BEHIND THE SCENES: SCIENCE AND EDUCATION AT THE SMITHSONIAN INSTITUTION

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

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BEHIND THE SCENES: SCIENCE AND EDUCATION AT THE SMITHSONIAN INSTITUTION

WEDNESDAY, JULY 21, 2010

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
Washington, DC.

The Subcommittee met, pursuant to call, at 2:50 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Daniel Lipinski [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

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Subcommittee on Research and Science Education
Hearing on

Behind the Scenes: Science and Education at the Smithsonian Institution

July 21, 2010
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. G. Wayne Clough
Secretary
Smithsonian Institution

Ms. Claudine Brown
Director of Education
Smithsonian Institution

Dr. Eldredge "Biff" Bermingham
Director, Smithsonian Tropical Research Institute
Smithsonian Institution

Ms. Shari Werb
Assistant Director of Education
National Museum of Natural History
Smithsonian Institution

HEARING CHARTER

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION
U.S. HOUSE OF REPRESENTATIVES

Behind the Scenes: Science and Education at the Smithsonian Institution

JULY 21, 2010
2:00 P.M.—4:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose:

The purpose of the hearing is to examine the Smithsonian Institution's research activities, educational programs, and management of scientific collections, as well as the intersection between those missions.

2. Witnesses:

- **Dr. G. Wayne Clough**, Secretary, Smithsonian Institution
- **Ms. Claudine Brown**, Director of Education, Smithsonian Institution
- **Dr. Eldredge "Biff" Bermingham**, Director, Smithsonian Tropical Research Institute, Smithsonian Institution
- **Ms. Shari Werb**, Assistant Director of Education at the National Museum of Natural History

3. Overarching Questions:

1. In what areas of research does the Smithsonian Institution (SI) play a prominent role? In what areas of research does SI play a unique role relative to other Federal agencies? How does SI coordinate its own research priorities and programs with those of other Federal agencies, including the National Science Foundation? How does SI collaborate or coordinate with non-profit research organizations, including universities, and with foreign research agencies and organizations?
2. What is the Smithsonian Institution's role in science, technology, engineering and mathematics (STEM) education? What kinds of programs does SI support and for what levels of education? How does SI take advantage of its museums and research institutes to carry out its programs? How is SI's education mission similar to or unique from that of other Federal research agencies, and how, if at all, does the SI coordinate or collaborate with other agencies and with non-governmental entities to achieve its mission? What is the intended role of SI's new Director of Education?
3. What is the Smithsonian Institution's plan for long term management of its scientific collections? In particular, how does SI intend to implement the 2008 recommendations of the Interagency Working Group on Scientific Collections? What are the greatest challenges to long-term preservation and access to scientific collections?

4. Background:

The Smithsonian Institution (SI) was founded in 1846 by the United States Congress in response to a bequest of $500,000 by British scientist James Smithson, donated "to the United States of America, to found at Washington, an establishment for the increase and diffusion of knowledge among men." The original Smithsonian 'Castle' contained a library, lecture halls, exhibits and demonstrations, laboratories, and scientific artifact collections. In the last 160 years, SI has expanded to include 19 museums and galleries and nine research facilities, and 168 other museums around the country are now affiliated with the Smithsonian. SI employs over 6,000 people and has as many volunteers, and publishes *Smithsonian* and *Air & Space*

magazines in addition to other scholarly works. The Smithsonian collections include over 137 million objects, specimens, and works of art. In 2009, SI museums and the National Zoo welcomed over 30 million visitors, while Smithsonian websites had over 188 million hits. The Smithsonian is currently the largest museum and research complex in the world.

Governance and oversight

Originally established by an Act of Congress, the Smithsonian is technically a 'federal trust instrumentality' and is not part of the executive branch. The 17-member Board of Regents acts as the Smithsonian's internal governing body. Traditionally, the Chief Justice of the United States is elected Chancellor, with the Vice President and Chief Justice both serving as ex-officio members of the Board. The rest of the board is composed of three Members each from the House and Senate, and nine citizen members authorized by a joint resolution of Congress. The Secretary is elected by the Board, as are the members of the Executive Committee. The current Secretary, Dr. G. Wayne Clough, was named to the position on March 15, 2008, and assumed office on July 1 of that year.

Currently, in the House of Representatives, the Committee on House Administration has legislative jurisdiction, with the Committee on Transportation and Infrastructure having oversight of construction projects. In the Senate, the Committee on Rules and Administration has full legislative jurisdiction. Federal funding falls under the Subcommittee on Interior, Environment, and Related Agencies on the House and Senate Appropriations Committees.

In this Congress, the above Committees have held hearings on Smithsonian budget requests, stimulus-funded projects, asbestos management, GAO recommendations, and broader projects related to specific Smithsonian research activities, but no hearings have been held to examine the overall research agenda and activities at the Smithsonian Institution or focused on SI's educational programs or collections.

Funding

Smithsonian has an annual budget of slightly more than $1 billion, of which about three quarters comes from direct federal appropriations. The remainder is held in general trust funds, separate from federal appropriations in SI's own budget, including revenue from museum and publication sales and licensing as managed by Smithsonian Enterprises, from private donations, and from both federal and non-federal grants and contracts. More than half of the total budget is allocated to salaries and benefits for Smithsonian employees, including researchers and scientists directly employed by the Institution. The Institution is also designated as a 501(c)(3) tax-exempt non-profit organization by the Internal Revenue Service.

For FY 2011, Smithsonian designed its budget around four "grand challenges," which provide the central strategy for planning and framing its efforts: Unlocking the Mysteries of the Universe, Understanding and Sustaining a Biodiverse Planet, Valuing World Cultures, and Understanding the American Experience. In this hearing, we will focus on the museums and research centers that fall under the Under Secretary of Science, fitting into three broad categories: astrophysics (Harvard-Smithsonian Center for Astrophysics, Air and Space Museum), ecology and environmental science (National Zoo/Conservation Biology Institute, Environmental Research Center, Tropical Research Institute, Museum of Natural History) and museum research, conservation, and collections (Museum of Natural History, Museum Conservation Institute, Smithsonian Libraries).

The Fiscal Year (FY) 2011 request for Congressional appropriations totals $797,600,000. This is roughly a four percent increase over FY 2010 levels, with the largest increases in discretionary funds requested for research on biodiversity (+$2 million) and climate change (+$4 million), digitization and web support (+$1.5 million), and collections care (+$2.45 million). For the first time, in FY 2011, the Smithsonian research appropriations request is large enough to be listed as an individual line item on the Administration's Research and Development budget summary; in the past, the request was too small and fell under "Other" R&D.

Research

In the early years of the Smithsonian Institution, its focus was largely on the science itself. Its first Secretary, American scientist Joseph Henry, focused on research and the "increase of knowledge" rather than its "diffusion," and was unenthusiastic about museums. Although the Institution has evolved to have a strong focus on cultural and historic knowledge as well, the first two of its "Grand Challenges" are directly related to scientific discovery and understanding. SI is a

world leader in many areas of scientific research, and houses some of the largest and most acclaimed research programs in their respective fields.

The science-based research centers, as well as several of the Smithsonian's museums and the National Zoo, are overseen by the Smithsonian's Under Secretary for Science, a post currently held by Dr. Eva Pell, while other museums and programs fall under the Under Secretary for History, Art, and Culture.

- **Center for Earth and Planetary Studies (CEPS)**

The Center for Earth and Planetary Studies is the research unit of the National Air and Space Museum, located in the museum complex in DC. and at the Steven F. Udvar-Hazy Center in Virginia. The Center focuses specifically on planetary and terrestrial geology and geophysics using remote sensing data, with ongoing research programs examining Mercury, Venus, Earth, Mars, and the moon.

- **Conservation Biology Institute (CBI)**

The Smithsonian Conservation Biology Institute includes conservation biology and research programs at the National Zoo and at CBI's Front Royal, VA headquarters, previously known as the National Zoo's Conservation and Research Center. Dedicated to preserving and promoting biodiversity, the Institute has centers for animal care, conservation ecology, conservation education and sustainability, conservation and evolutionary genetics, migratory birds and species survival.

- **Environmental Research Center (SERC)**

The newest of SI's research institutes, the Environmental Research Center is located on 3,000 acres of land bordering the Chesapeake Bay in Maryland, and conducts both research and education programs on the Chesapeake Bay and its watershed. Its research is distinguished from other Chesapeake research facilities by including terrestrial elements in its research, rather than focusing solely on the Bay. SERC scientists also have comparative and interdisciplinary research programs comparing their own coastal ecosystems to others around the world.

- **Harvard-Smithsonian Center for Astrophysics (CfA)**

The Harvard-Smithsonian Center for Astrophysics is the result of a collaboration between the Smithsonian Astrophysical Observatory and the Harvard College Observatory, headquartered in Cambridge, MA, with major research sites in Arizona and Hawaii. It is one of the world's largest astrophysical institutions and owns and operates a number of observatories around the world, including at the South Pole, as well as several satellite observatories. CfA also has an active Science Education Department conducting research on outcome-based teaching and assessments.

- **Museum Conservation Institute (MCI)**

Formerly known as the Smithsonian Center for Materials Research and Education, the Museum Conservation Institute is a leader in the field of collections care and preservation. MCI also conducts technical and interpretational research on museum specimens, including anthropological analyses, and provides consultation to both federal agencies and outside institutions in addition to working closely with the 19 Smithsonian museums. Located in Suitland, MD, the Museum Conservation Institute employs materials scientists, chemists, and specialists in museum conservation and technology.

- **Museum of Natural History (NMNH)**

The Museum of Natural History is the largest of the Smithsonian research centers and houses the scientific research departments of Anthropology, Botany, Entomology, Invertebrate Zoology, Mineral Sciences, Paleobiology, and Vertebrate Zoology. The Museum's research division places a major emphasis on interdisciplinary research, housing programs on the Evolution of Terrestrial Ecosystems, Archaeobiology, Arctic Studies, Human Origins, and Paleoindian studies in addition to discipline-specific research. NMNH also runs several external research facilities, including the Smithsonian Marine Station at Fort Pierce, FL, which conducts research on ecosystems and marine biodiversity, and the Caribbean Coral Reef Ecosystems Program at the Carrie Bow Marine Field Station on Belize's Meso-American Barrier Reef.

- **Tropical Research Institute (STRI)**

Located in Panama, the Tropical Research Institute has conducted research on tropical land- and marine-based ecosystems since 1923. It is the only SI bureau not based in the United States. STRI also hosts a number of research programs

in collaboration with outside universities and government institutions, including the Yale School of Forestry and Environmental Studies, the Panama Canal Authority, Panama's Environmental Authority, and Brazil's National Institute for Amazonian Research. It is one of the largest research centers for tropical biology in the world.

A significant portion of the Smithsonian's research is funded by its own direct appropriations. SI researchers are staff scientists with their own research budgets, reviewed periodically for progress, but do not have to go through a standard competitive process. In this way, they are more similar to federal scientists at mission agencies than to their academic counterparts. The National Research Council (NRC) reviewed this funding mechanism in 2003 and found that SI's non-competitive funding mechanisms are especially critical for SI's environmental and large-scale research activities. These often span over long periods of time and would be impractical under a standard three-year competitive grant cycle.

In many cases, Smithsonian scientists also compete for funding from other federal grant-making agencies, including NASA, NIH, DOD, and NSF. The Smithsonian's scientific community includes many of the top experts in their respective fields, and they are very competitive when applying for outside funds from agencies or private grant making organizations.

Education and outreach programs

The Smithsonian's museums and research centers are known for their commitment to education and outreach as well as scientific discovery. There are 32 museum- or research center-level education offices throughout the Institution, offering hands-on workshops for K–12 students as well as lectures and seminars at a more advanced level, in addition to on-site exhibits. More than 150,000 K–12 students and teachers visit the education centers each year. Many have formal, ongoing relationships with school districts, integrating field trips into the schools' existing curricula. Museums and research centers are also increasingly making their educational resources available online and developing 'hands-on' internet activities to reach students in communities across the country. In addition to its education programs, SI regularly publishes its own scholarly articles and books, and has designed numerous online encyclopedias and portals designed to support all levels of learning, indicating that education and outreach—James Smithson's "diffusion" of knowledge—are significant priorities for the Institution.

On June 20, Claudine Brown joined the Smithsonian as its first ever Director of Education, reporting directly to the Secretary. She oversees the two major educational entities at SI—the Center for Education and Museum Studies and the National Science Resource Center—in addition to coordinating the 32 individual education offices. Brown will also be responsible for developing a comprehensive education plan for SI's education and outreach activities.

The Smithsonian's Center for Education and Museum Studies provides educational information on museum visits as well as numerous educational resources for teachers, parents and students through its website. The National Science Resources Center (NSRC) is jointly operated by the Smithsonian and the National Academies; its mission is to improve the teaching and learning of science, provide professional development opportunities for science teachers, and develop and disseminate research-based curricula.

The Smithsonian's museums, research centers, and education, outreach, administrative and policy offices offer hundreds of internships and research fellowships each year, reaching students from the high school to the post-doctoral level. Most institutions manage their own internships and fellowships, augmented by its equal opportunity and cultural diversity programs for minorities, Native Americans, and persons with disabilities.

The Smithsonian Institution Libraries system (SIL) serves both the research and education communities, and is the largest museum library system in the world. SIL manages 20 museum- and discipline-specific libraries in D.C., Maryland, New York and Panama. SIL is designed as an academic and public library system, in addition to its primary mission of supporting Smithsonian Institution staff and research missions. There are also two Smithsonian-affiliated publishing companies—the Smithsonian Institution Scholarly Press, which publishes scholarly works written by Smithsonian researchers and museum curators, and Smithsonian Books and Harper Collins, publishing books by both SI-affiliated and outside authors.

Scientific Collections

The Smithsonian also has the one of the largest federal object-based scientific collections, serving as a resource for Smithsonian's own research and museum display

purposes and for other federal and academic scientists as well. In particular, its natural history collection is the largest in the world, composing about 92 percent of the Smithsonian's 137 million total specimens collected over more than 150 years. Many of the Smithsonian's collections are also available to outside scientists not directly affiliated with SI. Some federal employees from other agencies work out of the NMNH to reduce duplication of collections and to take advantage of the Smithsonian's resources, and those partnerships represent a significant financial contribution to the Museum's collections budget. There are also hundreds of ongoing digital imaging projects aimed at putting collections online and making them available to the public. The Smithsonian's websites receive eight times as many visitors as the museums, making digitization of Smithsonian collections an integral part of SI's greater education and outreach initiatives.

Other federal departments and agencies also have large scientific collections, such as USDA's collections of plants, insects, diseases, and other agriculture-related specimens, or NIST's calibration collections, used to define and calculate accurate weights and measurements. Some of the Smithsonian's own collections are also shared or maintained with other agencies; the Zoo's collaboration with the U.S. Fish and Wildlife Service is one example. The Smithsonian is believed to have the most individual specimens and artifacts of any collection in the world.

In 2005, the National Science and Technology Council (NSTC)'s Committee on Science created an Interagency Working Group on Scientific Collections (IWGSC) to "examine the current state of Federal scientific collections and to make recommendations for their management and use" [1] at the urging of OMB and the Office of Science and Technology Policy (OSTP). Co-chaired by the Smithsonian Institution and the Department of Agriculture, the IWGSC's report, *Scientific Collections: Mission-Critical Infrastructure for Federal Science Agencies*, noted both the importance and the lack of adequate staffing, funding, and documentation of federal collections. The working group had several recommendations related to cost projections, documentation, agency responsibilities, creation of an online clearinghouse, periodic reports, and improved long-term coordination of federal collections. In the *America COMPETES Reauthorization Act of 2010*, the Committee on Science and Technology included a provision requiring OSTP and the science agencies to implement several of the key recommendations in the 2009 report.

Strategic Plan

In SI's 2010–2015 Strategic Plan, three questions were proposed to measure the success of the Smithsonian's efforts and initiatives:

Has the Smithsonian:

1. "Made leading contributions to national and global efforts to unlock the mysteries of the universe, understand and sustain a biodiverse planet, value world cultures, and understand the American experience, through collaborative efforts among 19 museums, nine research centers, and numerous outreach and education programs?
2. "Harnessed the power of technology to grow and share the Institution's knowledge and collections through exhibition, education, and outreach, and to triple the number of meaningful learning experiences we offer daily?
3. Increased the number of visitors, employees, and key partners and stakeholders who rate us as an excellent organization in which to invest, work, and learn, through new and more efficient ways of working and increased collaboration, accountability, and financial stability? [2]

This hearing will examine these same questions, and attempt to identify areas of growth and improvement among Smithsonian research, education, and collections activities.

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[1] National Science and Technology Council, Committee on Science, Interagency Working Group on Scientific Collections. *Scientific Collections: Mission-Critical Infrastructure for Federal Science Agencies*. Office of Science and Technology Policy, Washington, D.C., 2009.

[2] Smithsonian Institution. *Inspiring Generations Through Knowledge and Discovery: Strategic Plan*. Washington, D.C., 2009. 5.

Chairman LIPINSKI. This hearing will now come to order. The Chair will recognize himself for five minutes for an opening statement.

Good afternoon. Welcome to today's Research and Science Education Subcommittee hearing on Science and Education at the Smithsonian Institution. When most Americans think of the Smithsonian, they think about the famous museums and the castle along the National Mall. Some that know a little more might also think of the National Zoo. But most people do not know that the Smithsonian Institution receives nearly $800 million a year in federal appropriations or that over $200 million of that goes toward basic scientific research and dedicated Smithsonian research facilities.

In spite of receiving almost $1 billion a year in taxpayer funds, the Smithsonian is not actually part of any branch of government. Although it began with a bequest from British scientist James Smithson, it is technically a 'federal trust instrumentality,' established by an act of Congress in 1846. As such, it is appropriate and necessary for the Congress to take a more active roll in oversight of the Institution's activities and long-term plans.

This hearing will focus on the Smithsonian's contributions to scientific research and education and its vast scientific collections, and on how the Institution collaborates with federal agencies. I am looking forward to learning what goes on behind the scenes at their 19 museums and nine research centers and how they share expertise with 168 affiliated museums from around the country.

I am particularly interested in hearing from the Smithsonian's first ever Director of Education and about her plans for improving education, outreach, and access programs. Informal science education has been a passion of mine on this subcommittee, probably because I know how my early experiences at the Museum of Science and Industry, Field Museum, and other museums in Chicago really influenced my interests in science and engineering. I hope both Director Brown and Secretary Clough will explain how the new position fits into the Smithsonian's strategy in the strategic plan, and what its role is and what it should be in federal STEM education programs.

The Smithsonian Institution's research centers stretch from the Tropical Research Institute in Panama to the Harvard-Smithsonian Center for Astrophysics. These facilities, which are home to some of the world's foremost scientific experts, are almost unknown to the general public. The Center for Astrophysics, for example, has 300 scientists and 12 telescopes on land and in the sky, but most of us have never heard of the Center or its work.

The Smithsonian is especially active in the life sciences, including ecology, with four of the research centers and the National Zoo focusing in these areas. As one of the co-chairs of the Congressional Zoo and Aquarium Caucus, I am particularly interested in learning about the Zoo's efforts to repopulate endangered species.

Finally, I would like to hear how the Smithsonian works with other federal agencies, including through coordinating bodies like the Office of Science and Technology Policy and the National Science and Technology Council. Although federal coordination is a bit more complicated because the Smithsonian is not a part of the Executive Branch, working with other science and education agen-

cies is extremely important if we want to maximize the impact of federal spending.

One area where it is especially important to coordinate between agencies is in managing and sharing scientific collections. The Smithsonian has one of the largest collections in the world, including over 137 million individual specimens and artifacts used for scientific research and museum displays. In 2005, the Smithsonian and the Department of Agriculture co-chaired an interagency working group that released a report highlighting the importance of improving collections management. I am looking forward to learning more about the Smithsonian's plans for implementing the recommendations in this report.

I would like to thank all of our witnesses for joining us, and I look forward to their testimony.

[The prepared statement of Chairman Lipinski follows:]

PREPARED STATEMENT OF CHAIRMAN DANIEL LIPINSKI

Good afternoon and welcome to today's Research and Science Education Subcommittee hearing on Science and Education at the Smithsonian Institution.

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I would like to thank all of our witnesses for joining us and look forward to their testimony.

Chairman LIPINSKI. And with that the Chairman will recognize Dr. Ehlers for an opening statement.

Mr. EHLERS. Thank you, Mr. Chairman, and I am sorry I held things up, but unfortunately, the Education Committee was holding votes, and as you know, votes come before statements.

Thank you, Chairman Lipinski. I am pleased the Committee is holding this important hearing today. The Smithsonian is one of my favorite enterprises. I was involved in it in a couple of different roles. One is on this committee and subcommittee, but also in the old days when I chaired the House Administration Committee we had to worry about animals dying in the zoo and various things like that. So I have somewhat of a history with the Smithsonian, and I think it is an absolutely marvelous institution.

I am also pleased that as director of the House Administration Committee, we were able to clear up some of the problems that had developed over the years. And we now have a superb leader hiding behind a pseudo beard, but he is someone I have known for a number of years from those years at Georgia Tech as well. I am just delighted that he was—accepted the position of the Smithsonian, and we are looking to great things from all of you.

The main thing the Smithsonian needs is money, and that is true, of course, of every government agency, but it is unique with the Smithsonian because it is not quite a government agency. It is an entity unto itself, and we should do whatever we can to help them in their fundraising efforts.

And I sincerely hope that we are able to develop excellent fundraising methods. The Smithsonian has so much to offer this Nation, and frankly if I had my way, I would like to provide a two-way fare for every citizen to come here and spend a few days in the Smithsonian. I don't think I could get that to pass, however.

The Smithsonian has a unique role in science and education. I did my best to learn everything I could about the Smithsonian's various research entities, and especially its work to improve STEM education. A number of years ago I took a trip with the Transportation and Infrastructure Committee to Central and South America. We were worried about security on shipments into the United States, and Panama, of course, is a major center of commerce, so we spent some time there. While I was there, I saw a sign for the Smithsonian Tropical Research Institution and decided to stop by. You can imagine the pleasure and dismay of the workers at the Institution to suddenly have two congressmen appear in the door and ask if we could look around. They did a great job of explaining the function of the Tropical Research Institution, and I was very impressed with the work they do. I would love to spend a few more days there, and unfortunately, we were on a Transportation airplane rather than Smithsonian airplane. I don't think you even have one, do you?

But at any rate, it was a very worthwhile trip. The staff there was extremely gracious in explaining their work and sharing their excitement for discovery.

I believe the Smithsonian has resources and insights unlike any other organization. It has subject matter experts who are also committed to public service. Hearing from the world's largest museum and research complex seems wise as we determine how to manage our diverse federal efforts in science education and research.

I look forward to hearing about this topic from our witnesses today.

With that I yield back.

[The prepared statement of Mr. Ehlers follows:]

PREPARED STATEMENT OF REPRESENTATIVE VERNON J. EHLERS

Thank you, Chairman Lipinski. I am pleased that the Committee is holding this important hearing today.

The Smithsonian has a unique role in science and education. When I served on the Committee on House Administration, my colleagues and I were responsible for overseeing this important institution. I did my best to learn everything I could about Smithsonian's various research entities, and especially its work to improve STEM education.

A number of years ago I took a trip with the Transportation and Infrastructure Committee to Panama, and while I was there I saw a sign for the Smithsonian Tropical Research Institution and decided to stop by. Despite the fact that I arrived unexpectedly, the staff there was extremely gracious in explaining their work and sharing their excitement for discovery.

I believe the Smithsonian has resources and insights unlike any other organization. It has subject matter experts who are also committed to public service. Hearing from the world's largest museum and research complex seems wise as we determine how to manage our diverse federal efforts in science, education and research.

I look forward to hearing about this topic from our witnesses.

Chairman LIPINSKI. Thank you, Dr. Ehlers, and I was on a different Transportation Committee trip down to Panama, and I didn't even have enough time other than for them to point out the window and say there is a Smithsonian building over there. I didn't get a chance to scare the people there by slipping in for a few minutes.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

And at this time I want to introduce our witnesses. We have Dr. Wayne Clough, who is the Secretary and CEO of the Smithsonian Institution, and I am very happy that he is also a civil engineer, and former President of Georgia Tech. Ms. Claudine Brown is the Director of Education at the Smithsonian Institution. Dr. Biff Bermingham is the Director of the Smithsonian Tropical Research Institute, and Ms. Shari Werb is the Assistant Director of Education at the National Museum of Natural History.

As our witnesses should know, you will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you get—if you do pass five minutes, I will start giving you a signal with the easy end of the gavel, and if you get past six, then you will hear the other end of the gavel just to let you know that—give you a little warning there.

We are hoping we will have enough time. We are going to have votes again coming up, another series of votes coming up, so hopefully we will have time to go through your testimony and questions

before that. But when you have all then completed your testimony, we will have the questions, and each Member will have five minutes to ask any question of the panel.

And so we will start now with Dr. Clough. Dr. Clough, you are recognized for five minutes.

STATEMENT OF G. WAYNE CLOUGH, SECRETARY, SMITHSONIAN INSTITUTION

Dr. CLOUGH. Thank you, Chairman Lipinski and Dr. Ehlers and Members of the Committee for having us here and giving us this opportunity.

Before I read my statement, I would like to introduce you to a couple of the objects that I have here on the table. On the far ends of the table are objects that have been collected from the Gulf and near the site of the Deep Horizon oil spill and problem. They represent the so-called 'voucher collections' for the Gulf, and the Smithsonian maintains these for the country, and they represent the baseline of the ecosystem for the entire Gulf and Atlantic side so that when the time comes to establish the damage that has been done and the ability to clean up the damage, we will have to use these voucher collections. This just illustrates the value of collections and having them and maintaining the importance of them.

In front of me, here on pins, are a group of mosquitoes, different types, some malaria bearing, others not so. We maintain collections of insects, entomological collections that are very useful, particularly for our military, and they venture into some of these dangerous areas to determine the types of insects that might be—the types of things that will create problems for our military. These collections are used in concert with other agencies to make those kinds of evaluations.

And finally, in front of me in this small orb is an object from Mars, a little piece of Mars. This is called a Mars meteorite, and it occurred as a result of a meteorite impact on Mars that freed up a piece of Mars, came through the Martian atmosphere and ended up on Earth. It is estimated that this object is four billion years old, so essentially the age of our Earth, and it is from Mars based on the chemical analysis that has been done of it. The Smithsonian keeps the meteorite collection, the National Meteorite Collection, for our country, and it is an interesting one. We invite you to come see those some time when you have the opportunity.

So just a little bit about myself. My career has focused on education and research, with much of this related to science and engineering, first as a university faculty member and subsequently to be fortunate to be named President of my alma mater, Georgia Tech. It is now a great honor for me to serve as Secretary of the Smithsonian, with wonderful colleagues that you will hear from later, and the passionate people who work there.

When I started at the Smithsonian, I felt we needed to re-energize our efforts in science and education so that we would have a much greater effect on what we did for our country. I am excited about the future of the Smithsonian. We have a new strategic plan and a commitment to create new approaches using our existing resources to work across disciplines, to attack big problems our country faces.

We are going to do that by building partnerships. Not by ourselves, but building partnerships with universities, NGOs, and federal agencies so we can leverage what we and they do rather than creating duplication.

As to education, the Smithsonian has always been an educational institution, so we will honor and enhance the traditional visits to our museums, while digitally, we will also reach people where they live and learn. This will be a new aspect of the Smithsonian. In doing so, we believe we can help revitalize K–12 education in our Nation.

We just hired a new Director of Education, Claudine Brown, to coordinate and to enhance our efforts, and you will hear from Shari Werb, who works on the front line of delivering education at our Museum of Natural History.

Smithsonian science has a storied history that goes back to the founding of the Institution in 1846. As the reach of our sciences grew over time, it became geographically distributed as those activities tended to move away from the Mall, since they didn't have to be here.

For example, we have a Conservation Biology Institute for the National Zoo that deals with endangered species that is located in Front Royal, Virginia; the Smithsonian Environmental Research Center is located in Edgewater, Maryland, 3,000 acres on the Chesapeake Bay; the Smithsonian Tropical Research Institute in Panama; and the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts.

These units, combined with the Mall-based Natural History Museum and the great Air and Space Museum, comprise a remarkable and uniquely-positioned national science enterprise.

Of course, it really all comes down to people, and I have learned much by personally going to meet our scientists in their laboratories as well as their field sites in places like Chile, Kenya, Panama, Antarctica, and the far reaches of Alaska, most recently. I can assure you our scientists are passionate about what they do. They are committed public servants, and they are enormously talented.

The Smithsonian science is really a diverse enterprise, and I want to take just a moment to attempt to define our role and the uniqueness of it. First, who are we? Today more than 500 Smithsonian staff scientists work in fields such as astronomy, biology, botany, zoology, entomology, paleontology, and earth sciences. The quality of their work is demonstrated, if you look over the last decade, by hundreds of publications in the most prestigious science publications, like *Nature* and *Science* magazines. Among our research staff, 17 are members of the National Academies, and we have one Nobel laureate.

The Smithsonian is exceptional and distinctive in conducting long-term studies that require large data gathering exercises, something that is critical in understanding these processes, and you see some of that evidence here on the table.

We have the largest and most used natural history collection on earth; 126 million of 137 million objects are natural history collections. They are used by almost all the federal agencies for their work. We have an ambitious idea to create a "Digital Smithsonian"

to deliver what we do here on the Mall out to people where they work and they live.

What do we do now? We believe we examine some of the most complex and time-sensitive problems that our Nation faces. Our scientists assess the consequences of climate change, we keep aircraft safe from bird strikes, we document and control invasive species, and assist our Armed Forces in keeping them safe from insect-borne disease.

What are we going to do differently in the future? Our strategic plan lays that out. We shape the future by preserving our heritage, discovering new knowledge, and sharing our resources with the world. We have a series of "Grand Challenges," and two of these deal specifically with our science mission.

First, "Understanding and Sustaining a Bio-diverse Planet," which is critical to the survival of our species. We have unmatched capacity to tackle this task. As an example, the Smithsonian Institution's Global Earth Observatories Network observes trees, millions of trees and forests around the world. You will hear more of that from Biff Bermingham.

And second, "Unlocking the Mysteries of the Universe," particularly based in our work at the Smithsonian Astrophysical Observatory, one of the world's great physical observatories.

Thanks to the help of Congress and the American people, the Smithsonian will continue to strive to enhance our relevance to the Nation by improving scientific literacy, providing information that is important to our policymakers, inspiring students, and insuring a brighter future for us all.

Thank you for this opportunity to be with you today.

[The prepared statement of Dr. Clough follows:]

PREPARED STATEMENT OF G. WAYNE CLOUGH

Introduction

Mr. Chairman and Members of the Subcommittee -

It is my privilege to appear before the Subcommittee to testify about the science research and education programs conducted at the Smithsonian Institution. Over the next decade, the Smithsonian is committed to using its resources to become more engaged than ever before with the great issues of our day and to energize our work with a new spirit, capitalizing on the passion of the people of the Smithsonian for their work. The Institution completed a year-long inclusive process resulting in a Strategic Plan that is interdisciplinary and entrepreneurial, and which has been embraced by both internal and external stakeholders. It calls for us to broaden access and reach new audiences by bringing the resources of our museums and research centers to people where they learn and live. Our goal is to serve not only the millions of people who visit our museums, but to reach those who are not able to come or who are not aware of the opportunities for learning that we offer. The plan also brings focus to our future efforts in science, creating new opportunities through crossdisciplinary and collaborative approaches within the Smithsonian itself as well as with partners who share our commitment and complement our strengths.

Every day, in every corner of the globe, Smithsonian science examines some of the world's most complex—and time-sensitive—problems. Whether they are protecting ecosystems that are threatened, assessing the consequences of climate change or keeping aircraft safe from bird strikes, Smithsonian scientists apply what they learn to improve the quality—and quantity—of life on Earth. Their work addresses some of our most pressing issues, including education about the impacts of volcanic eruptions, discovery of new planets, minimizing the growing effects of invasive species and setting the baseline for damage from the Gulf of Mexico oil spill.

Today, more than 500 Smithsonian staff scientists, augmented by an equal number of fellows and hundreds of international collaborators, conduct research in field stations and laboratories on all seven continents and serve as national and international experts in a wide range of disciplines. Over a thousand students intern

with us each year and work with our scholars, and many more learn by visiting our field stations, museums and the National Zoo. They come to be part of our exciting science agenda and we welcome the opportunity to help them grow to be the next generation of scientists for our nation.

The home of the Smithsonian science agenda is found in a group of key facilities and units, many historical and with long and distinguished histories.

Museums

The Smithsonian is home to the National Museum of Natural History (NMNH), the National Air and Space Museum (on the Mall and at Dulles International Airport), the National Zoological Park in Washington, D.C., and the Zoo's world-class biological conservation facility in Front Royal, Virginia. The NMNH opened one hundred years ago this year, and not only is a premier museum visited by 7.5 million people a year, but home to world class science in botany, biology, zoology, paleontology, anthropology, archeology, ornithology, earth sciences, and vulcanology. Its collections, with 126 million specimens and objects, are the largest in the world and are increasingly available to scholars and citizens alike around the world through digital access.

Combined, our science museums and the National Zoo host upwards of 15 million visitors annually, offering the largest single opportunity in the world to educate the public about science. The science research done by the Smithsonian informs museum exhibits and Zoo exhibits and insures that the extensive educational outreach that emanates from them is up-to-date and cutting edge.

Smithsonian Centers of Research

The nature and scope of Smithsonian science is built on a world stage, involving activities in over 80 countries. In addition to the museums, Smithsonian science is driven by a group of leading research centers that allow focus on crosscutting topics or build on physical platforms not found in the museums.

Smithsonian Environmental Research Center (SERC), Edgewater, MD

SERC is the leading national research center for understanding environmental issues in the coastal zone. Its scientists engage in interdisciplinary studies that address issues such as global climate change, watershed pollution, the maintenance of productive fisheries, the changes wrought by invasive species and the ecology of fragile wetlands and woodlands. The reach of the SERC efforts on land/water ecosystems includes not only the Chesapeake Bay, but the Atlantic, Gulf of Mexico, and Pacific coasts.

Smithsonian Tropical Research Institute (STRI), Panama

STRI is the world's premier tropical biology research institute, and is celebrating its 100th anniversary this year. Originated because of the construction of the Panama Canal, it has grown to become a world leader in preserving tropical forests and the ecosystems found there. Dedicated to increasing our understanding of the past, present and future of tropical biodiversity and its relevance to human welfare through studies in marine biology, terrestrial ecology and paleontology, STRI's facilities provide a unique opportunity for long-term ecological studies in the tropics and are used extensively by both Smithsonian scientists and hundreds of visiting scientists from around the world. STRI works with SERC on projects relating to carbon sequestration and invasive species. My colleague Biff Bermingham is here with us to give you additional information on STRI's activities.

Smithsonian Astrophysical Observatory (SAO), Cambridge, MA

SAO is arguably the largest and most diverse astrophysical institution in the world, where scientists carry out a broad program of research in astronomy, astrophysics, earth and space sciences and science education. The Observatory's mission is to advance our knowledge and understanding of the universe through research and education in astronomy and astrophysics. Its scientists are among the best in the world, and it also builds the remarkable instruments needed for astrophysical work and operates larger land- and space-based telescopes.

National Zoological Park (NZP)/Smithsonian Conservation Biology Institute (SCBI), Washington, D.C. and Front Royal, VA

National Zoo scientists are based at the Zoo in Washington, D.C., the Smithsonian Conservation Biology Institute in Front Royal, VA and at field sites around the world. They conduct research to aid in the survival or recovery of species and their habitats and ensure the health and well-being of animals in captivity and in the wild. During the past 28 years, more than 4,300 people from 109 countries have been trained through the Zoo's professional programs in conservation biology and

zoological medicine. In addition, the Zoo cares for more than 2,000 animals representing 400 difference species.

National Air and Space Museum (NASM), Washington, D.C.

Scientists at NASM's Center for Earth and Planetary Studies, a NASA-supported program, study a variety of geological processes, such as volcanism, floods, crater formation, tectonics and sand movement. Many of the studies also address topics of concern for climate change. The scope of research activities includes work on Mercury, Venus, the Moon, Mars, asteroids and some satellites of the outer solar system.

Museum Conservation Institute (MCI), Suitland, MD

Researchers use state-of-the-art instrumentation and scientific techniques to provide technical research studies and interpretation of art, as well as anthropological and historical objects. Their work assists scientists, art historians and conservators as they place objects within a culture and a time period, look for new cultural influences within societies and compare cultural and technological change across different periods and geographic areas. The Institute is the only Smithsonian resource for technical studies and analyses for the majority of Smithsonian collections.

Many of the most important issues facing our nation and our world cross disciplines and call for a new approach that melds the strengths of units and entities. Our new strategic plan lays the groundwork for the Smithsonian to lead in such efforts. While much is yet to come, we are on our way with a number of exciting efforts that involve not only multiple units at the Smithsonian but also in collaboration with other museums and universities. We have active involvements with universities like Harvard, George Mason, Yale, Arizona State, Maryland and George Washington and we work in partnership with the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the Office of Science and Technology Policy (OSTP), the Department of the Interior and the Department of Agriculture. These collaborations avoid duplication of effort and facilities bring teams together that can solve issues in ways that would not be the case otherwise.

Commitment to Long-term Research and Large Scale Science Platforms

The Smithsonian is exceptional in its ability to undertake long-term studies that require large-scale data gathering. Research carried out over years and even decades is now recognized as fundamental and vital, both to scientific understanding and to society's ability to make informed policy choices about such issues as ocean conservation. Many ecological processes vary over extended periods—something short-term observations may not detect. The Smithsonian has managed study sites for decades, obtaining valuable data on such long-term trends. The Smithsonian provides researchers with access to its unique network of scientists, collections, laboratories, field sites and past research. The Smithsonian also collaborates with universities and museums across the globe to tackle projects too complex for any one institution to undertake alone.

Promoting Science Literacy and Careers in Science

Through fellowships and internships in every science unit, the Smithsonian mentors and trains the next generation of researchers. But our interaction with nascent scientists starts even earlier. The National Science Resources Center (NSRC) was established in 1985 jointly by the Smithsonian Institution and the National Academies to improve science education in America's schools—a critical indicator of our nation's ability to lead in the future. NSRC improves the teaching and learning of science with K–12 science programs in more than 1200 school districts representing 30% of the U.S. student population in 48 states and more than nine countries. The Smithsonian Center for Education and Museum Studies (SCEMS) provides curriculum materials to teachers so they can incorporate museums, exhibits and collections into their work. SCEMS also conducts Internet webinars on various topics that attract 20,000 participants from across the United States and 100 countries. More will come as the Smithsonian mobilizes its pan-institutional educational programs, which is underway with the hiring of our first Director of Education, Claudine Brown, who is also here with me today. The Smithsonian is uniquely equipped to help with the important issue of scientific literacy, a growing challenge as the world of science moves faster and becomes ever more complicated.

National Collections

Scientific collections are an essential component of the national scientific infrastructure, as documented in the 2009 report of the Interagency Working Group on

Scientific Collections (OSTP, 2009). Irreplaceable and comprehensive, the Smithsonian has the richest, largest and most-used natural history collection on Earth. Tens of millions of artifacts and specimens, some as old as the Earth itself, serve as a baseline against which to measure change; they are a reference for Smithsonian scientists and those in other federal agencies as well as scientists around the world who study processes that have modified Earth and shaped the human environment. They reflect a legacy of more than 150 years of research, exploration, discovery and conservation, and they inform Smithsonian publication, education and exhibition. Universities have researchers, but not extensive collections—our collections set us apart from all other research and scholarly institutions.

The Smithsonian has developed an ambitious plan to create a "Digital Smithsonian"—to digitize the resources of the Institution, including much of its collection, for the widest possible use by current and future generations. This will broaden access to those treasures, safeguard them for future generations, speed research, add meaning, encourage collaboration, and integrate our holdings across museums and programs. Our collections have been used repeatedly to answer basic and historical questions regarding many significant issues of the day. For example, regarding the impacts of the Deepwater Horizon oil spill, knowing what the conditions were like before the event is essential. The Smithsonian is committed to long-term studies of ecosystems and biodiversity, and the data and collections that have resulted can play a crucial role in situations such as that posed by the Gulf of Mexico oil spill.

This spill already has been described by many experts as the worst man-made ecological disaster in U.S. history. The extent of the ecological impact, its geographic extent, and possibilities for remediation at this point are only estimates, not known facts. Given the likely economic impacts of the spill and future costs, the accuracy of before and after comparisons is important. The NMNH collections contain hundreds of thousands of specimens collected by the Department of Interior's Bureau of Ocean Energy Management, Regulation and Enforcement and others since 1974 at different depths and locations in the Gulf over many years.

My staff recently estimated that fully 58% of publicly available specimen-based records from the Gulf of Mexico are housed at the Smithsonian. I would like to emphasize that many marine research institutions around the Gulf and elsewhere will play key roles in assessing damage and measuring remediation and recovery in the years ahead. The Smithsonian is ready to collaborate and support that work in any way it can.

Other efforts in regard to responding to the oil spill include coordinating with the U.S. Fish and Wildlife Service to send four veterinarians from the National Zoo to the Gulf Region to work in conjunction with other federal agency vets. The vets from the National Zoo will work on a rotating basis for the next eight weeks; each of the four vets will serve for two week intervals at an incident command center in Houma, Louisiana in a mostly strategic basis coordinating relief efforts. The vets will oversee the logistics and release of recovering wildlife—primarily birds—from the affected region. The first vet, Dr. Judilee Marrow, was deployed, Sunday, July 11.

The Strategic Plan and Focus on Grand Challenges for Science

Unlocking the Mysteries of the Universe

Since the late 1800s the Smithsonian has played a lead role in developing the understanding of the fundamental nature of the universe, dark matter and galaxy formation. The Smithsonian, particularly the Smithsonian Astrophysical Observatory, the National Air and Space Museum and the National Museum of Natural History will focus on applying the integrative research of their scientists to today's big questions regarding the origin and evolution of the Earth, planets, stars, galaxies, and the universe, thereby harnessing the collaborative energy of scientists, scholars, and cultural experts.

Areas of specific focus will be the study of the origin and evolution of the Earth and solar system; the effects of geologic and meteoric phenomena on Earth's atmosphere and biosphere; research into the discovery and characterization of exo-planets in the habitable zone; research using our rich collections, including the national meteorite collection; and research into the next generation of ground- and space-based astronomical telescope mirrors and instrumentation that will enable the next generation of research.

The Smithsonian Astrophysical Observatory (SAO) is a prime example of the way in which the Smithsonian collaborates with other organizations. SAO's partnership with Harvard University to form the Harvard-Smithsonian Center for Astrophysics has, since 1973, grown to be the most powerful astronomical observatory in the world. SAO's pioneering efforts in the development of orbiting observatories and

large ground-based telescopes, in the application of computers to astrophysical problems, and in the integration of laboratory measurements, theoretical astrophysics and observations across the electromagnetic spectrum have contributed greatly to unveiling the secrets of the universe. These efforts have principally been supported by competitively awarded contracts and grants from NASA and NSF. From studying planets around other stars to charting galaxies moving at almost the speed of light, SAO scientists remain dedicated to the increase of knowledge about those physical processes that shape the natural world, and to the diffusion of this knowledge to the scientific community, to teachers and students and to the general public.

Understanding and Sustaining a Biodiverse Planet

Research will focus on such questions as: how to sustain a biologically diverse Earth; how does this diversity change across geography and through time; and how do we better understand the life-sustaining services of ecosystems and best sustain their contributions to human well-being locally and globally?

The Smithsonian's research supports many strands of the U.S. Global Change Research Program (USGCRP) by providing baseline data, measurements and monitoring of change in the biosphere and atmosphere. The Smithsonian's observation and monitoring capabilities ensure a long-term, high-quality and high-resolution record of the state of natural variability and change in climate; improve our understanding of the natural and human-induced forces of change; and increase the accuracy of environmental models and projections of future conditions. This includes a focus on forests through the expansion and sustainment of the Smithsonian Institution Global Earth Observatories (SIGEO) network. SIGEO is a leader in the world in forming international partnerships involving 21 countries that have joined together to promote large-scale environmental monitoring and maintain banks of data allowing for sophisticated analyses.

The Smithsonian is also a leader in DNA barcoding which includes leadership in an international initiative devoted to developing a global standard for the identification of biological species. The new technique uses a short DNA sequence from a standardized position in the genome as a molecular diagnostic for species identification. As the recognized U.S. leader in DNA barcoding, the Smithsonian seeks to increase its capacity in research and training. These activities directly support the biodiversity theme of our Strategic Plan, and also link to access initiatives, such as the Encyclopedia of Life and SIGEO.

The Encyclopedia of Life, (EOL at *www.eol.org*) is an ambitious project at the National Museum of Natural History that will become a key repository of scientific information about virtually every form of life on Earth. The EOL is a Web-based, online database that has financial, logistical and research support from numerous partners including private foundations. It is expected to encompass the 1.9 million known species of animals, plants, and other life forms in about ten years. The database will be configurable for all types of audiences, from students and scientists to policy makers and the general public, and is intended to allow free access to all. The NMNH is uniquely positioned to contribute to this global effort of documenting every known species currently living on Earth, through its extensive and broad collections as well as through the scientific staff who provide the context for these specimens. The specimens require scientific expertise to provide related ecological and evolutionary information.

EOL is an unprecedented research initiative that is designed to broaden access to Smithsonian collections and knowledge, and share these resources with America and the world. It includes collaboration with other parts of the Smithsonian and leading institutions across the country and abroad. The first phase of this initiative was developed with support from the MacArthur and Sloan Foundations, and currently provides access to 180,000 species pages, as well as 20 million pages of literature related to biological diversity, through the Biodiversity Heritage Library. The next phase of this project will expand information to 500,000 species pages and some 50 million pages of literature, as well as develop resources for students and teachers across the Nation over the next three years.

Another example of the Smithsonian's external collaborations is looking at the amphibian extinction crisis. A systematic global assessment of all 5,743 known amphibian species has found that one-third of them are in danger of elimination at an alarming rate by a pathogen known as the chytrid fungus, according to the American Association for the Advancement of Science. In May of last year, eight institutions joined together to save amphibians from the brink of extinction in the eastern region of Panama—an area rich with diverse amphibian species. Experts from the Smithsonian's National Zoological Park, the Smithsonian Tropical Research Institute, Africam [sic] Safari Park, the Cheyenne Mountain Zoo, Defenders of Wildlife, the Houston Zoo and the Zoo New England have pooled their energy and resources

to form the Panama Amphibian Rescue and Conservation Project to protect a number of species from complete loss. The project consists of three distinct and complementary parts: the ongoing operation of El Valle Amphibian Conservation Center in western Panama, run by the Houston Zoo; the Amphibian Chytrid Cure Research Program initiated at the National Zoo in collaboration with Vanderbilt University; and the construction and operation of the new Summit Park Amphibian Rescue Center in Panama.

The Future

To maintain its cutting-edge research in the years to come, the Smithsonian needs to be attuned to where it can best contribute to solving complex scientific issues and adjust its unique resources accordingly. In the coming months, through both the strategic plan and deeper discussions scheduled for the Board of Regents early next year, these issues will be examined:

- Increasing capabilities for interdisciplinary research.
- Connecting important scientific assets to create more synergy.
- Developing a clear vision for science education, which my colleague Claudine Brown will address in her testimony.
- Addressing the national needs for scientific literacy.
- Finding additional key partners within the federal and university sectors.

With the help of our 6,000 employees, hundreds of volunteers and extensive collections, and through internal and external collaborations, the Smithsonian strives to address important issues in science today, improve scientific literacy and ensure a brighter future for us all.

In conclusion, thank you for this opportunity to share with you some of the unique aspects of the Smithsonian Institution's science research and the various ways in which we contribute to the world's understanding of complex and important issues.

BIOGRAPHY FOR G. WAYNE CLOUGH

Wayne Clough is the 12th Secretary of the Smithsonian Institution, leading the world's largest museum and research complex with 19 museums, nine research centers, the National Zoo and research activities in more than 90 countries.

Clough envisions a new era for the 164-year-old Institution, expanding the Smithsonian's global relevance and helping the Nation shape its future through research, education and scientific discovery on major topics of the day. One of his first initiatives led to a new strategic plan that speaks to four grand challenges that will bring together the diverse resources of the Smithsonian's museums and science centers through interdisciplinary approaches.

Ensuring that the Institution's vast collection is accessible and available to everyone is a priority for Clough and the new strategic plan. Efforts are underway to digitize much of the Smithsonian's 137 million objects in the collection and use the World Wide Web and Smithsonian experts and scholars to reach out to new audiences in the United States and around the world.

Since Clough began as Secretary in July 2008, he has overseen several major openings at the Smithsonian, including the reopening of the National Museum of American History, the David H. Koch Hall of Human Origins and Sant Ocean Hall at the National Museum of Natural History.

Before his appointment to the Smithsonian, Clough was president of the Georgia Institute of Technology for 14 years. He received his bachelor's and master's degrees in civil engineering from Georgia Tech in 1964 and 1965 and a doctorate in 1969 in civil engineering from the University of California, Berkeley.

Clough has been a professor at Duke University, Stanford University and Virginia Tech. He served as head of the department of civil engineering and dean of the College of Engineering at Virginia Tech, and as provost at the University of Washington.

The Georgia Tech campus served as the Olympic Village for the 1996 Centennial Olympics while Clough was president. Research expenditures increased from $212 million to $425 million and student enrollments from 13,000 to 18,000. More than 1.5 billion dollars was raised in private gifts, and campus operations were opened in Savannah, Ga., Ireland, Singapore and Shanghai.

Clough completed a building program of more than $1 billion that incorporated sustainable design. Georgia Tech was also ranked among the top 10 public universities by *U.S. News and World Report* during his tenure. The publication *Diverse Issues in Higher Education* cited Georgia Tech as the top producer of African Amer-

ican engineers, and *Hispanic Business* magazine named the school among the top institutions for study by Hispanic students.

Clough was elected to the American Academy of Arts and Sciences in April 2010. In March 2009, he was inducted into the Technology Hall of Fame of Georgia, and in February 2009, he received the Joseph M. Pettit Alumni Distinguished Service Award that recognizes a lifetime of leadership, achievement and service to Georgia Tech. In 20l2, Georgia Tech is scheduled to open the G. Wayne Clough Undergraduate Learning Commons building to honor his commitment to undergraduate students.

Clough received nine national awards from the American Society of Civil Engineers, including the 2004 OPAL lifetime award for contributions to education. He is one of 14 civil engineers to have been twice awarded civil engineering's oldest recognition, the Norman Medal, in 1982 and in 1996. He received the George Westinghouse Award from the American Society of Engineering Education in 1986 for outstanding teaching and research. In 1990, he was elected to the National Academy of Engineering (NAE), and in 2008 was recognized with the NAE Bueche Award for his efforts in public policy. He was awarded the 2002 National Engineering Award by the American Association of Engineering Societies and in 2004 was named as a Distinguished Alumnus from the College of Engineering at U.C. Berkeley.

In summer 2010, Clough received honorary Doctor of Science degrees from Oglethorpe University in Atlanta; University of Maryland, Baltimore County; and Williams College in Williamstown, Mass. He is also a recipient of honorary doctorates from Shanghai Jiao Tong University, Florida Southern College and the University of South Carolina.

Clough chaired of the National Research Council Committee on New Orleans Regional Hurricane Protection Projects and serves as a member of the National Science Board. He served on the President's Council of Advisors on Science and Technology (2001–08) and as co-chair of the 2004 National Innovation Initiative and University vice chair of the U.S. Council on Competitiveness; he chaired the Engineer of 2020 Project for the NAE and served as a member of the National Governors Association Innovate America Task Force (2006–07).

He served on the boards of Noro-Moseley Partners and TSYS Corp. as well as the International Advisory Board of King Fahd University of Petroleum and Minerals.

Clough's interests include science, technology and higher-education policy, sustainability, international programs, museums and history. His civil engineering specialty is in geotechnical and earthquake engineering. He has published more than 130 papers and reports and six book chapters and has co-written numerous committee reports. Clough was born in Douglas, Ga., Sept. 24, 1941.

Chairman LIPINSKI. Thank you, Dr. Clough, and I figured I would give you a little extra time there because you were doing a good job of going through exactly what you are doing, a very good explanation. Of course, the only thing I keep thinking, though, is I am going to have nightmares of that thing that you have sitting there in front of you as I am sitting there, sitting here watching you, listening to you give your testimony.

But the Chair now recognizes Ms. Brown for five minutes.

STATEMENT OF CLAUDINE BROWN, DIRECTOR OF EDUCATION, SMITHSONIAN INSTITUTION

Ms. BROWN. Mr. Chairman and Members of the Subcommittee, it is my great pleasure to appear before the Subcommittee to testify about science education at the Smithsonian Institution. I was recently named the Director of Education for the Smithsonian, and prior to this I served for more than a decade as the Director of the Arts and Culture Program at the Nathan Cummings Foundation in New York City.

This is not my first tour of duty at the Smithsonian Institution. I also served as the Director of the National African-American Museum Project and was at one time the Deputy Assistant Secretary for Arts and Humanities.

Secretary Clough has made it clear that the Smithsonian will be focused on education. The Smithsonian has a long history of serving educators by providing extensive informal and formal education for learners of all ages. During this time in our history, when we are, of necessity, considering our world holistically, encyclopedic institutions like the Smithsonian are uniquely suited to help learners understand the connections between the sciences, the arts, and the humanities. We believe that the Smithsonian is essential in helping educators better understand and explain our complex and inter-connected world.

As the Director of Education, I have been tasked with the development of an Institution-wide plan for educational initiatives, the implementation of assessment strategies that will measure our impact on the field, and securing support for projects that will benefit K–12 students. In this capacity I will also oversee the Smithsonian's education organizations, and I will coordinate the efforts of 32 education-based offices in museums and scientific institutions throughout the entire museum complex.

Currently, many of the Smithsonian museums, research centers, and outreach offices work with educators on both the local and national level to enhance the teaching of science through the use of our collections and our research. We assist school administrators with the development of strategic plans that lead to the implementation of research-based science education programs in their districts.

We provide traditional curricula and digital teaching tools so that we can enhance school-based learning. We also train teachers throughout the country who use our curricula to teach science in innovative ways. We continue to be well respected for offering timely and engaging on-site programs that give educators and students direct access to primary source materials and expose them to concrete examples of natural phenomena and scientific innovations.

One of my challenges will be to unify our many education initiatives and help the Smithsonian become a greater national resource for students and teachers, especially those who will never be able to participate in on-site programming on the Mall.

An excellent example of the Smithsonian's ability to bring science literacy to learners of all ages is the research and programming around the National Museum of Natural History's Oceans Initiative. Based on extensive research in marine science, the Museum developed a major exhibition that reaches families, individuals, and school groups. There is a publication, "Oceans: Our Water, Our World," a teacher's guide, and the family guide. The website, Ocean Portal, provides information that is available in the exhibition as well as current news about oceans, including stories on the Gulf oil spill and sustainable seafood.

I was with a group of teachers last evening who work in rural communities who had just been through that exhibition, and they were most excited about the Portal, which would allow them to teach lessons in their home communities. The Portal also encourages members of the public to submit essays and share their opinions on a blog, through videos, photographs, and polls.

The Smithsonian online conference on climate change also included research on coral reefs. More than 20,000 learners of all ages have participated in the Smithsonian's online conferences.

The Smithsonian's museums, zoo, libraries, and scientific research centers offer hands-on learning experiences that can play an important role in transforming education in our Nation. The lessons that we are learning from teaching science on-site are rapidly being translated into digital forms that can be broadly disseminated. We are living in the moment when the convergence of the intellectual and creative capital of the Smithsonian Institution and the opportunities made possible by the digital revolution can lead to broad and engaging points of access for learners of all ages.

Technology presents us with an opportunity to reshape the future of education. It is no longer acceptable for us to share only a small percentage of our 137 million specimens and artifacts in an age when the internet and technology have made it possible to share it all.

Our job is to authenticate and inform the significance of the collections, not to control access to them. In doing this, the relevance of the Smithsonian to education can be greatly enhanced, as we learn—from learners—new applications for our scholarships.

Thank you for the opportunity to testify.

[The prepared statement of Ms. Brown follows:]

PREPARED STATEMENT OF CLAUDINE BROWN

Mr. Chairman and Members of the Subcommittee -

It is my great pleasure to appear before the Subcommittee to testify about science education at the Smithsonian Institution. I was recently named the director of education for the Smithsonian. Prior to this position, I served for more than a decade as the director of the arts and culture program at the Nathan Cummings Foundation in New York. Although I have been away for awhile, I am not new to the Smithsonian. In 1990, I was the Smithsonian's director of the National African-American Museum Project. In this position, I coordinated the efforts of advisory committees that considered the role of the Smithsonian in the development of a national museum devoted exclusively to the documentation of African American life, art, history and culture. In 1991, I was the deputy assistant secretary for the arts and humanities and developed policy for many Smithsonian museums. It is good to be back at the Smithsonian, especially at such a pivotal time in its history, a time when our education offerings will reach new audiences on the Mall in Washington, DC, throughout the country and the world.

As early as his installation ceremony, Secretary Clough made it clear that the Smithsonian would be focused on education. The Smithsonian has a long history of serving educators by providing extensive informal and formal education for learners of all ages. During this time in our history when we are of necessity considering our world holistically, encyclopedic institutions like the Smithsonian are uniquely suited to help learners understand the connections between the sciences, arts and humanities. We believe that the Smithsonian is essential in helping educators better understand and explain our complex and interconnected world. The Smithsonian looks forward to partnering with more educators in schools and institutions of higher education to provide access to resources that will help prepare students for the future. The Smithsonian's new strategic plan referenced by Secretary Clough in his remarks has already begun to make important inroads regarding our educational outreach as we address our four Grand Challenges.

As the director of education, I will be responsible for defining the Smithsonian's education program and will report directly to the Secretary. I have been tasked with the development of an Institution-wide plan for educational initiatives, the implementation of assessment strategies that will measure our impact on the field and securing support for projects that will benefit K–12 students. In this capacity, I will also oversee two of the Smithsonian's educational organizations—the National Science Resources Center, the Smithsonian Center for Education and Museum Studies and hope to oversee the Smithsonian Institution Traveling Exhibition Service,

the Smithsonian Associates, and the Smithsonian Affiliates program as well. I will also coordinate the efforts of 32 education-based offices in museums and science centers throughout the Smithsonian.

Currently, many of the Smithsonian museums, research centers, and outreach offices work with educators on both a local and national level to enhance the teaching of science through the use of our collections and research. We assist school administrators with the development of strategic plans that lead to the implementation of research-based science education programs in their districts. We provide traditional curricula, and digital teaching tools so that we can enhance school based learning. We also train teachers throughout the country who use our curriculum to teach science in innovative ways. We continue to be well-respected for offering timely and engaging on-site programs that give educators and students direct access to primary source materials and expose them to concrete examples of natural phenomena and scientific innovations. One of my challenges will be to unify our many education initiatives and help the Smithsonian become a greater resource for students and teachers across the country—especially those who don't have the opportunity to participate in on-site programming.

High-quality, inquiry-oriented science instruction is essential for effective science education programs. Museums, zoos, our 20 libraries, botanic gardens and other sites that offer hands-on learning can play an important role in transforming education in our nation. The lessons that we learn from teaching science in our museums and research centers are rapidly being translated into digital forms that can be broadly disseminated.

We are living in a moment when the convergence of the intellectual and creative capital of the Smithsonian Institution and the opportunities made possible by the digital revolution lead to broad and engaging points of access for learners of all ages. By using new technology extensively, we will reach new generations and audiences and make it easier for them to reach us. The social networks that did not exist until recently such as blogs, Twitter, YouTube, Wikipedia, podcasts, and Web cams are quickly becoming transformative for the Smithsonian.

Technology presents a new opportunity to shape the future of education. It is no longer acceptable for us to share only a small percentage of our 137 million specimens and artifacts in an age when the Internet and technology have made it possible to share it all. In addition to technology, we need to continue our focus on education programs—which are areas of profound strength at the Smithsonian. We need to make our collections, talented scholars, researchers, and educators accessible worldwide by providing additional platforms, opportunities, and creative vehicles for educating and inspiring people of all ages and cultural backgrounds. Our job is to authenticate and inform the significance of the collections, not to control access to them. In doing this, the relevance of the Smithsonian to education can be greatly enhanced as we learn from learners new applications for our scholarship. By focusing on these areas, we can inspire people on a national and international basis.

The Smithsonian is playing a key role in advancing science education across the country. I would like to take a few minutes to highlight some of the many Smithsonian educational programs that have a direct impact on science education.

Smithsonian Center for Education and Museum Studies

The Smithsonian Center for Education and Museum Studies (SCEMS) has made great use of technology by hosting a number of virtual conferences. People from around the world join Smithsonian scientists, curators, and educators in real time as together they explore Smithsonian research and collections. In addition to live interactive sessions, the conferences include moderated forums, demonstrations of educational resources and strategies, virtual exhibit hall presentations, podcasts, social networking, and gaming/simulations. All sessions are closed captioned and archived for future viewing.

To date these conferences have included 34 hours of live programming, 20,000 participants from 100 countries, all U.S. states and territories, more than 3,000 cities, and 6 continents. Audiences have included K–12 teachers and students, university and community/technical college faculty and students; librarians; congressional staff members; Girl Scout troops, tribal councils; and staff members of congressional offices and government agencies, non-governmental organizations, museums, corporations, as well as the general public.

SCEMS also uses technology to take Smithsonian experts and collections into our nation's classrooms. Educators search by state standards from a database of over 1,700 educational resources on SmithsonianEducation.org. Teachers and their students participate in interactive Smithsonian online conferences—making predictions, asking questions, and posting ideas of their own. Students play simulations and games and complete community-based missions inspired by Smithsonian re-

search. In Smithsonian workshops, teachers and teens create their own games, scavenger hunts, blogs and podcasts and share them through social networks. Recent topics for the Centers programs have included climate change, understanding spatial relations in the universe, and problem solving methods across disciplines.

National Science Resources Center

As part of its mission, to insure "the increase and diffusion of knowledge," the Smithsonian is committed to scientific literacy for learners of all ages. The National Science Resources Center (NSRC) was established in 1985 by the Smithsonian Institution and the National Academies to improve the learning and teaching of science for all students in the United States and throughout the world. To achieve the Smithsonian's and the Center's missions, NSRC has, for more than two decades, leveraged the research and expertise of the Smithsonian, the National Academies and other institutions to develop science education programs in partnership with dozens of government agencies, academic institutions, corporations and museums.

The Smithsonian, through the auspices of the NSRC is committed to helping leaders learn how to implement a systemic approach to science education by connecting educators and decision makers to the vast resources and research of the Smithsonian Institution and the National Academies. NSRC programs are now in K–12 science programs in more than 1,200 school districts representing 30% of the U.S. student population in 48 states as well as overseas in nine countries. More than 90% of the school districts with which NSRC works have made long-term improvements in the way they teach science, resulting in significant gains in student achievement.

Smithsonian Astrophysical Observatory and the Harvard-Smithsonian Center for Astrophysics

The Smithsonian is fortunate to have a national program known as the Smithsonian Astrophysical Observatory (SAO). SAO's mission is to advance the public's knowledge and understanding of the universe through research and education in astronomy and astrophysics. SAO engages in cutting-edge research in areas ranging from small, individual projects to major partnerships with other government organizations and academic institutions. Founded in 1890, SAO is the largest and most diverse astrophysical institution in the world. It has pioneered the development of orbiting observatories and large, ground-based telescopes; the application of computers to study astrophysical problems; and the integration of laboratory measurements and theoretical astrophysics. Observational data are gathered at SAO's premier facilities including the Sub millimeter Array (SMA) observatory on Mauna Kea Hawaii.

The Harvard-Smithsonian Center for Astrophysics (CfA) brings the resources and research facilities of the Harvard College Observatory and the Smithsonian Astrophysical Observatory under a single director to pursue studies of basic physical processes that determine the nature and evolution of the universe. CfA is involved in many aspects of education and public outreach, from major museum exhibits to curriculum development to education research. CfA's Science Education Department is a leadership organization that provides professional development in astronomy and basic science for teachers and curricula for grades K–12.

Smithsonian Environmental Research Center

Established in 1965, the Smithsonian Environmental Research Center (SERC) is the leading national research center for understanding environmental issues in the coastal zone. The site encompasses 3,000 acres of land and 14 miles of protected shoreline on the Chesapeake Bay that serve as a natural laboratory for long-term ecological research. The unique location provides valuable opportunities to study the interactions of aquatic, terrestrial and atmospheric components of complex landscapes. Through interdisciplinary, experimental research, SERC scientists are working to understand how ecosystems interact and are linked in this critical zone where the land meets the sea, and how physical and chemical processes sustain life on Earth.

Education and outreach are major components of the Smithsonian Environmental Research Center (SERC). SERC offers a broad array of opportunities for people of all ages to learn about the ecology of the Chesapeake Bay area and to increase their appreciation for the environment. SERC offers on-site K–12 programs, distance learning, public programs and professional training.

SERC has been a prime location for groups to get hands-on experience with environmental science and ecology. Recently, SERC has dramatically increased its efforts to educate a larger population about the Bay and its watershed by providing

distance learning and web-based education programs for K–12 students and adults. These new programs are designed to complement, not replace, the existing hands-on education programs, by expanding our reach and offering students nationwide an opportunity to learn about an important ecosystem, and visit behind the scenes at SERC where conventional visitors are unable to go. Geographic distance, cost, and limited time can prevent members of the public, especially schoolteachers and students, from making the trip. Communication technologies developed for distance learning, however, have connected students and teachers from across the country to Smithsonian scientists who study the Chesapeake Bay and its watershed. SERC's Education Program is committed to broadening society's understanding of the environment, communicating an awareness of how human activities influence ecosystems, and training future generations of environmental scientists.

Smithsonian Tropical Research Institute

The Smithsonian Tropical Research Institute (STRI) in Panama is dedicated to fostering a greater understanding of biological diversity issues. The training of future generations of tropical biologists has been identified as a priority among the goals for scientific excellence in STRI's strategic plan. Fellowships are the primary goal of scientific training at STRI, but other strategies include internships, field courses, seminars and workshops. STRI in collaboration with McGill University developed an interdisciplinary and inter-institutional graduate program based in Panama. Recently, the Smithsonian joined Arizona State University in an innovative education and science partnership aimed at sustaining a biodiverse planet. The partnership will create opportunities for ASU undergraduates, graduate students and faculty to participate in fieldwork at Smithsonian facilities in Panama, as well as for the development of virtual global classrooms that center on current research in tropical ecosystems. Smithsonian scientists will also participate in ASU degree programs.

Smithsonian Conservation Biology Institute

The Smithsonian Conservation Biology Institute (SCBI) is a program of the Smithsonian's National Zoological Park. It is one of the world's most extensive programs of conservation biology research. SCBI works directly with teachers, students, and their parents to develop awareness of and appreciation for the need to preserve biodiversity at home and abroad. Hands-on methods of teacher training and student involvement in conservation education are used at SCBI. National Zoo staff and research associates have offered training courses in the United States and at more than 20 international locations on a variety of topics for over three decades. During this time, more than 5,000 individuals from more than 85 countries have taken part in such efforts.

In October 2008, the Smithsonian and George Mason University created a new, comprehensive academic program, the Smithsonian-Mason Global Conservation Education Program. This new program incorporates multidisciplinary faculty from the Zoo's Center for Conservation Education and Sustainability and George Mason University's Center for Conservation Studies and will train students to help avert and treat the looming biodiversity crisis. The program will provide academic opportunities for as many as 50 undergraduate students per semester, and an additional 60 professional or graduate students.

National Air and Space Museum

The National Air and Space Museum (NASM) offers a variety of free educational programs for school groups and organized youth groups. The museum has developed teaching posters and guides for students in grades K–12 that will advance their knowledge of science and technology. Areas of focus for curricula include: *Living and Working in Space*, which introduces students to the environmental conditions in space, the challenges that must be overcome to live and work there, and advances in spacesuit technology; *Embracing The Impossible: Popular Response to the Aerial Age* exposes students to primary source materials that help them understand how people felt about the new technology of flying in the early 1900s; *Reflections on Earth: Biodiversity and Remote Sensing* includes lessons for interpreting satellite images and field studies; Students learn to measure and monitor forest biodiversity on a local, regional, and global scale; and *Destiny in Space* is a guide that examines our future prospects for space exploration. NASM's activities, information, and resources cover a range of topics including: muscle response to weightlessness, robotic guides, suiting up for space, communication and gardening in space.

Students may also interact with the National Air and Space Museum without leaving the classroom! The museum offers Interactive Videoconferencing programs

featuring the museum's staff and docent volunteers. NASM also offers Electronic Field Trips (two-way distance learning interactions) as well as occasional webcast educational programs. Use of the unique National Air and Space Museum collection and the universally-engaging nature of aviation and space make these programs relevant and exciting. These interactive electronic experiences augment teacher lesson plans.

National Museum of Natural History

As one of the largest science classrooms in the world, the National Museum of Natural History supports the work of teachers who seek to explore the natural world through the Museum's exhibits, and online resources. The Museum's work is built on a foundation of scientific research by the Museum's staff of over 150 scientists and curators as well as the national and international community of scientists. There are more than 126 million artifacts and specimens in its collections. The Museum provides both field-trip-related and non-field-trip-related lesson plans, web-based activities for students, and other resources that can help teach a range of science and natural history topics.

A visit to exhibitions such as the O. Orkin Insect Zoo and the Butterfly Pavilion bring the natural world up close and personal with the opportunity to interact with living creatures. Venues such as the Discovery Room and the Naturalist Center offer a hands-on approach to learning, using artifacts and specimens from the Museum's collections to make science and scientific processes real. The museum's goal is to educate and inspire the next generation and encourage respect for the natural world. The museum's programs are designed to address these goals. Two of its key professional development programs are *Dig it: Secrets of Soil* and *Project Archaeology: Investigating Shelter-Archaeology of the Colonial Chesapeake*. Lesson plans cover such topics as Measuring Biodiversity Across North America, Anthropology, Ecosystems, and Lewis and Clark as Naturalists.

National Zoological Park (NZP) and Friends of the National Zoo (FONZ)

The Smithsonian's NZP and FONZ offer a wide variety of programs, resources, internships and volunteer opportunities for students of all ages. Each year thousands of school groups, individual students, and teachers use the Zoo as a living classroom. They come to gain a better understanding of the natural world in which we live, to enjoy beautiful animals in an outdoor oasis, and to engage in exciting, hands-on science. On average, the National Zoo reaches 5,800 DC students and trains 75 teachers in workshops each year. Uncounted thousands more students enjoy the Zoo during field trips. There are many exciting programs at the Zoo that teach about science for example, Bridging the Americas/Unidos por las Aves is a cross-cultural environmental education program that partners elementary and middle school classes in the DC Metro area with classes in Latin America and the Caribbean. Partnered classes learn about the migratory birds that connect these two regions of the hemisphere. The program is designed to instill an appreciation for migratory birds and the need to protect the habitats they depend on throughout the year, as well as to stimulate an interest in learning about other countries and their cultures. Teachers are provided with content, materials, and support that enable them to use birds as a theme for teaching required standards and beyond in multiple subject areas.

Smithsonian Institution Traveling Exhibition Service

In its nearly 60 years of delivering Smithsonian exhibitions to museums and science centers across the nation, SITES has devoted fully one third of its program to science. From projects that bring North American visitors close to the wonders of the tropical rainforests in the southern hemisphere to tracking the elusive giant squid, the work of Smithsonian scientists and researchers is always on exhibit somewhere in the United States. SITES exhibitions invite its audiences to explore anthropology, astronomy, biology and environmental studies, entomology, geology, paleontology, ichthyology, oceanography, polar studies, vertebrate biology and veterinary studies. Current offerings include a close-up look at the fascinating world of ants, satellite images of Earth seen from space, insights into the scientific research at McMurdoe Station in Antarctica and x-rays of spacesuits along with rarely exhibited astronaut gear. Future projects include an interactive exhibition about diseases that pass from animals to humans and back again and a careful assessment of invasive species.

The Smithsonian Associates

The Smithsonian Associates (TSA) provides science education as a part of GEAR UP through the U.S. Department of Education. Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) encourages middle and high school students to consider pursuing higher education. GEAR UP is a federal program that grants funding to states and partnerships that provide programs and services for increasing low-income students' preparation for postsecondary education. GEAR UP programs serve cohorts of students before they begin seventh grade and supports them through high school.

TSA is working with the Lafayette Parish School System in Louisiana on a six year effort to engage teachers and students from 6th to 12th grade in science learning. Smithsonian scholars will deliver 11 programs for the duration of the GEAR UP grant. TSA's upcoming informal science education programs include: *Time and the Brain*; *Our Asymmetrical, Imperfect and Gloriously Messy Universe*; *Northern Lights*; *A Message from the Sun*; and *Dark Matter and Dark Energy: Cutting-Edge Findings*.

Thank you for giving me the opportunity to testify. I look forward to working with the committee and Members of Congress in providing the Smithsonian's insight, experience and expertise regarding science education. I know that the Smithsonian can continue to play an important role as a resource for change in the current science education paradigm. I would be pleased to answer any questions you might have.

BIOGRAPHY FOR CLAUDINE BROWN

Claudine Kinard Brown began her professional career as an art and drama teacher in New York City Public Schools. In 1976 she joined the staff of the Brooklyn Museum where she served for thirteen years in several capacities. She began her career in Brooklyn, as a museum educator. In 1984 she served as Manager of School and Community Programs and in 1985 she became the Museum's Assistant Director for Government and Community Relations.

Brown left the Brooklyn Museum in 1990 to direct the Smithsonian Institution's initiative to create a National African American Museum. Her responsibilities included: conducting a needs assessment, developing a vision statement and program plan, and opening a Center for African American History & Culture pending passage of authorizing legislation to create a museum. In 1991, she added to her responsibilities by concurrently assuming the position of Deputy Assistant Secretary for Museums. She developed policy for 13 national arts and humanities museums, and reviewed their long-range plans and assisted in prioritizing institution-wide budget requests, which were presented to Congress.

Brown was the Director of the Arts and Culture Program at the Nathan Cummings Foundation from 1995 to 2010. Over the course of fifteen years she developed funding initiatives that have strengthened and stabilized community-based arts institutions. Beginning in 2001, she worked to build the field of practitioners and funders who are committed to art and community building, art and social justice and art and civic engagement. She is a co-founder of the Art and Social Justice Funders Working Group and she has supported efforts to research, map and document the work of the field.

In 2010 she became Director of Education for the Smithsonian Institution. As the director of education, Brown will be responsible for defining the Smithsonian's education program and will report directly to Smithsonian Secretary Wayne Clough. She will develop an Institution-wide plan for educational initiatives, assessment strategies and funding for students in the K–12 range. Brown will oversee five of the Smithsonian's educational organizations—the National Science Resources Center, the Resident Associates, the National Affiliates, the Smithsonian Institution Traveling Exhibition Service and the Smithsonian Center for Education and Museum Studies—and coordinate the efforts of 32 education-based offices in museums and science centers.

Claudine K. Brown has served on several nonprofit boards, including the American Association of Museums, the National Museum of African American History and Culture Plan for Action Presidential Commission, the Association of Black Foundation Executives and as President of the Board of Grantmakers in the Arts. She has taught graduate courses in the Arts Administration program at New York University, and the Museum Leadership Program at Bank Street College. Claudine Brown has a Bachelor of Fine Arts degree from Pratt Institute, a Masters of Science degree in Museum Education from Bank Street College and a Doctor of Jurisprudence degree from Brooklyn Law School.

Chairman LIPINSKI. Thank you, Ms. Brown.

I turn now to Dr. Bermingham.

STATEMENT OF ELDREDGE "BIFF" BERMINGHAM, DIRECTOR, SMITHSONIAN TROPICAL RESEARCH INSTITUTE, SMITHSONIAN INSTITUTION

Dr. BERMINGHAM. Thank you, Chairman Lipinski, Dr. Ehlers, Mr. Baird, and Members of the Subcommittee for the opportunity to provide testimony today. You are all invited to STRI in Panama, announced or unannounced.

My name is Biff Bermingham. I am the Director of the Smithsonian Tropical Research Institute or STRI. I have been at STRI for 20 years, first as a staff scientist, during which time I published more than 140 articles and books on tropical bio-diversity. For the past seven years I have served as Deputy Director and now Director of STRI. I am responsible for 40 Ph.D. staff and 350 technical staff.

Located in the Republic of Panama, STRI is the only bureau of the Smithsonian Institution located outside the United States. We serve as custodians for the Barro Colorado Nature Monument, which sits in the middle of the Panama Canal. The monument is the only mainland tropical forest reserve in the world under U.S. stewardship.

This year, we begin celebrations of 100 years of Smithsonian science on the Isthmus of Panama, a history tracing back to the 1910–1912 Smithsonian expeditions to Panama—authorized by President William H. Taft—to provide data on tropical biological diversity in light of the Panama Canal construction effort. Tropical diseases and their insect vectors defeated the French in their effort to construct a canal across Panama, and the Smithsonian expedition aimed to provide detailed biological understanding of tropical bio-diversity to ensure U.S. success.

With laboratories on both coasts of Panama, STRI is the only institute in the Americas providing direct research access to both the Pacific and Atlantic Oceans. The recurring two-ocean theme in science education and marine science at STRI has resulted in landmark studies of the evolution and ecology of tropical marine species and communities, as well as research funded by the National Science Foundation and National Institutes of Health for ecologically-guided discovery of novel pharmaceutical compounds.

Immediate access to two oceans makes STRI a critical U.S. resource for studying the impact of climate change and ocean acidification on near-shore coral reefs, sea grasses, and mangroves.

And given the Gulf oil spill, it is worth noting that the first ever study of the impact of an oil spill in tropical marine ecosystems was financed by the Mineral Management Services and carried out at STRI more than 20 years ago.

The STRI mission is superbly well-aligned to the Smithsonian grand challenge "Understanding and Sustaining a Bio-diverse Planet." This challenge requires integrating information across different biological scales and different fields of scientific inquiry.

Towards this end, STRI administers the Smithsonian Institution Global Earth Observatories, or SIGEO, a global network of 40 large-scale forest plots in 21 countries. The first observatory in the

network was established 30 years ago at STRI, and the forest survey methodology we developed was unprecedented in scale and scope. Over the years the standard census methods developed at STRI to address complex questions about tropical biodiversity have also proved to be a powerful approach to studying the impact of global climate change on forest ecosystems. To date we have made more than 11 million measurements representing 8,500 tree species around the world.

Given scientific uncertainty and the importance of new research regarding forest response to climate change, the network is expanding rapidly. In the United States alone, and supported by a $1.25 million increase to the Smithsonian fiscal year 2010 budget, we have added new forest plots in Maryland, Virginia, Wisconsin, Washington, California, and Hawaii. More than 200 university and government scientists have published research based on results from the Smithsonian Forest Observatories. This week's cover article in *Science*, our Nation's premiere science magazine, is a recent, high-profile example of the critical importance of long-term data for understanding a forest change through time.

As we look to the future, forest remediation in the developing world will take on increasing prominence as we consider food and water security and human migration associated with landscape degradation and sea level rise. Research and science education in this light is critical, a need that the Smithsonian is addressing with the Panama Canal Watershed Experiment. This experiment will run for at least 25 years and is designed to be a global example for understanding the relationship between land use decisions, climate change, and biological diversity. It is a powerful example given the impressive list of ecosystem services provided by the Panama Canal watershed. To name just a few, regulation of water supply to the canal in order to reduce risk of flooding and infrastructure damage while ensuring sufficient water to operate the locks; avoided deforestation, reforestation, and carbon sequestration, which couple to represent an important research agenda for the United Nations Framework Convention on Climate Change; provision of habitat for endangered species; and regulation of disease vectors.

STRI has recently been awarded a $3.8 million National Science Foundation International Partnership in Research and Education grant to study new fossils and geology exposed by the excavations of the multi-billion dollar expansion of the Panama Canal. This massive excavation provides researchers an unparalleled opportunity to strengthen our understanding of the role the Isthmus of Panama has played with regard to climate and bio-diversity change through time, and a unique perspective on how increasing carbon dioxide levels may shape the forests of the future.

In closing, I cannot emphasize enough the importance of the Smithsonian's commitment to long-term research and education. With our research perspective, sustained effort, and long-term data sets and educational assets, we are uniquely positioned to assess, identify, understand, and predict environmental threats to bio-diversity and incorporate rigorous science into resource management and stewardship decisions.

Thank you very much.

[The prepared statement of Dr. Bermingham follows:]

PREPARED STATEMENT OF ELDREDGE BERMINGHAM

Introduction

Thank you, Chairman Lipinski and distinguished members of the Subcommittee for the opportunity to provide testimony today. My name is Eldredge Bermingham. I am the Director of the Smithsonian Tropical Research Institute, or STRI, located on the banks of the Panama Canal in the Republic of Panama, the only bureau of the Smithsonian Institution located outside the United States. I hold a Ph.D. degree in Genetics. I have spent 20 years guiding molecular genetics research programs at STRI and have published more than 140 scientific articles. For the past seven years I have served as Deputy Director and now Director of STRI, where I oversee about 40 Ph.D. scientists and 350 technical staff. I participate on the Smithsonian's steering committee for its Marine Science Network, and on Secretary Clough's strategic planning teams responsible for the 2010–2015 Strategic Vision for the Smithsonian. I have played the lead role over the past five years transforming the Center for Tropical Forest Science that began in Panama more than thirty years ago into the pan institutional Smithsonian Institution Global Earth Observatories (SIGEO). SIGEO is a global network of 40 large-scale forest dynamics plots in 21 countries. The network is a U.S.-led resource that investigates forest dynamics and the response of forests and the ecosystem services they provide—carbon storage, water provision and biodiversity conservation—to climate change. National and international science education, training and capacity building are core missions of STRI and SIGEO.

My purpose today is to use my experience at STRI to summarize the main themes and importance of post-secondary STEM education at the Smithsonian. At STRI we host more than 1000 visiting undergraduate, graduate and postdoctoral researchers. Our approach is to partner outstanding scientists with outstanding young scholars. At STRI, we apply state-of-the-science technologies to understand the nature and origins of biodiversity, the causes and consequences of climate change, the interconnectedness of global ecosystems, and the cultural heritage of Native American peoples. We mix the necessary, more traditional long-term measurement and observations about the natural world with innovative, new analytic techniques and approaches. At each of the science research units at the Smithsonian the contribution to training the next generation of scientists is impressive and the Institution is recognized at the national and international level for producing scientific leaders. Outstanding examples include education in tropical biology (STRI), astronomy and astrophysics (Smithsonian Astrophysical Observatory), species survival biology (National Zoological Park), biodiversity (National Museum of Natural History) and invasive species biology and coastal zone processes (Smithsonian Environmental Research Center). And the Smithsonian partners with the National Academy of Sciences to develop award-winning science curricula through the National Science Resources Center. We are a remarkable U.S. resource responsible for training the next generation of scientists.

Background:

What has made STRI such an important resource for educating the next generation of scientists? The answer is long-term federal investment in world-class resident scientists supported by superb research facilities located adjacent to tropical forests and coral reefs. This year, 2010, the Smithsonian marks a century of research in Panama, tracing back to the 1910–1912 Smithsonian Expeditions to Panama authorized by President William H. Taft. From the humble beginning of a single research station on Barro Colorado Island (BCI) located in the middle of the Panama Canal, STRI has developed dramatically. STRI is an international focal point for scientists and students interested in the ecological and evolutionary processes that underlie the extraordinary biological diversity of rain forest and coral reef ecosystems. These processes are palpable on an isthmus that formed three million years ago and transformed our planet by joining the continents of South and North America, and separating the Caribbean Sea from the Eastern Pacific Ocean. Long-term environmental research is a STRI trademark, more than eighty years in the case of the forests on Barro Colorado Nature Monument (BCNM), protected under the terms of the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, ratified by the U.S. Senate in 1941. The BCNM is the only mainland tropical forest reserve in the world under U.S. stewardship.

The long-term research conducted by STRI scientists, collaborators and students is a critical contribution to the Smithsonian Institution's 2010–2015 strategic plan "A Smithsonian for the Twenty-First Century" set forth in 2009, particularly through its contributions to the Grand Challenge, *Understanding and Sustaining a*

Biodiverse Planet, but STRI also contributes through its Paleontology program to *Unlocking the Mysteries of the Universe*, and through its Anthropology and Archeology programs to *Valuing World Cultures*. As noted in the Smithsonian's strategic vision, the importance of long-term assessment and analysis of forests and ecosystem function in a world marked by significant biodiversity loss and climate change led to the establishment of the BCI 50 hectare forest plot in 1980, a model that has now been replicated at 40 sites around the world including six in the United States providing an innovation platform for new observation technologies.

With laboratories on both coasts of Panama, STRI is the only institute in the Americas providing direct research access to both the Pacific and Atlantic oceans. The two-ocean stage provided by STRI marine facilities permits scientists and their students to move between experiments in the eastern Pacific and Caribbean in a few hours, and represents a principal component of the Smithsonian Marine Science Network extending from the Chesapeake to Florida, Belize and Panama. The recurring two-ocean theme in marine science at STRI has resulted in landmark studies of the evolution and ecology of tropical marine species and communities, as well as research funded by the National Science Foundation (NSF) and the National Institutes of Health (NIH) for ecologically guided discovery of novel pharmaceutical compounds, and research funded by the U.S. Department of Agriculture (USDA) for discovery of novel agrochemicals from nature. Marine facilities with easy access to two oceans take on increased importance as an experimental platform for studying the impact of climate change and ocean acidification on near shore coral reefs, sea grasses, and mangroves.

In addition, BCI and STRI represent important facility resources for other federal agencies, and serve as the base for tsunami monitoring equipment installed by the U.S. Geological Survey; and as sites to monitor mosquitoes and their role as disease vectors by the Environmental Protection Agency, or survey wildlife that could be carriers of avian influenza and other animal-borne diseases in projects funded by NIH.

Thus extraordinary science facilities, the unique geography of Panama and the country's long-term and strongly positive association with the United States, and a world-class group of 40 resident scientists has led STRI to play a key role in the education of tropical biologists. It is fair to say that nearly all tropical biologists pass through STRI at some point in their careers—many in the formative stages of their development.

Science/Technology/Engineering/Math Education at STRI—General:

STRI's research excellence is a function of our ability to attract and nurture the best and brightest young researchers. Indeed, supporting and training promising young scholars is a cornerstone of STRI science and builds our capacity to understand a biologically diverse planet and solve Earth's most challenging environmental problems. STRI actively participates in science, technology, engineering and math (STEM) training: directly by supporting interns, Ph.D. students and postdoctoral scholars, and indirectly by partnering with universities concerned with tropical research and education. Both education avenues foster transformational science by connecting researchers and students with diverse backgrounds, experiences and skills. STRI also partners with institutions in Panama to develop STEM training for Panamanian students at our facilities.

Education at STRI is strongly assisted by mentors of exceptional ability. The relevance, quality, and performance of STRI scientists as mentors of the next generation of tropical biologists is top tier, as evaluated by a Visiting Committee of outside experts. In a recent review, the Visiting Committee used National Research Council criteria to measure the productivity and impact of STRI science compared to 142 of the best university research departments in the United States; STRI scientists ranked first in all measures of scientific relevance (e.g., publication citations), quality (e.g., scientific honors), and productivity (e.g., publication numbers). Furthermore, the number of young scientists who choose STRI as the base for their graduate and postgraduate research training provides an annual measure of the relevance and quality of STRI science to the future of tropical biology and policy. 2009 marked the fifth year in a row that the number of visiting scientists and students choosing to base their research at STRI has increased, from the previous year, to the point that STRI now participates in the training of more than 1000 scientists annually.

The extraordinary hallmark of STEM education at STRI is the mentor-directed research training provided at the undergraduate level to research interns, and at the graduate level to Master's and Ph.D. candidates, and to postdoctoral researchers carrying out independent or collaborative research. Over the past five years NSF grants have directly supported 81 undergraduate students, 97 graduate students

and a remarkable 71 postdoctoral scholars at STRI facilities. For the same period 57 university faculty spent time at STRI on NSF-supported research.

The numbers that I have provided for NSF-associated scholars are exceeded by the numbers in each category of young investigators supported by Smithsonian funds, non-NSF grants and contracts and donations. For example, we received a $1.5 million dollar donation from a private citizen to fund three five-year postdoctoral positions in tropical neurobiology. The idea behind the donation is to use the remarkable biological diversity found in the tropics to inform new approaches to nanotechnology by understanding how insects carry out complex behaviors as brains decrease over evolutionary time to very small sizes. In 2007, we received an $8 million dollar grant from the Hong Kong Shanghai Bank (HSBC) to establish a regional training center at SERC in Maryland in collaboration with the environmental organization Earthwatch Institute in order to promote science education and citizen involvement in climate change science. The HSBC grant funds citizen scientists, undergraduate research interns, graduate students and postdoctoral researchers to study how climate change impacts carbon fluxes across SIGEO forest dynamic sites in Maryland and Virginia as well as across companion training centers located in Brazil, United Kingdom, China and India.

To provide a sense of the resonance associated with the educating of scientists at STRI, it is useful to highlight the experience of Dr. Phyllis Coley, a Ph.D. student at STRI in the 1980s. Dr. Coley went on to a career as professor of biology at the University of Utah, and then supported by NSF continued her groundbreaking studies of herbivory and plant defenses in the field in Panama. In the late 1990s Dr. Coley's insights into chemically mediated plant defenses led her to develop a Panama International Cooperative Biodiversity Group (ICBG) grant. The ICBG program is a unique effort that addresses the interdependent issues of biological exploration and discovery, socioeconomic benefits, and biodiversity conservation. Dr. Coley was successful with her application and the Panama ICBG is now in its third round of funding by NIH, NSF, and now includes funding from USDA as well. Twelve years later the program has trained 21 students—including 10 Ph.D.s and 2 MD's—representing 19 U.S. universities. The program has also educated 135 Panamanian students and 15 young investigators from other nations in the study of ecology and natural products chemistry. But the true resonance comes from the fact that four recent Panama ICBG Ph.D.s and postdoctoral researchers are continuing with their Panama-based research as beginning faculty in departments of Chemistry or Pharmaceutical Sciences at the University of California, Santa Cruz, University of Connecticut, York College of Pennsylvania and Oregon State University.

STRI also maintains robust partnerships with a number of universities that offer degree-granting, semester-abroad, capstone or collaborative research programs. These partnerships provide students, teachers, and policy makers with an up-close and personal experience with biological diversity at our field stations across Panama, and an increased understanding of global threats to tropical ecosystems. To provide some numbers, in the past five years alone STRI has hosted 43 U.S. universities offering 65 different courses in tropical biology and anthropology. These courses have utilized STRI facilities, STRI staff scientists and the knowledge of the tropics gleaned across a century of study to educate 825 undergraduate students. Princeton University has run a semester abroad at STRI every year since 1998. Courses range from forest ecology, marine ecology, tropical evolution, tropical conservation, tropical landscape ecology, tropical paleontology, Mesoamerica anthropology and archeology, conservation genetics and tropical environmental policy. Courses are typically run from STRI facilities at our Gamboa campus and BCI in the midst of tropical lowland forest, and our Bocas del Toro marine laboratory adjacent to mangrove, sea grass and coral reef ecosystems, in addition to a tropical cloud forest field site at La Fortuna and archeological excavations at Cerro Juan Diaz and El Caño.

STEM Education at STRI—The SIGEO model:

A major goal of the 2010–2015 strategic plan for the Smithsonian is headlined "Crossing Boundaries," which refers to the implementation of interdisciplinary consortia aimed at sparking innovative research and education programs, and brokering partnerships. These consortia are being established in recognition of the fact that solving the grand challenge of *Understanding and Sustaining a Biodiverse Planet* requires integrating information across different biological scales (i.e. from cells to individuals to ecosystems) and different fields of scientific inquiry. Key to these challenges is training scientists to: 1) work comfortably across research disciplines and biological scales, 2) interact synergistically, 3) incorporate new and innovative technologies, and 4) participate in larger national and international collaborations.

Presently, SIGEO is the best example of an interdisciplinary center and boundary-crossing training opportunities at SI. Global climate systems and life on the planet are in flux. Policy-makers and scientists need long-term data on the fluctuations in primary productivity of forests around the globe, as well as changes in the abundance and distribution of biological diversity, to distinguish the components of global change that can be ascribed to planetary processes from those that may be caused by human activity. The Smithsonian Institution is building on its unique research and science education infrastructure to provide the required data by expanding its global network of long-term tropical forest dynamic plots into the temperate zone and by collecting additional data on vertebrates, insects and soil microorganisms, in addition to the trees that we have monitored for three decades. It is the students being educated by the Smithsonian that will answer the following questions: Does climate change significantly alter forest biomass, and does the rate of carbon sequestration by forests vary with latitude, hydrological condition and soil fertility? How are the diversity and the relative abundance of forest organisms changing over time and space? What components of observed changes are due to human activities? How can we modify our behavior and economies?

SIGEO promotes large-scale environmental monitoring and maintains enormous banks of data and metadata, which help galvanize advanced data networks and sophisticated analyses, extending from single forest plots to the remote sensing of forests at landscape scales monitored from space-based observatories. The result—big data sets, global comparisons and research and policy opportunities to investigate the impact of climate change on forest function—attract top-caliber students and provide extraordinary opportunities in science education. Thus it is little wonder that students attracted to the long-term data of SIGEO go on to big things. Dr. Helene Muller-Landau, for example, went on from her Princeton University Ph.D. dissertation research on seed dispersal and community dynamics of the BCI SIGEO forest plot to a position as an Assistant Professor at the University of Minnesota. In quick turn, Dr. Muller-Landau was honored with an $875K Packard Fellowship for Science and Engineering—one of 16 new faculty members selected out of 100 national nominees by university presidents across the U.S. Dr. Muller-Landau is now the lead scientist for the SIGEO Global Forest Carbon Research Initiative.

The Global Forest Carbon Initiative provides *in situ* measures of above- and below-ground carbon and its change over time in response to rising levels of carbon dioxide. Two recent and high profile publications by young scholars associated with the SIGEO network provide direct evidence of the quality of science education based from the network. In the first study a Ph.D. student using 25 years worth of data from two forest plots (BCI, Panama and Pasoh, Malaysia) has shown that, despite increased atmospheric carbon fertilization, the growth rates of trees have decreased in at least some tropical forests, perhaps in response to global warming. On the other hand, research led by a SIGEO postdoctoral investigator using 30 years of data on long-term changes in species survival and growth in mapped plots of tens of thousands of trees at SERC on the Rhode River in Maryland, has demonstrated that that the rate of carbon sequestration is increasing in the Maryland sample of temperate forests. These two studies demonstrate the need for objective long-term data, and the utility of the global network of forest plots to provide opportunities for educating scientists and for the critical empirical data needed for modeling carbon dynamics and directly measuring the response of global forests to environmental change. Young scholars play a direct role in the network's overall aim to forecast the consequences of global climate change on forest function and biodiversity in tropical and temperate forests, and to provide objective and rigorous scientific data quickly via the World Wide Web to scientists, policy makers, and people around the world.

It is worth emphasizing that students and scientists like Dr. Mueller-Landau play a major role for STRI and SIGEO in directly supporting U.S. government goals in the environmental sciences. Such activities send an international message regarding the U.S. commitment to the provision of objective, long-term data needed for understanding the consequences of climate change. As one of the premier U.S.-led international partnerships, SIGEO integrates the SI network of forest dynamics plots with the U.S. Group on Earth Observations (USGEO), and promotes an international Global Earth Observation System of Systems (GEOSS) to further advance the progress of science and science education across borders. In the context of Global Earth Observatories, the Smithsonian collaborates with the Environmental Protection Agency (EPA), United States Geological Survey (USGS), U.S. Department of Agriculture (USDA) Forest Service, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and NSF's National Ecological Observation Network (NEON). NEON and SIGEO sites are co-located in Virginia/Maryland (Smithsonian Conservation Biology Institute/

SERC), the Harvard Forest, MA, and the Wind River Experimental Forest, WA, providing a tremendous opportunity for cross-fertilization and synergy between the two earth observation networks.

Moreover, SIGEO extends globally beyond the Smithsonian and direct partners. As an educational resource, the SIGEO network leverages huge intellectual horsepower, much of that from Ph.D. students and postdoctoral fellows. The network is extremely well used by independent, university-associated faculty, students and network partners. More than 200 scientists have published research from the SIGEO data sets, many of them students, attesting to the broad usability and science education benefits of the network. One measure of this effective leveraging is the large number of NSF-funded research projects based within the network. As one example, Dr. Stephen Hubbell, currently a UCLA professor of biology and originator of the first 50 hectare forest plot on BCI 30 years ago, has directed approximately $7 million dollars in NSF support to his studies of forest dynamics. In the process Dr. Hubbell has chaired the Ph.D. committees of 19 students currently found on the faculties of Stanford University, University of Minnesota, Ohio State University, Louisiana State University, Taiwan University and others, and as science leaders on the staff of SAS Institute, Wisconsin Department of Natural Resources, National Park Service of Portugal and The Nature Conservancy. Dr. Hubbell has also trained 9 postdoctoral researchers on the faculties of the University of Illinois, University of Pittsburgh, STRI and others, who carry on the tradition of STRI-based science education. The tradition of science education is so profound across the SIGEO network, that Harvard and Yale universities have provided $9 million over five years to support the network and its science education and policy initiatives.

STEM education at STRI—looking forward:

The long-term, cross-disciplinary, multicultural and collaborative nature of STRI science provides unique STEM training opportunities for the leaders of tomorrow. As we look to the future, landscape transformation and remediation in the developing world will take on increasing prominence as we consider food and water security and human migration associated with sea level rise and desertification. Science education in this light is critical, a need that the Smithsonian is addressing with the Panama Canal Watershed Experiment, a collaboration between the Panama Canal Authority, Panama National Environmental Authority, the HSBC Climate Partnership and universities around the world. The experiment is large-scale and aims to quantify the diverse set of ecological, social, and economic services provided by tropical forests and alternative land use in the Panama Canal Watershed. The project is a remarkable science education tool that takes advantage of the Panama Canal's central role in world commerce to focus global attention on ecosystem services provided by tropical forests.

The Panama Canal Watershed Experiment is also an extraordinary research and education opportunity. The experiment provides scaling opportunities across the 300,000-hectare Panama Canal watershed using remote sensing technologies. These studies are carried out in conjunction with students and postdoctoral researchers at the Carnegie Global Ecology Institute at Stanford University. It is also important to note that climate variation in the Panama Canal Watershed, particularly El Niño and La Nina events, provide experimental results that can be used to build models permitting the forecasting of ecosystem services under different climate change scenarios. In addition to studying services delivered locally, the experiment takes specific aim on ecosystem services that affect people at some distance. For example, the Panama Canal shortens shipping routes and reduces carbon emissions associated with transportation, thus extending the benefits of water management in the Panama Canal watershed from local to global.

The list of ecosystem services that the Panama Canal watershed provides and different opportunities for science and engineering education is impressive: 1) regulation of water supply to the canal—ensuring sufficient water to run the locks and reduction of the risk of floods; 2) regulation of drinking water quality for more that 50% of the population of Panama; 3) hydropower; 4) regulation of soil erosion and siltation in the Panama Canal; 5) avoided deforestation, reforestation and carbon sequestration, which couple to represent a low-risk opportunity for the United Nations Framework Convention on Climate Change Reduced Emissions from Deforestation and Degradation approaches; 6) timber and food production; 7) provision of ecosystem processes and habitat for endangered species; 8) regulation of disease vectors; and 9) ecotourism.

We also continue to build on our record of research and training excellence through increased partnerships with U.S. universities. Recently, the Smithsonian has established research and training partnerships with the University of Maryland, George Mason University and Arizona State University (ASU). The ASU part-

nership, in particular, seeks to connect undergraduate and graduate students interested in global environmental change to the tropical ecosystems where environmental transformation is the most pronounced. Student researchers are also using information about past tropical environments to inform our interpretation of earth's response to climate change. The University of Florida and STRI, led by paleontologist Carlos Jaramillo, have recently been awarded $3.8 million dollar NSF International Partnership in Research and Education (PIRE) grant to study new fossils and geology exposed by the excavations of the multi-billion dollar expansion of the Panama Canal. This massive excavation provides PIRE undergraduate and graduate students with an unparalleled opportunity to strengthen our understanding of the role the Isthmus of Panama has played with regard to climate and biodiversity change through time, and a unique perspective on how increasing CO_2 levels may shape the forests of the future.

Lastly, STRI is in the process of developing new relationships aimed at utilizing STRI's scientific legacy and position in the tropics to increase STEM education for an increasingly diverse student community. As a concrete step in this direction, STRI established the new position of Academic Dean in late 2009—a first for the Institution. The role of the Dean is to further align STRI science with education and training opportunities, and immediate results are new relationships with: 1) NSF Tree of Life, Encyclopedia of Life and taxonomy workshops focused on the marine biology of Bocas del Toro; 2) Louisiana State University to create a NSF/Louis Stokes Alliance for Minority Participation Center for International Research (funding pending); 3) University of Texas at Austin to establish a NSF Research Experiences for Undergraduates collaboration (application in development); and 4) University of Illinois Urbana-Champaign to develop a NSF Integrative Graduate Education and Research Traineeship (IGERT) program (application for full proposal to NSF approved June 2010). Reviewers of the IGERT pre-proposal favorably recognized the strengths that STRI brings to the collaboration, and to a science education model that aligns emerging genomic technologies with intimate knowledge of the organisms themselves.

Conclusions:

(1) The unique combination of top-notch resident research scientists, excellent laboratories and field stations, and geographical position adjacent to tropical lowland rainforests and coral reefs has led to an extraordinary long-term knowledge base at the Smithsonian Tropical Research Institute, and has established an exceptional resource for 21st century innovation and education.

(2) The STRI knowledge base and resident scientific staff has served as a magnet for educating scientists at the undergraduate, graduate and postdoctoral levels, financed in order of amount by U.S. federal funds awarded through Smithsonian fellowships and grants, NSF PI-led grants, NIH–NSF ICBG grants, NSF PIRE grant, NSF predoctoral fellowships, NSF Dissertation Improvement grants, NSF International Fellowships, NSF workshop grants, and NSF Research Experiences for Undergraduates grants. The U.S. federal investment in science education at STRI is nearly matched by non-government grants and contracts, EU fellowships and private fellowship donations.

(3) STRI serves as one example of post-secondary STEM education at the Smithsonian, but the Smithsonian formula of long-term investment in top-flight resident scientists and science facilities has led to similar excellence and educational success at all the science units at the Smithsonian.

I cannot emphasize enough the importance of the Smithsonian's commitment to long-term research and education. With our research perspective, sustained effort and long-term data sets, we are uniquely positioned to assess, identify, understand and predict environmental threats to biodiversity and incorporate rigorous science into resource management and stewardship decisions. We will continue to work with academic institutions, government agencies, and the public to educate and cultivate the science leaders of tomorrow.

Thank you for the opportunity to testify today and I look forward to answering any questions you may have.

BIOGRAPHY FOR ELDREDGE BERMINGHAM

Eldredge Bermingham is the director of the Smithsonian Tropical Research Institute a unit of the Smithsonian Institution headquartered in Panama City, Panama, since September 2008. He joined the institute's scientific staff in 1989 and has served as director since 2007.

As STRI's director, Bermingham oversees one of the world's premier biological research institutes, dedicated to increasing the understanding of the past, present and future of tropical biodiversity and its relevance to human welfare. STRI promotes research conducted primarily in tropical forest and coral reef ecosystems. STRI scientists discover new species, test scientific explanations for ecological adaptation and evolutionary innovation, develop methods to restore degraded ecosystems, promote the conservation of tropical ecosystems, and train the next generation of tropical scientists. One of STRI's programs, the Smithsonian Institution Global Earth Observatories [SIGEO], which evolved from STRI's Center for Tropical Forest Science, encompasses 40 forest plots in 20 countries around the globe, and represents the best observational platform in the world for evaluating the impact of global change, including climate, on the ecosystem function of forests. Bermingham has been a strong proponent of cross-unit and intergovernmental collaborations at the Smithsonian, encouraging the development of projects through the Smithsonian Marine Science Network, the Smithsonian Barcode of Life Initiative, and the Smithsonian Global Earth Observatories.

Bermingham's laboratory has advanced knowledge of range expansion of organisms across the land bridge formed as the Isthmus of Panama rose to connect North and South America 3 million years ago, and has informed understanding of contemporary biological invasions. His analyses of bird populations on the islands of the Lesser Antilles contribute to the understanding of extinction, and his studies of marine organisms separated by the Isthmus of Panama has refined understanding of molecular clocks and their use in the study of evolution.

Bermingham has published over 140 peer-reviewed articles; edited the book *Tropical Rainforests: Past, Present and Future* published by the University of Chicago Press in 2005; has sponsored more than 20 postdoctoral students; advised over 30 predoctoral students, and served on the committee of 17 of the latter. Bermingham earned a bachelor's degree in biology from Cornell University in 1977 and a doctorate degree in genetics from the University of Georgia in 1986.

Chairman LIPINSKI. Thank you, Dr. Bermingham.

I now recognize Ms. Werb.

STATEMENT OF SHARI WERB, ASSISTANT DIRECTOR OF EDUCATION, NATIONAL MUSEUM OF NATURAL HISTORY, SMITHSONIAN INSTITUTION

Ms. WERB. Chairman Lipinski and other distinguished Members of the Subcommittee, thank you for the opportunity to testify before you on the science education activities of the Smithsonian. I have been the Director of Education and Outreach at the National Museum of Natural History for about two years. Before I arrived, my knowledge and experience of the museum was that of a DC resident, a mother of two boys, and 18 years as a museum professional. I now fully appreciate that the scientific resources at the museum are an incredible treasure trove.

The museum has more than 200 active scientists and hundreds of experts, including conservators, collection specialists, and educators, who bring to their work research, deep knowledge, passion, and great stories. There are more than 126 million objects that represent a unique collection of evidence about the universe, the Earth, life on this planet, and human culture. With more than seven million visitors on-site and tens of millions more online, and as a national science museum, we have both a unique responsibility and an opportunity to further science, literacy, and public engagement around science.

This especially resonated when President Obama launched the "Educate to Innovate" campaign for excellence in STEM education, challenging the Nation to strengthen America's role as the world's engine of scientific discovery in the 21st century.

The National Museum of Natural History is itself an engine of scientific discovery. Its mission is to inspire curiosity, discovery, and learning about nature and culture through research, collections, exhibitions, and education. The museum plays an important role in the Smithsonian Institution's new strategic plan, helping to meet the plan's "Grand Challenges" as referenced in the Secretary's testimony.

Visitors to the Museum, both on-site and online, are exposed to ongoing research which enhances their critical thinking skills. Students of all ages are being invited to actively participate in science. For example, a family may visit the Sant Ocean Hall with an invertebrate zoologist examining a newly-identified jellyfish species at the "Scientist Is In" station.

I have included more detailed examples of these programs in my submitted testimony, but will focus my remarks on one creative program that illustrates how the museum is bringing science to students. This program is the Youth Engagement through Science, or Y.E.S.! program, which provides access to educational and career development opportunities in science to minority youth in the Washington, DC region. This summer we have 15 rising tenth and eleventh grade students. During this six-month program students explore natural history and pursue meaningful research projects with the museum's best scientists in the biological, geological, and anthropological disciplines.

Y.E.S.! provides a curriculum to enhance the students' communications skills and support their college preparation activities. This component is crucial, because tenth grade is the year when students need to prepare for college. Y.E.S.! ensures that as students experience scientific careers as viable, they are also engaged in college preparation. That planning includes improving critical reading, writing, and mathematical skills, as well as understanding the college entrance process. By the end of their Y.E.S.! experience the participants will have been engaged in important research with world-class scientists, started planning for college, and produced a project based on what they have learned.

Here is an excerpt from a letter one of our participants wrote to her grandparents. "I started my internship at the Museum of Natural History, and I absolutely love it. My assigned project is fossilized charcoal where I am going to work with 73-million-year-old objects. The Museum is not only a tourist attraction. It is actually a major research facility and education center. We are not only learning the facts of the Museum, but we are going to be doing research alongside scientists. These first days have been fun, and I am excited to work with them for the next six months. I definitely want to study science. I can't wait to see what we will be doing tomorrow. Camille."

The museum is having a major impact in minority communities by using our tremendous science resources to train students in research at the undergraduate and high school level, providing valuable experiences that will prepare them to compete for positions.

In addition to the 400 interns and fellows that the museum hosts each year, we have also launched the Natural History Research Experiences program. These summer internships pair undergraduates with mentors on the Museum's research and collection staff, pro-

viding a hands-on introduction to research. The program provides participants with a stipend, travel allotment, housing and funds for a research proposal. This summer we are hosting 18 students, 40 percent of whom are from under-represented groups.

These are just a few examples of how the Museum is providing access to its scientific assets to engage and educate the public.

Again, thank you for giving me the opportunity to testify. I am happy to answer any questions you may have.

[The prepared statement of Ms. Werb follows:]

PREPARED STATEMENT OF SHARI WERB

Chairman Lipinski and other distinguished Members of the Subcommittee, thank you for giving me the opportunity to testify before you today on some of the science education activities of the Smithsonian. I have been the Director of Education and Outreach at the National Museum of Natural History for a little more than two years. Before I arrived, my knowledge and experience of the Museum was that of a District of Columbia resident, a mother of two boys, and a Museum professional (I had been working at the Holocaust Museum for 18 years prior to coming). However, I had no idea of the incredible treasure trove of scientific resources hidden behind the scenes at the Museum. Out of reach of most visitors are more than 200 active scientists, hundreds of other experts including conservators, preparators, collections specialists and educators, and their research, their deep knowledge, their passion and their great stories. Behind the scenes and out of reach of most visitors are the more than 126 million objects and specimens that represent a unique collection of evidence about the universe, the Earth, life on this planet and human culture. With these assets, with more than 7 million visitors onsite and tens of millions more to its website, and as a National science museum the Natural History Museum has both a unique responsibility and an opportunity to further scientific literacy and public engagement and dialogue around science. This especially resonated when President Obama launched the Educate to Innovate Campaign for Excellence in Science, Technology, Engineering and Math (STEM) Education, challenging the Nation to strengthen America's role as the world's engine of scientific discovery in the 21st Century.

The National Museum of Natural History is itself an engine of scientific discovery. Its mission is to inspire curiosity, discovery and learning about nature and culture through outstanding research, collections, exhibitions and education. The Museum plays an important role in the Smithsonian Institution's new Strategic Plan, helping to meet the Plan's Grand Challenges of Understanding and Sustaining a Biodiverse Planet, Valuing World Cultures and Unlocking the Mysteries of the Universe. Specifically, our education programs are designed to further the Plan's priorities of Broadening Access and Revitalizing Education, with exciting offerings for learners of all ages everywhere.

Through education and outreach programs, visitors to the Museum (both onsite and online) are becoming exposed to ongoing research and discovery and are enhancing their critical thinking skills. Regardless of how much time they have, students of all ages are being invited to actively participate in authentic science. For example, a family on a short visit may spend time in the Sant Ocean Hall with an invertebrate zoologist closely examining a newly identified jellyfish species at the "Scientist Is In" station. Teenagers doing an assignment on human evolution may spend hours on the new Human Origins website manipulating and comparing 3-dimensional early human skulls—one of our new collections- and evidence-based websites for the public. Latino and other minority students may spend six months with Youth Engagement through Science (Y.E.S.!), an in-depth program at the Museum that provides access and opportunities for underrepresented minorities.

The following are three examples of education and outreach programs that have connected the public with the Museum's authentic science and collections. Eighteen months ago, in partnership with the Museum's forensic anthropologists, the Education and Outreach Office opened its very popular Forensic Anthropology Lab, an experimental hands-on, interactive, educational space embedded in the Museum's exhibition *Written in Bone: Forensic Files of the 17th Century*. The Lab provides students and the public with a unique opportunity to explore the past first-hand by examining bones and artifacts "found" at realistic research sites based on actual Smithsonian Forensic Anthropology cases. Through these activities, students learn to use the tools, technology, techniques and problem solving skills of forensic anthropologists. During the investigation, students collect evidence at six stations, exam-

ining real human bones and artifacts as well as reference materials, such as charts, graphs and databases. When the students finish collecting data, they analyze and synthesize it to form a conclusion about the person whose bones are part of the case. There are also other activities at which visitors can learn about anatomy, for example by using x-rays to examine bones and teeth. Already approximately 125,000 people have participated in these authentic science programs.

While the Forensic Anthropology lab is a temporary educational space connected with a temporary exhibition, the Museum is planning to open a much larger permanent laboratory experience in late 2012. The Museum's vast scientific assets and its educational resources will be brought out from behind closed doors so that hundreds of visitors each day will be able to engage actively and enter into dialogue with the Museum's world-class team of scientists and experts and the largest natural history collection in the Western Hemisphere. It will function as a physical learning center at NMNH, as a virtual learning space on the Museum's website, and as an open collaborative laboratory for the study and investigation of learning natural history science.

With the Museum's Sant Ocean Hall welcoming more than 5 million visitors each year and with the assets of the Smithsonian's active and extensive marine science research and collections program, the Museum fulfilled its commitment to Ocean Education by recently launching the Smithsonian Ocean Portal (*www.ocean.si.edu*) designed to inspire awareness, understanding and stewardship of the world's ocean through exploration of the Smithsonian's collections, science and variety of online ocean adventures, educational quests and teacher lesson plans. This project was led by the Natural History Museum in collaboration with other Smithsonian units as well as with more than 20 organizations including the National Oceanic and Atmospheric Administration (NOAA), Encyclopedia of Life (EOL), National Geographic, and the Ocean Conservancy. The Ocean Portal is already providing access to the Museum's collections that serve as a record of life in the Gulf of Mexico before the recent Gulf of Mexico oil spill. In the "For Educators" section of the Ocean Portal, there are a number of lesson plans to support teachers' efforts to communicate the impact of the spill on the ocean.

The Museum's commitment to bringing its scientific assets to students is being realized through the new Youth Engagement through Science (Y.E.S!) program. This program provides access to educational and career development opportunities in science to Latino and other minority youth in the Washington DC. region with the first year generously funded by the Smithsonian Latino Center and the Marpat Foundation. This summer from approximately 50 applications, we have selected 15 rising 10th and 11th grade students who have already had one year of science instruction laying the foundation for their research activities in Y.E.S!

During this six-month program students will explore natural history science and pursue meaningful authentic research projects with the Museum's best research scientists in the biological, geological and anthropological disciplines. It will also provide a curriculum to enhance the students' communication skills and support their college preparation activities through a partnership with the Center for Minority Achievement in Science and Technology (CMAST). This component is crucial because 10th grade is the year during which students begin to prepare in earnest for postsecondary education (e.g. PSATs, college visits). Y.E.S! will ensure that as students experience scientific careers as viable options for their future, they are also preparing for that future through college preparation planning. That planning will include improving critical reading, writing and mathematical skills, as well as understanding the college entrance process. By the end of their Y.E.S.! experience the youth involved in the program will have participated in important research with world-class scientists; started planning for college; and produced a project based on what they have learned. Students will share these projects, and NMNH will promote what the students have accomplished.

The Museum can have a great impact in Latino and other minority communities by using its tremendous science resources to train students in scientific research activities, at both the undergraduate and high school level, providing valuable experiences that will prepare these students to compete for positions outside the Smithsonian.

In closing, let me briefly mention one more program at the Museum that illustrates our strong commitment to training the next generation of scientists at the undergraduate level. In addition to the 400 interns and fellows that the Museum hosts each year, this year we have launched the Natural History Research Experiences (NHRE) program. NHRE summer internships pair undergraduates with members of the Museum research and collections staff, providing a hands-on introduction to scientific research and a scientific mentor from one of the Museum's research departments. NHRE provides successful candidates with a stipend, travel allotment,

housing and funds for a research proposal. Students are being provided with behind-the-scenes events and tours of the Museum and all research departments. This summer we are hosting 18 students, and 40% of them are from under-represented groups. We are currently in discussions with the National Science Foundation to jointly host this effort in the future.

These are just a few examples of how the Museum is providing access to its scientific assets to engage and educate the public in furtherance of the Smithsonian's Strategic Plan, develop programs to train the next generation of scientists, and answer President Obama's call to action to join with him in a national campaign to engage young people in the STEM fields.

Again, thank you for giving me the opportunity to testify. I am happy to answer any questions you might have.

BIOGRAPHY FOR SHARI WERB

Shari Rosenstein Werb joined the Smithsonian's National Museum of Natural History in April 2008 as the Assistant Director for Education and Outreach. During her tenure she has brought the Museum's rich "behind-the-scenes" resources to the fore by encouraging the personal involvement of scientists and increasing the presence of scientific research in all educational offerings (programs and websites). She has also fostered innovation and leadership in programs, technology and social media; expanded and professionalized the Museum's volunteer corps; and elevated the role of research and reflective practice in all education and outreach projects. Under Ms Werb's leadership, the Education and Outreach Staff have won several awards for original web projects and have been awarded grants for innovative programs. In January 2010, Ms Werb was selected to participate in the Federal Executive Institute's month long Leadership for a Democratic Society program.

Prior to her current position, Ms Werb worked for 18 years at the United States Holocaust Memorial Museum. She held a number of different positions there including Director of Institutional Outreach, where she developed strategic partnerships to engage new audiences and produced programs that helped inspire the public to make connections between the Holocaust and today's world. She also served as Director of Educational and Public Programs and proudly identifies as one of the Museum's founding staff members. She co-authored a chapter, "Transforming Practice: Disability Perspectives and the Museum," published in *Re-Presenting Disability: Activism and Agency in the Museum* in 2010, and also contributed the chapter "Using Art to Teach about the Holocaust," to the publication *Teaching and Studying the Holocaust*. Ms Werb participated in an International Partnerships among Museums (IPAM) exchange program in Croatia in 2005, assisting in the development of a new education center on the grounds of Jasenovac, a former concentration camp site. She has also served as an educational advisor to several museums.

Shari Werb has a Masters of Science degree focusing on Leadership in Museum Education from Bank Street College of Education and a Bachelor of Arts in Anthropology and Art History from Boston University. She is married and is the mother of two boys ages 14 and 9. She is an enthusiastic kayaker and loves to travel.

Mr. BAIRD. [Presiding] I thank the witnesses. Our Chairman will return shortly. I will recognize myself for five minutes, and then we will proceed to Dr. Ehlers. With the last name of Baird it was mandatory that I attend the hearing on the Smithsonian, but it is also a delight.

A couple of issues I hope you will just expand on a little bit. First of all, I was thrilled to see the opening of the oceans exhibit. Many of us on this committee have worked very hard to raise awareness, and it is a spectacular exhibit. It really does a good job.

I am also very interested in the issue of science diplomacy, and the international presence of the Smithsonian elsewhere I think speaks well to that, but I wonder if you could talk about how the Smithsonian fits into international efforts to educate the public about science and to fit into our mission, or opportunity, rather, to build relationships. I have been to the Library of Alexandria, for example, and I understand the origin of the meaning of the word 'museum' actually traces back to that.

So, anyway, talk to us a little bit about what the Smithsonian is doing internationally that can help build relationships internationally.

Dr. Clough.

Dr. CLOUGH. I will go first and then maybe others want to comment. We are in about 90 different countries in terms of the things and activities that we do. I mentioned some of the countries that I have visited. I haven't been to 90 countries, but it is fascinating to be there, and I think science is really a language that is a global language and helps people understand. The problem of the environment is something that affects every nation, not just one nation.

So I think that our science work is global to begin with. Our scientists are very much known globally. I think the Smithsonian is pretty unique in that activity. For example, the Smithsonian Tropical Research Institute would be open to scientists from other countries coming to work there and learn from us. They certainly can visit us, and many do visit the Natural History Museum to use the collections that are quite unique. And we do see technology as a way of improving that, because rather than coming over at a particular time to see a particular object, they might be able to see—if it is digitized, they can see it digitally. They can do their work at home and then spend much more effective time when they come see us.

We are visited continuously by people who want help from us, and we do the best job we can. We have just created a program called an International Museum Studies program to help countries in other places, and we had a visitor from Egypt not long ago because they want to build a new science museum, and they would love to get advice from us in terms of those kinds of activities. So I think we generously give advice, we offer access to our collections, we invite their scholars to come here, and then through a multiple range of activities, then, we are active in that regard.

Mr. BAIRD. Anyone else wish to comment on that?

Dr. BERMINGHAM. I would be happy to say something very quickly. At STRI we host about 1,000 visiting scientists a year, of which about four out of every ten—six out of every ten are from the U.S., four out of ten are international. So we play a remarkable role in

providing science opportunity for both researchers and students from around the world.

In addition, I mentioned SIGEO, which is this global network in 21 countries, and with support from National Science Foundation and others we provide analytical workshops. And I think it is always important to remember that all of the world's great universities are in the developed world, and I think what we do is we provide up and coming young scientists in the developing or emerging economies the opportunity to learn from some of the best. So we are very proud of what we have done in that way. Phenomenal.

Mr. BAIRD. Please, Dr.

Dr. CLOUGH. To add one other different note on that, I just got back from Haiti last week, and we are working with the State Department and with the White House on helping with recovery efforts down there. Now, our efforts there are related to art and historical documents, which are today lying in the ruins of their museums and their great buildings and their universities. And so we have a team down there who are working with the Haitians to help train them on how you recover this art and save these precious documents before they get lost.

The reason it comes back to science is a lot of it has to do with materials science. We are working on saving murals. You've got to have the materials scientists there who understand how these things adhere to the surface. If you are going to maintain the integrity of some of the frames and some of the documents, again, it is a scientific matter. And so the Smithsonian brings that to the table. So that is another example of cultural diplomacy through science.

Mr. BAIRD. Those are all great examples.

Very last, and briefly, talk to us very briefly about the funding for the research aspect of Smithsonian and then briefly if you care to allude to it, Dr., the—my understanding—Smithsonian had a fairly significant infrastructure backlog. I don't know if that—the status of that. Maybe briefly address both of those.

Dr. CLOUGH. Sure. Well, the Smithsonian is a trust, as was alluded to I think earlier, and about 65 percent of our funding comes from federal appropriations. The rest of it we "earn" ourselves, some of which we actually compete for, grants from federal agencies, where that is allowed. We do a lot of work with NASA. We operate the Chandra X-ray satellite telescope, and so we are reimbursed from NASA for that service. We also build telescopes for NASA and others, and so we are in that business as well.

So there are the competitive grants. Then we also compete on—we get philanthropic grants for a lot of the science that we do. Dr. Bermingham just came back from England, where the HSBC, the banking corporation, has provided almost $10 million to do documentation with the SIGEO effort.

So we try to be on top and get the funding where it makes sense to get the funding to do the work that we do, and so you will find that to be—but there is always a challenge. As Congressman Ehlers alluded, there is really not enough money to do the work we need to do, given the opportunities that we have. And so there is a constant struggle.

In addition, it is very important, and I think Congress has been—particularly lately—more aware of the importance of maintaining collections. That is not—if you want to use the word, 'sexy' research, but it is very necessary and very important, and so that is the sustaining kind of support we need to get from Congress. We really can't get a donor to support those kinds of activities.

Now, you mentioned the business of the infrastructure issues that we face. Like any great institution with lots of buildings—we have 770 all total around in our different operations—we do have some challenges in terms of maintenance, and I do like to make the point that the Smithsonian museums are open every day of the year but Christmas. We have upwards of 30 million people going through our buildings, so that is a tremendous load on those buildings, a tremendous wear and tear on those buildings, and that is where Congress, I think, really has to help us in that public service effort that we have.

Now, we roughly need, our calculation suggests, and you could use industrial standards and things of that sort, guidelines, about $150 million a year based on our cost of our infrastructure to revitalize the museums and then secondarily about $100 million a year to upkeep and do maintenance. So that is about 250 million a year annually. We are running probably around 180 in that total. Congress has been generous again. One hundred and eighty is not 250, and so there is always a little fall back, but we are working very hard to try to stay on top of the most critical maintenance and revitalization issues that we have, and we try to use your funds as leverage, so we work with donors in many cases to raise funds over and above what the Federal Government would give us to supplement those activities so we can make major renovation.

Mr. BAIRD. Thank you very much.

I recognize Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman, and the buzzing I assume means we have a vote coming up very soon, so I will try to be fairly brief.

The Smithsonian is an absolutely wonderful institution. There is just no question about it. Nothing like it in the world, especially given its history, its origin. Out of anger against another nation, and its success and everything it has done.

At the same time I probably worry more about the Smithsonian than I do most federal institutions because you are quite different and your funding pattern is quite different, and it seems to me that one of your big problems is, of course, fundraising. You are one of the few federal institutions that has to go out and raise a very substantial part of its budget. That is an opportunity, but it is also a burden on you, especially Dr. Clough, but also on the whole staff. They are all aware of it.

I think another problem is that you are first and foremost an education and research organization, and yet I don't believe you are treated that way very well in the budgetary process. It is, you know, you are looked at more as a museum for the public, I think, and rightfully so because you do that very well, and you have huge attendance figures. But even so, NASA has set an example, I think, for government agencies, in how to reach out to the schools. They, of course, have more money to do that than you do, but I think that

sets a good pattern that you should try to emulate if you can only extract the same amount of money from the Congress and perhaps from donors that NASA does.

So—and I am rambling here a bit, but maybe it is because I feel so strongly about the Smithsonian, and I have been involved with you not recently but prior to that to a great extent, and I really think we—it is not just your problem to solve. I think the Congress has to address this in a more direct fashion, and I would like to see you in the elementary and secondary schools as much as NASA is, but you can't possibly do it without appropriate funding.

And so there is so much to be done and so little money to do it at this point. I think there really has to be a strong awakening, perhaps even a reawakening, among both the public and the Congress about the Smithsonian, what it does, what it can do, what it could do with more money, and so forth.

I suspect you don't disagree with me on that, but I guess what I am really trying to do is lead up to the fact that I think you need a workforce of some sort, a task force to examine those issues, but there has to be something happening at the Congressional level as well and working with you, and I don't see a framework for that. That is what frustrated me with the House Administration Committee, which really had very little to do with the Smithsonian, but yet we got called in constantly to solve problems which we didn't create and which we in many cases were not suitably able to solve given the resources and the assignment we have.

So I would think it would be beneficial to try to really reexamine the role the Smithsonian plays in science in this Nation, and also in terms of education and helping all the museums across the country, many of which are also in dire fiscal straits.

So I have rambled on a bit, but I would appreciate your reaction to that.

Dr. CLOUGH. Sure, and my colleagues, again, may want to join in. I think you hit the nail right on the head, and one of the problems that I do get frustrated about is when people think of us as a museum. Now, it is lovely that we have these fabulous museums, but people don't understand what it takes to make them work, make them tick, and that they are educational institutions, they are research institutions, and they have 100 new exhibits every year. You don't do that without a tremendous amount of effort and work for—directed towards education.

To me, I think the breakthrough for us, really, is the digital revolution and the fact that we can now take collections that are largely unseen, we can take researchers who are fabulous people that, I mean, this probably represents that type of person on this panel more than anyone else, but I love to be with Terry Erwin, who knows more about beetles than anybody in the world. He is a fascinating person, and we have dozens of people who just are really remarkable scientists, and with web technology we can get these folks out, and as we get—penetrate into the schools, there will be a lot more visibility of the Smithsonian and what we actually do and what we actually stand for.

We had a conference with Secretary Duncan this morning on rural education, and our online programs that Claudine has referred to have penetrated into the rural sector. I grew up in a rural

community, and I have made sure that our educational programs get to Douglas, Georgia, whenever we do that. And the fact of the matter is, they are more—they are so profoundly meaningful there because those communities don't have the great cultural assets of the big cities, and they value what we bring to them, and right now they don't know we exist. And the more we can get out there, we can reach people where they live, work, and play, and have a more profound impact on young people, the better off we will be.

But we are working very much on this line to get Smithsonian science and education known out there by folks so they will understand us better. Clearly additional funding would be a tremendous help to us to take advantage of the opportunities we have to serve the American people in a much more profound way.

Mr. EHLERS. If I may just add one note to that, and perhaps I should have been more diligent in educating my colleagues about doing this, but we speak in schools a lot, and whenever I speak in a school, particularly elementary school, I tell the children, now, when you go home tonight, you talk to your dad and mom and tell them that you want to go to Washington, DC, and you don't just want to see flags and monuments and parades but that you want to go to the Smithsonian museums, and you tell them that they will never find a better deal for vacation because everything is free. That is a lot cheaper than Disneyland, even when you take into account the excess of lodging cost here.

But I really give them the sale pitch nice, and now, you go home and tell your parents you want to go to Washington, you know, the whole family go, you want to visit the Smithsonian, and it is not going to cost them a cent except for a place to stay, and you are willing to camp.

So at any rate, I think you really need a sales pitch like that to get more of the young people interested.

Thank you.

Chairman LIPINSKI. Thank you, Dr. Ehlers.

I just want to ask Mr. Bilbray, are you going to have questions? Okay. Let me go——

Mr. BILBRAY. Let me just make just a short statement because I am going to be coming back in touch base.

Chairman LIPINSKI. Okay, because I want to wrap this up, and there is six minutes left in the vote.

Mr. BILBRAY. Okay. Just very short.

Chairman LIPINSKI. I will recognize Mr. Bilbray.

Mr. BILBRAY. I appreciate that. I just have to say to Dr. Biff, sorry I missed you in Panama, and let me just say, Mr. Chairman, I think that, no offense to the other Members, but one of the things that—the opportunities that the Smithsonian provides is very diverse. The research facility in Panama shows you just exactly how diverse. I really would love to get Vernon and Dana Rohrabacher over to the Smithsonian in Panama because I think that is the way that research facility's working out some ideas, there is something for everybody and enough to raise everyone to be not so sure of their conclusions today.

I think that is one of the fresh things about research is that you got to be brave enough to really do proper, I mean, to be brave enough to do it right, you got to be brave enough to question as-

sumptions and be willing to chance being proven wrong, and that is one thing this town doesn't ever like to do.

So hopefully we will be able to talk about tapping into that, and Biff, just tell—I hope that I can take Mr. Herzog out and teach him surfing because he obviously does not understand inter-coastal tides appropriately yet, and a little more time in the salt water might be better than him sitting in those lakes over there. Okay?

Dr. BERMINGHAM. I would be delighted to. It will be a true honor, and I agree with what you say. I think what is really setting STRI and all the Smithsonian science apart from others right now is the long-term attitude we take and we serve as honest brokers for data. I mean, we are there to collect high-quality data over the long term and not to politicize it.

I would just like to also say that I think that in terms of funding, and we need the funding, there is no question about it, but Dr. Clough referenced the HSBC association we have, but I think what we are going to find—and I think one of the reasons that we were successful in getting additional funding from HSBC was the strong support that we get from the Federal Government, recognizing that what they give us in addition to that will be carried on because of the federal investment.

But at the same time I think you are going to find corporate America—but also beyond our borders more and more—interested in investing in the type of science that the Smithsonian does, because they recognize that to predict the future, they need that type of science.

But I am looking forward to getting you back to Panama.

Mr. BILBRAY. Well, Dr., if it is possible, before you leave I would like to be able to discuss something with you in a secure environment that is time sensitive that specifically affects your opportunities of expansion in the Panama region. So we need to talk about that whenever you get a chance. My office is on this floor. I have got to go vote, but I will be available as soon as possible if possible. Okay?

Dr. BERMINGHAM. I will be there.

Mr. BILBRAY. Okay.

Chairman LIPINSKI. Thank you, Mr. Bilbray, and the Chair recognizes himself for five minutes, although I don't think we will have five minutes.

I just wanted to echo Dr. Ehlers' comments about education and thank him for—we agree about Members going out and promoting the Smithsonian.

What I want to ask is, Dr. Clough, you were a President of a university, Georgia Tech. How does—as a former assistant professor, I wanted to ask you how do the—what is the comparison between researchers at the Smithsonian and those at a, you know, in academe? How are—how do people get their positions? How do things work differently? We have, you know, tenure in academe. So can you just give me a comparison?

Dr. CLOUGH. There are many similarities, of course, because both types of individuals love research, they are passionate about what they do. Both are interested in translating their research into education. So that is the similarity.

The differences comes back to this long-term issue. The Smithsonian tends to be in things for the long haul. Universities tend to be driven by grant cycles. They will work on a series of issues for a while while there is grant money, and if the grant money moves over here, they move over here. And so universities tend not to be as long-term focused as the Smithsonian would be.

STRI has been in the business for 100 years. We are fortunate, for example, in some of the climate change work we have done with fossils that we have done for probably 30 years, and you wouldn't see that at a university. We also do collections-based research. Universities can't afford to have collections anymore, and so the Smithsonian has this marvelous set of collections which even today are being used with new techniques of DNA studies to discover new species without leaving Washington, DC, but simply going to our collections center and finding new species by virtue of DNA research.

I think there is a strong component of service-based research at the Smithsonian When the Hudson River incident occurred and the plane went down and the remains of the birds were brought down here, we were the ones who identified what those birds were, what the sex of the birds were, and where they came from, and we were able to point out they were Canada geese, of course. They were from Canada because we knew where they had been feeding based on the analysis of the feathers and the remains. And so that gave the folks in New York a good handle on how to begin to deal with the bird issues around airports.

There is a lot of service-based focus at the Smithsonian. You don't see quite as much of that at a university. Universities, of course, teach, and therefore, they have direct impact on large numbers of students. The Smithsonian has a large number of interns, but ours are more short-term internships and connections there.

And I do think in the future we will find the Smithsonian particularly able to deliver its research to the K–12 community in a more effective way than universities can.

Chairman LIPINSKI. And what do you do in terms of fellowships?

Dr. CLOUGH. We have our own fellowship sources, so we have funding from—even though James Smithson's money is long gone, we do have an endowment of almost $1 billion, and much of that has been given, like at the universities, for specific purposes. And so, for example, recently Mr. Peter Buck, who is on the Natural History Museum Board, who is himself a physicist, gave $20 million to the Smithsonian for fellowships, and it is a wonderful gift. So it allows young people from universities and other entities go come to the Smithsonian and study with us in the sense of a graduate student, if you will, or a post-doc, here at the Smithsonian.

Now, in addition, we have another pool of funds we use for interns, and that would be for young undergraduates who come to the Smithsonian and study here. Some universities—Smith, being one, has its own endowment from an alumnus for 13 of their students to come here and spend a year at the Smithsonian each year. And so we are trying to build those relationships, we are signing MOUs [Memorandums of Understanding] with universities, we are working with universities so we have more direct connections with

them in terms of our research, and that is something I have been able to use my former experience to good effect with.

For example, with George Mason, we offer a joint degree in conservation biology, which has been—now, they will have the—they have the admissions department and all the degree granting ability, but we share responsibility for the degree. The students study at the Zoo and in Front Royal there. So we have facilities they don't have. We can use that to help educate students in a different way than they can.

Chairman LIPINSKI. I have a bill to try to increase the collaboration between museums and national labs. Is there any collaboration with the Smithsonian and national labs, if you can answer that in 30 seconds or less?

Dr. CLOUGH. Uh-huh. We do have connections with national labs, particularly, you know, with the different agencies, typically though the agencies more than the national labs. A lot of the national labs are energy related, and we don't do energy research per se. Now, we do research that informs energy through, for example, climate change. We have had discussions with Dr. Chu and with a number of the people—Biff, I know you met recently with the Department of Energy, because they are looking for ways to begin to quantify the beneficial effects of carbon sequestration. We can do that when we work with them, and we are working with the Department of Energy and with the Arizona State University because we don't have an economics department, and they do have one that focuses on that activity.

So we are looking to partner with groups where we have something in common and we can have good—we are working with Battelle on education, and I know Claudine has been talking to them as well. They are very interested in inter-city education, as we are, and so we are going to be working with Battelle on delivery, particularly in the DC school systems, I think, fairly soon about that.

I don't know if you would want to speak to that, Claudine.

Chairman LIPINSKI. I am sorry. I would love to hear about it, but unfortunately, we are out of time. There is a vote on the floor. We still have some—a good number of Members out. We will be able to make it there, but I am going to need to bring this hearing to a close.

I want to—before that, I want to thank all of our witnesses for testifying. The record is going to remain open for two weeks for additional statements from the Members and for answers to any follow-up questions the Committee may ask of the witnesses.

And, again, I want to thank the witnesses for their testimony today and their work with the Smithsonian, and with that the witnesses are excused, and the hearing is now adjourned.

[Whereupon, at 3:57 p.m., the Subcommittee was adjourned.]

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