Testimony of

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Chairman Gordon, Ranking Member Hall, and distinguished members of the Committee, my name is Ellen Futter and, as President of the American Museum of Natural History, it is an honor and a pleasure to have the opportunity to testify before you on the topic of "Reform in K–12 STEM Education."

As you are well aware, the United States has a history of unparalleled innovation in science, technology, engineering, and mathematics that we are in danger of squandering. In these remarks, I will offer a way to support schools in improving science education, and to expand their access to vital resources for doing so. Specifically, I would like to describe the unique and powerful role that so-called informal science education (ISE) institutions like the American Museum of Natural History—other natural history museums, science centers, zoos, botanical gardens, aquaria, and other science-based cultural institutions—can play and increasingly are playing in improving the teaching and learning of science and science literacy more broadly among the general public, including tomorrow's workforce. These institutions have a wealth of resources and, as a field and sector, we stand ready to bring those resources to bear on the science education crisis in new ways, joining forces with formal education institutions and other key players to reform STEM education.

The need for systemic, long-term change in K–12 education is well recognized and has been underscored by several major national commissions in the past few years, including: the National Academies' "Rising above the Gathering Storm"; the National Science Board's "A National Action Plan"; the National Governors' Association report "Innovation America"; and the Carnegie–IAS Commission on Mathematics and Science Education's "Opportunity Equation."

American Museum of Natural History

Founded in 1869 as an institution of scientific research and education, and chartered as an educational institution by the New York State Board of Regents, the American Museum of Natural History, located in New York City, is today one of the world's foremost centers of research and education in the natural sciences, the physical sciences, and anthropology. The Museum's mission is: "to discover, interpret, and disseminate—through scientific research and education—knowledge about human cultures, the natural world, and the universe." The Museum welcomes approximately four million visitors annually onsite and was voted the third most popular family destination in the nation, and the first non-commercial enterprise on the list, in the Zagat Family Travel Guide.

The Museum is home to one of the world's most important natural history collections, including traditional collections of more than 32 million specimens and artifacts and new forms of collecting such as frozen tissue and scientific data. Together they constitute an invaluable and irreplaceable record of life on Earth. The Museum has a scientific staff of more than 200, led by over 40 curators (tenure or tenure-track positions). In 2006, the Museum was authorized by the New York State Department of Education as the first American museum authorized to grant the Ph.D. degree. With this, the Museum launched the Richard Gilder Graduate School, which embraces both a new doctoral program in comparative biology and maintains the Museum's longstanding graduate training partnerships with such universities as Columbia, Cornell, New York University, and City University of New York. The Ph.D. program in comparative biology has now admitted two classes of students and is fully accredited.

The Museum's robust scientific enterprise, with a century-plus record of leadership in field science, theoretical science, and the professional training of scientists, provides the foundation for a wide range of public outreach and educational initiatives including professional development for teachers, permanent halls, temporary exhibitions and space shows (which travel both nationally and internationally), public programs, major conferences, and special seminars and symposia.

The scientific enterprise provides the foundation for the Museum's extensive educational program that serves learners of all ages, backgrounds, and levels of preparedness—both

onsite and online. Pre-school children and their parents and caregivers are introduced to scientific investigations through collaborations with community-based organizations and through programs onsite in the Museum's Discovery Room. The Museum has extensive partnerships with the New York City school system and schools nationwide. It is the most-visited field trip destination for New York City public schoolchildren, who visit the Museum free of charge. Each year, approximately 400,000 children visit in organized class or camp groups. Visiting groups and their teachers are supported with a wide range of pre- and post-visit materials. Middle and high school students participate in an array of programs after school, on weekends, and during the summer, including an intensive program of independent research for high school students working under the supervision of Museum scientists.

The Museum is also a leader in professional development of primary and secondary school teachers, having made the strategic decision to focus on teachers as a way to ameliorate the crisis in preparing, supporting, and retaining science teachers nationwide. The Museum provides institutes, courses, and programs—both onsite and online—to more than 3,300 teachers a year. All programs are developed by scientist-educator teams and many offer graduate credit. I will describe several of these initiatives shortly.

At the American Museum of Natural History, science education is distinguished by a focus on authentic science experiences that expose teachers and students to the scientific process, including inquiry, investigation, evidence and data collection, and analysis, while also elucidating key scientific concepts. The overarching aim is to enhance science literacy for all people, especially children, to inspire full citizenship and informed participation in life; for families, who are key to children's college and career choices; and for those children who will become tomorrow's scientists or work in the STEM fields.

Informal Science Education Institutions

Schools will of course remain at the center of all efforts to reform K–12 STEM education, but they cannot and need not shoulder this responsibility alone. Indeed, in the face of this seemingly intractable STEM education problem, we must think more broadly about what constitutes an educational setting and how best to enhance the scientific resources currently available to schools. Each science-based institution has a unique and valuable combination of assets and resources to offer. Institutions like the American Museum of Natural History are

grounded in authentic science, and provide access to collections of real specimens and artifacts—"the power of reality," ranging from the 65-million-year-old *T. rex* to a 34-ton meteorite to a towering totem pole—along with working scientists, laboratories and equipment, and extensive educational expertise, including many decades of experience interpreting and presenting complex topics in science for a broad public in ways that inspire, engage, and educate.

Science-based cultural institutions of all kinds are building innovative partnerships with schools, governments, corporations, foundations, and other entities that seek not only to educate teachers and improve educational outcomes for students, but, equally important, to create sustained learning opportunities that span not only a child's week and year, but his or her entire life. These efforts are transforming our definition of the schoolhouse by providing access to educational resources beyond the school walls—from museums and similar institutions—and are also, in the process, redefining science education itself.

Museums and similar institutions have always been places of inspiration that enjoy a special connection with the public, one that is marked by trust, familiarity, and enjoyment. Inspiration and awakening curiosity have long been recognized as the first, essential stop, or gateway, to learning. Building on that awakening, however, is equally critical to enduring improvement in science education, and institutions like the American Museum of Natural History have a strong role to play in that regard as well. We join the chorus of voices, including the Carnegie-IAS Commission on Mathematics and Science Education, on which I was privileged to serve, and the Race to the Top initiative, in pointing to museums and other science-based institutions not only as powerful catalysts of STEM education reform but as uniquely qualified to forge and sustain cross-sector partnerships.

There is a growing understanding of the key role informal science education institutions can play in addressing the crisis in STEM education. "Opportunity Equation," the 2009 report of the Carnegie–IAS Commission on Mathematics and Science Education explicitly points to ISE institutions: "Programs [at a growing universe of museums] are giving hundreds of thousands of students and teachers access to museum collections and staff expertise—along

with powerful insights into what people find most fascinating about science."[1] The National Research Council's 2009 "Learning Science in Informal Environments: People, Places, and Pursuits" recognizes the important learning that occurs in out-of-school settings and articulates approaches to the complexities involved in assessing outcomes.[2]

Importantly, the federal Race to the Top initiative, funded as a $4.3 billion initiative in the ARRA (American Recovery and Reinvestment Act), explicitly recognizes the valuable role museums and similar institutions can play in reforming STEM education: the program provides for a single competitive preference priority for STEM education, and it specifically includes museums, calling on States not only to "offer a rigorous course of study in mathematics, sciences, technology, and engineering" but also to "cooperate with industry experts, museums, universities, research centers, or other STEM-capable community partners to prepare and assist teachers in integrating STEM content across grades and disciplines, in promoting effective and relevant instruction, and in offering applied learning opportunities for students…."[3] It cannot be overstated how significant and historic this inclusion is.

Exemplar STEM Programs

The community of science museums and other ISE institutions is deeply engaged in the national call to accelerate solutions to the crisis in STEM education. Many of the directions undertaken by the Museum and similar institutions across the nation are built on a partnership model—among science-based institutions and school systems, local governments, institutions of higher education, and other entities. These institutions, with their unique resources, collections, working scientists, labs and equipment, and educational and interpretive expertise are increasingly taking the lead in building and managing these partnerships, and municipalities are increasingly looking to these institutions for educational leadership as are families and local communities.

Exemplar Programs at AMNH

[1] Carnegie–IAS Commission on Mathematics and Science Education. *The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy*. New York, NY: The Carnegie Corporation of New York, 2009.

[2] Bell, Philip, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder (eds). *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, D.C.: The National Academies Press, 2009.

[3] "Race to the Top Funds: Notice of Proposed Priorities." *Federal Register* 74:144 (29 July 2009) p.37806.

Following are a few examples of American Museum of Natural History–led partnerships that are working to improve the teaching and learning of science, both locally in New York City and on a wider scale. All these partnerships are characterized by the collaboration of scientists and educators; the utilization of Museum resources including exhibitions, collections, public programs, and digital resources; and access to online educational resources. In addition, and importantly, national and local science standards, assessments, scope and sequence, and other forms of demonstration are built into the design so that these offerings directly support the work of teachers. Because New York City's population and student population are so diverse there is great emphasis on combining rigor with equity and access in these partnerships and programs.

Urban Advantage

Over six years ago, the Museum began to analyze the status of science education in New York City's public middle schools. The middle school years are considered a "sweet spot"[4] when children either develop a sustained interest in science or, too often, turn away from science altogether. Findings[5] pointed to a severe shortage of qualified science teachers, which coincided with a new City mandate requiring all eighth-graders to complete a long-term scientific investigation known as the "exit project" before progressing to ninth grade.

These findings led to the development of Urban Advantage (UA), a keystone program of the Museum's Gottesman Center for Science Teaching and Learning. Based on the notion that urban settings often have a wealth of educational resources in the assets of the local science-based cultural institutions that schools could more effectively draw upon, UA is a pioneering, eight-institution collaboration with the American Museum of Natural History as lead institution and including the New York Hall of Science, the New York Botanical Garden, the Brooklyn Botanic Garden, the Queen Botanical Garden, the Bronx Zoo, the Staten Island Zoo, and the New York Aquarium, together with the New York City Department of Education under the leadership of Chancellor Joel Klein, and launched with support from the New York City Council and Speaker Christine Quinn, along with private funders.

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[4] Carnegie Council on Adolescent Development, Task Force on the Education of Young Adolescents. *Turning points: Preparing American Youth for the 21st century*. Washington, D.C.: Carnegie Council on Adolescent Development, 1989.

[5] Poitier, Johanna Duncan. *Progress Report on Teacher Supply and Demand*. Report to the Higher Education Committee of the State Education Department. Albany, NY: University of the State of NY, 2008.

UA incorporates professional development for teachers; classroom resources; laboratories and equipment for schools; access to the assets of the partner institutions for teachers, students, and families; educational outreach that specifically engages families; capacity building with lead teachers, school leadership and demonstration schools; and, importantly, ongoing assessment of program goals, student learning and systems of delivery.

UA has increased in scope and reach each year since it was piloted in 2004. It began with 60 teachers and 35 schools and now, in its sixth year, supports over 300 teachers in more than 150 middle schools—fully one-third of all New York City public middle schools—and serves more than 37,000 New York City students.

Museums and other similar institutions are increasingly incorporating assessment of the effectiveness of STEM education programs into the program design, and Urban Advantage places high priority on outcomes assessment. Preliminary evaluations support the initiative's primary goal of improving student understanding of scientific inquiry as defined in the New York State Core Curriculum. Sample findings include the following: 83% of UA teachers have observed evidence of improvement in the quality of UA students' science content knowledge; and 80% of UA teachers have reported increased understanding of the process of scientific investigations. The program is also fueling new levels of partnership among the collaborators and the New York City Department of Education in creating effective professional development for science teachers, and has led to increased visitation rates to the institutions by science classes and families.

Professional Development of Teachers

Since the quality of a student's experience with science is largely determined by his or her science teacher, the professional development of both pre- and in-service teachers is a key priority in the Museum's STEM education strategy. The National Academies' "Rising above the Gathering Storm" states that "few factors are more important than [high quality K–12 mathematics and science instruction] if the United States is to compete successfully in the

21st century."[6] Science-based institutions not only can bridge teachers to science content, but, more importantly, they can bridge teachers to the actual practice of science and to working scientists. Teachers who have practiced inquiry-based investigations themselves—and who understand the scientific method—are far more capable of and likely to foster such learning behavior in their students.

Partnerships at the K–12 and the university levels are essential in the Museum's professional development programs. The Museum currently serves up to 200 teachers each year through higher education partnerships with degree-granting programs, and more than 3,300 a year through various other professional development programs at the Museum and online. The Museum collaborates with a number of local colleges and universities, including Bank Street College of Education, Teachers College Columbia, Barnard College, and three City University of New York(CUNY) schools (Lehman, Brooklyn, and Hunter Colleges). These partnerships take various forms, including customized courses; supervised internships in science and museum education; thesis and dissertation advisement; Summer Institutes in Earth, space, and biological sciences; and online science courses in the biological, physical, and Earth sciences. These courses are co-developed with faculty from each institution to determine which Museum components add value and resources that enhance the experiences of participants.

With support from an NSF Teacher Enhancement grant in 2004, the Museum developed the Teacher Renewal for Urban Science Teaching program (TRUST), a partnership with Lehman and Brooklyn Colleges (of CUNY), to establish a Museum-based component of their Master's programs in Earth science. NSF's initial support was critical to the full development and implementation of the Museum's partnerships with institutions of higher education; not only did it enable the program to prepare 120 new Earth science teachers, it also provided the necessary resources and support for the Museum to develop successful and sustainable program models. It also enabled the Museum to leverage this support to obtain foundation funding for a similar program for biology teachers in partnership with three of the CUNY colleges. This model and these partnerships have since become institutionalized and self-sustaining, supporting state certification in Earth and biological sciences. They also have

[6] National Academy of Sciences, The National Academy of Engineering, and The Institute of Medicine. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C.: The National Academy of Sciences, 2007.

spurred the creation of additional collaborations and partnerships with other area colleges and universities, including Teachers College Columbia, Bank Street College of Education, and New York University.

The Museum also reaches out to teachers across the country and increasingly around the world through Seminars on Science, an online teacher education initiative. Serving more than 1,300 teachers in 2009, the program currently offers eleven online science courses, co-taught by Museum scientists and science educators, covering areas in the biological, Earth, and physical sciences. Several institutions across the country award graduate credit for these six-week courses, and four universities specifically include them as part of the teacher preparation and certification programs: Bank Street College of Education, CUNY School of Professional Studies, Brooklyn College, and Western Governors University.

The Science Generation Pipeline

One key dimension that museums and similar institutions offer is the ability to provide a sustained exposure to the actual practice and excitement of science and discovery—revealing for children, as well as their teachers and families, the thrilling quest that science really is. To that end, the Museum has developed and launched the Science Generation Pipeline, a complete pre-K through graduate school continuum of exceptional out-of-school science-learning opportunities. The Pipeline offers educational programs ranging from the Science and Nature Program, where parents and children as young as 2 are exposed to and engage in science together, to the Science Research Mentoring Program, where a highly diverse cohort of high school students are paired with scientist mentors to conduct authentic research in museum laboratories and collections.

Exemplar Programs at Other ISE Institutions

There are many other examples of effective and innovative model partnership programs at institutions and communities across the country.

In Washington state, for example, the Pacific Science Center is the lead institution for the Washington LASER (Leadership and Assistance for Science Education Reform) program. The program, which aims to improve science teaching and learning through teacher

professional development, curricular and material support, and leadership training, was created in 1999 as an NSF-funded dissemination and implementation project.

The Arkansas Discovery Network was created in 2003 to make hands-on, interactive museum experiences more accessible to schoolchildren and their families throughout Arkansas. The Discovery Network provides geographic coverage across the state, is composed mostly of ISE institutions, and supports the state's STEM agenda.

As of January 2009, the North Carolina Museum of Natural Sciences provided all of the state's schools with access to high definition programming of breaking news in science and the environment through a program called the Daily Planet.

The Role of the Federal Government

With all these "islands of innovation"[7] throughout communities across the country, how can these model programs be transformed into catalysts for broad-scale change? And what role can the federal government play in supporting the role of ISE institutions and fostering effective partnerships that integrate formal and informal educational institutions?

I should first stress that the American Museum of Natural History and the informal science education community have enjoyed significant and important support from NSF, NASA, NOAA, and NIH for educational initiatives, and we are most grateful for it.

Beyond that, however, grant competitions should be designed to foster K–12 STEM partnerships such as those described here among formal, informal, and private entities. Moreover, the value of learning in out-of-school settings—and the institutions that provide those opportunities—must be recognized and should be represented in discussion and policy development regarding STEM education, as you have done here today, and ISE institutions also must be made eligible for funding in programs that relate to these discussions.

The fact that the Race to the Top Program specifically encourages states to look to museums and other community partners in their STEM reform efforts is an important milestone, as is the STEM education work of this Committee. However, there have been several very

[7] Carnegie–IAS Commission. *Opportunity Equation.* 2009.

alarming efforts to exclude museums and other informal institutions from participating at all. While museums can participate in American Recovery and Reinvestment Act programs, zoos and aquaria have been excluded; and there have been efforts to impose similar restrictions in other legislation.

Concerning reauthorization of America Competes Act that this hearing is focused on, the Act currently makes no reference to informal education. For the reasons stated, it is imperative that the Act recognize the role of informal institutions and refer to them explicitly, including by providing access to funding. And it is essential that Congress fully fund the Act.

In addition, as recommended by the Carnegie–IAS Commission, common math and science standards that are "fewer clearer and higher" and susceptible to assessment should be developed. Such standards should be matched with state and local assessments that tie to authentic science teaching and learning. And such state accountability assessments should be internationally benchmarked to assessments such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment), and to the Nation's Report Card, the National Assessment of Educational Progress.

As an overarching point, efforts to reform STEM education suffer from lack of coordination among the federal agencies. In this regard we support efforts to provide for government-wide coordination, as embodied in the bill H.R. 1709, STEM Education Co-ordination Act of 2009.

Experience with NSF and other Federal Agencies

The National Science Foundation's role is unique among the federal agencies—in science education, its scope is comprehensive, embracing K–12 through graduate and lifelong learning, in both formal and informal settings. NASA, NOAA, and other science agencies, in turn, each contribute their own area of science and are critical to the Federal government's overall STEM education capacity.

The Museum has been tremendously grateful for the support of NSF, NASA, NOAA, and NIH, which has been essential to some of our key partnership programs, as mentioned above.

Also with NSF support, we are currently able to carry out, with our Urban Advantage partners and Michigan State University, education research that will advance knowledge and practice of middle school science education, including building a greater understanding of the role of ISE institutions, and the role of inquiry-based education in supporting student learning and science literacy for teachers, administrators, and families.

Similarly, with support from the NSF ITEST Program and NASA's Competitive Program for Science Museums and Planetariums, we have been able to launch and assess the innovative Student Research Mentoring Program, described above. NASA has also generously supported our digital space shows which engage millions of viewers worldwide, while NOAA's support has enabled us to improve public understanding of climate change.

I referred earlier to the importance of ISE institutions' interpretive and educational expertise and I return to this point here to stress that these institutions can play a powerful role in translating and interpreting current science and research for the public. NSF (and other federal agencies) should fully tap this enormous and sophisticated outreach capacity.

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In conclusion, I am gratified by the increasing recognition of the unique and powerful role that museums and similar institutions can play in reforming K–12 science education. Communities throughout the country have an array of science-based institutions—some large, some small, but nearly all housing resources and expertise that can enable schools to improve K–12 science education. As a field, institutions like ours are prepared and eager to take a larger, more formal, structural, and leadership role.

What institutions like the American Museum of Natural History have long done so well, and which is in many ways the hardest part to get right, is awaken wonder and curiosity. Today, and this is essential, this is amplified and extended by our demonstrated ability to create opportunities for sustained exposure to exploration and inquiry. We do so by sharing the power of discovery and real science with teachers, students, and families, providing a platform for sustained inquiry and learning that, in turn, enables schools to be vastly more effective. By increasingly working in cross-sector partnerships, the full value and promise of

this approach can be realized and brought to scale. And, importantly, the instinct for inquiry and discovery that this approach nurtures is also precisely what drives innovation and will fuel our country's global competitiveness.

Thank you, Chairman Gordon, Ranking Member Hall, and all the Committee members for your time and for the opportunity to speak before you today. I look forward to answering your questions.

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