

VIRUS AND THE WHALE: EXPLORING EVOLUTION IN A MUSEUM COLLABORATION

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Abstract

A major new collaboration of museums in the U.S. will teach the public about current research in evolutionary biology. This project, entitled Explore Evolution, combines the strength of interactive exhibits, Web activities and outreach programs for youth to feature seven influential research projects on organisms ranging in size from the smallest, HIV, to the largest, a whale. Launched in 2003 and funded by the Informal Science Education Program of the National Science Foundation (NSF), Explore Evolution is one of the most comprehensive informal education projects in the U.S. to focus on teaching about evolution research.

The concept of biological evolution is one of the most important ideas ever generated by the application of scientific methods to the natural world. (Bruce Alpert qtd. in National Academy of Sciences 1999)

Introduction

Concepts about evolution are far from being fully understood or accepted by much of the American public. For example, about half of adult Americans believe that God created Adam and Eve to start the human race (Numbers 1982), and about the same percentage believe that the earliest humans coexisted with dinosaurs (National Science Foundation 1999). A 1993 Gallup Poll showed that 47 percent of Americans continue to believe that God created man pretty much in his present form some time within the last 10,000 years (Numbers 1998). Approximately 45 percent of college students surveyed agreed with the statement that some races of humans are more evolved than others (Ahlquist & Cronin 1988). There are regional differences as well: college students in the Midwest and South are significantly less likely to give scientific answers to questions about evolution than students from other parts of the U.S. (Ahlquist & Cronin 1988). Anti-evolution movements in states like Kansas and Ohio have been well publicized, but there are many more subtle efforts that reduce school time spent on learning about evolution. Many school districts throughout the Midwest quietly are decreasing the time spent on teaching evolution. For example, the Lincoln Public Schools, a Nebraska school district of over 31,000 students, has recently shifted one of its science requirements from rocks and fossils, where evolution was taught, to rocks and minerals, where it is not. In this district, ideas about evolution now are not taught until students are 14 and older.

Museums and other informal science education institutions play an important role in making scientific ideas available where the schools fail to do so. The

Explore Evolution project combines the strength of museum exhibits and informal outreach programs to reach a broad sector of the public in the midwestern United States. Launched in June 2003, this project is one of the most comprehensive informal education projects in the U.S. to focus on teaching about evolution research. This project is designed to create a difference in the ways that the adult and youth audiences think about evolution and the role of scientific research in developing new ideas. Our aims for museum audiences are to create an understanding of evolution as a topic of current and ongoing scientific research, an awareness that ideas about evolution are accessible and relevant to their lives, an awareness of the diversity of scientists, including women and minorities, who conduct research on evolution and an appreciation for the role that research on evolution plays in understanding the natural world. We plan to show adults and youth that evolutionary research is a dynamic field, supported by multiple lines of scientific evidence, in which researchers are constantly making new discoveries that strengthen our understanding of how life evolves.

Museum Collaboration

Explore Evolution is a comprehensive museum-based program that will give the public and educators opportunities for understanding the science underlying current concepts in evolution. It is an outgrowth of a decade of discussions among the staff of museums in the Midwest on how to be more proactive in teaching evolution (Diamond 2000). The exhibits and outreach components of the project will be disseminated through three methods. First, a consortium of six major science museums will display permanent exhibits to their public audiences and disseminate outreach materials through their educational programs. Second, activities based on the exhibits will be disseminated throughout 4-H Youth Development, the largest youth organization in the U.S. Third, a national science education publisher will

disseminate the Explore Evolution activity books widely to formal and informal audiences.

All of the participating museums will take part in development decisions, including final topic choice and feedback on prototypes. The museums will receive and display copies of the final exhibits, and also disseminate the activity units through their educational programs and web sites. The combined annual attendance of these museums in six states is over 1.8 million.¹

Formative Approach to Teaching About Evolution

An important component of the Explore Evolution project is an ongoing evaluation of the most effective means to communicate concepts about evolution. We will present research on evolution in a way that is consistent with students' abilities to understand the concepts (Evans 2000, 2001). As suggested by the American Association for the Advancement of Sciences (AAAS):

Poor reasoners tend to retain nonscientific beliefs such as "evolutionary change occurs as a result of need" because they fail to examine alternative hypotheses and their predicted consequences, and they fail to comprehend conflicting evidence. Thus, they are left with no alternative but to believe their initial intuitions or the misstatements they hear. (2001)

According to Evans, by the end of elementary school, children are ready to consider and cognitively accept the concepts of evolution (2000, 2001). Developmentally, this early adolescent time is critical to accepting the concept of evolution.

This project integrates front-end and formative evaluation into the development process for the exhibits and outreach materials (Diamond 1999). The evaluation builds on previous and current work being conducted on what the general public and museum visitors understand about evolution, and about science in general (Diamond et al. 1987; Evans 2001; MacFadden & Camp pers. com. 2004). Formative evaluation and subsequent visitor research will allow visitor feedback from various regions in the U.S. to guide the presentation of information. Several concepts about evolution will require intensive formative development to ensure that they are presented clearly. For example, middle school and high school students have difficulty with the word "adaptation," because they often assume that adaptations result from some overall purpose, design or intent. They also confuse non-inherited traits acquired during an individual's lifetime with adaptive features that are inherited in a population. Students also have difficulty understanding that change in a population results from the survival of a few individuals that preferentially reproduce, not from the gradual changes of all individuals in the population (American 2001). Evans

(pers. com. 2004) suggests that even the most targeted instruction aimed at imparting Darwinian theory fails to change students' intuitive concepts of species change.² She suggests that interventions that target both students' naïve epistemology and their intuitive biology appear to be more successful in effecting conceptual change in the classroom. The Explore Evolution project will combine the drawing power of entertaining and well-designed interactive exhibits and activities with careful formative research to create a positive and understandable learning experience about evolution.

National Science Education Standards

Explore Evolution creates a learner-centered communication, education and assessment environment built around exploration, identification with strong role models and the development of critical thinking. The Explore Evolution exhibits and activities incorporate many of the skills required by the National Science Education Standards. By including skills from the standards, the Explore Evolution project builds a bridge between learning at school and extracurricular learning—the most effective way for children to retain newly acquired knowledge and maintain new interests sparked by their science explorations.

The project's content falls within the content standards for students 10 to 13 years of age (U.S. school grades 5–8) in life science, science as inquiry, unifying concepts and processes, earth and space science, science and technology and science in personal and social perspectives (National Research Council 1996). Life science content standard C for 10–13-year-olds (U.S. school grades 5–8) under Diversity and Adaptations of Organisms specifies:

Biological Evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. (National Research Council 1996)

Explore Evolution Exhibits

Similar evolutionary principles operate on different kinds of organisms. To emphasize this point, the Explore Evolution exhibits will be organized along a transition from the smallest organism to the largest. Each exhibit unit will include a section about the scientist, an explanation of how this particular research project demonstrates an important idea in evolution, an explanation of how our ideas of this evolutionary topic have changed since Darwin's time and a participatory opportunity to investigate this research project and its relevance to visitors' lives.

The Explore Evolution exhibits feature seven research projects, and each of the lead research scientists participates in and supports the corresponding project. We chose research studies that were highly influential; they are cutting-edge investigations published in leading scientific journals. Each of the research projects fundamentally changes ideas about evolution that have been around for a long time, and they represent ideas that are supported by multiple lines of evidence. We also felt that, although the science is complex, each of the projects can be made accessible to museum audiences.

At the outset, an executive group composed of representatives from the six museum partners met to review a detailed proposal for how each exhibit is to be built. The feedback from the partners on the detailed plans has shaped the development of the exhibit prototypes. These prototypes will be tested with visitors and then modified accordingly (Diamond 1999). The executive group will then consider the results of the formative evaluation when making decisions about the design and production of the finished exhibits. Explore Evolution includes the following exhibits.

HIV, Master of Disguise—One of the deadliest viruses in the world, HIV—the virus that causes AIDS—continues to elude medical efforts to eradicate it. Although initially susceptible to a variety of drugs, the virus has evolved rapidly, enabling it to dodge every drug in our biotech arsenal. This exhibit features the work of Charles Wood, Director of the University of Nebraska Center for Virology. Wood studies the mechanism of viral evolution in search of a vaccine against HIV. In this exhibit, visitors explore what a virus is, interact as a virus inside a host cell, and look at “snapshots” of HIV as it evolves from a mother to her infant.

Diatom, One-Celled Wonder—In core samples taken from Yellowstone Lake, Sherilyn Fritz and Edward Theriot discovered the origin of a new species, a single-celled diatom named *Stephanodiscus yellowstonensis*. Their work documents the most rapid evolution of any species in the fossil record. Visitors to this exhibit examine lake core samples to experience first hand the excitement of viewing how a new species emerges in response to climate change.

Fungus, Partners for Life—In dark gardens underground, leaf-cutter ants grow a fungus for food. The ants groom their crop and protect it from pests as carefully as any farmer. The partnership has lasted more than 50 million years. Biologist Cameron Currie from the University of Kansas discovered that this system actually involves four coevolved partners: the ant, the fungus, a parasitic mold and a bacterium. In this exhibit, visitors take a powers-of-10 video tour of an ant fungus garden and investigate an evolutionary “arms race” in Petri dishes.

Fly, Explosive Evolution—From one ancestral species of fruit fly that blew ashore on the remote islands of Hawaii, more than a thousand species have evolved.

Kenneth Kaneshiro, from the University of Hawaii, explores the ways that sexual selection has shaped the evolution of *Drosophila* diversity in Hawaii. Visitors to this exhibit investigate the courtship of fruit flies and other features of their biology to understand what drives the remarkable diversity of this group.

Finch, Rapid Response—Research by Rosemary and Peter Grant sheds new light on Darwin’s finches. Their study of finch populations on the Galapagos Islands demonstrates that evolutionary changes in bill size and shape occur very rapidly in response to severe environmental changes. In this exhibit, visitors take bill measurements of Galapagos finches and learn how selective effects of environmental change, acting through abundance of different food types, influence variation in finch bills.

Human, Family Ties—Genetically speaking, chimpanzees are close relatives of ours, sharing more than 98 percent of our DNA. Humans and chimps may have shared a common ancestor as recently as 5 million years ago. Henrik Kaessmann and Svante Pääbo, from the Max-Planck Institute for Evolutionary Anthropology, use the techniques of molecular biology to investigate the origin and evolution of the human family. This exhibit invites visitors to explore how modern molecular genetics give us insight into the relationship between humans and our closest relatives, the apes.

Whale, Walking Giants—Digging for fossils in the desert of Pakistan, Philip Gingerich from the University of Michigan made a series of startling finds. They demonstrate that whales evolved from 4-legged mammals much like the ancestor of the modern-day hippo. Visitors to this exhibit travel back with Gingerich to an ancient shore—the cradle of walking whales—and investigate some of the earliest known fossil whales and his most recent discovery, *Rodhocetus*.

Explore Evolution Outreach

The outreach component of the Explore Evolution Project consists of an activity book based on the University of Nebraska State Museum’s award-winning *Wonderwise, Women in Science* kits. These kits, funded by grants from the Howard Hughes Medical Institute and the NSF, received national awards for excellence, including the 1998 top award for children’s programming given by the National Education Association, the largest educational organization in the U.S. The *Wonderwise* kits have been used by over 11 million youths throughout the U.S. and Canada.

Each of the seven Explore Evolution activity units will be designed for 10 to 13-year-olds as a series of inquiry-based investigations into one topic in evolution. Each unit will be supported by the Explore Evolution exhibits and a web site that includes background information on the scientist, interactive extensions of

the activity, links to local and national science education standards and links to other evolution sites.

The Explore Evolution activities will be developed by the nationally-known curriculum writer and author, Linda Allison. She is the author of over a dozen science activity books, including the Wonderwise activity books and *Blood and Guts*, one of the only science curriculum projects to be on *The New York Times* best selling list (Allison 1976). The activities will be inquiry-based (Tobin 1993), easy to use, accessible to leaders and youths with no science background and constructed from readily available materials. All activities will undergo formative evaluation to ensure that the materials are designed specifically to enhance youths' understanding of evolutionary concepts. Through this project, museum visitors and 4-H youth have the opportunity to make connections between collecting data and applying their analysis and deductive reasoning to real-life situations, and to gain an understanding of the central relationship of evolutionary ideas to all fields of science. The activities encourage autonomy in the learning situation by embedding the reasons for learning in the activity, thereby helping learning to occur in a real-life context that mirrors a technologically oriented society (Bybee 1997; Tobin 1993).

A strong network is already in place for the dissemination of Explore Evolution outreach materials. A consortium of 4-H youth programs throughout the Midwest currently disseminates the Wonderwise project (Diamond et al. 1996; *Wonderwise*). This network also serves as the basis for the dissemination of the Explore Evolution outreach materials. Wherever possible, we will establish connections between the partner museums and state 4-H programs to integrate the exhibits and outreach parts of the project. The 4-H Youth Development organizations are logical partners because they provide a vast network of youth services throughout the U.S., they share many common educational goals with museums, which emphasize learning by doing, exploration and inquiry, and they currently have no curriculum materials on evolution. The Explore Evolution project will reach a wide diversity of youth, including over half a million who will experience the activities through 4-H clubs, camps, schools and after-school programs.

The Explore Evolution project will be completed within three years. By the end of the second year of the project, participating museums will receive a set of the completed exhibits to have in their permanent collection for display on an ongoing basis. Some of the museum partners plan to incorporate these exhibits into existing galleries on related topics, while others plan to display them in a separate gallery. By the project's third year, the participating youth groups will have begun youth leader professional development. The results of the project's research and evaluation studies will be published for dissemination to educators and other researchers

interested in how to make effective learning tools to teach about evolution.

The Explore Evolution collaboration serves as a model for how museums can work together to create significant educational experiences for the general public. Explore Evolution has created partnerships between museums, youth groups and scientists and is incorporating careful learning research to develop educational materials on this difficult and important topic.

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Notes

¹ The following museums form the Explore Evolution consortium: Exhibit Museum of Natural History at the University of Michigan, Kansas Museum and Biodiversity Center at the University of Kansas, Sam Noble Oklahoma Museum of Natural History at the University of Oklahoma, Texas Memorial Museum at the University of Texas at Austin, University of Nebraska State Museum and the Science Museum of Minnesota.

² See also Bishop & Anderson 1990.

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