated to make fuller use of present expertise in science museums.

Federal policy through the authorization and appropriation process could help bring about a better balance between research, collection maintenance, exhibits, and educational functions at various science museums where the balance is tilted inordinately toward one end of the spectrum of such museum activities, whether it be the research and collections functions or the public outreach functions.

7.2 <u>What future changes in federal policy toward science, financial and non-financial, would you wish to see introduced with respect to the museum research effort?</u>

Federal policy, hand-in-hand with the changes suggested in 7.1 above, should provide more funds for basic research on collections and for maintenance of collections, which continually deteriorate.

Greater respect at the federal policy level for taxonomy/systematics (i.e., "natural history") as a legitimate science and recognition of the fundamental need for basic research are desired, rather than the lip-service that has been extended in recent years. It must be recognized that demands for services and facilities create a need for increased support. If, for example, a natural science museum is to do the job it is expected to do (exhibition, research, collection maintenance), it must have adequate support. Larger appropriations could be put to good use for the admittedly expensive publication of taxonomic research by both our own staff and by those in other institutions who prepare important reports on research on the Smithsonian's collections that cannot be published elsewhere.

Long-range commitment to reasonable increase, maintenance, and research of natural history collections and their associated data is a critical need that may, in the end, require new or strengthened legislation.

Expansion of staffing and increase in travel and equipment budgets would be of inestimable value to all science museums in which fieldwork for making collections, observations, and manipulative experimental studies is crucial and in which sophisticated state-of-the-art instrumentation is required for laboratory investigations at the museums themselves. Modern scientific instrumentation at science museums is essential if they are to attract the most competent researchers in competition with the academic community, federal laboratories, and industry.

Funding for grant and contract disbursement through such rigorously peer-reviewed federal agencies as NSF should be increased. Funding and peer-review selecting of proposals should be improved for the more mission- and goal-oriented agencies such as the USDA, USGS, NOAA, FWS, DOA, DOD, NBS, and NWS. Researchers in federal agencies with intramural research programs often receive less support for basic museum-related research than do researchers in academia and industry who can apply to NSF and other federal agencies with extramural granting programs for basic research related to the goals of their agency.

Question 8

8.1 To what extent and through what agencies does the Federal Government now provide funds for museum-based research?

8.2 Is this principally done through block grants or through project grants?

8.3 Apart from the Federal Government, what are the main sources of funds for museum-based research?

8.4 In your view, what should the Federal Governments role be in the coming decades?

The Smithsonian is unable to comment on the range of federal funding and its mechanisms, but can offer information on its own resources.

The total FY 1985 Federal allotment for the National Museum of Natural History was $20,127,400, of which $15,781,400, or 78.4% supported direct and indirect research costs. In addition to these basic operating funds, the Museum receives Federal grants and contracts for specific research projects. In FY 1985, the following Federal agencies provided such support:

National Science Foundation	336.3
U.S. Geological Survey	5.6
Agency for International Development	708.5
Dept. of the Army	168.2
Office of Naval Research	1.7
National Historical Publications & Records Commission	7.0
National Institutes of Health	455.2
Bureau of Land Management	167.4
National Oceanographic & Atmospheric Administration	87.3
National Marine Fisheries Service	29.1
Total ($000's)	1,966.3

In addition to support from the Federal Government, the Museum receives support from individuals and private foundations and corporations in the form of endowments, gifts, and grants for specific research projects and activities. Examples of such support in FY 1985 include endowments for operation and research at the Smithsonian Marine Station at Link Port in Fort Pierce, Florida, including costs associated with maintenance of the Johnson Sea Link submersible by the Harbor Branch Foundation ($898,100), and grants from Exxon, Wenner-Gren Foundation, National Geographic Society, the Cousteau Society, the Noyes Foundation, Chevron, Earthwatch, Texaco and the International Union for the Conservation of Nature and Natural Resources ($368,800).

Funds are provided to the Museum from Smithsonian revenue-producing activities (Smithsonian magazine, Museum Shops, concessions) in the form of program allotments, Research Opportunity awards, and Scholarly Studies awards made by central Smithsonian offices. These funds are usually granted for individual research projects or activities but, in some cases, multi-investigator projects. In FY 1985, the Museum obtained $142,741 for 72 Research Opportunity requests, 37% of the total FY 1985 Research Opportunity awards made to Smithsonian bureaus. Scholarly Studies awards totalled $307,970, 32% of the amount available for the fiscal year for Smithsonian. Special Purpose funds—generated from Museum Shop and concession profits, other small revenue-producing activities, and honorariums--expended in FY 1985 in support of various research activities totalled $129,500.

A summary of the several sources of funding for Museum research is provided below (FY 1985 expenditures or awards in thousands of dollars):

FY 1985 Federal allotment	15,781.4
Federal grants and contracts	1,966.3
Restricted endowments	1,016.7
Gifts	126.1
Foundation grants	368.8
Total outside funding support	19,259.3
Special Purpose funds	129.5
Program allotments	71.9
Research Opportunity awards	142.7
Scholarly Studies awards	308.0
Total Smithsonian-generated support	652.1
Total FY 1985 funding	19,911.4

Question 9

9.1 What is the present balance of federal and non-federal support for the science efforts at the museums?

9.2 What share of total funds available from the non-federal sources do research museums allocate to research support in comparison with other museum functions?

Again, the Smithsonian must respond to these as one question based on figures from the budget of the National Museum of Natural History.

The research portion of the Federal appropriation for the National Museum of Natural History represented 78.4% of the funds available to the Museum in FY 1985 for research (science) activities. If Federal grants and contracts are added to that figure, then direct and indirect Federal support amounted to 89.1%. Thus, Federal support represents the major source of science research efforts at the Museum.

Almost all of the funds available from non-Federal sources for other Museum functions--exhibits, education, and building management--are not allocated by the Museum for these purposes. Rather, support is obtained through program allotments made by central Smithsonian offices. gifts and foundation grants, and revenue-producing activities such as By-Word (recorded tours for visitors). Non-Federal support for these activities in FY 1985 is summarized below:

Exhibits programs	1,555.7
Education programs	69.2
Building management activities	6.0
Total non-Federal support	1,630.9

In comparison, the Museum allocated $4,346,000, or 21.6% of the FY 1985 Federal appropriation for non-research activities, broken down as follows:

Exhibits	2,444.0
Education	1,104.0
Building management	798.0
Total Federal support	4,346.0

Question 10

10.1 What are the manpower needs facing science museums today and in the future?

Science museums have manpower needs at all levels, but from the point of view of research and curation the critical needs are for (1) more scientists and (2) more support staff, including research assistants, curatorial assistants, and other technical personnel.

Given the enormous range of collections and subject areas, the scientific staffs of even the best-staffed museums necessarily are always spread extremely thin, leaving many more gaps than they fill. Thus, even under the best of circumstances, museums can only give token expert coverage to the fields within their domain; consequently, the pattern of coverage often is as much an accident of history as it is the result of deliberate planning. The need for more systematists is especially acute because of the vast number and diversity of the species of plants and animals to be dealt with. One Smithsonian entomologist has estimated that there may be as many as 30 million species of insects alone in the world, most of them in the tropics. Of the numerous kinds of organisms in the world, there are large groups, even of economically important organisms, for which there are few if any available specialists.

If science museums are to undertake the large efforts that are needed, particularly in the tropics, to study threatened ecosystems and mount urgent, broadscale biological surveys--in short, to make an all-out assault on the task of assessing the earth's biological diversity before it is too late, then in the future museums will have to increase their scientific ranks by several if not many orders of magnitude. Even the proposed National Biological Survey here in North America, a relatively well known area compared to the neotropics, could not be carried off successfully if only today's level of manpower were available.

The need for more support staff is, if anything, more critical. Most science museums are woefully understaffed with professionally trained and experienced technical support staff. In many cases, highly trained scientists are not provided with a single assistant, research or curatorial, even part-time, and the scientist must spend a high proportion of his/her time doing routine specimen preparation and curation as well as routine research preparation, including illustration for lack of technical illustrators. Even secretarial support may be so limited that the scientist has to type his own manuscripts, a task mitigated partly nowadays by the spread of word-processors. Museums cannot go forward and be leading centers of research conquering the many challenges before them if they cannot make the best use of their highly trained experts by freeing them from the technical work to do what only they can do. Furthermore, today's best technicians are so professional that they can take over most if not all of the purely curatorial work and even carry out the type of descriptive research that formerly was done by the research scientist.

As the problem of orphan collections grows in the future and museums are asked to absorb more and more of such collections from universities and other institutions, the need for expanded curatorial staffs will become ever more acute.

Finally, in the future museums are going to need many more specialists in exhibits, educational outreach programming, public relations, publications, fund-raising, and even marketing and sales, if they are to take fullest advantage of their collections and their research staff and fulfill their mandate to science and the public.

10.2 To what extent are they abl to complete effectively with industry, government, universities for the best people?

The answers to this question are mixed, depending on the museum, the field, and one's perspective. Naturalists and curators tend to be born rather than made, and the best natural history scientists often are attracted out of dedication to organismic biology, field exploration, and collections and not out of concern for salary or other perquisitas. Most are scientists for a cause, not money.

Research positions in museums generally are a scarce commodity, and when they do become available usually topnotch candidates apply, at least at the larger institutions such as the Smithsonian, because of the research opportunities afforded and the chance for broeder contact with the worldwide network of scholars.

Strictly speaking, museums often cannot compete with universities and private industries and organizations on their terms, i.e., in terms of salary, laboratory facilities, teaching opportunities grant support, etc., particularly in trying to attract senior, tenured scientists or the most outstanding persons in the field. Other intangible factors often win out, however, and help the museums to be competitive. There is no gainsaying the fact, however, that many museum salaries are too low, particularly for the senior people, and a higher salary structure is needed generally ng museums.

10.3 Do museums share with universities the same commitment to the training of scientists?

Yes, increasingly so, although the training roles and strengths of universities and museums are different. Many museum scientists are fanatically dedicated to replicating their kind. But whereas universities do formal teaching and grant degrees, museums serve more to provide resources and expertise for internships, apprenticeships, and independent doctoral or postdoctoral studies. Curators often supervise graduate students in dissertation research, but as a rule do little formal teaching. In fact, many scientists come to museums for the very reason that they want to escape the daily grind of teaching.

In some cases, museums are able to establish formal, joint training programs with universities to give graduate and even undergraduate students experience in both environments. These can be extremely fruitful, particularly if the university is close at hand and already has strong natural science departments. It works best when there are clear benefits for both organizations. Some outstanding examples could be cited.

Today, large museums with active field programs abroad are getting more and more involved in setting up training programs for foreign countries, especially developing countries where the need for trained scientists is so great. This movement is fueled by the deepening concern for the environmental crises in many countries, especially in the tropics.

Historically, museums have not been thought of as training institutions like universities, and thus many are poorly funded and equipped for undertaking major training programs.

10.4 <u>Are there employment opportunities in museums to meet the anticipated demand from those being trained for research positions?</u>

At present levels of support, employment opportunities in museums are limited. Budgets have tapered off, and, consequently, so has staff growth. At present, museum staffing is in a steady state in which research hiring is restricted mainly to filling positions that fall vacant through attrition. Indeed, the employment picture presents something of a contradiction. With the slowdown in growth at universities, teaching positions are less available, and more systematic and related biologists are being trained than the traditional job market can absorb. At the same time, topnotch specialists of the types needed in museums often are in short supply. There are so few research opportunities in museum-based systematics programs in general that many interested students are discouraged from undertaking the arduous advanced training to qualify for the openings that do occur. This means that museums frequently have an inadequate pool of candidates to draw from when recruiting in some specialized fields. They may end up filling the positions with researchers who are qualified in their own way but are not especially interested in organismic or collection-based research.

Universities at present have the capacity to train many more researchers for museum research jobs than they are now producing. How much longer this capacity will remain is debatable, as more and more first-rate universities begin to downgrade or phase out their own programs in organismic and evolutionary biology and disperse their collections. If museums are to take on some of the large, urgent tasks outlined above, they will need to take a quantum leap in staffing at the research and support levels, and some indication that this is going to be possible should come before it is too late at the universities—the prime training grounds.

PANEL: THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS

Mr. BROWN. We will next call a panel from the Associated Natural Science Institutions consisting of Dr. Thomas Peter Bennett, who is president of the Academy of Natural Sciences of Philadelphia; Dr. Thomas Nicholson, director of the American Museum of Natural History; Dr. George Davis, chairman of the Department of Malacology in Philadelphia; Dr. John McCosker, director of the Steinhart Aquarium in San Francisco; and Dr. John Fitzpatrick, chairman of the Department of Zoology at the Field Museum of Natural History in Chicago.

Now, I think there is room for all of you gentlemen up there.

Mr. LUJAN. Mr. Chairman?

Mr. BROWN. Yes, sir?

Mr. LUJAN. Before we start, I have an opening statement that I would ask unanimous consent to put into the record at the beginning.

Mr. BROWN. Without objection, the opening statement of the distinguished ranking minority member will be placed into the record at the appropriate place.

Mr. FUQUA [resuming the chair]. Please proceed, Dr. Bennett. I apologize for having to step out.

[A biographical sketch of Dr. Bennett follows:]

DR. THOMAS PETER BENNETT

Thomas Peter Bennett was born in Lakeland, Florida, in 1937. At Florida State University he majored in Chemistry and was elected to Phi Beta Kappa, Phi Eta Sigma, and Phi Kappa Phi He was an Eli Lilly fellowship student while at Florida State, and a research assistant in the laboratory of Prof. Earl Frieden. After graduating cum laude in 1959, he studied with Fritz Lipmann (Nobelist, 1953) at the Rockefeller University, receiving his Ph.D. in 1965.

Dr Bennett remained at Rockefeller for two years as a research associate and instructor in the laboratories of William Trager and of Fritz Lipmann. He was appointed Assistant Professor at Harvard University in 1967, where he was associated with George Wald in teaching Natural Sciences 5. The University of Kentucky then appointed him professor in 1971. He became Professor and Chairman of the Department of Biological Sciences at Florida State University in 1972 and was subsequently appointed Special Assistant to the President and Acting Executive Vice President As Special Assistant to the President he served as liaison to the Board of Regents' Task Force on Role and Scope, and Chairman of the Florida State University Role and Scope Task Force. In addition, he coordinated service efforts between the Governor's Office and the State University system in connection with the physical, economic, and ecological damage caused by Hurricane Eloise. He served as Chairman of the Research Award Committee of the Southeastern Association of Biologists and was a member of the Governor's Bicentennial Committee On August 16, 1976, he became President of the Academy of Natural Sciences of Philadelphia. He holds a Courtesy Professorial Appointment in Biological Sciences at Florida State University.

Dr. Bennett has written numerous research publications on molecular biology and developmental cell biology, as well as many biology and biochemistry teaching articles. He is also the author of the 2-volume *Graphic Biochemistry*. In addition, he is co-author with Earl Frieden of a review article on metamorphosis (1961) and a textbook, *Modern Topics in Biochemistry* (1965). He developed an instruction model and text for teaching protein synthesis. *Elements of Protein Synthesis*, and was a contributing consultant to *Biology Today* and *The Physical Basis of Life*. With Frank Bradley Armstrong he coauthored *Biochemistry* (1979, 1981), now in its second edition. In recent years he has become increasingly interested in the history of science in America, particularly the 18th and 19th centuries, and is completing a book manuscript on this subject Dr. Bennett has also contributed a number of articles to news papers and magazines, and made presentations at professional symposia about contemporary issues of academic and corporate interrelationships, as well as ethical issues relating to science and technology.

Professional and honorary affiliations include, among others, the Harvey Society, Linnean Society (London), American Chemical Society, American Asociation for Cell Biology, American Institute of Biological Sciences, National Association of Biology Teachers, and Sigma Xi Dr. Bennett is included in numerous biographical reference works including *Who's Who in America*. A founding member and President of the Friends of Logan Square Foundation, and co-founder and Chairman (1978-1984) of the Museums Association of Pennsylvania, Dr. Bennett is a member of the Governor's Commission on Academic Affairs (Pennsylvania), a member of the Board of Managers of The Wistar Institute and chairman of its Science Advisory Committee, a trustee of the Boy Scouts of America (Philadelphia chapter) and Shipley School, a member of the National Board of the Explorers Club and chairman of the Editorial Review Board of the *Explorers Journal*, and a member of the Advisory Board of the World Affairs Council. He is Chairman of The Associated Natural Science Institutions (TANSI), Vice President of the Association of Science Museum Directors, and Co-Chairman of the Science Education Advisory Council to the School District of Philadelphia He is a member of the Franklin Inn Club, Explorers Club of New York (Member and Fellow), and Cosmos Club (Washington, D.C.).

Dr Bennett is married to Dr Gudrun Staub Bennett, Assistant Research Professor, Department of Anatomy, University of Pennsylvania School of Medicine They have two children.

STATEMENT OF DR. THOMAS PETER BENNETT, PRESIDENT, THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA, PHILADELPHIA, PA

Dr. BENNETT. Very good.

Chairman Fuqua, Mr. Brown, Mr. Lujan, we appreciate the opportunity to testify before your group today.

I am Peter Bennett, president of the Academy of Natural Sciences of Philadelphia. I am chairman of the Associated Natural Science Institutions. We are a group of free-standing private institutions.

Mr. Brown has mentioned the names of our institutions in introducing the witnesses. I might add that also a member of our group is the Los Angeles Museum of Natural History. Unfortunately, Dr. Black, the director, is not able to be here today.

We have, basically, in a continuation of the dialog that was begun by Secretary Adams, testimony about the nature of research and education at these types of institutions. The packet which includes our testimony as well as other pertinent information has been submitted for the record.

[The prepared statement of Dr. Bennett follows:]

INTRODUCTION - THE ROLE OF THE RESEARCH MUSEUM
THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS

Good morning, Chairman Fuqua and members of the Task Force on Science Policy of the House Committee on Science and Technology.

I am Dr. Thomas Peter Bennett, President of the Academy of Natural Sciences in Philadelphia. I am currently serving as Chairman of The Associated Natural Science Institutions, which are private, free-standing natural history museums that have affiliated in the interest of scientific research and graduate education. These institutions, with the Smithsonian, are the major scientific research museums in the country. Our relationship to the Federal government is in fact very much the same as that of free-standing private research universities. Here with me today representing our institutions are Dr. Thomas D. Nicholson, Director of the American Museum of Natural History in New York, and Dr. Harold K. Voris, Vice President for Collections and Research of the Field Museum of Natural History in Chicago. (Unfortunately, Dr. Frank H. Talbot, Executive Director of the California Academy of Sciences, Dr. Craig C. Black, Director of the Los Angeles County Museum of Natural History, and Dr. Willard L. Boyd, President of the Field Museum, could not be with us today.)

Addressing the issue of natural science museums and their importance for the national scientific research effort are Dr. Nicholson; Dr. George M. Davis, past President of the

54-939 O - 86 - 4

Association of Systematics Collections, and Curator and Chairman of the Department of Malacology of the Academy of Natural Sciences of Philadelphia; Dr. John E. McCosker, Director of the Steinhart Aquarium at the California Academy of Sciences; and Dr. John W. Fitzpatrick, Chairman of the Department of Zoology of the Field Museum of Natural History.

Mr. Chairman, Representatives, and staff, we of The Associated Natural Science Institutions very much appreciate your invitation to appear before the Task Force and the opportunity to discuss with you today the importance of museums such as ours in advancing the national scientific research effort.

Dr. Nicholson is our first panelist.

Mr. FUQUA. Without objection, the entire packet will be included in the record. [See appendix II.]

Dr. BENNETT. I would like to call first on Dr. Tom Nicholson, the director of the American Museum of Natural History. Dr. Nicholson will use slides.

Throughout our presentation, we will be using some of the materials from our collections which have been mentioned by Dr. Adams earlier; for example, material from the Lewis and Clark Herbarium, specimens that were collected during that expedition, the bitter root of Montana labeled by Lewis himself.

Dr. Nicholson?

[A biographical sketch of Dr. Nicholson follows:]

DR. THOMAS D. NICHOLSON

Dr Thomas D Nicholson, Director of The American Museum of Natural History, is an administrator with an extensive practical and academic background in astronomy, navigation and the teaching of science.

He was born in New York City in 1922 and graduated from the United States Merchant Marine Academy at Kings Point, N.Y., in 1942. He was with the Merchant Marine for four years during World War II, serving in every rank through Chief Officer on troop transports and cargo supply ships in all theaters. He is a licensed Ship's Master.

In addition to a B.S. degree from the United States Merchant Marine Academy, Dr. Nicholson also received a B.A. degree from St. John's University, Brooklyn, from which he graduated summa cum laude in 1950. In 1953 he obtained his M.S. degree from the School of Education, Fordham University, and in 1961 he received his Ph.D. from that school.

Dr. Nicholson taught at the United States Merchant Marine Academy from 1946 to 1954, first as an instructor, and later as an Assistant Professor of Navigation and Astronomy He also served as Assistant to the Head of the Department of Nautical Science.

Dr Nicholson was a guest lecturer and instructor at The American Museum-Hayden Planetarium for two years, beginning in 1952, before his appointment as Associate Astronomer in 1954. He was promoted to Astronomer in 1957, to Assistant Chairman in 1958 and to Chairman in 1964.

In January, 1968, Dr Nicholson was named Assistant Director of The American Museum of Natural History In October, 1968, he was appointed Deputy Director, and on July 1, 1969, he became Director of the Museum.

Early in 1956, Dr Nicholson served as a group leader in a two-month geodetic surveying program for the Western Electric Company at Canadian Arctic Distant Early Warning Sites. He returned to the Arctic in 1958 to lead a site selection and surveying team working on the Greenland Ice Cap. He led The American Museum-Hayden Planetarium's eclipse expeditions in Michigan in 1951 and in Quebec in 1963 He was a member of the eclipse expedition to Ceylon in the summer of 1955.

Dr Nicholson has written extensively about astronomy and related fields in both popular and scientific publications. He is co-author with Joseph M Chamberlain of *Planets, Stars and Space*, published by Creative Education Society in 1957, and author of *Adventure With Stars*, published by Capitol Publishing Company in 1959. He is a Contributing Editor of *Natural History* magazine and Editor of the *Astronomy Highlights Series*, published by the Natural History Press.

His professional memberships include those in The American Astronomical Society, The Institute of Navigation, The American Institute of Aeronautics and Astronautics, The Astronomical Society of the Pacific, The Royal Astronomical Society, The American Meteorological Society, and The American Association for the Advancement of Science.

Dr Nicholson resides with his wife, the former Branca Costa, and four children, Lester, Diana, Glen, and Gail, in Woodcliff Lake, N.J

STATEMENT OF DR. THOMAS D. NICHOLSON, DIRECTOR, THE AMERICAN MUSEUM OF NATURAL HISTORY OF NEW YORK, NEW YORK, NY

Dr. NICHOLSON. Thank you, Peter.

Congressmen, Peter mentioned that we were private museums. The word "private" is really not an appropriate term. We are really public institutions but nongovernmental public institutions. Just as many of the great universities of our Nation are public universities but, by and large, not governmentally managed, ours also are not, although they are public institutions.

We know there are about 3,000 museums throughout our country, and they are all the same in some ways, different in others. In some ways all of them are recreational, cultural, artistic, educational, and scholarly institutions. But the purpose and the degree of resources and services they give to each of these aspects of their work vary enormously.

Collections are the one element that binds us together. But collections do not make museums, any more than a warehouse of books would make a library. Collections become a museum where there is purpose and use related to some services that society—science and other agencies of society—demands.

The institutions that comprise the Associated Natural Science Institutions that are speaking to you this morning were founded to be centers of scholarship in the sciences of nature. They were founded to be repositories of the material evidence of the world, of life, and of human culture.

The purpose for being such repositories, however, was to learn through research and to teach through exhibition and by other means, and these institutions derive their authority as teachers on all the levels on which they do teach from their authority in scholarship. Like the university, museums such as ours teach, train, and educate.

The goals of collection-oriented research museums, and the relations to other goals that the same institutions may have, were described in a science policy report that I prepared at the American

Museum in 1971. A copy of it will be made available to you and appended to our presentations today. (See appendix I.)

The report explains why great natural science institutions must be research-oriented in order to serve their other purposes. It explains why it is that we cannot really choose which is the more important of what we do—research, collecting, exhibition, or teaching. Like the human body, in which all the vital organisms are essential, all of these functions are essential to our institutions for organic unity.

The report I refer to stresses that the research goals of our institutions must be appropriate to museums. They must be distinctive from the goals of the university in some ways. The goals should be appropriate to an institution that is collection oriented in its basis of founding.

The report stresses the unique quality of scholarship and training that can and are being produced in museums. It also emphasizes the strength of the commitment to research as a process and as an essential function carried out in our institution.

Not all museums are, nor should all be, research oriented. Not all collections are intended to support scholarship and training. Some must. Those in the natural science institutions that we represent a. e.

I would like to show you now, in a series of pictures, what some of our collections look like, just what they are, and, to some extent, why we have them.

Newt n, would you put on the projector?

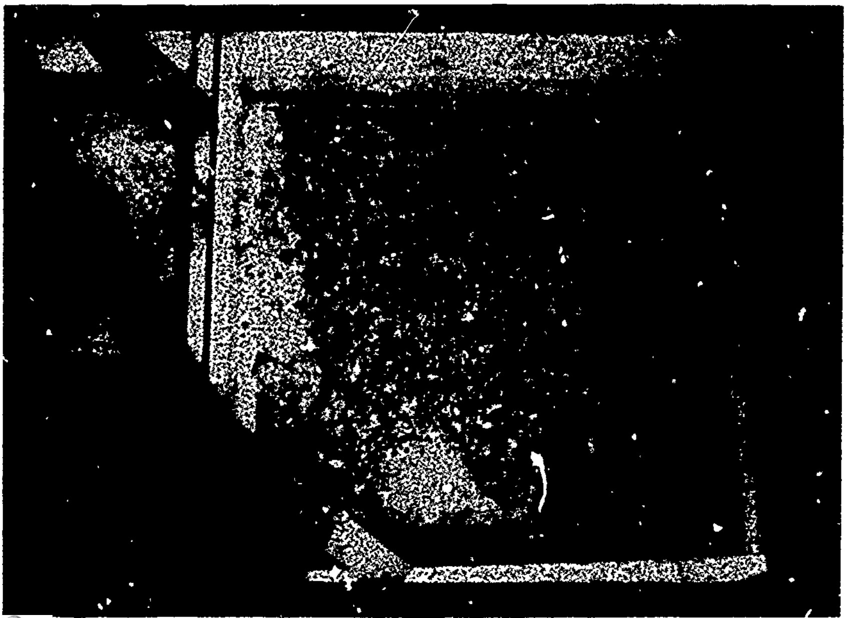
The first picture shows a skull of Tyrannosaurus rex being cast in one of our museums. Casts are exchanged for research and exhibition. [Slide 1 follows:]

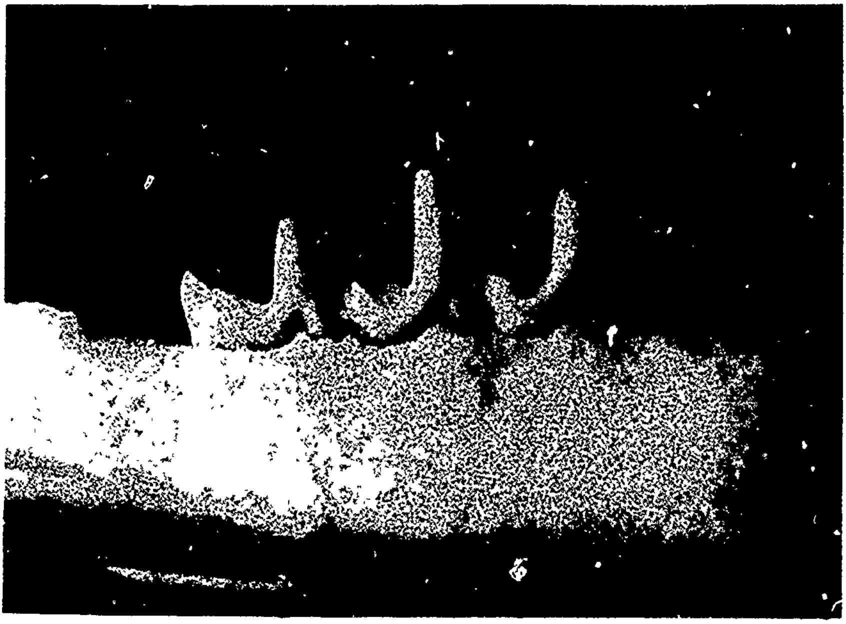
Mr. LUJAN. What did you put up there? I am sorry, I didn't catch what it was.

Dr NICHOLSON. That was a cast of a gigantic animal called Tyrannosaurus rex, a carnivorous dinosaur. A few specimens are found in museums, but those specimens are exchanged throughout the world through the casting processes that we undertake.

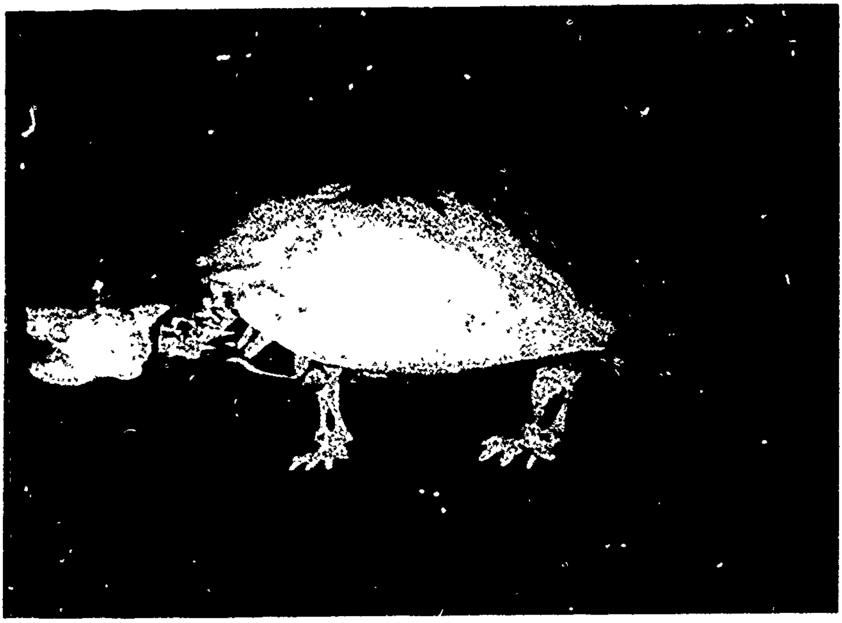
As I said, my first slide shows one of the large fossils that we have in our collections, but not all fossils are large. Many of them come small. This is a group of our scientists collecting cretaceous rock in Lance Creek, Wyoming, to screen for some of the other fossils in the world. [Slide 2 follows:]

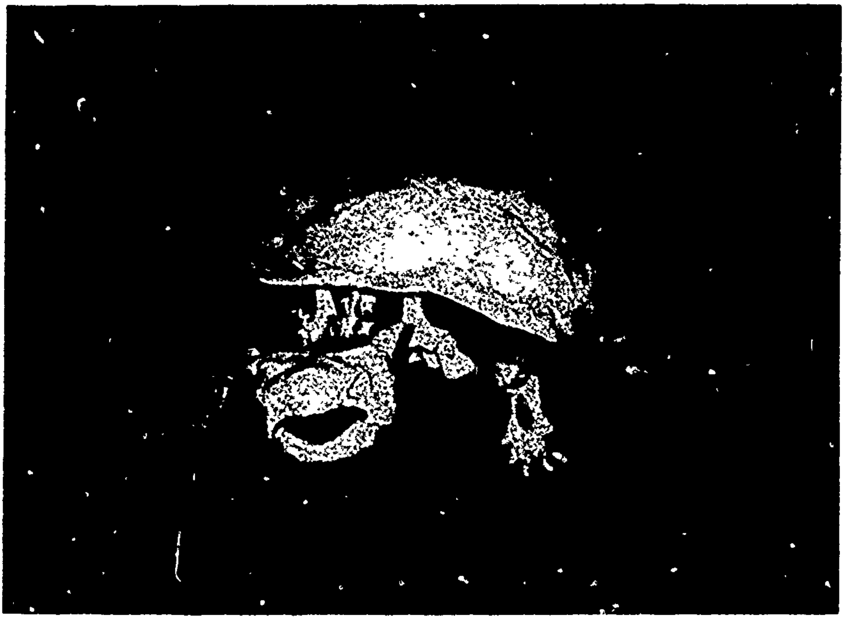
The tailings from hundreds of tons of cretaceous rock in that area leave a few particles such as these, and if you look closely at one of them, we find the left jaw of a small anim l called Profungulatis, a small cretaceous ancestor of the ungulates that roam our plains today. This little jaw is about one centimeter long. [Slides 3 and 4 follow:]



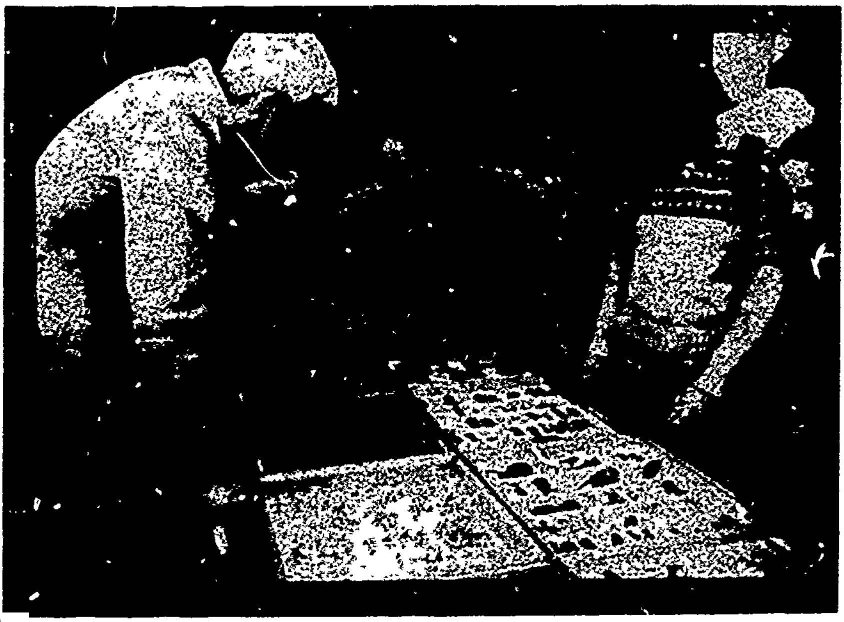


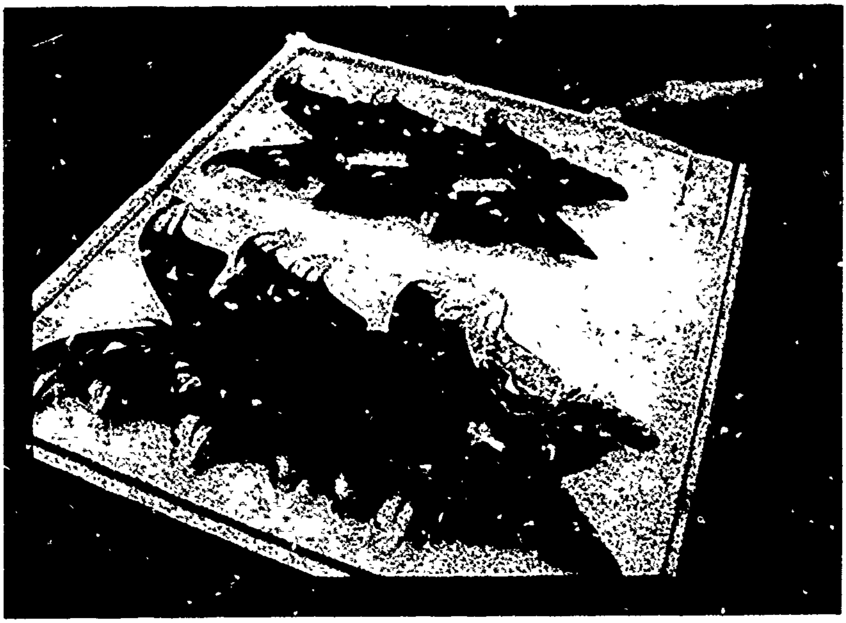
We also collected recently, on Lord Howe Island, an island off the coast of Australia in the South Pacific Ocean—not all fossils are really old. This is a very exotic animal that disappeared from the living animal record about 10,000 or 15,000 years ago. It is a horn-headed and club-tailed turtle. Why it became extinct, we really don't know, but it is in our collections. [Slides 5, 6, and 7 follow:]



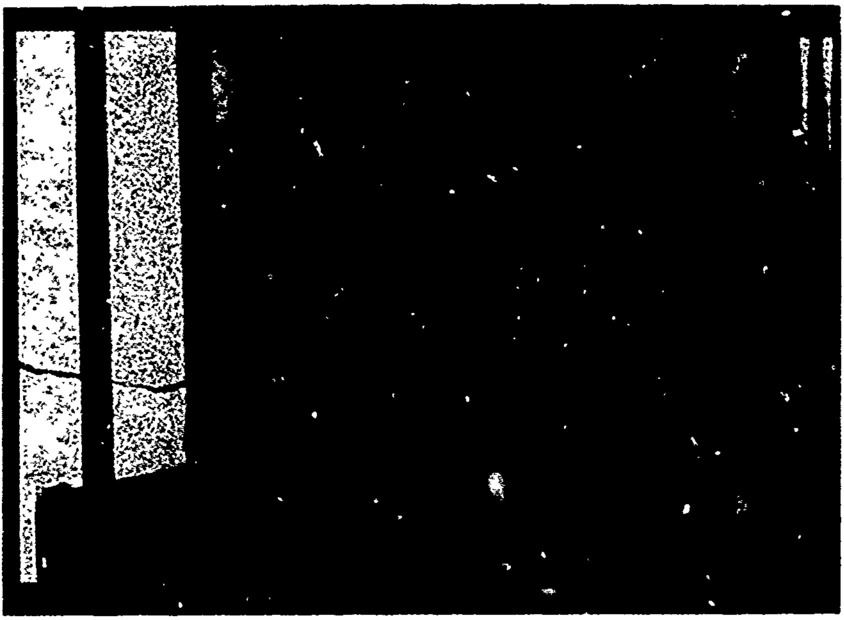


Insects represent the greatest diversity in the animal world and also, therefore, the greatest diversity in our collections, as Secretary Adams pointed out. They are tiny, but we number them in the tens of millions in our collections, and yet we still only have representation from about one-fourth of the insect species that probably exist in the world [Slides 8 and 9 follow:]

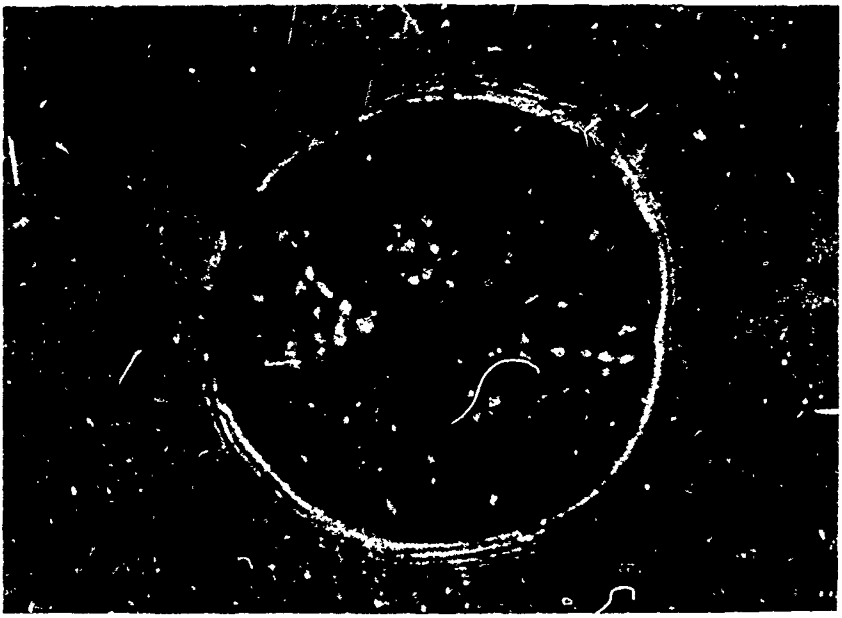




Our collections also include skeletal collections such as these skulls of sea mammals. As you know, they range up to the size of whales. To the best of my knowledge, there is only one blue whale skeleton in any institution in the United States of America. A hundred years from now, it may be the only specimen of a blue whale that we will have available for study. [Slide 10 follows:]

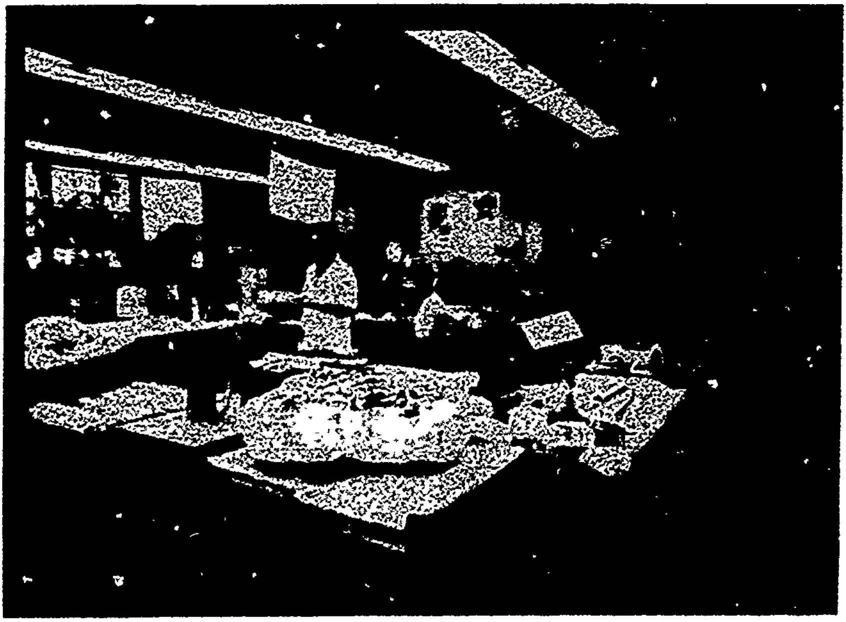


Our collections also include imprints of many of the soft-bodied animals of the past left in sandstone, the only record we have of such life. [Slide 11 follows:]



The problems with our collections are so great that we resort to the techniques of compact storage today, stretching our static buildings. I have just installed 10,000 square feet of this at a cost of $600,000 for the cases, plus another $300,000 that must be spent on the trays that will go inside the cases in that space, so that is $900,000 for a 10,000-square-foot storage area. [Slide 12 follows:]

Skilled preparators are required to work with fossil sea lions such as these. It may take several weeks or even months for a preparator to remove one fossil from the matrix in which it comes from the field. [Slide 13 follows:]

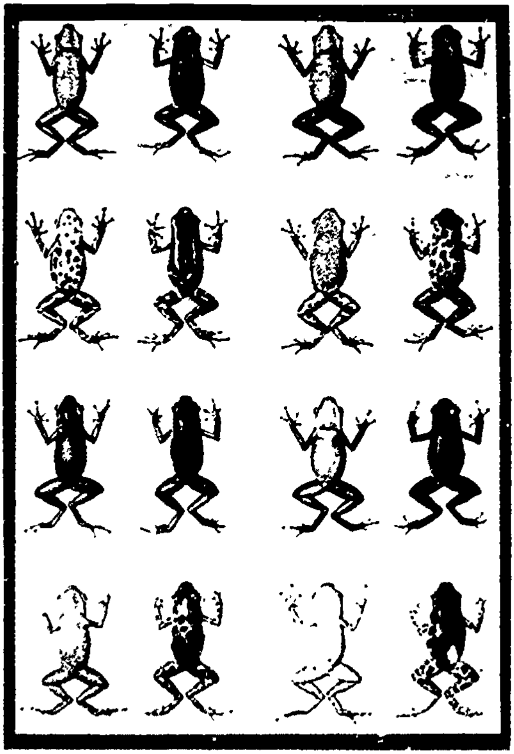


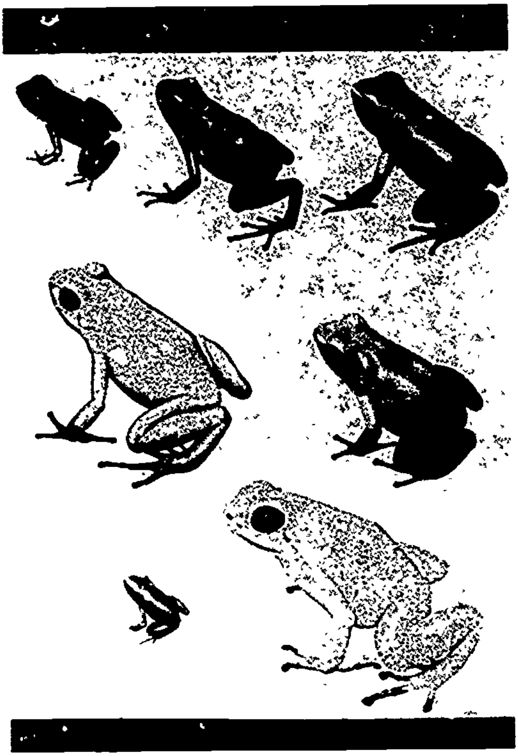
I am one slide ahead, I think. You are now looking at a group of—see, I told Newton I wasn't worried when the slides went out of sequence. People either laugh or they let you know. [Laughter.]

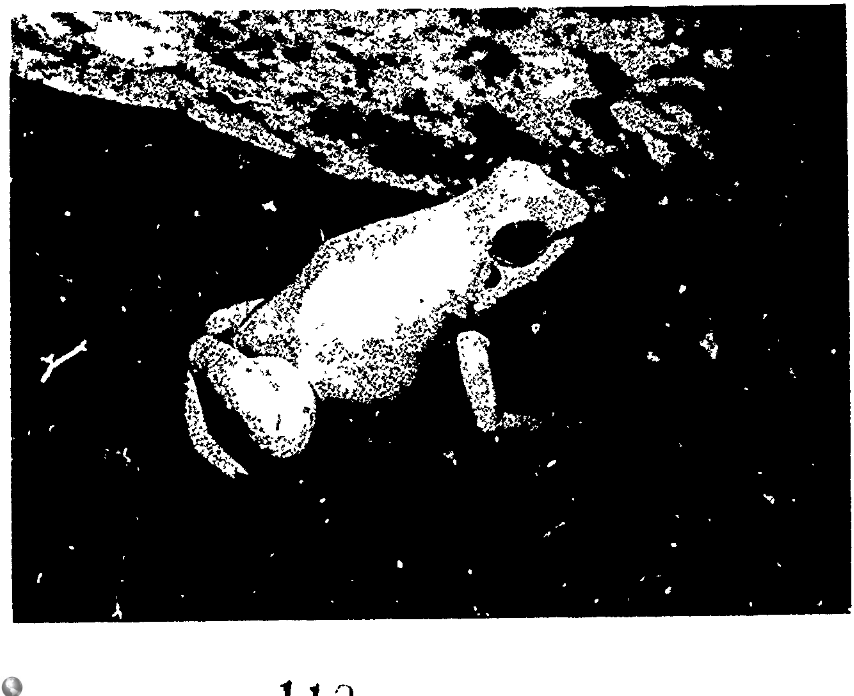
This is a group of white-headed woodpeckers being studied to show variations in the animals. These are all the same species, but you and I vary from one another in innumerable ways. So do woodpeckers, and students and scientists who wish to study them have to have more than one in which to do so, just as they would need more than one of us to understand the human species. [Slide 14 follows:]

We also use live animals in our museums. Here a group of reptiles are being maintained at the California Academy of Sciences from which fresh tissues are being withdrawn to analyze biochemical genetics. [Slide 15 follows:]

Dart poison frogs are found throughout the rain forest areas, the lakes mostly, in North and South America and Middle America, very tiny little animals. This gives you some idea of their scale. But they also come in enormous variations such as this, not only in color and other ways, but the toxins that they secrete on their skins vary enormously. Over 200 new amino-alkaloids of potential medicinal value to humans have been found from the secretions of the variety of these animals that we found in recent years. [Slides 16, 17, 18, and 19 follow:]

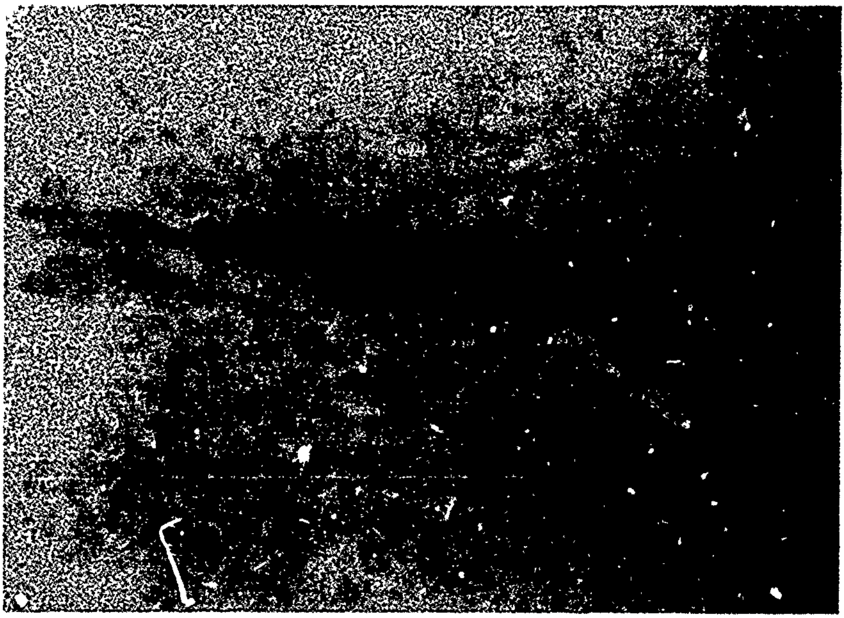


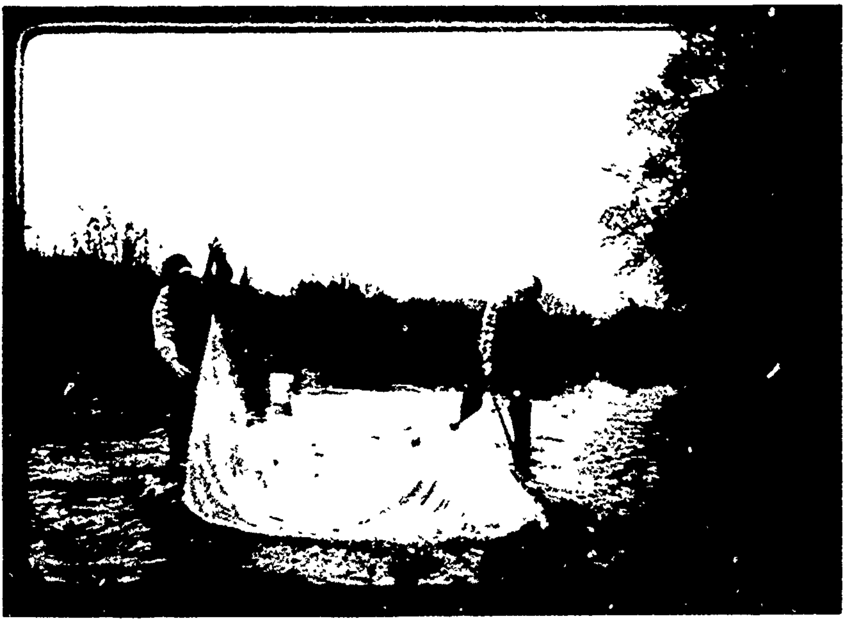




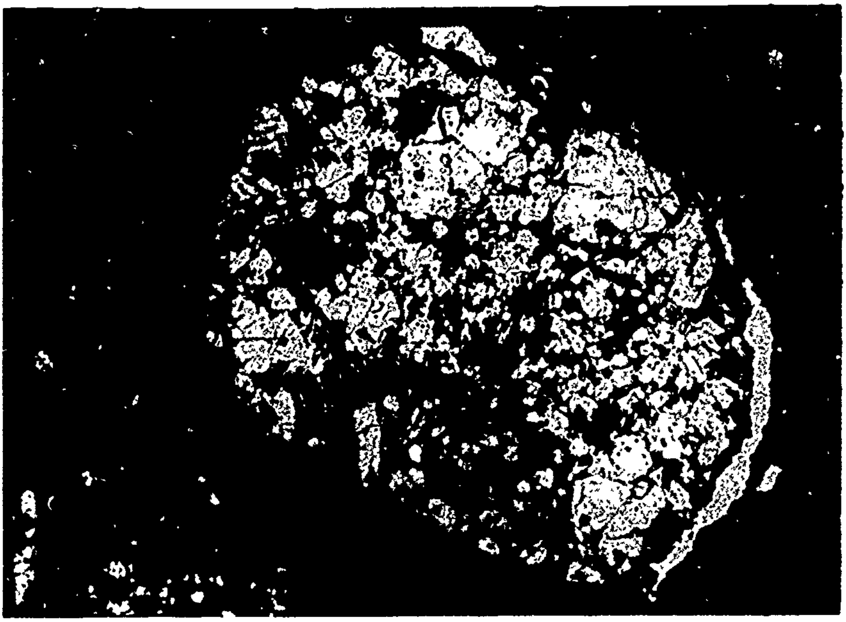
We have been conducting, over the last 10 years, the first survey of the fresh water fishes in New York that has been done in 50 years. We are trying to find out what, where, how many, and how they have changed in the past 50 years, and the collections that we will gather as a result will be the document that they will compare the collection of 100 years from now with in order to see what is happening to the waters of our country.

In addition, we are doing the first study of developmental specimens from the fresh waters of New York. A fish egg only 3 days old, and a fish larva from the Hudson River, the first time in the collections of our institution and most that we have taken an interest in collecting and recording and documenting the developmental stages of these animals. [Slides 20 and 21 follow:]





Finally, this tiny little white grain is in a meteorite. It existed before the solar system came into being. It is part of the material from which the solar system was made, and it is the kind of material that we have in our museums from which we get the answers to where the Earth came from and why. [Slide 22 follows:]



I would like to show you now what some of those specimens look like. I will just hold them up for a moment.

Here is a cast of that horn-headed turtle that I showed you. They come bigger than this, and we cannot help but wonder why it was ever designed so that it couldn't retract its head inside its carcass, but the horns prevented it from doing so. That is one kind of fossil; here is another one. Inside this, there is a tiny little, oh, less than a centimeter long, jaw of a small tarsier-like primate that was found in Mongolia. It is the oldest known primate from Mongolia, and it is the ancestor of everybody who sits in this room.

Here are some casts of those tiny little poison dart frogs I showed you.

This is a cast of Taung. This is believed to be the earliest homonid that walked on Earth, the earliest animal that bore most of the characteristics of a human being. It was a young child, perhaps 10 or 12 years old, in which we can still see parts, and study parts, of its fossilized brain.

Here is the evidence for the latest possible date at which mankind could reach the southern tip of South America. These are the bones of fossilized horses that became extinct in South America more than 10,000 years ago. These are some spear points and stone tools left there by humans in association with these animal remains, carbon dated to 11,000 B.C. We know mankind reached Tierra del Fuego at 11,000 B.C.

These are two little vials of fish larvae found from the Hudson River. You can see the problem we have in storing them. These are easy to store in volume but difficult in type.

We have two specimens of a material called asbestos here. One of them is asbestiform in the sense that it is fibrous; it is a cancer-causing agent, we know. We have another specimen of asbestos here which is not asbestiform, and it is not harmful to humans. Why? What is the difference between these kinds of asbestos and others, and what are the characteristics that cause human health problems?

This is the oldest rock we know, 4½ billion years old, a chunk of Allende, in which we can see those tiny little white specks that were there before the rock was formed, that probably came together into the protoplanets because of some shock wave moving through the then gaseous and dust-filled solar system without planets.

Finally, I brought a group of insects to show you the comparison between a group of insect cells, of bee cells, 40 million years old, found in the western part of the United States. They built cells in this now-solidified sandstone.

This is a modern group of bee cells from a honeybee found in the same area today. Forty million years separate them, but they are bees of exactly the same tribe and many of the same habits.

One of those bees was found on top of a plateau in southwestern Venezuela only recently, in Nablina, where the Smithsonian Institution scientists and ours and others from other institutions traveled. The bee is in here. This is a bee of the same tribe that produced those cells 40 million years ago, and we found it on Nablina.

Finally, I brought a sample of one of our living animals. This is a tarantula from our collection. We have roughly 3.5 million spiders in our collection. Some day Betsy will join that collection, but right now Betsy is alive and well, and I would like to introduce her to you personally after I finish my testimony, on the principle that once you have petted and held a tarantula, you will never forget the person that introduced her to you. [Laughter.]

Dr. BENNETT. Thank you, Tom.

Dr. NICHOLSON. I just want to say one or two words to close, Peter.

I don't know whether you are interested, but we are interested, and we think most of the world is interested, in when and how the Earth was formed; how pollutants may affect the development of fish in our streams; why Meiolania, that turtle, could not pull his head inside his shell; why some asbestos is harmful and other is not; whether Taung really was a human; how humanity migrated through the Americas; what beneficial chemicals does nature build of use of mankind; and who was living on the Earth with the dinosaurs.

Well, these are the kinds of questions that collecting, collections, and research in natural history museums are prepared to answer. These are research museums, distinct and unique, with goals essentially a part of the science establishment, equipped, staffed, functioning to address things that we want to know, things that we need to know about life, about nature, and about human institutions.

Thank you.

[The prepared statement of Dr. Nicholson follows:]

THE RESEARCH MUSEUM

The total number of museums in the United States is probably about 3,000. All of them are recreational cultural, artistic, educational and scholarly institutions, to a degree, though they are by no means uniform in the purpose, resources and services that reflect these roles.

Collections of material objects comprise the one element common to all museums. But a collection of itself is no more a museum than a warehouse of books is a library. Only when collections and collecting serve certain purposes that society considers important do they become a museum. The differences and degrees of purpose to which collections are applied account for much of the differences among museums.

The five research institutions that comprise TANSI, and others like them, were founded to be centers of scholarship in the sciences that relate to the world of nature. They were established to collect with purpose, to collect and maintain collections representing the world around us and the life styles of its human inhabitants, to help us learn about the world through research, and to enable us to teach what it is like through exhibition and other means.

The research goals of collection-oriented science museums, and the relationship between these goals and other areas of institutional purpose, were expressed in the "Science Policy Report" formulated and published by the American Museum of Natural History in 1971. A copy is appended in this statement.

The "Report" identifies the original and unique contribution to research appropriate to natural science institutions, the research goals to which they can best contribute, and the strength of their commitment to research as a process and a function essential to their institutional goals.

Not all Museums are strong research institutions, not all collections are maintained for that purpose. But some must be. Those represented in IANSI are.

I have with me some pictures and materials to illustrate what research collections are, what they look like, and what we do with them.

First, the photographs:

LIST OF SLIDES

1) Casting skull of <u>Tyrannosaurus</u> <u>rex</u>. L.A.C.M.

2) Screening for fossils in Lance Creek, Wyoming. AMNH

3) The tailings from 300 tons of cretaceous rock. AMNH

4) Left jaw of Protungulatum, tiny Cretaceous ancestor of our hoofed mammals. AMNH

5) Lord Howe Island, South Pacific.

6) Meiolania (horned turtle). AMNH

7) Insect Trays, C.A.S.

8) Skeletal Collections. C.A.S.

9) Fossil bearing sandstone. C.A.S.

10) Compact storage equipment. L.A.C.M.

11) Preparation of fossil sections, Southern California L.A.C.

12) White headed woodpeckers being studied for variation. L.A.C.M.

13) Live reptiles as a source of fresh tissue for analyzing biochemical genetics. L.A.C.M.

14) Dart poison frog, Phyllobates terribilis, paratopotype. AMNH

15) Dart Poison frog D. <u>steyermarki</u>. AMNH

16) Variation. Dart poison frogs. AMNH

17) Sampling N.Y. Allegheny River. AMNH

18) Three-day old egg. Percopsis omiscomaycus. AMNH

19) Fish larva. AMNH.

20) Micrograph of particle in Allende meteorite. AMNH

Some of the objects represented in the pictures I've shown are laid out on the table before you.

LIST OF OBJECTS

1) Cast of skull, Meiolania.

2) Samples of asbestos, one asbestiform, one not.

3) Piece of Allende meteorite.

4) Casts of Dart Poison frogs.

5) Stone tools from Milodont Cave, Chile.

6) Artifacts from Huanuco Pampa, Northern Andes, Peru.

7) Jaw of Altanius orlovi, tiny primate from Mongolia, Asia's oldest tarsier-like primate.

8) Fish larvae vials, Hudson River, New York

9) Taung skull, cast.

10) Fossil Bee Hive, 40,000,000 years.

To close, I would like to pose some simple questions. Do you think it is important to know

1) When and how the earth was formed?

2) How pollutants affect fish propagation in our rivers?

3) Why Meiolania had horns which kept him from pulling his head in?

4) How and why some asbestos is harmful and some apparently isn't?

5) Whether Taung was truly human, and why his lineage died out?

6) When mankind arrived in the New World?

7) How the Inca thrived and built a great civilization in the Andes?

8) If secretions from some of those cute little dart poison frogs have therapeutic value for humans?

9) If the fossil record of earth's little animals can help us learn when and how the continents were formed and changed, and life went through periodic great extinctions?

These are the kind of questions that research museums and their collections are prepared to answer. They are an essential element in the science community, equipped, staffed and functioning to address things we want to know, need to know about life, nature and human institutions.

Dr. BENNETT. Our next witness is Dr. George Davis, former president of the Association of Systematics Collections, Chairman of the Malacology Department at the Academy of Natural Sciences.

[A biographical sketch of Dr. Davis follows:]

DR. GEORGE MORGAN DAVIS

PERSONAL INFORMATION

Birthdate: 21 May 1938, Bridgeport, Connecticut
Marital Status: Married, two children
Citizenship: United States.

EDUCATION

Ph D., 1965. Zoology-Malacology. University of Michigan
M S., 1962. Zoology. University of Michigan
B A., 1960. Biology, Marietta College.

WORK HISTORY

Curator and Chairman, Department of Malacology, Academy of Natural Sciences of Philadelphia, 1978 to date.

Adjunct Professor, Department of Biology, University of Pennsylvania, 1982 to date

Adjunct Professor. Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania. 1983 to date

Adjunct Professor. College of Marine Studies, University of Delaware. 1982 to date

Adjunct Associate Professor. Department of Biology. University of Pennsylvania, 1972 to date.

Adjunct Associate Professor. Department of Pathobiology, University of Pennsylvania. 1976 to 1983.

Chairman. Department of Malacology, Academy of Natural Sciences of Philadelphia, 1972 to date.

Adjunct Associate Professor, Department of Microbiology, Thomas Jefferson University, 1971 to 1980.

Associate Curator of Malacology, Academy of Natural Sciences of Philadelphia, 1970 to 1978.

Chief, Malacology Section, 406th Army Medical Laboratory, Japan, 1965 to 1970.

Research Associate, Research and Development, Medical Malacology, University of Michigan, 1962 to 1965.

HONORS/AWARDS

Fellow, Linnean Society, 1979.
Fellow, American Association for the Advancement of Science, 1976.
Arthur S. Fleming Award in Science (Group of 10), 1970.
Sustained Superior Performance Award, U.S. Government, 1968, 1969.
NIH Traineeship, 1964 to 1965.
Rackham First-year Fellowship, 1960 to 1961.
Phi Sigma (Vice President, Local Chapter), 1962.
Eggleston-Ruby Prize in Biology, 1960.
Phi Beta Kappa, 1960.
Sigma Xi, 1962.
Who's Who in American Colleges and Universities,, 1960.
Omicron Delta Kappa, 1959.
Beta Beta Beta (President, Local Chapter), 1959.

NATIONAL-INTERNATIONAL RESPONSIBILITIES

Current:

Member, Steering Committee for the American Foundation for Negro Affairs, Computer, Engineering and Business Division, 1984.

Member, Editorial Board, *American Malacological Bulletin*, 1982.

President, Association of Systematics Collections, 1982 to 1984.

Chairman, Council of Systematic Malacologists, Committee on Course Standards for Graduate Training in Malacology, 1982 to 1983.

Field Reader, Grant Reviews; Institute of Museum Services.

International Congress of Malacology, Chairman, Committee for assessing mechanisms ensuring adequately and properly described species, 1980 to date.

Chairman, American Malacological Bulletin Archive Committee, 1980 to date.

Co-Editor-in-Chief, *Malacologia*, International Journal of Malacology, 1974 to date.

Executive Secretary/Treasurer, Institute of Malacology, 1972 to date.

A.N.S.P. Representative, Association of Systematics Collections 1977 to date.

Past:

Chairman, Editorial Board, *American Malacological Bulletin*, 1982 to 1983

Vice President, Assoc. of Systematics Collections, 1981 to 1982.

Chairman, Special Publications Committee, A.M.U., 1981 to 1982.

Chairman, Council of Systematic Malacologists, National Plan for Malacology, 1980 to 1982.

Treasurer, A.S.C., 1977 to 1981.

Member, Council on Resources, A.S.C., 1977 to 1981.

Chairman, Council of Systematic Malacologists, 1977 to 1979.

Nominating Committee, A.S.C., 1977 to 1978.

President, American Malacological Union (A.M.U.), 1976 to 1977.

Treasurer, Organizing Committee, Joint Meeting Royal Society of Tropical Medicine and American Society of Tropical Medicine, 1975 to 1976.

STATEMENT OF DR. GEORGE M. DAVIS, CHAIRMAN, DEPARTMENT OF MALACOLOGY, ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA, PHILADELPHIA, PA

Dr. DAVIS. Mr. Chairman, as a research scientist, I am going to address the question of systematic research and the value of collections. The presentation I am going to make is an abbreviated form of the one that has been submitted for the record.

Systematics is the fundamental and most essential field within the biological sciences. The systematist studies the diversity of life on Earth, describes and identifies species, and studies the relationships among species using all available techniques and data. The systematist also studies the processes involved in the origin and extinction of species.

It is important to realize that the systematist today is a modern research scientist thoroughly trained as a specialist in one or more groups of organisms. But what does a systematist do?

As an example of what one systematist actually does, consider a scientist studying the relationships of snails and human diseases transmitted by snails. I have two examples here of snails from China and snails from the Mekong River transmitting the world's second worst disease, schistosomiasis, affecting over 200 million people and growing at a rate of 5 percent to 8 percent per year.

In studying this relationship of snails and disease, the scientist collects snails from targeted areas of the world, determines the identity of the specimens by comparing the specimens newly collected from the field, going to the museum, using the specimens that are in the museum, using the libraries of the museum, and the research facilities of comparative anatomy and cytology to determine their status as identified or as new.

The scientist then determines the relationship among species of close genetic relationship to species actually transmitting a disease. He does this by using sophisticated laboratory techniques such as molecular genetics, involving complex biochemical processes and operations within the museum.

Within the museum, powerful computers are used to model pathways of evolution based on anatomical and biochemical data. Such a model may involve studying 100 to 200 different species located on different continents. The data show that the 100 to 200 species have evolved in entirely different pathways.

It is then learned that the potential to transmit a disease is actually associated with specific anatomical and biochemical features found in only one of these evolving pathways. Then the scientist begins to use these data for many ends—to determine the genetic relationships between parasites and only those snails capable of transmitting disease, to determine the rate of change in snails and parasites, to predict that other species transmitting disease will be found, and where they will be found, and to redefine the nature of parasites and the diseases they cause.

We must consider that biological diversity on Earth now exceeds 1.5 million known species of plants and animals. Yet there is an estimated 8 to 10 million additional species that have yet to be discovered and described.

Identification of species requires not only the trained scientist but also collections of organisms and reference libraries. Large collections of organisms are as essential to the systematist as telescopes are to the astronomer and particle accelerators are to the nuclear physicist.

Systematic biological collections provide the infrastructure for all biological research, and are essential for cutting-edge research in systematics and evolutionary biological problems.

Systematic biological collections stand alone as information banks for the storage and retrieval of basic biological information. There are today some 4,000 collections in the United States, housing between 500 million and 750 million biological specimens. Approximately 85 percent of these collections are housed in 100 major institutions. The 20 largest collections housed in natural history museums contain about 20 percent of all specimens maintained in the United States.

Systematic biological collections contain specimens preserved as dry specimens such as these shells of clams which were used for t ic studies of clams in the United States; or preserved in alcohol, such as these specimens. Likewise, clams collected from river systems in the United States are used for genetic studies or preserved as frozen, both as whole organisms or as protein extracts for molecular genetics studies, such as these lyophilized extracts of proteins which, 10 years from now, will yield viable enzymes for genetic studies.

This tremendous file of indispensable data represents generations of work by thousands of skilled people. More than ever, it is a priceless, irreplaceable instrument of research for human betterment.

No one major collection is comprehensive in coverage, but each complements the others both as to groups of organisms and the geographic areas represented, thus reaching encyclopedic proportions when considered as a single national entity.

The integrity of these collections must be guaranteed because if they are lost, they can never be replaced. If not maintained, they cannot be used, and if static and warehoused unused, the fabric of organismic biology itself unravels.

The major collections are primarily housed in nonuniversity museums. With the ever-increasing diversification of fields of biological research on college campuses, and with different universities—and I think it is important to understand this—different universities specializing in evolving different fields of biology, more and more collections are being transferred from departments of biology to nonuniversity museums.

Natural history museums today have become the primary centers for systematic biological research. Modern techniques such as molecular genetics and computerized data processing are being used within museums to obtain new data from existing collections and from new types of collections. It is important to realize that collections grow today at a rate of 1.5 to 3 percent per year due to modern research activities carried out on a global scale.

Natural history museums are now the training centers for future systematists. Systematists employed by museums frequently are adjunct professors in one or more universities. They teach courses in systematics, ecology, and evolution as well as train future Ph.D. systematists.

Natural history museums now share with universities the responsibilities of conducting basic research in the biological sciences. To a considerable extent, the future of organismic biology is coupled with the future of collections-oriented research in museums.

Thank you.

[The prepared statement of Dr. Davis follows:]

SYSTEMATIC RESEARCH AND THE VALUE OF COLLECTIONS

George M. Davis
The Associated Natural Science Institutions
Past President: Association of Systematics Collections

Systematics is the fundamental and most essential field within the biological sciences. The systematist studies the diversity of life on earth, describes and identifies species, studies the relationships among species using all available techniques and data. The systematist also studies the processes involved in the origin and extinction of species.

The systematist of today is a modern research scientist thoroughly trained as a specialist on one or more groups of organisms. But what does a systematist do? As an example of what one systematist actually does consider a scientist studying the relationships of snails and human diseases transmitted by snails. The scientist collects snails from targeted areas of the world, determines the identity of the species by a comparison of newly collected animals with identified specimens stored in museum collections, by use of scientific publications, and by use of comparative anatomy and cytology. The scientist then determines the relationships among species suspected of close genetic relationship with species actually transmitting a disease using sophisticated laboratory techniques such as molecular genetics involving complex biochemical operations. Powerful computers are used to model pathways of evolution based on anatomical and biochemical data. Such a model may involve studying 100 to 200 different species located on different continents. The data show that the 100 to 200 species have evolved along different pathways. It is learned that the potential to transmit a disease is associated with specific anatomical and biochemical features found in only one of the several pathways of evolution. The scientist then uses these data for many ends: to determine the genetic relationship between parasites and only those snails capable of transmitting the parasites; to determine the rate of change in snails and parasites; to predict that other species transmitting disease will be found, and where they will be found; to help redefine the specific nature of parasites and the diseases they cause.

Biological diversity on earth exceeds 1.5 million known species of plants and animals. An estimated 8 to 10 million additional species have yet to be discovered and described. Identification of species requires not only the trained scientist but also collections of organisms and reference libraries. Large collections of organisms are as essential to the systematist as telescopes are to the astronomer and particle accelerators are to the nuclear physicist. Systematic biological collections provide the infrastructure for all biological research and are essential for cutting-edge research in systematics and evolutionary biological problems.

"Systematic biology collections stand alone as information banks for the storage and retrieval of basic biological information."[1] There are some 4000 collections in the United States housing between 500 to 750 million specimens. Approximately 85% of these colletions are housed in 100 major facilities. The 20 largest collections housed in natural history museums contain about 20% of all specimens maintained in the United States.[2] Systematic biological collections contain specimens preserved as dried specimens, preserved in alcohol, or preserved frozen both as whole organisms or as protein extracts. "This tremendous file of indispensable data represents generations of work by thousands of skilled people. More than ever, it is a priceless, irreplaceable instrument of research for human betterment. No one major collection is comprehensive in coverage, but each complements the others both as to groups of organisms and geographic area represented, thus reaching encyclopedic proportions when considered as a single national entity."[1] The integrity of these collections must be guaranteed because if they are lost, they can never be replaced; if not maintained, they cannot be used; if static and warehoused unused, the fabric or organismic biology unravels.

The major collections are primarily housed in non-university museums. With the ever-increasing diversification of fields of biological research on college campuses, and with different universities specializing in different fields of biology, more and more collections are being transferred from departments of biology to non-university museums. Natural history museums today have become the primary centers for systematic biological research. Modern techniques such as molecular genetics and computerized data processing are being used within museums to obtain new data from existing collections or from new types of collections. Collections grow at a rate of 1.5 to 3% per year due to modern research activities carried out world-wide.

Natural history museums are now the training centers for future systematists. Systematists employed by museums frequently are adjunct professors in one or more universities; they teach courses in systematics, ecology, and evolution as well as train future Ph.D. systematists. Natural history museums now share with universities the responsibilities of conducting basic research in the biological sciences. To a considerable extent the future of organismic biology is coupled with the future of collections-oriented research in museums.

9 April 1985

1. excerpts from the Steere Report (1971) to the National Science Foundation: The Systematic Biology Collections of the United States: An Essential Resource.

2. data compiled by the Association of Systematics Collections (1983-1984) in conjunction with a report prepared for the National Science Foundation.

Dr. BENNETT. Our next witness is Dr. John McCosker, the director of the Steinhart Aquarium, the California Academy of Sciences in San Francisco, who will discuss the implications of the scholarly research and activities that go on at these institutions.

[A biographical sketch of Dr. McCosker follows:]

DR. JOHN E. MCCOSKER

Since 1973, Dr. John E. McCosker has been Director of the Steinhart Aquarium, a division of the California Academy of Sciences. Born in Los Angeles in 1945, he graduated cum laude and Phi Beta Kappa from Occidental College in 1967. He received his Ph.D. in Marine Biology from the Scripps Institution of Oceanography in 1973 based upon original research concerning the evolution of a large family of tropical eels. Other related employment included a lectureship at the University of California at San Diego, a Research Associate at the Smithsonian Tropical Research Institute in Panama studying the potential biological effects of the proposed sea-level canal, and an adjunct professorship in Marine Biology at San Francisco State University, a position which he now concurrently holds.

Although trained as an evolutionary biologist, with research expertise based largely upon museum collections, his research activities have subsequently broadened to include such diverse topics as the symbiotic behavior of bioluminescent fishes, the behavior of venomous sea snakes, the predatory behavior of the great white shark, and dispersed and renewable energy sources as alternatives to national vulnerability and war. His most recent research projects have concerned attacks upon humans by great white sharks and involves the formulation of public safety plans. His work was summarized in a 1984 NOVA program entitled "Jaws: the True Story". He is the author of more than 100 popular and scientific articles and books.

STATEMENT OF DR. JOHN E. McCOSKER, DIRECTOR, STEINHART AQUARIUM, CALIFORNIA ACADEMY OF SCIENCES, SAN FRANCISCO, CA

Dr. MCCOSKER. Thank you.

In order to allow more time for questions—and for you all to handle Tom's tarantula—I, too, will present an abridged version of the document that I have left with you.

My colleagues have explained to you the rationale behind research collections, their importance to evolutionary biologists and, therefore, to all branches of scientific investigation. They have left me an opportunity to go beyond the search for knowledge and the meaning of life, and to suggest to you examples of the economic benefits of research collections; in short, the bottom line.

I will address the short-term and long-term benefits of such research with but a few examples. There are many.

In the short run, the knowledge we have now gained allows the most efficient and cost-effective way to rationally exploit the living and nonliving resources of our globe. For example, nearly one-half of the pharmaceuticals now in use are biological in origin. The aspirin I took before coming to this meeting first came from a willow; when I last needed penicillin, it came from a green mold. You may be pleased to hear it is not on display. Conservatively, it is estimated that there are more than 5 million unique kinds of plants and animals living on our planet. Most of these remain unknown and uncollected. In that taxonomic studies provide an evolutionary roadmap to biological similarities among organisms, the use of these collections provides the most efficient direction for further research.

One must appreciate that for eons, plants and animals have been coevolving as a means to avoid each other. Through their evolution, these living laboratories have manufactured chemical defenses against pests and predators, and we have only recently begun to take advantage of these naturally occurring products. Collections have played, and continue to play, a key role in this. For example, during World War II, when critically needed sources of the antimalarial, quinine, from Indonesia were unavailable, botanists turned to herbaria. There they examined thousands of specimens of wild cinchona trees and were able to prepare distribution maps of those species and identify areas where cinchona was available. Well, the rest is history.

Such a chemical treasure trove has so far only been minimally explored. In the past few years, taxonomists and biochemists have isolated useful substances from invertebrates, for example, including potential heart drugs from fireflies, a cockroach repellent from a millipede, and shark repellents from a marine mollusk and the Moses sole.

I cannot stress enough the importance of massive collections that must be made as soon as possible in key areas of the world where deforestation and habitat change is so rapidly occurring. Species of plants and animals are going extinct in the great rain forests before we will even have a chance to explore their potential as pharmaceuticals or future crops. Based on what we now know about the interrelationships of organisms, we can most efficiently direct our attention to life forms that hold the most promise by using the collections.

The long-term benefits of research collections are priceless in that they are the only record of life on earth before, during, and after the industrialization of our environment. Like a great library, the specimens in our collections allow us an opportunity to refer back to a time and place in history. We cannot predict which specimens we will ultimately need, but if properly collected, preserved and maintained, they will be available when we need to consult them.

For example, when it was discovered that the death in America of many pelicans, falcons and other birds was caused by eggshell thinning due to DDT interference with calcium metabolism, scientists hurriedly turned to our research collections in order to analyze the critical uptake and residence time of dangerous pesticides. The usage of such pesticides was found to be detrimental to our own survival, and these birds thus acted as "canaries in our fragile goldmine."

Similarly, the discovery in the 1970's of mercury in swordfish tissue resulted in the collapse of the southern California fishery. The immediate presumption that our discharging of industrial mercury had resulted in a Minimata-like catastrophe was later proven unsound after museum scientists analyzed fish specimens collected before the turn of the century. Old specimens had similar mercury levels in their tissues, indicating that the accumulation of naturally occurring mercury in the marine ecosystem is a natural process and not caused by our perturbations. Further study has allowed the resumption of that previously beleaguered fishery. In like manner, collections of reptiles from the far West and corals from the South Pacific have allowed baseline studies of radionuclide accumulation since 1945, and the good news so far is that they do not evidence any deleterious effects.

I will end by returning to my comparison of research collections to a great library of life on Earth. The analogy is only partially adequate, however, because there is no equivalent to the Xerox machine for the volumes that we are missing. It is imperative that we increase our collecting efforts both in America and abroad as specimens disappear and new threats to our health are discovered. The collections that now exist can never be replaced. They must be properly supported, adequately maintained, and expanded. There is no alternative.

Thank you.

[The prepared statement of Dr. McCosker follows:]

ECONOMIC BENEFITS OF RESEARCH COLLECTIONS: THE BOTTOM LINE

Testimony Presented by John E. McCosker

Before the House Committee on Science and Technology

17 April 1985

My colleagues have explained to you the rationale behind research collections, their importance to evolutionary biologists and, therefore, to all other branches of scientific investigation, as well as the role they play in the training of future scientists. They have left me an opportunity to go beyond the search for knowledge and the meaning of life, and to suggest to you examples of the economic benefit of research collections -- in short, the bottom line.

I will address the short-term and long-term benefits of such research with but a few examples. There are many.

In the short run, the knowledge we now have gained allows the most efficient and cost-effective way to rationally exploit the living and non-living resources of our planet. For example, nearly one half of the pharmaceuticals now in use are biological in origin. The aspirin I took last night first came from a willow; when I last needed penicillin, it came from the green mold Penicillium notatum. There are more than 5,000,000 unique living species of plants and animals, most of which remain unknown and uncollected; in that taxonomic studies provide an evolutionary roadmap to biochemical similarities among organisms, the use of collections provide the most efficient direction rather than a helter-skelter approach.

One must appreciate that for eons, plants and animals have been coevolving as a means to avoid each other. Through their evolution, these "living laboratories" have manufactured chemical defenses against pests and predators and we have only recently begun to take advantage of these naturally-occurring products. Collections play a key role; for example, during World War II, when critically needed supplies of the antimalarial, quinine, from Indonesia were inaccessible, botanists examined thousands of herbarium specimens of wild cinchona trees from whose bark quinine is derived. They were thus able to prepare distributionn maps of the species and identify geographic areas where harvestable stands of the tree were likely to occur, and thus revealed new sources of the drug. Such a chemical treasure trove has so far only been minimally explored. In the past few years, taxonomists and biochemists have isolated useful substances from invertebrates including potential heart drugs from fireflies, a cockroach repellent from a millipede, and shark repellents from a marine mollusk and the Moses sole. Similarly, Dr. Peter Raven relates that the evening primrose has been found to contain a chemical which may have a role in controlling heart disease and arthritis. There is no question that we have only begun to explore the beneficial pharmaceuticals available from a wide variety of plants and animals.

I cannot stress enough the importance of massive collections that must be made as soon as possible in key areas of the world where deforestation and habitat change is rapidly occurring. Species of plants and animals are going extinct in the great rain forests before we will have a chance to explore their potential as pharmaceuticals. Based on what we now know about the interrelationships of organisms, we can most efficiently direct our attention to life forms that hold the most promise.

The value of collections to teach evolutionary biology cannot be understated due to the benefits they provide researchers in other disciplines. The petroleum industry is dependent upon indicator species of microscopic algae called diatoms which occur in exploratory oil drillings. Specimen collections are used for identification and comparison to other oil-bearing strata with similar species assemblages. Those same microscopic creatures once served a more obscure purpose several years ago. Our specimens were used to solve a kidnapping in southern California by the identification of diatoms in mud collected from the suspect's car tires. And, to cite personal experience, I suggest that my training as an evolutionary biologist at a collection-based institution has allowed me direct solutions to very complex and seemingly-unrelated problems. I was recently approached by Chevron with an expensive problem concerning their deep ocean wellheads. Large eels had clogged their well bores and stymied their operations. Given photographs taken by robotic devices, I was able to identify the responsible species with the aid of preserved specimens for comparison. Based upon knowledge of the behavior of related shallow water species, I teamed up with a biochemist and devised an environmentally benign eel repulsant, now called "Eel-Away" in the trade.

The long term benefits of research collections are priceless in that they are the only record of life on Earth before, during, and after the industrialization of our environment. Like a great library, the specimens in a collection allow an opportunity to refer back to a time and place in history. We cannot predict which specimens we will ultimately need, but if properly collected, preserved and maintained, they will be available when we need to consult them.

For example, when it was discovered that the death in America of many pelicans, falcons and other birds was caused by eggshell thinning due to DDT interference with calcium metabolism, scientists hurriedly turned to research collections to analyze the critical uptake and residence time of dangerous pesticides. The useage of such pesticides was found to be detrimental to our own survival and those birds thereby served as "canaries in our fragile goldmine". Similarly, the discovery in the 1970's of mercury in swordfish tissue resulted in the collapse of the Southern California fishery. The immediate presumption that our discharging of industrial mercury had resulted in a Minimata-like catastrophe was later proven unsound after museum scientists analyzed fish specimens collected before the turn of the century. Old specimens had similar mercury levels in their tissues, indicating that the accumulation of naturally-occurring mercury in the marine ecosystem is a natural process, and further study has allowed the resumption of that beleaguered fishery. In like manner, collections of reptiles from the far west and corals from the south Pacific have allowed baseline studies of radionucleide accumulation since 1945. And the good news is that they do not evidence any deleterious effects.

I will end by returning to my comparison of research collections to a great library of life on Earth. The analogy is only partially adequate because there is no equivalent to the xerox machine for missing volumes. It is imperative that we increase our collecting efforts both in America and abroad as species disappear and new threats to our health are discovered. The collections that now exist can never be replaced: They must be properly supported, adequately maintained, and expanded. There is no alternative.

Dr. BENNETT. Our next panelist is Dr. John Fitzpatrick, Chairman of the Department of Zoology, Field Museum of Natural History in Chicago. Dr. Fitzpatrick will elaborate on the topic that was discussed earlier about the educational role of our institutions, not only in informal science education, to which we have a very major commitment, but as a research role as well—predoctoral, postdoctoral, and internships.

[A biographical sketch of Dr. Fitzpatrick follows:]

DR. JOHN W. FITZPATRICK

Born: 17 September 1951, St. Paul, Minnesota.

Married: 9 July 1983 to Mary Ellen Wyer.

Current position: Chairman, Department of Zoology, Associate Curator and Head, Division of Birds, Field Museum of Natural History, Roosevelt Road at Lake Shore Drive, Chicago, IL 60605-2496, telephone: 312-922-9410.

Education: A.B. magna cum laude, Harvard University, Dept. Biology, 1974, Ph.D. Princeton University, Dept. Biology, 1978.

Academic and research honors: Harvard College Honorary Scholarships, 1971-1974; USF Undergraduate Research Participant, 1972; Sigma Xi, elected 1973; NSF Graduate Fellowship Hon. Mention, 1975; Harry R. Painton Award (outstanding published papers), Cooper Ornighological Society, 1981.

Fellowships and grants: NSF Undergraduate Research Grant, 1972, Archbold Biological Station student research aid, 1973; Princeton University Graduate Fellowship, 1974-75; 1977-78; NIH Predoctoral Traineeship, 1975-1977; Chapman Memorial Fund Grants for Research, 1975; 1976-78; NSF Doctoral Dissertation Grant, Field Sciences, 1976-78; National Research Council Travel Award to West Berlin, 1978; National Geographic Society Research Grant, 1979-80; NSF Biol. Research Resource Support Grant (DEB 80-21414), 1981-86; NSF Travel Award to Moscow, USSR, 1982; and four grants from private foundations (LeBus Charitable Trust, Combined Insurance Group) for ornithological research.

Professional memberships: American Association for the Advancement of Science; American Society of Naturalists; Society of Systematic Zoology; Animal Behaviour Society, American Ornithologists' Union (life member); Cooper Ornithological Society; and Wilson Ornithological Society (life member).

Adjunct faculty positions: University of Chicago, Comm. on Evol Biol., lecturer, 1980-presen.. Northern Illinois University, Department of Biology, adjunct assistant professor 1982-present; Dept. Biology Graduate Faculty, 1983-present.

Professional offices, committees, honors: Elective Member, American Ornithologists' Union, elected 1979; AOU Student Awards Committee, 1979-1981; Chairman, Local Committee, 100th annual meeting, AOU, 1982; Council, American Ornithologists' Union, 1981-1984; AOU Bylaws Committee, 1982-present; and AOU Committee on Classification and Nomenclature, 1983-present.

Field museum administrative posts, committees: Head, Division of Birds, 1978-present; Chairman, Scientific Support Services, 1979-1983; Member, Science Advisory Council, 1980-present; Chairman, Science Advisory Council, 1983; Chairman, Dept. Zoology Promotions Committee, 1982; and Systematics Symposium Committee, 1981-present.

Foreign field work: Peru (1974, 1975, 1976, 1977, 1979, 1981, 1983, 1985); Venezuela (1974, 1975, 1977); Brazil (1977, 1980); Colombia (1972, 1974); Ecuador (Field Museum tour lecturer, 1982); Mexico (1973, 1983); Dominican Republic (1975); and Panama (1974).

Fields of research: Systematics, evolution, and adaptive radiation of New World flycatcher; Zoogeography of South American birds, especially eastern Andes; Avian community structure in Neotropical forests; General systematics of Neotropical birds; Field tests of optimal foraging theory among insectivorous birds; and Demography and social evolution among cooperative-breeding birds (collaboration with G.E Woolfenden).

STATEMENT OF DR. JOHN W. FITZPATRICK, CHAIRMAN, DEPARTMENT OF ZOOLOGY, FIELD MUSEUM OF NATURAL HISTORY, CHICAGO, IL

Dr. FITZPATRICK. Mr. Chairman, honorable Congressmen, I am a birdman by trade but, like many of my colleagues here, I have become a part-time educator as well. For that reason, my comments are directed specifically this morning to the problem of training new systematic biologists and the importance of this endeavor within the nation as a whole.

In a very real sense, the great systematic collections around the country, both public and scientific, are the property of everybody. Their millions of irreplaceable specimens must be organized and identified and housed in a manner that ensures their permanent usefulness to the national and international community. Proper care and educated use of the great systematic collections therefore demand the presence of skilled professionals who are trained in the highly specialized field of systematic biology. Without them, the priceless archives and biological inventories easily languish into chaos.

I am sad to report that countless once-valuable systematic collections in less farsighted countries around the world now attest to the tragedies of such neglect. Ultimately, these tragedies stem from the disappearance of centers where new, young systematists can continue to be trained.

So my main message to you this morning is that training in systematic biology has become more and more localized to those few universities around the Nation that have access to the major systematic collections of animals and plants. Even at these universities, continued opportunity for superior training in systematics is threatened. More fashionable—and certainly more expensive—fields of biological research are proliferating and dominating, and for good reasons.

But universities are increasingly directing their attention and resources toward the staffing and the funding of such fields as molecular biology and even biotechnology, and the mounting economic pressures that demand this make it impossible to reverse the trend at these universities away from their support of basic systematic research. Yet the need for this research is as acute as ever, and perhaps more so, given the great environmental uncertainties that are now looming over all of us.

The few national centers for systematic research bear an increasingly heavy financial burden. They are providing the collections, the libraries, the personnel, the professional expertise needed for the training of new graduate students entering this crucial field of scholarly research, and without these students, the very fabric of biological research itself is threatened.

So these great museums participate in graduate education with pride and conviction as a service to the community and to the biological profession. But they are doing so at an ever-increasing cost, with shrinking financial support, and with growing demands at the museums for more visible, relevant, and also expensive programs for general public education.

Please permit me one brief example. At the Field Museum of Natural History, close interaction has existed for years between its 35 Ph.D. research scientists and the graduate departments of four of Chicago's finest universities. This interaction is increasing in recent years as other universities around the Nation close their doors to the systematics programs.

The University of Chicago, for example, is home to an internationally known Committee on Evolutionary Biology, which is a degree-granting department made up of both university professors and museum curators working together. That university—and this is the critical point—that university now attracts some of its very finest students in biology specifically to train in part with professionals at the Field museum. Many of those students do not happen to be eligible for NSF doctoral fellowships because they actually arrive with too much prior training, and yet those are, of course, the students that would make up the optimal pool to form a new cohort of systematists in the future.

So we have to support and train these students at our museums increasingly if systematics is to remain a viable field. The research museums are contributing their unique services and priceless collections to graduate education in a field which the National Science Foundation itself has identified as a national priority.

The students, the universities, the applied researchers everywhere, and ultimately the general public, all benefit from this important and growing contribution by the museums. But, like everything else, this contribution, of course, has its costs. Expenses in time and direct funding are especially difficult for these private, nonprofit institutions that traditionally have not benefited from Federal support for graduate training.

As institutions that are committed to serving both the scientific and the lay community, the research museums need to continue their commitment to graduate education through joint efforts universities and their communities. But as this need keeps growing, it is outstripping the museums' ability to keep up financially.

At present, we cannot even support the students we are training now, let alone more students in the future. So we certainly hope that the extent and the value of the research museums' commitment to graduate education is recognized as vital and irreplaceable and a contribution to the public good. And so we feel justified in seeking, hoping for, public assistance in this endeavor in the form of direct support for graduate students whose educational careers include substantial time spent within the walls of these great museums.

Thank you.

[The prepared statement of Dr. Fitzpatrick follows:]

DR. JOHN W. FITZPATRICK

HONORABLE CONGRESSMEN:

You are hearing this morning about the absolutely critical role played by the research and collections at the nation's major natural history museums. These institutions, and the research they foster, literally provide the foundations upon which all biological, biomedical, and agricultural research depend. I hope and trust that the public interests served by these national research centers have been made clear: These collections comprise our only reliable libraries of the physical and natural world. As such, these collections -- both public and scientific -- are in a very real sense the property of everybody. Their millions of irreplacable specimens must be identified, organized, and housed in a manner that insures their usefulness to the national and international community.

Proper care and educated use of the great systematic collections demands the continued presence of skilled professionals who are trained in the highly specialized, labor intensive fields of systematic biology. In the absence of active professionals, these priceless archives and biological inventories easily languish into chaos. I am sad to report that countless, once valuable systematic collections in less farsighted countries around the world attest to the tragedies of such neglect. Ultimately, those tragedies stem from the disappearance of centers where new, young systematists are actively trained.

My message to you is that training in systematic biology has become more and more localized, in this country, to those few universities around the nation that have access to the few, major systematic collections of animals and plants. Even at these universities, continued opportunity for superior training in systematics is threatened. More fashionable (and more expensive) fields of biological research are proliferating and dominating. Universities around the country increasingly are directing their attention and resources toward the staffing and funding of molecular biology and even biotechnology. Mounting economic pressures for huge grants at these universities are making it impossible to reverse the trend away from their support of basic systematic research. Yet, the need for such research is as acute as ever -- perhaps even more so, given the great environmental uncertainties now looming over us all.

P. 2

My message to you is that the few national centers for systematic research are bearing an increasingly heavy financial burdon. They are providing the resources, collections, libraries, facilities, and professional expertise needed for the training of new graduate students attempting to enter this crucial field of scholarly research. We see no lack of outstanding and interested students seeking such training. Without them, the very fabric of biological research would be in peril. The great museums now participate in graduate education with pride and conviction, as a service to the community and the biological professions. But they do so at ever increasing cost, with shrinking financial support, and with growing demands for the more visible, relevant, and expensive programs of general public education.

At the Field Museum of Natural History, close interaction exists between its 35 Ph.D. research biologists and the graduate departments of 4 of Chicago's premier universities. This interaction is increasing dramatically in recent years, as other universities around the nation continue to close their doors to systematics programs. The University of Chicago, for example, is home to the internationally renown Committee on Evolutionary Biology, a degree-granting graduate department made up of university professors and museum curators. The University of Chicago now annually attracts some of its very best students in biology specifically to train with professionals at the Field Museum. Many of these students are not eligible for NSF doctoral fellowships because they arrive with too much training in hand. Yet, these are precisely the sample of students who could form the best possible cohort of new systematic biologists. We must support and train these students at our museums if systematics is to remain a viable field in the biological sciences.

The Field Museum and its sister institutions are contributing their unique services and priceless collections to graduate education, in a field which the National Science Foundation itself has identified as a national priority. The students, the universities, applied researchers, and ultimately the general public all benefit from this important and growing contribution. Like everything else, though, this contribution has its costs. Expenses in time and direct funding are especially burdonsome to private, non-profit institutions that traditionally have not benefitted from federal support for graduate training.

P. 3

As institutions that steadfastly are committed to serving both the scientific and the lay community, the research museums perceive a need to continue their commitment to graduate education, through joint efforts with universities in their communities. But as this need keeps growing it is outstripping the museums' ability to keep up financially. At present, we simply cannot support the students we train now, let alone more in the future. We sincerely hope that the extent and value of the research museums' commitment to graduate education is recognized as a vital and irreplacable contribution to the public good. We therefore feel justified in seeking some small level of public assistance in this endeavor, in the form of direct support for graduate students who spend significant portions of their educational careers within our own walls.

John W. Fitzpatrick
Chairman, Department of Zoology
Field Museum of Natural History
Chicago, Illinois

Dr. BENNETT. For the record, I should comment that when John and I used the term "private," we were using a legalistic term, 501(c)(3). We agree with Tom Nicholson that we are perhaps next to public libraries, perhaps equal with public libraries, public institutions—free access to all scholars, researchers, visitors. We are supported by public funds, city, State, county, Federal, as well as private.

Thank you for your courteous attention to our testimony, and we are delighted to answer any questions you may have at this time.

PANEL DISCUSSION

Mr. FUQUA. Thank you very much. It was very, very interesting.

Do you grant, or do research museums grant, postgraduate degrees such as master's and Ph.D.'s in the scientific disciplines?

Dr. BENNETT. We do this through our collaborative programs with universities—the University of Pennsylvania, Columbia University, and others.

Dr. NICHOLSON. One of the last things we want to become is universities, and that is what granting degrees would mean. We would be involved in an entirely different area of operations. We prefer to participate in that part of the training where we are best able to do so.

Mr. FUQUA. And where do these people find employment, with other museums or research-type institutions?

Dr. NICHOLSON. Museums, Government agencies, universities as teachers, even some at high school levels as teachers, all through society.

Dr. BENNETT. State agencies, city agencies.

Dr. FITZPATRICK. Agricultural research centers, and so on.

Mr. FUQUA. I believe you mentioned, Dr. Fitzpatrick, that there was not enough staff. Do I take it there is an undersupply of qualified Ph.D.'s in these fields?

Dr. FITZPATRICK. I think it is fair to say that the supply is at least roughly matching the demand, and that is partly because these few major museums are not capable of infinitely growing themselves, and so they are keeping at roughly a steady state in terms of supplying new professionals in those fields.

Dr. NICHOLSON. Do you want to comment on that, Dr. Davis? I think you have some specific figures.

Dr. DAVIS. One of the things that you can keep in mind is that there are 4,000 major collections in the United States today. There are only about 2,000 qualified systematists to work with those and to maintain those resources. So there is a decided need in terms of the resources to have more input in terms of qualified manpower.

Dr. NICHOLSON. I would also suggest that supply ought to be measured by the need, not so much by the number of jobs and the funds that may be available.

Dr. FITZPATRICK. That is an excellent point.

Mr. FUQUA. So how do you see this in the longer term, say, the next 10 or 20 years?

Dr. DAVIS. Basically, if you look at the demand for use of these resources for research, the use is increasing exponentially as the technologies become available to get more data from collections. We are now finding that with collections growing at a rate of about 3 percent a year, I think about 3 percent of 750 million specimens, plus the need for rapid exploration of the neotropics where the destruction of habitats is causing a marked decrease in understanding biological diversity, if you look at that, we do not have a set figure to present before you at this time. We could work one up, but it would be a substantial increase.

The need for manpower and facilities has been projected by this community and by the Association of Systematics Collections, looking at the problems of developing resources for the futures. Yes, there is a considerable need.

Mr. FUQUA. How do you see the public's perception? Do you see it on the increase in their awareness of these types of museums and the flow of people through the museums? Is that increasing, and the ability of people in the private sector to support museums?

Dr. FITZPATRICK. I would like to make one comment about that relating to public perception. It is, of course, I think, well known to everybody here that the general public perception and awareness of environmental problems over the last 20 or 30 years has increased dramatically. In part, that is a result of the availability in the popular press of field guides and so on, as well as well-done museums across the country who base their studies and base those guides and those pictures and the movies we see on TV on the work of these specific professionals we have been discussing.

So, in at least one step removed, the public is definitely much more aware, and this awareness is continuing to grow very rapidly.

Mr. FUQUA. Dr. Nicholson?

Dr. NICHOLSON. Faced by the economic pressures of the 1970's and by other factors, we found that our traditional sources of support from endowment and from local government shrank from 82 percent of our gross funds to 36 percent of our gross funds in 15 years. The difference was made up by support mostly from the private sector, and that support is evidence of the degree to which the private sector perceives that we are providing services that they consider to be worthwhile, essential, and useful.

Dr. McCOSKER. May I comment as well that the public, for the most part, does not realize that research is going on, particularly to the degree that it is going on. For example, we have heard in your own testimony that some of you were surprised to discover all the leaves on display in the research part of the museum, not on display, that is.

It is very difficult to educate the public. We have hundreds of millions of visitors to the museums each year in America; yet, of course, we cannot take them through the research collections to show them what we do. For that reason, it has been very difficult to replace the shortfall in Federal funding, statewide funding—particularly in California since Proposition 13—and private funding has not satisfactorily made up for the difference.

The other problem is we are a national resource. Each of our museums maintains collections that are important on a national level, so it is often quite difficult to convince someone locally that they should be supporting a national resource. But it is fair to say that museum visitation is on the rise in America, but that is only paying for the displays, and barely that at all, not the research activities that go on.

Mr. FUQUA. The history of science and technology is a very important part of any of the science museums. What evidence do you see, if any, that that is contributing to the overall science policy of this country?

Dr. BENNETT. I think the science policy should be a continuation of the science policy that was established during the opening up of our country, the founding of our country, the collections that were going into the museums, such as the Lewis and Clark herbarium specimens. These are data bases, historical data bases, which are being examined by scholars in the humanities. They are also data bases for biological materials that go back in time, that give us an understanding of our country since its early inception, and continuing on in the future, and it will be a data base that will be with us into the 21st century and will have both scientific as well as historical value

Mr. FUQUA. Dr. Nicholson.

Dr. NICHOLSON. Two aspects of the history of modern biology have both had their beginnings in museum-like environments and with museum-like purposes. That is the one central concept that pervades all of biological thinking today; that is, the evolution of organic life on Earth. This had its origins in collections of materials and is still being pursued as a science and a philosophy principally in museums.

The second point that pervades modern biology is also something that is central to the concepts that museums have held for years and is reflected in museums' purposes, and that is the essential uniqueness of the organism, of the individual, not simply as a person, as a self versus nonself, but in terms of such things as the immune system, neurobiological processes, developmental processes

54-939 O - 86 - 6

in all organisms. These, we are beginning to learn in all branches of biology, are essentially unique with respect to each individual on Earth. They go on separately, independently, and uniquely in each and every one of us. This is the concept behind the pressures to maintain collections of individual specimens in natural science institutions.

Mr. FUQUA. I was going to comment earlier, Dr. Nicholson, on the horned turtle. I think I understand why it is extinct now. [Laughter.]

Do you think—and this is for all of you to comment if you choose—do you think the current science policy complements the work of the museum natural scientists?

Dr. Davis.

Dr. DAVIS. I think that, basically, there has been some very determined awareness of the importance of collection-based research in this country, and in fact policies and mechanisms have come to the fore to begin to try to address these very important questions.

This has primarily come, of course, through the National Science Foundation. There is a very important program within that which is called the Biological Research Resources Program. This program certainly grew out of the national awareness reports made by Steere early on, years ago, presented to the National Science Foundation, stating that these collections had to have some Federal support because they were essentially being used to back up—being the fundamental platform for biological research in the United States, the resources had to be protected and maintained.

So, indeed, there has been an awareness. Perhaps it could be much more. Perhaps it needs to be refocused and growing. But if you look at the history of the United States and its Federal policies in terms of exploring expeditions, trying to put together Federal programs to understand what our resources are, store our resources, then modern overlays of the National Science Foundation to try to fund some of the burden of maintaining some of these largest resources as national necessities and treasures for biological research these programs have continuously engendered, I think they should continue to be reevaluated and certainly to grow in proportion.

Mr. FUQUA. Dr. Nicholson.

Dr. NICHOLSON. Evidence that Federal science policy is becoming increasingly aware of the role museums are playing is here in this hearing room. We have been invited to appear before you. Concern that Federal policy does not adequately reflect our role is evidenced by the fact that we requested the hearing. We feel that there is a story that should be told, that has to be told. The reason why we feel that, more than anything else, is that we have perceived over the past 10 to 20 years instances in which we have been judged in our requests for support with respect to some kinds of our activities; we have been judged as museums and not as research institutions. There have been, and there still remain, programs in those agencies that the Federal Government has established to support research scholarship and training. There have been programs from which we have been excluded, not because we don't participate in those processes, but because we are museums, and the perception of us has been as museums, and not as an essential element in the processes they were intended to support.

Mr. FUQUA. Mr. Brown.

Mr. BROWN. Just to follow up on that a little bit, Professor Nicholson. There are actually institutions of higher education doing research that are excluded, also, for similar reasons, valid or not, and we have tried to correct some of these problems where it has been brought to our attention, and I think we would like to do that with regard to research museums. Certainly the contribution that they make warrants a degree of Federal concern for them. Do any of you happen to know how much is available through this resource in the Division of Biology of the National Science Foundation for providing resources for museums?

Dr. NICHOLSON. The total annual appropriation is about $4 million. Jim, is that right?

Mr. TYLER. It is about $9 million right now, $9.5 million. The program director for that particular program at NSF, the new one, is Jim Edwards, sitting behind Secretary Adams over there, and he probably has the figure off the top of his head.

Dr. NICHOLSON. That is in the BRR Program.

Mr. TYLER. Biological Research Resources Program.

Mr. BROWN. All right. This is the first time that particular program has been specifically brought to my attention. As a matter of fact, this is kind of a first. I don't think this committee has ever had a presentation as comprehensive as you gentlemen have given us on the work of the research museums, and we appreciate it very much.

Now, you are stressing research, as Dr. Adams also stressed for the Smithsonian, and that is a very important element for us to have in mind. You are not downgrading the public education and science aspects of your work, are you? [Laughter.]

Dr. BENNETT. In no way.

Dr. NICHOLSON. No, sir; as I tried to explain, the heart and the spleen, and the liver are all essential, at least to us.

Dr. BENNETT. As we read the guidelines for your task force, the thrust of it, we decided to not emphasize at this particular hearing the science education aspects. But we are most concerned about that.

Mr. BROWN. All right.

Now, I would like to have, if not here orally, at least in some written form, any examples that you might be able to give us of programs for the support of graduate students in biology or any other field which, by regulation or guideline or whatever, exclude research museums from participation. I don't see any reasonable justification for that, where the research museum provides a necessary ingredient in the research of the scientists that——

Dr. BENNETT. We can provide that for you, Congressman Brown.

Mr. BROWN. I would appreciate it. For example, if NSF has got guidelines, or NIH, or any of these institutions that support a large number of scientists, both predoctoral and postdoctoral, and if there is anything there that precludes participation is support of scientists working in your setting, I think we would like to know that.

Mr. FUQUA. Or statutorily.

Mr. BROWN. Yes; right.

Let me ask you one other thing. You have undertaken a huge job, of course, to put into museum collections all of the biological and other resources that exist. In a sense, there is no limit to what you could be doing. You could almost replicate the universe. You don't want to do that, of course. You have to select, and you have to do so in some fashion that provides some representation of the real universe.

Also, it seems to me that it would be logical that you make an effort to coordinate your collections. Can you speak to that point? Is there an effort on the part of the major research institutions to coordinate their efforts in such a way that they can obtain the maximum value from the resources that they have available, so that you don't all collect the same kind of bug, for example, or whatever it may be; that you don't all try to duplicate that horned turtle?

Dr. BENNETT. The fact that we have formed this group indicates that we are very conscious of this, and I think Dr. Davis can speak to the issue, particularly.

Dr. DAVIS. Mr. Brown, basically, the Association of Systematics Collections was formed as an organization in the United States to have a meeting of all of the institutions which house collections, both living and preserved. Basically, out of that has come an awareness of policies within museums relative to the growth of collections, because, obviously, one cannot collect everything.

The growth of collections, then, basically, there are some fundamental rules, and some of those fundamental rules are that basically, since you cannot collect everything, what are the methods by which you progress?

Fundamentally, collections serve science; collections exist for science. They grow primarily because of the research activities of the mind of the scientist that is doing work. The scientist doing work has got to have well-structured programs. Most of these are funded as research grants and proposals. These themselves come under peer review from the scientific community.

So there is a very strong selective process not to have duplication of the kinds of research efforts that are going on. It is also generally a policy within institutions, in looking at materials to be accessioned, that you set very strong policies for these so that in fact you will not have duplication; you will just not accept every kind of collection which is offered to a museum. You have very stringent rules looking at the value of the material for research, its origin, and how it fits the specific needs of the institution relative to its own specialities.

For instance, there are certain organisms which may be offered to our museum in Philadelphia which we would say definitely belong to the California Academy of Sciences because they are going to serve the west coast better than the east coast, and we do have these cooperative arrangements and understanding. So there is a whole level of interactive kinds of situations whereby in fact we do not duplicate; we are not looking just to cram museums full of every kind of specimen.

Dr. FITZPATRICK. I might just add very briefly that the museums around the country are increasingly dedicating some of their resources and time to computerizing the inventories of their collections, and part of the rationale for that is exactly what you have pointed out, to be able to coordinate materials among the different institutions.

Mr. BROWN. Let me just continue——

Mr. FUQUA. Dr. McCosker had a comment, I think.

Dr. McCOSKER. My comment was just that: We all speak computer to each other, and this modern technology has given us, in the data storage and data base management, an opportunity to very significantly reduce the overlap. If you were to ask for an area where we would probably benefit significantly, it would be the improvement of our computer facilities so that we could interlock within our institutions and realize long-term savings for all of us.

Mr. BROWN. Well, that is a very important point. Looking at the parallel example of libraries, and in fact research laboratories in general, we find a great and greater need to maintain systematic computer-based information exchanges as a part of our overall problem of managing scientific and technical information, which we are still not very good at.

I was thinking about libraries in connection with some of what you said here. The Library of Congress is sort of a museum. It collects old books—and new books, too—but all kinds of books, and it is running into a real preservation problem, as you do in museums. I was wondering if you feel that the programs that you have for preservation are going to be adequate to maintain a record for posterity when some of the things you are collecting just disappear.

This also involves the public education part. You have got to be able to find ways of preserving, of putting on film or tape or some other way, these great collections, which not only preserves them for posterity but in some cases makes it possible to provide greater public access to them.

I am concerned that you are not neglecting this aspect of the program. I am sure you are not. That is not a question. Forget it. [Laughter.]

Mr. FUQUA. Mr. Volkmer?

Mr. VOLKMER. No questions. I have laryngitis.

Well, let me ask one to follow up on Congressman Brown's question as to the approach we are now taking. We are seeing ecological changes continuing to take place, and there are going to be more changes as evolutionary processes continue. How do you make a determination as to what species or what type of things that you wish to collect because they are no longer going to be here; they are being terminated for one reason or another? How do you determine that it is going to be terminated?

Dr. BENNETT. George, do you want to speak to that?

Mr. VOLKMER. Does the research end have anything to do with that?

Dr. DAVIS. Basically, you have to realize that the scientists, today's scientists, who are taking care of these resources, these collections, are the world authorities and active scientists in their field. The numbers of these in different institutions, interested in different parts of the biota of the world, in fact communicate with each other and, through their field activities, can make an assessment of the underestimate of the species that have been described; how many should be described from an area.

There are people who specialize on the Amazon from all over the world. They get together and they communicate and they determine that if they do not in fact move rapidly to collect in the Amazon or in Malaysia that they are going to lose something like 3 million or 4 million species which will never be known in terms of what their potential is in terms of the biosphere.

They have made trial collections. They have gone out and made trial estimates of how much has been undescribed, the diversity they have gotten from certain areas, and they have regular meetings. The scientific congresses have meetings, sectional meetings of specialists on beetles or sectional meetings of the people studying moths or snails or something of that sort.

As world authorities, they are responsible for determining this need and bringing it forward to the public or to the National Science Foundation. So, basically, the individual scientists do pursue this and do present these programs to responsible agencies.

Mr. VOLKMER. Then do you, in your museum collecting, make any attempt to assist in making sure those items are preserved?

Dr. DAVIS. Basically, again, every one of these scientists in these institutions is dedicated by the job that he or she is doing to not only collect those specimens, but the specimens not properly preserved do not then represent the research you wish to present or publish, so all of these specimens are really voucher specimens held in perpetuity for the research which is published and documenting the various nature of these biota. So the care and the preservation and the subsequent use and reuse of those specimens is absolutely part of the process of exploration, discovery, and scientific publication.

Mr. VOLKMER. Thank you.

Mr. FUQUA. Thank you very much for being here this morning. We may have some additional questions that we will submit to you for written answers.

[Answers to questions asked of the panel follow:]

THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS

499 SOUTH CAPITOL STREET, S W —407
WASHINGTON D C 2000
(202) 554 7983

RESPONSES TO QUESTIONS POSED

BY THE SCIENCE POLICY TASK FORCE OF THE U. S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE AND TECHNOLOGY

Submitted by

Thomas Peter Bennett

President, The Academy of Natural Sciences
and Chairman, The Associated Natural Science Institutions

October 11, 1985

THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS
499 SOUTH CAPITOL STREET, S.W.—407
WASHINGTON, D.C. 20003
(202) 554-7983

THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA
THE MUSEUM OF NATURAL HISTORY OF LOS ANGELES COUNTY
THE FIELD MUSEUM OF NATURAL HISTORY
THE AMERICAN MUSEUM OF NATURAL HISTORY
THE CALIFORNIA ACADEMY OF SCIENCES

October 11, 1985

RESPONSES TO QUESTIONS POSED

BY THE SCIENCE POLICY TASK FORCE OF THE U. S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE AND TECHNOLOGY

1. Question: **Natural history museums have the most obvious and the longest research tradition. How have the research contributions of natural history museums changed since World War II? In what direction are they now headed? In your view, have the contributions of museums to basic research climbed or fallen off since 1945? How can this be accounted for?**

Research on the great diversity of life on this planet began in natural history museums two centuries ago; all subsequent biological research ultimately rests on such studies. The natural science institutions' traditional focus on the whole organism continues today, but much of the research now conducted in such institutions would be unrecognizable to the scientists of two centuries ago. Since World War II, society has begun to place new demands on systematists. For example, with the implementation of the National Environmental Policy Act of 1970, which required the preparation of impact statements for certain kinds of projects, systematists were requested to apply their expertise on the identity, habitat, and behavior of organisms to predict the effects of human activities on the environment. Other scientists also began seeking them out for information relating to food production, disease control, and energy sources. In these applied areas, as well as in the basic science for which they were trained, systematists have increasingly made valuable contributions.

2. Question: **What areas of science seem most promising from the perspective of the research museum? What basic research priorities can be identified for the next few decades? Within limited federal resources available, what role should the natural science institutions play? What effects have recent developments**

in high technology had on the conduct of museum-based scientific research?

Research museums and the systematists on their staffs are uniquely qualified to respond to what is increasingly perceived as the major environmental threat of our times: the rapid destruction and deterioration of the tropics which is causing extinction of species at an unprecedented rate. This threat to biological diversity has been identified as an issue of concern by such varied organizations as Global Report 2000, the President's Commission for a National Agenda for the 80's, the United States Departments of Agriculture and the Interior, the Agency for International Development, World Wildlife Fund-International, and Lutheran World Relief. Why does destruction of the tropics and hence of biological diversity matter? As E.O. Wilson says in his article **The Biological Diversity Crisis: A Challenge to Science:**

> It [biological diversity] comprises a vast reservoir of potential new crops, pharmaceuticals, and other natural products, as well as plant species capable of restoring depleted soils. . . The magnitude and cause of biological diversity is not just the central problem of systematics; it is one of the key problems of science as a whole. It can be said that for a problem to be so ranked, its solution must promise to yield unexpected results, some of which are revolutionary in the sense that they resolve conflicts in current theory while opening productive new areas of research. In addition, the answers should influence a variety of related disciplines. They should affect our view of man's place in the order of things and open opportunities for the development of new technology of social importance. The several criteria are very difficult to satisfy, of course, but I believe that the diversity problem meets them all."

Systematists should play a major role in inventorying and evaluating the biological diversity of threatened tropical regions, and the specimens and data collected should be stored, managed, and disseminated from natural science institutions. Costs for such projects are not high--basically all that is required is the cost of airfare, local guides, and food and equipment suitable for a strenuous camping experience.

Systematics, like other areas of research, has utilized developments in high technology. Tools such as the scanning electron microscope and techniques such as electrophoresis and analysis of DNA have revolutionized our understanding of some organisms.

3. **Question:** It has been noted that there is a trend toward transfer of collections from universities to non-university institutions such as museums. What is the basic cause of this? How do the non-university institutions handle the financial burdens of housing and maintaining such newly acquired collections? Are there any instances where collections have been dispersed or otherwise been lost to scholarly work? Are there, conversely, significant cases where universities have made an affirmative commitment to the continued maintenance of important collections? Are there any signs of a counter-trend, that is, cases where universities have decided to initiate or expand collection-based research?

There are two basic reasons for the transfer of university collections to natural science institutions. First, with declining enrollments during the 1970's, universities were forced to reduce faculty size and cut expenses. Biology departments were particularly hard hit during this time because economic concerns led students into business, computer, and other fields in which financial security was more likely. Because collections have enormous and sometimes expensive housing and space requirements and because their elimination did not necessarily mean the loss of positions in the department, they were relative easy line items to eliminate. The second reason that universities have been willing to divest themselves of their collections is perhaps more subtle. Systematics research is long-term research; sometimes a systematist devotes his entire professional lifetime to the study of one group of organisms. University faculty cannot afford to commit themselves to this type of research; they are under far greater pressure to produce substantial publications on their research if they wish to retain their positions. Consequently, other fields of biology in which data are more quickly obtainable are more attractive to them. In addition, graduate students are at a university for only 4-6 years, and they are equally eager to obtain their data quickly and relatively easily. Many feel that they haven't the time to devote to systematics research. University research is more subject to funding trends than is research at natural science institutions.

Adequate financial support rarely accompanies the transfer of a university collection to a natural science institution. If the collection transferred is small, the costs of accessioning it into the institution's own collection and of maintaining it will be absorbed by the department's general operating budget. In the case of larger collections, the institution will either seek private funds or request support from the National Science Foundation. Frequently, simply the cost of the move from one location to another is staggering.

There are no major collections that have been lost to scholarly work. Universities have been very conscientious about ensuring that their collections are transferred to responsible natural science institutions. There are still major universities, particularly state-supported ones, that are committed to the preservation of their collections. These include the universities of Michigan, Kansas, California, and Florida, and Harvard and Cornell. Other universities maintain small, regional collections, but we are not aware of any recent attempts to establish larger collections.

4. **Question: Why should public funds be expended for basic research in museums to any significant extent? Realistically, isn't most leading-edge scientific research being conducted in universities and medical centers? Within the overall framework of scientific achievements in the United States, what have natural science museums contributed, and what is the relationship between the independent natural science institutions and the universities?**

In the natural sciences, research in museums and research in universities are not in competition; rather, they are complementary, and it is to the benefit of all for both to receive public funds. To support one but not the other would be analogous to sacrificing apples in order to have oranges. Universities have developed in ways that permit them to respond quickly to new conceptual and technical developments and opportunities. Their material resources can be developed rather quickly for specific projects, and they can respond to the public's perceived priorities (cancer or AIDS research, for example) rapidly. The material resources of natural science institutions, however, are their collections and related library material. These resources demand long term planning independent of current applications; planning must anticipate the general nature of future needs. The data base must already be substantially in place when a project is initiated.

Universities and natural science museums recognize the importance of one another's contributions. Both conduct "leading-edge" research and they rely upon one another to fill gaps in their expertise. Mutually beneficial relationships have been established between several universities and museums: the Field Museum and the University of Chicago, the American Museum and Columbia University, the Los Angeles County Museum and USC, the California Academy of Sciences and Stanford, and The Academy of Natural Sciences of Philadelphia and the University of Pennsylvania.

5. Question: How do the achievements of natural history museums contribute to the public good? How do they contribute to the advancement of modern science? What kind of payoff could federal investment in research and development at national science institutions generate? Are there spillovers from achievements of natural science institutions into other areas of the economy?

The systematics research conducted in natural science museums is as important to the public good as is any basic science. It is from basic science that technology and most solutions to societal problems are derived. Systematists are the scientists most qualified to (1) identify the millions of life forms on this planet, (2) evaluate the potential value of this "vast reservoir" of new crops, pharmaceuticals, and other natural products, and (3) estimte the impact on mankind of the rapid decline--caused by the deterioration of natural environments, especially in the tropics--of the world's gene pool.

Examples illustrate how the knowledge acquired through basic systematics research is utilized to produce solutions to specific problems.

1. Systematic botanists discovered a new wild species of corn with two traits that would be highly valuable to farmers if they could be bred into conventional varieties of corn: it is a perennial and it is immune or highly resistant to many viral diseases. If the perennial trait can be bred into conventional varieties of corn, the annual labor and expense of plowing and sowing may eventually be eliminated, and if the disease resistance can be incorporated, losses in annual crop yields can be significantly reduced.

2. A systematist who studies amphibians discovered that a certain Australian species of frog lays its eggs and then swallows them. By the time the ninth egg has been swallowed, the frog's digestive system is completely shut off. Pharmaceutical companies are intensely interested in the enzyme system and chemical environment that make this phenomenon possible, and they hope to develop a process to synthesize the substance for use in digestive disorders and ulcer treatment.

Investors in any basic research should understand that not every discovery has an immediate and direct "payoff." Basic research is undertaken to acquire knowledge and accumulate a data bank which can be used by others attempting to apply the knowledge to derive solutions to problems. Without the underlying knowledge, there can be no "solutions."

6. **Question: Have changes in federal policy toward science in recent years affected museum research, and if so, how? Are there areas of federal policy other than financial support that should address the needs of science museums? What future changes in federal policy toward science, financial and non-financial, would you wish to see introduced with respect to the museum research effort?**

The most obvious change in federal policy during the last few years has been financial. During the last twenty years, constant dollar support for the Biological Research Resources and Systematic Biology programs at the National Science Foundation, the primary funding source for natural science institutions, has not increased although demands on the systematics community have proliferated. In addition, although support has remained constant, costs have risen and the NSF has in many instances increased its requirements for cost sharing on certain types of grants. Recognition of natural science museums as the equals of universities would make us eligible for certain existing programs in which we can not now compete (such as the Presidential Young Investigators Award, a program currently available only to institutions granting doctoral degrees, and the Visiting Professorships for Women program, available only to degree granting institutions). We also recommend a reallocation of existing resources within NSF to permit more long term studies, such as are required for most systematics work.

7. **Question: To what extent and through what agencies does the Federal Government now provide funds for museum-based research? Is this principally done through block grants or through project grants? Apart from the Federal Government, what are the main sources of museum based research? In your view, what should the Federal Government's role be in the coming decades?**

The principal source of federal funds for museum-based research is the National Science Foundation, which provides project funds for periods of one to five years. The recently-published report "The Systematics Community," published by the Association of Systematics Collections, lists 17 federal agencies that provide support for systematics research (i.e., the Department of Agriculture, the National Institutes for Health, the United States Agency for International Development, the Environmental Protection Agency, and the United States Fish and Wildlife Service). However, this number is somewhat misleading since the amount of support provided by these agencies is so small relative to that provided by NSF and since the support is usually for a more restricted range of projects. Federal support is overwhelmingly through project grants, rather than through block grants. Apart from the Federal Government, the main sources of support for museum-based research are: institutional, state, county, and local government, industry, individuals, and private foundations. In coming decades, we would like for the Federal Government's role to include multiple-year block grants to major institutions. Such predictable funding levels would help to ensure program continuity for the institutions with the best record, the greatest potential, and for continuing progress in museum-based research. These grants should be given in three general areas: collection support and maintenance, general support for museum-based research, and graduate and postgraduate student training and assistance. The Federal Government can strengthen support for museum-based research not only through increased financial support, which is badly needed, but also through changes in its perception of the role that museums play in the scientific community. The government's recognition of the importance of the kinds of research carried out in museums can be communicated to the public and the scientific community through changes in policy statements and regulations that clearly include and emphasize their role. Such recognition by the government would hopefully have a snowballing effect and increase the financial support of natural science institutions by individuals and private foundations.

8. Question: What is the present balance between federal and non-federal support for the science efforts at the museums? What share of total funds available from the non-federal sources do research museums allocate to research support in comparison with other museum functions?

The Association of Systematics Collections' report, "The Systematics Community," indicates that the National Science Foundation provided approximately 40% of the systematics research support during the period 1977-1982; it is likely that the percentage of support for museum-based research is even higher. Regarding the share of total non-federal funds available for research support in museums, little data is available. However, two of the museums presenting this testimony have provided estimates for their institutions. One estimates approximately 50% of non-federal funds are used for research, the other estimates about 32%.

9. Question: What are the manpower needs facing science museums today and in the future? To what extent are they able to compete effectively with industry, government, and universities for the best people? Do museums share with universities the same commitment to the training of scientists? Are there employment opportunities in museums to meet the anticipated demand from those being trained for research positions?

At present, universities, in cooperation with museums, are still producing qualified graduates in systematic biology, and museums are very competitive with universities and the private sector in hiring qualified professionals, as evidenced by the number of university faculty that apply for vacant museum positions. Opportunities are not evenly spread over the field of systematics, however; some disciplines, such as ornithology and entomology, experience great difficulty filling positions in both universities and museums, while systematists in other disciplines (such as Polychaeta) cannot find positions anywhere.

The focus should be on the development of expertise in disciplines in which we can predict great need during the coming decades. Pulitzer Prize winning scientist E.O. Wilson of Harvard University states in an article in ISSUES IN SCIENCE AND TECHNOLOGY (fall, 1985) that there are about 4000 systematists working in 3900 systematics collections in North America. Of these, however, only a few are trained in the systematics of organisms from the tropics. Wilson points out, for example, that there are only eight entomologists in the world trained to identify tropical termites and ants, despite the facts that these organisms make up about one-third of the animal biomass in tropical forests, that they cycle a large part of the energy in all terrestrial habitats, and that they include the foremost pests of agriculture.

Museums do share universities commitment to training systematists, yet they lack the financial resources to participate to the extent that they would like. A particular need is funding for postdoctoral positions to continue with and improve the training of young systematists. There is also a concern in the systematics community that our universities are not producing enough systematists to cover our needs into the next century. Systematics is a field that usually requires a strong mentor relationship with an established professional; as the current faculty of museums and universities retires, there will not be enough systematists to replace them and continue the mentor relationship.

10. Question: **What is the state of the research infrastructure, that is, the instrumentation, storage facilities, buildings, and support staff on the research museums? What are the future needs and to what extent can the various sources of funds, such as private donors, state government, industry and business, and the Federal Government be expected to assist with this?**

In the larger research museums, it is generally true that the National Science Foundation provides sufficient funding to maintain major collections at adequate or nearly adequate levels.

There are still, however, some institutions with important holdings that have not yet benefited. Funds for instrumentation (scanning electron microscopes, transmission electron microscopes, dissecting microscopes, x-ray and dark room facilities, chemical laboratories, computers) and for support of the libraries that are essential for systematics research are less available than are funds for storage facilities. In addition, virtually every institution requires more permanent support staff. Because the current level of funding at NSF provides an essential but only minimal core of support for systematics collections and research, there are few opportunities to initiate new programs without jeopardizing vital existing programs. Yet future needs in systematics will require the establishment of sophisticated biochemical laboratories and the development of new methods of preservation (such as freeze-drying, tissue culture, and new liquid preservatives), as well as provision for large computer systems to manage collections internally and network between institutions.

We concur with the recommendation in "Trends, Priorities and Needs in Systematic Biology," published by the Association of Systematics Collections in 1981, that the National Science Foundation not be considered the only appropriate source of support for systematics collections and research. This document states: "Government agencies at all levels, but particularly those of the Federal government, including the Bureau of Land Management, Fish and Wildlife Service, Environmental Protection Agency, Department of Agriculture, Department of Defense, and others that use systematics collections as references or require large scale collecting for their purposes, have an obligation to provide ongoing support for these collections." Institutions will themselves continue to solicit support from private donors and foundations, but these sources more readily support projects than the underlying infrastructure. Many institutions have established fee structures for business and industrial users of collections, but these funds comprise only a tiny fraction of what is required.

THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS
499 SOUTH CAPITOL STREET S W —407
WASHINGTON D C 20003
(202) 554 7983

THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA
THE MUSEUM OF NATURAL HISTORY OF LOS ANGELES COUNTY
THE FIELD MUSEUM OF NATURAL HISTORY
THE AMERICAN MUSEUM OF NATURAL HISTORY
THE CALIFORNIA ACADEMY OF SCIENCES

December 6, 1985

Dr. John D. Holmfeld, Science Consultant
House Subcommittee on Science, Research
& Technology
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear John:

This letter is written in response to Congressman George Brown's question to Dr. Thomas Peter Bennett, President of the Academy of Natural Sciences of Philadelphia, during the hearing on the role of the research museum in U.S. Science. Mr. Brown asked the following question:

"Now, I would like to have, if not here orally, at least in some written form, any examples that you might be able to give us of programs for the subject of graduate students in biology or any other field which, by regulation or guideline or whatever, exclude research museums from participation. I don't see any reasonable justification for that, where the research museum provides a necessary ingredient in the research of scientists that--"

Before answering the question directly, it will be worthwhile to characterize the museum graduate education programs. First, an obvious point, natural history museums are not degree granting institutions. Predoctoral graduate programs at natural history museums are conducted in cooperation with the universities at which the students are matriculated. The ultimate responsibility for the education of the student rests with the university that sends the student to the museum for study. With that said, it is important to add that, in the university-museum relationship, museum curators normally become equal partners with university faculty in providing instruction and guidance for the student. In most cases one or more curators sit with university faculty on the student's dissertation committee.

Since the university is the responsible entity, it can be reasonably asked, why should museums qualify for fellowship support? The answer rests with the need of museum sciences (systematic biology, mineralogy and collection based anthropology) to attract a share of the country's best young scholars. Universities that have access to fellowships, for good and logical reasons, will guide students to research for which they have their own resources. Since, increasingly, independent museums shoulder the burden of instruction in academic fields that require extensive collections, museum sciences currently attract only a few of the very best young college graduates.

The argument in favor of fellowships for non-degree granting institutions prevailed in the House committee markup of a new fellowship program in the Higher Education Act. The enclosed amendment had the support of the national higher education associations and was accepted without dissent.

As might be guessed, federal fellowship programs vary considerably from agency to agency. There are two major types of programs, portable and institutional. NSF, Navy and Air Force fellowships are portable. The award goes to the student and the student takes the award to the institution of his or her choice. Obviously, the issue of museum access to fellowships does not arise in the case of portable fellowships. The situation at NASA is similar except that the student and his advisor apply. There is no reason why a faculty member who advises students in systematic biology could not be a party to a NASA application.

At the other extreme are NIH, Energy and Agriculture. Only degree granting institutions may apply for NIH predoctoral training grants (although postdocs can go anywhere) and the Department of Agriculture has a similar rule. The Department of Energy appears to be the most restrictive. It maintains a list of institutions, all degree granting, and no others, degree-granting or otherwise, need apply.

The NSF Presidential Young Investigator Program is a special case because, in this examination, we have been concerned only with predoctoral training. The Presidential Young Investigators program is cited here because the program would fit well in museum scholarly activities. However, the NSF program is limited to Ph.D granting universities and candidates for awards must hold tenure track positions. Young museum curators obviously would not qualify.

Thank you very much for allowing us to respond to Mr. Brown's inquiry. Let me conclude with the note that we think agencies should rely on their normal review processes to keep unqualified applicants at bay. Denying museums the right to apply for fellowship support does nothing but limit the competition that both we and agency officials support.

Sincerely,

Newton

Newton O. Cattell
Director

NOC
Enclosure

cc: Dr. Thomas Peter Bennett
Dr. Craig C. Black
Dr. Willard L. Boyd
Dr. Thomas D. Nicholson
Dr. Frank H. Talbot

Mr. FUQUA. It has been very helpful. I want to thank all of you for being here. It has been a very enlightening process, and we thank you for being here.

The task force will stand adjourned until 2 o'clock on Tuesday next, when we will have research in industry. Thank you very much.

[Whereupon, at 11:25 a.m., the task force recessed, to reconvene at 2 p.m. on Tuesday, April 23, 1985.]

APPENDIX I

Science Policy Report—The American Museum of Natural History

Science Policy Report

THE AMERICAN MUSEUM OF NATURAL HISTORY

The American Museum of Natural History ranks among the most eminent natural history museums in the world. Its prestige is derived from its exhibitions, its collections, the research productivity of the scientific staff, and its educational program. The Museum's popular reputation, especially strong in the New York City area, but reaching across the nation and around the world, is based on a meaningful and exciting exhibition program combined with public instruction. The national and international reputation accorded the Museum by the world's scientific and intellectual community stems from its extensive and scientifically valuable collections and from the scholarly and productive research of the staff members. These criteria—research, collections, exhibition, education—are the same as those that account for the reputation of the British Museum (Natural History), the Smithsonian Institution, and all other important natural history museums.

The scientific staff and its supporting personnel are the keystone of the Museum's reputation, be this reputation global or local, popular or scientific. The following is an explanation of why this is so and, further, explains the major activities of the scientific staff. The responsibilities of the staff fall into four major areas, as follows:

1. Research. Almost all members of the scientific staff at The American Museum of Natural History are engaged in basic research. This research is not necessarily directed at immediate solutions to man's everyday problems, but rather, it endeavors to answer fundamental scientific and phil-

osophical questions about the nature and diversity of the universe. History shows that basic research is the fountainhead of most human knowledge, and even the seemingly most esoteric research sooner or later may be relevant to man's needs. Without basic research, present society would eventually find itself reduced to the intellectual climate of the Dark Ages. Teaching alone will not advance man's thinking, for teaching must be continually infused with new concepts, new theories, and new discoveries, or it becomes a litany of stale facts that will stifle the expansion and development of society. In science the researcher provides the new concepts and the new facts.

Clearly, The American Museum of Natural History, because of limited resources, cannot carry on basic research in all areas of science or even of biology. Its endeavors must be restricted to fields for which the staff and the institution are particularly suited. These fields are primarily but not exclusively those requiring collections as their basis. If a museum has no other function, it stores systematic collections of plants and animals, anthropological collections, and samples of the earth's crust. Museums, therefore, are uniquely equipped for research that requires collections.

Through the years, research at The American Museum of Natural History has been channeled into systematic zoology and anthropology and, to a lesser extent, geology, astronomy, animal behavior, and physiology.

Systematic zoology deals with the diversity of animal life, that is, with the classification, identification, and evolution of animals, past and present. It is a fundamental servant of the pragmatic activities of man and of other aspects of biology, and, at the same time, it is a mature scientific discipline in its own right. Man must know the names and characteristics of the multitude of animals that compete for his food, endanger his health, provide nourishment, and contribute to his shelter, comfort, and pleasure. The first order of business in any biological (including biochemical or biophysical) study is the identity of species, because differences in the species reflect differences in structure, function, and relationships to the organic and inorganic world Systematic studies are absolute requirements in understanding the ecological interrelationships of all the organisms on the earth and in managing natural ecosystems. Systematic zoology as a scientific discipline is continually contributing new facts and concepts about the evolutionary and ecological relationships of animals and about the mode of speciation and other forms of evolution in the animate world.

The importance of systematic biology in the modern world, therefore, cannot be overemphasized Since research in systematic zoology is dependent on large, well-documented collections of specimens, the large museum has become the principal kind of institution where intensive research on biotic diversity can be pursued effectively.

Aspects of geology and anthropology are also dependent on the existence of large collections of specimens for comparative analysis As in the case of systematic biology, these aspects are essential facets of the Museum's research program because their study falls uniquely within the province of an institution capable of maintaining a large and excellent collection and because these fields are important to a well-balanced program that attempts to investigate the nature of the earth's crust and its inhabitants.

Although the major emphasis over the years has been directed toward collection-oriented research, as described in the preceding paragraphs, the Museum has for a long time interpreted the meaning of natural history broadly to include investigations of what animals do, that is, behavior (how they function), physiology, and their relationship to each other and to the environment (ecology) Several departments have pursued research in these areas of science where there is tremendous current interest and rapid advancement in knowledge and theory Important theoretical advances have stemmed from this research, particularly in the development and evolution of behavior and in the nature of instincts. This work was strongly influenced by the milieu of the Museum and its emphasis on the comparative aspects of biology, and the work in turn has provided innovative points of view both to the Museum's research program and to its exhibition program. There is no doubt that these efforts in behavior, physiology, and ecology help to bring the Museum into greater contact with the mainstream of current scientific development and thus further enhance the Museum's reputation These and other areas of investigation should be continued and encouraged, where their pursuit by the Museum will yield promising new insights into the nature and meaning of diversity and the scientific concepts that relate to it

It should be clearly understood that a philosophy of research based primarily on collections is *not* a recommendation for maintaining a status quo attitude for museum research Rather, it is an attempt to define a logical framework for the kind of research that the museum is best equipped to pursue and for selecting and evaluating other areas of biological and physical research in which the museum should be involved. Within this framework the museum must employ the most brilliant, energetic scientists available, for the key to success for a scientific institution is a creative staff These scientists must be urged to explore new and promising leads in science as they develop and to employ the most modern techniques and instruments in implementing their research. We must also recognize that important related projects may develop during the course of the research Although such outgrowths may not be collection-oriented, they should be pursued, for they may contribute significantly to science and to the affairs of man.

No statement regarding research at The American Museum of Natural History is complete without due recognition of the substantial contributions by the staff over the past century to fundamental theoretical advances in systematics, evolution, behavior, physiology, anthropology, and kindred areas.

2 Care of Collections. The American Museum of Natural History's zoological, anthropological, and mineralogical specimens are among the most extensive and scientifically valuable in the world. In some areas, such as the collections of birds, fossil mammals, and termites, the Museum's holdings unquestionably surpass those of all other institutions. The Museum's specimens are the raw material on which most of the staff base their research However, the collections have an importance that transcends the research activities of The American Museum of Natural History. Available to scientists throughout the world, they are an international resource of the scientific community and, as such, are held in trust by the Museum.

The care of these invaluable collections is the responsibility of the scientific staff Because of the specialized nature of these collections and the intricacy of cataloging and maintaining them, their care must be in the hands of highly trained technicians and scientific assistants supervised by scientists Unfortunately, some institutions have tried to maintain their collections without competent scientific direction, with disastrous results. Because of the ever-deteriorating environment of the world, collections once lost cannot be completely replaced, no matter what the expense.

3 Authenticity of Exhibits. The area in The American Museum of Natural History that is devoted to exhibition is greater than in any other natural history museum in the world. Most of the exhibits are developed by appropriate scientists working in conjunction with the Department of Exhibition. The scientific staff is responsible for the rationale of exhibits and the authenticity of both material and labels. Because of staff involvement in the exhibition program, the exhibits are among the most instructive and accurate of any in the world The exhibits do more than acquaint visitors with natural history and with the richness and variety of the animal world, they also deal in depth with important evolutionary, systematic, ecological, behavioral, geological, and anthropological concepts. Hence they appeal to the general public, to primary and secondary school students, to the college undergraduate, and to the graduate student.

4. Education. Because of exhibition, because of the collections, and because of the expertise of its scientific and educational staff, The American Museum of Natural History is a uniquely endowed educational institution. Its potential as a teaching institution exists at many levels, and at each of these levels the participation of the scientific staff is essential. The exhibits stimulate and awaken the interest in natural history of even the most youthful visitor. The exhibition halls are a prime resource material for the Education Department and for undergraduate and graduate bi-

ology, anthropology, and geology classes at universities The unique collections are used by advanced undergraduates, graduate students, and established scientists not only in universities in the New York City area, but all over the world Some members of the scientific staff teach classes in advanced zoology, animal behavior, anthropology, and geology at local universities, and many staff members serve as graduate advisors for students seeking Master's and Ph.D. degrees. The staff recognizes its obligation to train future scientists. Cooperative programs between the Museum and nearby universities have produced over a hundred outstanding scientists, many of whom hold leading positions in institutions across the country.

The scientific staff cannot f ıction effectively in isolation. It must ob- viously have the support of the President, the Board of Trustees, the Administration, the Exhibition Department, the Education Department, and other service divisions of the Museum, and it can operate effectively only in a creative, scholarly atmosphere. The staff and its work also require support of other kinds, such as:

1. Large collections cannot be maint. ined and curated properly unless space and storage facilities are available for this purpose.

2 Exciting research programs can be initiated and pursued only if the necessary modern equipment and laboratory space are readily available

3. Research stations are especially important to systematists working on present-day animals from an ecological or behavioral point of view. The value of a research station is in providing sophisticated laboratory equipment facilities in an area where natural populations can be studied Because of today's emphasis on ecology, we can anticipate a growing demand for better facilities at our stations.

4 An adequate Graphic Arts Department and Photographic Department are prime requisites for reporting the results of the Museum's research to the scientific community

5. Scientific libraries are at the very heart of systematic zoological and geological investigation. The luseum's library, one of the outstanding natural history libr s in the world, must be maintained and improved to provide the nece ry support for the scientific staff. The library is not only important for the research interests of the staff, but also for the exhibition program of the Museum and for students and schools in the New York City area.

6 Original scientific research, no matter how profound or how revealing, can be of no assistance to mankind unless it is communicated to the scientific world and to the lay world Scientific publications, such as the Museum's Bulletin, Novitates, and Anthropological Papers, are the most important means of disseminating discoveries in science.

In summary, research, exhibition, education, and the care and preservation of collections are the elements of the Museum's program, of its status and reputation among the great institutions of the world In all of these, the scientific staff has a vital role. It is essential to the Museum's status and reputation, and to each of the elements on which they are based, that the Museum maintain, support, and strengthen its scientific staff and the associated resources and facilities on which this staff is heavily dependent.

December 21, 1971

APPENDIX II

THE ASSOCIATED NATURAL SCIENCE INSTITUTIONS

Dr. Thomas Peter Bennett, Chairman

Dr. Thomas Peter Bennett, President
The Academy of Natural Sciences
19th & The Parkway
Logan Square
Philadelphia, Pennsylvania 19103

Dr. Craig C. Black
Director
Museum of Natural History of Los Angeles County
900 Exposition Boulevard
Los Angeles, California 90007

Dr. Willard L. Boyd, President
Field Museum of Natural History
Roosevelt Road at Lake Shore Drive
Chicago, Illinois 60605-2496

Dr. Thomas D. Nicholson
Director
The American Museum of Natural History
Central Park West at 79th Street
New York, New York 10024

Dr. Frank H. Talbot
Director
California Academy of Sciences
Golden Gate Park
San Francisco, California 94118

The Washington Office
(202) 554-7983

499 South Capitol Street, S.W.
Washington, D.C. 20003

Newton O. Cattell, Director

THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA

The Academy of Natural Sciences of Philadelphia was founded in 1812 by a group of men who gathered together to form a society for the discussion and exchange of information on their studies in the natural sciences. The society was labeled by some at that time as "Godless" and "radical", for it was a new and different type of institution for the then young American nation.

Within its walls, many of the then new and developing disciplines and sciences of Botany, Entomology, Geology/Mineralogy, Ichthyology, Malacology and Paleontology had their start. Thomas Say, one of the founders of the Academy, was father of both American Entomology and Malacology. In the early 20th century, the works of Joseph Leidy, describer of the first dinosaur found in America, professor of anatomy, and founder of Microscopical Society, formed the basis for the now highly active and well-regarded Division of Limnology and Ecology. Dr. Ruth Patrick, now curator emeritus, member of the National Academy of Sciences, and recipient of the coveted Tyler Award in Ecology, discovered that diatoms were of immense importance as indicators of stream health. In the late 1940's, she established the Department of Limnology and with it a concept far ahead of its time, i.e., the need to assess the impact of industry and industrial waste on stream ecology and the need to educate industry on how to preserve healthy stream environments.

The Academy today has four centers of activity which evolved from the programs of the early twentieth century. They are: the Library; the Division of Systematics and Evolutionary Biology; the Division of Limnology and Ecology; and the Division of Education and the Natural History Museum.

The work of the Division of Education and the Public Museum is an outgrowth of the early exhibits made by Academy naturalists to demonstrate objects of their study to fellow naturalists and to the public on special occasions. From these early exhibits grew the museum dioramas and the educational programs which make use of these educational tools.

The scientific divisions accomplish their mission through the study of the identity, order and relationship of organisms in order to understand the diversity of life and the biological changes in organisms; through studies in evolutionary biology, which explores the dynamics of biological change, including adaptation, survival and extinction; and through studies in global ecology, which teaches man to understand the natural world so that he can develop civilizations within the constraints of natural laws.

Through its educational programs, its publications, its service to the community, its museum exhibits, its scientific research and consultation, the Academy communicates an understanding of the wonder and excitement of the living world. It interprets natural objects and reveals their relevancy to everyday interests and experiences. It reveals the underlying principles and relationships which tie natural objects to each other in a dynamic and evolving system. It seeks to stimulate concern and responsibility toward the earth and its ecology.

FIELD MUSEUM OF NATURAL HISTORY

Founded in 1893, the Field Museum of Natural History in Chicago is a non-profit institution supported largely by private funds. Its present distinguished position is a result of its comprehensive scientific and educational programs. Building great collections has been a sustained goal of the Field Museum for more than 80 years. Through world-wide expeditions, exchange, purchase, and many notable gifts, the Museum collections have grown until they now number more than twelve million specimens. These collections represent major stages in the history of the earth and of human societies, and are concerned with the composition and evolution of the earth, its nearest neighbors, and all forms of life, past and present, non-human and human. They range from intensive coverage of geographic area, biotic group, or single culture to extensive coverage of a world biota or a broad culture area.

Each of the four scientific departments has had a different historical pattern of collection development and emphasis. Anthropology has focused on selected culture areas, amassing premier collections of primitive cultures and high civilizations of the past. Botany, while specializing on the vascular plants of Latin America, has attempted to build a collection as a representative index of the vegetation of the world. Geology, in the course of building research collections in the areas of immediate staff interest, has acquired a large systematic collection. Zoology has tried to develop world-wide collections in each of several taxonomic groups.

The collections of meteorites, Pennsylvanian and Permian fossil vertebrates and invertebrates, Central American plan specimens, tropical and neotropical birds and mammals, Oceanic and Tibetan ethnological artifacts, and primitive art are world-renowned. Research by its own scientists or the research associates based on a study of these collections is published in 225 volumes of four series of Fieldiana: Anthropology, Botany, Geology, and Zoology.

The activities of the scientific staff include basic research, management of collections, and collaboration in public programs with the Departments of Education and Exhibition. The resources of the Museum have been made available to universities responsible for the training of graduate students. Seminars, aided by study of specimens, are held in Museum laboratories and classrooms. Museum specialists -- many of whom also hold academic appointments on the faculties of local universities -- lecture to graduate classes and supervise doctoral students. The collections and the Museum professional staff play a vital role in training of students who plan careers in natural sciences.

THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

The Natural History Museum of Los Angeles is the largest and most comprehensive institution of its kind in the western half of the country. A balanced program of exhibits, education, and research in history and natural history is carried on by an outstanding professional staff. Support comes from the County of Los Angeles, from the private sector through the Museum Foundation, and through a variety of Federal, State, industry and private foundation grants and contracts.

A broad range of research is conducted by 26 science curators specializing in archaeology, ethnology, fossil fungi, invertebrates and vertebrates, recent cryptogams and flowering plants, molluscs, insects, crustaceans, fishes, amphibians, reptiles, birds, mammals and minerals. Most research is related to the Museum's collections, which for many of the disciplines listed above are world wide in scope, of national or international importance, and are extensively utilized by local students and visiting scholars as unique scientific and cultural resources. Research on material object-related topics in history, mostly of the southwest, is conducted by a staff of eight history curators.

Curators are assisted in their work by a staff of collection managers, curatorial assistants and research assistants. Scientific studies by Museum curators and research associates are published in the Museum's widely distributed serial Contributions in Science as well as in a broad range of other specialized journals.

Many museum curators serve as adjunct faculty at the University of California and University of California at Los Angeles and help to train graduate students, some of whom are in residence in the Museum.

More than 1,500,000 visitors a year view exhibits in the main Museum building in Exposition Park and in the branch museum in Hancock Park.

American Museum of Natural History
Central Park West at 79th Street
New York, NY 10024

Since its founding in 1869 the American Museum has conducted investigations in the anthropological, mineralogical and zoological sciences in an attempt to learn more about the natural world. Research projects in these disciplines form the basis for education programs and exhibitions which were enjoyed by some 2.6 million visitors in 1983-84.

The Museum complex occupies 22 interconnected buildings on 25 acres—four square blocks—on the upper west side of Manhattan across from Central Park. There are 39 exhibition halls, three theaters, classroom and lecture facilities, laboratories, a library, cafeteria and restaurant, and storage areas for more than 35 million artifacts.

The American Museum is the largest natural history museum in the world and is a renowned center of research in the basic sciences. Among its collections are 16 million insect specimens, 23,000 reptiles and amphibians, 600,000 fish, 8.5 million invertebrates, 250,000 mammals, 120,000 rocks, minerals, gems and meteorites, one million birds, 330,000 fossil invertebrates, and 8 million anthropological artifacts.

Some 200 researchers—scientists and their assistants—study these specimens for clues to evolutionary history, life cycles, chemical composition and cultural significance. They conduct field studies around the world and share their findings with colleagues from other institutions through publications. Their research efforts at times form the bases of further applied studies in the health sciences and technology-related industries.

The American Museum was incorporated 115 years ago by the New York State Legislature. Today the Museum receives support for its facilities and programs from several major sources, including the City of New York which provides budgetary funds and owns the Museum buildings, the New York State Council on the Arts, National Endowment for the Arts, National Endowment for the Humanities, National Science Foundation, Institute for Museum Services, some 300 corporations, 100 private foundations, 485,000 members, and numerous individual contributors. Visitor contributions and fees for special services also provide a significant and growing source of revenue.

HIGHLIGHTS

1983/July

- South of Winter: Scenes from Aransas National Wildlife Refuge" funded by Conoco, a Du Pont company opened as one of three special exhibitions held in conjunction with the Centennial Meeting of the American Ornithologists' Union.

August

- The special exhibition "Louis Agassiz Fuertes: A Celebration of Birds" featured 100 watercolors, sketches and oils by the artist who is known for dramatic, lifelike illustrations of birds in motion.

September

- The American Ornithologists' Union, founded at the Museum in 1883, marked its 100th anniversary with a meeting at the Museum attended by more than 1000 scientists.
- The special exhibition "Frances Lee Jaques: Artist and Naturalist," a collection of 50 drawings by Jaques, honored the artist who specialized in birds and painted many of the dioramas at the Museum.
- Twenty New York film premieres were featured among 50 films in the seventh annual Margaret Mead Film Festival.

October

- Three stunning gems on loan from New York gem dealer Allan Caplan were displayed in the Morgan Memorial Hall of Gems.

November

- The traditional Origami Holiday Tree lighting ushered in the holiday season with caroling and festive treats. The annual tree is an Arthur Ross Exhibit of the Month.

December

- A gala party "A Night for All Creatures" attracted 500 new supporters of the Museum and raised funds for the Natural Science Center.

1984/January

- The National Endowment for the Humanities supported the upcoming special exhibition "Asante: Kingdom of Gold" with a grant of $148,878. The Federal Council on the Arts and Humanities provided an indemnity.
- For the third year a grant from Mobil enabled the Museum to remain open free of charge from 5 p.m. to 9 p.m. on Fridays and Saturdays.

February

- The special exhibition "Silk Roads/China Ships," funded by the American Express Foundation, explored 2000 years of east/west trade.
- A benefit held in connection with "Silk Roads/China Ships" and funded by the American Express Foundation raised $260,000.
- Pop singer Michael Jackson chose the Theodore Roosevelt Memorial Hall as the site of a CBS Records tribute to his music.
- Fifteen Museum scientists joined an international expedition to Cerro de la Neblina, the "Mountain of the Mists" in southern Venezuela.

March

- Lewis Thomas, author, scientist, physician and educator, delivered a series of three addresses titled "The Developing Human Species" in the annual Mack H. Lipkin Man and Nature Lectures.
- The Booth Ferris Foundation awarded $150,000 to renovate the Hall of Human Biology and Evolution.

April

- Scientists from 20 institutions in 10 countries gathered at the Museum to examine 40 of the world's most important human and pre-human fossils assembled for the special exhibition "Ancestors: Four Million Years of Humanity."
- Gallery 1, a new special exhibition hall, opened with the "Ancestors" exhibition.

May

- The American Association for the Advancement of Science opened its annual meeting with a reception at the Museum.
- The special exhibition "Peonies of Greece: Myth, Science and Art" opened in the Naturemax Gallery.
- The Department of Anthropology completed installation of a metal compact storage system and created a new 10,000-square-foot mezzanine level to store portions of its ethnographic collections.
- Alexander Marshack, Research Associate at Harvard University's Peabody Museum, delivered the 54th annual James Arthur Lecture on the Evolution of the Human Brain.

California Academy of Sciences

Natural History Museum & Aquarium

THE CALIFORNIA ACADEMY OF SCIENCES
1853-1985

When a young California was overrun by gold hungry pioneers, a group of seven naturalists decided it was time to take a systematic survey of the natural resources available in the West. Their first meeting of what was to become known as the California Academy of Sciences took place on April 4, 1853 in an office on Clay Street. Each week scientific papers were presented on topics of interest to a growing membership of San Francisco citizens and collections of specimens from the field began to grow. The business of identifying and classifying and naming species, known as "systematics", had begun.

The next step was a place to house and display the collected material. After two or three temporary locations, James Lick bequeathed a magnificent six-story building on Market Street between 4th & 5th Streets to the California Academy of Sciences. For 15 years visitors streamed in to see the displays of birds, mammals, plants, human skulls, insects and natural "curiosities" like the extinct Dodo and woolly mammoths, to name a few. Then disaster struck the earthquake and fire of 1906 left the museum building in [illegible] ruins.

The citizens of San Francisco, through a [illegible], agreed that the California Academy of Sciences [illegible] in Golden Gate Park, [illegible] Museum and Japanese Tea Garden. In [illegible] building was opened, the [illegible]. In order the next buildings were [illegible] (1923), Simson African Hall (193[illegible]), Morrison [illegible] (1952), Cowell Hall (1969), Wattis Hall of Man (19[illegible]), and the Fish Roundabout (1977).

As the public museum grew, so did the research collections which are today considered national treasures - veritable lending libraries of specimens from the natural world, available for scientific study by scientific colleagues from many disciplines.

The California Academy of Sciences is a private scientific institution, supported by donations from companies, foundations and individuals, by admission fees, royalties from book shop and cafeteria concessions, and by money from the City and County of San Francisco earmarked specifically for the operation of Steinhart Aquarium. Membership dues are also an important part of financing the Natural History Museum and Aquarium's activities and in return members receive many benefits including educational and travel opportunities.

NEWS