ESSAYS ON SCIENCE AND SOCIETY

Safeguarding the World's Natural Treasures

Long viewed as repositories for dinosaurs, mummies, and stuffed animals, natural history museums do far more than generate awareness and engage the public through exhibits. As dynamic research institutions with a global presence, museums, along with zoos and botanic gardens, interpret and conserve Earth's biological and cultural riches. The manner in which natural history museums pursue conservation—conducting biological inventories, undertaking research on which long-term strategies depend, and building scientific and technical capacity in local communities—means that such contributions often go unheralded or even unnoticed.

The challenge of articulating the importance of museums to conservation extends beyond a problem of awareness. Natural history museums themselves have long debated whether they should assume an advocacy role while maintaining scientific objectivity. However, through careful science-based advocacy and partnerships, natural history museums can and should directly advance conservation goals. Such action ensures that the full power of museum collections, scientific research, and public outreach programs is harnessed to conserve the world's living heritage.

Collections. The enormous collections found in museums provide data that document the diversity of life on Earth. To date, scientists have described fewer than 2 million living organisms, representing as little as 15% or possibly only 2% of all species estimated to be in the world.* These remarkable statistics reflect our limited understanding of the world's biodiversity. Natural history museum collections provide a seminal reference for the biological inventories that help us understand the richness of life. By comparing the morphology, behavior, ecology, and DNA of a newly obtained specimen to those in museum collections, scientists can ascertain when an unusual specimen represents a new species. Yet museum collections are not encyclopedic, so scientists constantly strive to add new specimens to their collections.[†]

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The American Museum of Natural History in New York, the Smithsonian's National Museum of Natural History in Washington, DC, the Natural History Museum in London, and the Field Museum in Chicago together house approximately 248 million specimens. Although their sheer size is impressive, the power of collections lies in their data: anatomic, morphologic, genetic, and geographic information that contributes to our overall understanding of how species evolved, how they are related, and how they operate in ecological systems. Scientists use advanced technologies to mine specimen information for purposes as varied as correlating eggshell thinness to pesticide levels, measuring historical CO_2 levels in plant specimens in order to plot the rate of global climate change, or determining the genetic variability among species located in forest fragments to test the effectiveness of conservation corridors.

Public policy-makers often blame a lack of scientific information for their inability to set priorities for conservation. Museum collections contain basic data that can be used to make informed and appropriate decisions; the challenge is to make this information more accessible. Several natural history museums have initiated major efforts to place specimen data in computer databases, available through Web interfaces.[‡] From these databases, scientists generate comprehensive lists, predict species composition, and measure the rate of loss of species collected from areas that have since been transformed by human beings.[§] An exemplary database, created by the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), an analytical center for museum-based and other biodiversity data, has helped to set national priorities for conservation in Mexico. Interactive identification keys, which consist of digital images and associated text, also allow museums to increase accessibility to their collections.

"An advocacy role is a delicate one...."

Natural history museums maintain active research programs that enable hundreds of scientists to pursue specimen-based research and to fill critical niches in systematic and evolutionary biology. Basic taxonomic and phylogenetic research at museums provides the foundation for more visible work in biogeography, ecology, and conservation biology. As noted by Robert M. May, "without taxonomy to give shape to the bricks, and systematics to tell us how to put them together, the house of biological science is a meaningless jumble."[‖] Developing expertise in little known taxa and providing training in the fields of systematics and evolution are just

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two of the many ways in which natural history museums contribute greatly to addressing international needs in organismal biology.

Biodiversity is an unfolding story of evolution. Collections-based research contributes to our understanding of the origin and distribution of life on Earth and of the forces that drive extinction, which are the key ingredients for shaping conservation strategies and priorities. For instance, museum scientists use data from collections along with remote sensing, Geographic Information Systems, and georeferencing tools to develop predictive models for the distribution of rare and threatened species. Museums also bring their expertise to bear in developing management plans, constructing models for restoration, and creating monitoring protocols for protected areas.

Collections-based field research by social scientists also has a direct bearing on conservation. Anthropologists have long studied the relationship between people and their environments, and, in some natural history museums, curators focus on this research through the study of material culture (artifacts). Because museums facilitate interdisciplinary research, anthropologists and biologists can quickly collaborate to understand current and past patterns of human impact, thereby providing useful data for effective conservation design.

Conservation education. Children from an indigenous Cofan community in Ecuador examining color botanical field guides of local plants, which are valuable tools for field identification.

Resolving questions regarding boundaries for protected areas, the effectiveness of various conservation strategies, and the need to set priorities among competing demands necessitates the availability of sound biological data. Just as comparatively few species have been formally described, major areas of the world have yet to be inventoried. For instance, the first modern comprehensive biological inventory of Bhutan was initiated earlier this year. Furthermore, scientists have only recently begun to document freshwater and marine resources as extensively as terrestrial resources.

Museum scientists assemble interdisciplinary teams from across the globe to conduct comprehensive biological inventories and to process and identify the large number of specimens collected. Data gathered through these biological inventories can then be used to help governments and conservation organizations allocate resources efficiently. Given that policy-makers can rarely wait for comprehensive inventory data before making resource management decisions, rapid biological inventories provide a particularly powerful means to bridge this information gap.¶

Public Outreach. The attention paid to high-profile exhibits overshadows the important part that natural history museums play in interpreting the natural world. A family or a school group may begin their visit with mummies and dinosaurs, but surrounding exhibits and educational programs draw them into a much deeper dialogue, involving exploration of the entire spectrum of biodiversity and how to conserve it.

Successful conservation education programs not only increase environmental knowledge but also develop the skills, expertise, and commitment necessary to address environmental challenges. By nurturing a habit of inquiry, museums provide the scientific framework within which young people learn how to evaluate these important issues. With little conservation education offered in elementary, secondary, or university curricula, natural history museums fill a crucial gap by making such programs personally relevant to students and the general public. New distance-learning technologies and Web-based applications greatly expand opportunities to build global communities engaged in science-based action.

Beyond public programs, natural history museums have long offered advanced academic training to university students from U.S. and overseas institutions. Museum experts also provide technical assistance to foster the development of collections-based institutions in other countries. With this support, these collections-based institutions become vital in-country training centers and clearinghouses for biological information.

Some museums have now augmented their training programs to include intensive, short-term programs for highly motivated individuals who will become the next leaders in conservation. By training managers for protected areas, forest rangers, policy-makers, and concerned citizens how to identify species, develop management plans, monitor conservation targets, and interpret basic scientific data, natural history museums greatly increase the global capacity for conservation.

No single institution or organization can fully protect biodiversity. As scientifically objective players that tend to shy away from the political limelight, natural history museums serve as excellent initiators of productive, lasting partnerships. Museums and zoos were at the center of launching Chicago Wilderness, an unprecedented partnership of more than 130 public and private organizations joining forces to restore natural communities (tallgrass prairies, oak savannas, woodlands, marshes, fens, and meadows) in the Chicago region. In addition to strong partnerships with international conservation organizations, collaborations with small organizations and educational institutions based in high-biodiversity countries are critical because local partners will manage and monitor conservation projects for the long term.

A Call to Action. Natural history museums are essential for sustaining the world's biological and cultural diversity. Yet they can do more without undermining their commitment to thorough and rigorous science. For example, they can increase the accessibility of their collections. The advent of new information technologies allows natural history museums to digitize collections and to make associated scientific data accessible to wide audiences. These technologies enable the sharing of data with countries that have provided collection material, thereby closing the digital divide. Database and imaging technologies can also transform enormous collections into innovative tools for identification in the field.

Natural history museums should collect and disseminate information faster. The economic forces that drive unsustainable natural resource depletion are strong and gaining speed. Rapid biological inventories provide time-sensitive, accurate data for areas of high conservation concern. By actively forging relationships with government officials, scientists, and community leaders, natural history museums can increase the number and impact of concurrent rapid biological inventories.

They also must draw new audiences into the conservation fold. Through carefully crafted exhibits and education programs, museums can reach and mobilize large audiences. They should capitalize on these opportunities to raise awareness among nontraditional, untapped audiences about the precarious state of the world's remaining natural treasures.

They need to engage local communities to take immediate action. Participation of local communities living in and around regions of high conservation priority is essential to the success of conservation efforts. By placing scientific resources and tools in the hands of those most able to influence conservation action, *museums can* significantly augment the number of community stakeholders, citizen scientists, and expert professionals participating in local conservation efforts. For example, the indigenous Cofan community in Zabalo, Ecuador, uses color botanical field guides

CREDIT: D. A. BRINKMEIER/THE FIELD MUSEUM containing both scientific and Cofan plant names, to preserve local knowledge and to reinforce understanding of the traditional uses and importance of local plants (see the figure, previous page).

Museums must raise their public profile and undertake an ambitious search for funds to support the capital investment, technology, and human resources required to sustain successful conservation programs. No longer can we countenance the disconnect between critical conservation needs and the significant lack of funding for conservation.

Natural history museums must exercise scientific leadership. They hold a position of relative objectivity and scientific authority that enables them to act as both consensus builders and catalysts to convene productive partnerships for conservation. Also, as specialized scientists with decades of experience, museum researchers often have access to policy-makers to whom they can effectively convey inventory data and recommendations for conservation action.

Now more than ever, scientific leadership is necessary to meet the world's conservation needs. By contributing the underlying scientific rigor of research and engaging talented local and international partners, natural history museums have moved beyond being storehouses of knowledge and have become active participants in the struggle to investigate, to preserve, and to restore biologically and culturally important areas of the world.

When science informs conservation, the results are dramatic. Last year, the Field Museum, with many Peruvian and international partners, conducted a rapid biological inventory of the northern Cordillera Azul range in the Andean foothills of Peru. The scientific team identified at least 28 species that are new to science, along with registering dozens of new records for the country. Armed with critical scientific data, the Peruvian government worked hard and fast to create the 5212-square-mile Cordillera Azul National Park, roughly the size of Connecticut, barely 8 months after the team left the field.

An advocacy role is a delicate one that must be exercised appropriately. Scientists, rather than policy-makers or lobbyists, populate the laboratories of natural history museums. Our strength lies in the scientific light we can shed on targeting priorities for conservation and on designing effective plans of action. Access to basic science and the skills to apply it—when combined with an ability to form partnerships and to build local capacity—uniquely enables museums to extend their resources into conservation action. Time is running out: the sixth great extinction,# caused by *Homo sapiens sapiens*, is already under way.

*P. H. Raven, E. O. Wilson, *Science* **258**, 1099 (1992).
†Because organic materials decompose, museums must invest in state-of-the-art storage facilities to protect their collections.
‡Specimen-based databases assembled by natural history museums contain distribution and other data that can be readily verified.
§Work undertaken at the Centre for Biodiversity and Conservation Research at the Australian Museum, to test the reliability of collections data, promises to make conservation predictions based on museum data even more robust.
||R. M. May, *Nature* **347**, 130 (1990).
¶Rapid biological inventories (RBIs) involve documenting visible taxa as proxies for less conspicuous and little-known species. RBIs provide critical biological data within the narrow time frames required by decision-makers, but they are not a substitute for comprehensive biological inventories.
#E.O. Wilson, *The Diversity of Life* (Harvard Univ. Press, Cambridge, MA, 1992), p. 32.

ESSAYS ON SCIENCE AND SOCIETY

Romanticism, Race, and Recapitulation

CREDIT: ALLAN BURCH

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Ontogeny recapitulates phylogeny.

Haeckel's parallel between the development of individual organisms and the hierarchy of species ranks with other outmoded doctrines of the 19th century.* The analogy, which may serve as the epitome of Romantic biology, concerns the evolution of organic form, such that each successive stage in growth, from the tiniest gamete to the mature adult, mirrors the increase in complexity in the phylogenic order. To visualize the idea we need only recollect that sequence of images presented in school science texts: the human embryo compared with a tadpole's, a chick's, a deer's, etc. As a theory of development it seems embarrassingly antiquated, like exercises with Indian clubs or ruler slaps on the palm.

Recapitulation nonetheless remains a powerful idea, and if it no longer aids the modern discipline of embryology it persists in our contemporary conception of race. I want to examine why this is so, first by looking at the history of recapitulation in Romantic racial theories, and second by reflecting on the ends that the idea of race still serves. My thesis is that the notion of race preserves in nature the social idea of class. In a world where Darwinian struggle seems ubiquitous, this desire for order is hard to relinquish.

Recapitulation in Race

The late 18th and early 19th centuries witnessed a boom of new writing on race. Three figures from this period, each of whom might be called Romantic, offer interesting case studies. Since historical styles are notoriously hard to define, let me highlight the main features of their thinking: argument by analogy, concern with polarity, and elision of the social and the natural.

Henrik Steffens (1773–1845) was probably the strangest of the group. A Dane born in Norway, Steffens studied natural history, mineralogy, and philosophy in Germany, where he went on to enjoy a successful career as a university professor. His writings, which mixed transcendental eschatology, geological speculation, and conservative nationalism, permanently alienated fellow scientists with their muddy bombast; nevertheless, Steffens enjoyed great popularity among students, drawing both

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