Intuition and Understanding: How Children Develop Their Concepts of Evolution

By E. Margaret Evans

Cognitive scientists are interested in the way people reason about the world in the absence of expert training. Such commonsense, or "everyday," reasoning has been portrayed as a limited series of intuitive theories about the world, each of which potentially describes a different kind of knowledge, such as a "naive" biology or psychology.

Intuitive theories differ from scientific theories in many ways, but like scientific theories they frame the way we view the world and provide both questions and explanations. These are the kinds of everyday explanations, or "hunches," that most easily come to mind when we try to figure out what is going on in the world.

Over the past 15 years or so, my colleagues and I have begun to map out the emergence of children's everyday understanding of natural transformations such as metamorphosis and evolutionary change. In the process we have interviewed hundreds of children and parents from different religious backgrounds. To make sure the children really think through the issues, we ask them unexpected questions and give them unusual tasks. We also compare their intuitions about natural transformations, such as seasonal change, with their intuitions about artificial transformations, such as the making of chairs or toys.

What we have found is that children are subject to some prevalent cognitive biases about the biological world: namely, that species are stable and unchanging and that animate behavior is goal directed and intentional. Left unaddressed, these biases often persist into adulthood, where they are clearly at odds with an evolutionary perspective.

The following are some observations about the ways that children of different ages reason about different types of transformations.

Four- to 7-year-olds

In preschool through about second grade (ages 4 to 7), most children reject the idea of almost any kind of radical biological change, from metamorphosis to adaptive variation. From the perspective of the young child's intuitive biology, living things cannot change. Perhaps because this age group is learning so much that is different and new, they find it useful to believe that the world around them is permanent and enduring.

Although young children do know that animals possess adaptive features, such as wings for flying or fins for swimming, they have little sense of what would happen if the environment changed. And if you ask a child from this age group where the first animals came from, you will get a variety of answers. Some are likely to respond that "God made them." Others may reply that the first animals came "from someplace else" or that they "came out of the ground." In other words, they appear to think the animals were always here on Earth, but someplace else, where they could not be seen. This idea may be rooted in everyday experience, such as the burst of new life we see each spring after the snow melts or the first rains arrive.

Eight- to 10-year-olds

From about third grade to the end of fourth grade (ages 8 to 10), there is a gradual shift in children's reasoning. This age group is more likely to accept some kinds of radical biological change, such as metamorphosis. Interestingly, whatever their family background, most children in this age range endorse the idea that the first kinds of animals were "made by someone," and often that someone is God.

One reason for this belief is that, unlike their younger siblings, this age group is beginning to think about existential questions. They are more likely to know about death and to understand that animal kinds are not eternal—that they were not always here on Earth, nor will they continue to be on Earth. Intuitively understanding the human as an intentional manufacturer of new tools, they transfer that understanding to objects that have arisen naturally, such as new species.

Simultaneously, children in this age range are starting to integrate different kinds of causes into a complex causal structure. Preschool children, seeing "Josh" knock over a glass and break it, are perfectly capable of reasoning...
about the immediate cause: "Josh didn’t see the glass." But if you ask them to think a little harder about "why" Josh knocked over the glass, they have more difficulty.

Eight- to 10-year-olds are better able to engage in a more complicated reasoning process: Josh knocked over the glass "because he was in a bad mood ... because he didn’t get lunch ... because he forgot his lunch money"... and so on until they arrive at the most distant or original cause. This sort of reasoning is necessary for understanding the origins of novel animal kinds: Why and how did something come into existence in the first place?

Ten- to 12-year-olds

On the surface, at least, the beliefs of preadolescents (ages 10 to 12) are similar to the beliefs of the adult members of their community, with the same percentage endorsing evolutionist and creationist beliefs. Children exposed to evidence that animals change—metamorphosis, adaptive variation within species, fossils—are the most likely to accept major evolutionary changes. They will agree that one kind of animal could have originated from earlier and very different kinds of living things, although they are likely to exhibit many misconceptions about evolution. For these children who take the perspective of a naturalist, this is the beginning of a more complex understanding of the fundamental interrelationships among all living things.

Conversely, children who know the least about natural history and fossils and who go to schools that endorse Biblical literalism are likely to endorse the idea that God created each kind of animal with its own unique "essence." Interestingly, these beliefs seem to vary depending on the organism. For example, many children and their parents agree that butterflies and frogs evolve, but state that God created mammals—and, in particular, humans.

Older youth and adults

Adolescents (ages 12 and up) are often ready to assimilate basic evolutionary concepts, although their everyday intuitions continue to undermine the teaching of Darwinian theory. Along with many adults, most endorse pre-Darwinian theories of evolutionary change. This makes it difficult for them to grasp contemporary Darwinian concepts. For example, when a visitor interviewed for *Explore Evolution* was asked to explain the changes in the beaks of Galápagos finches, she said, "Well, in order to survive, their body parts had to adjust to certain things, similar to the way giraffes’ necks probably grew long as they reached for the plants at the top of the trees, so the beak grew longer to deal with the tougher seeds."

Many adolescents and adults believe that adaptations acquired over the lifetime of an individual animal can be inherited by future generations. Such Lamarckian views appear to have their roots in these respondents’ intuitive understanding of the way humans fit in with or adapt to their environment.

Education researchers have found that science learners also tend to think of evolution as growth and improvement over time. Many adults and children accept the extinction of the dinosaurs, for example, but are less willing to generalize this understanding to include contemporary species, especially humans. Despite scientific consensus to the contrary, they appear to hold to the idea that species continually adapt to new environments and do not really become extinct.

The problem may be less one of ignorance than of existential concern. For many people, the idea that humans and other species alive today might cease to exist is difficult to contemplate. One parent expressed her concern thus: "I don’t know what to believe. I just want my kid to go to heaven." A visitor to the *Explore Evolution* exhibition commented, "The Bible says, 'God created the heavens and the earth.' It also explains that He created mankind in his image. To me it is comforting to know where I’m going when I die..... Where will

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### Exploring Evolution in Michigan

On January 14, 2006, *Explore Evolution* opened at the University of Michigan’s Exhibit Museum of Natural History, Ann Arbor. The museum was one of six U.S. science centers, led by the University of Nebraska State Museum, that developed the permanent exhibition in partnership with five statewide 4-H organizations (see Spotlight, *ASTC Dimensions*, November/December 2005). The exhibition highlights the current research of seven evolutionary scientists, including University of Michigan paleontologist Philip Gingerich, left.

The debut in Ann Arbor was also the impetus for a special winter semester on evolution in the university’s school of Literature, Science, and Arts (LSA), organized by Exhibit Museum director Amy Harris. Public events include a speaker series, symposia, films, author readings, exhibit openings, teacher trainings, and family events.

To learn more about *Explore Evolution*, visit [www.explore-evolution.unl.edu/](http://www.explore-evolution.unl.edu/). For details on the LSA semester program, visit [www.lsa.umich.edu/lstheme/exploreevolution/](http://www.lsa.umich.edu/lstheme/exploreevolution/).
you go when you die?..."

These kinds of findings illustrate the importance of developing exhibits that speak directly to visitors’ everyday intuitions about the biological world. In many ways, evolutionary theory is counterintuitive: It presents a world that is dynamic and ever-changing and, even more critically to some, a world that apparently lacks purpose and design. Perhaps museums could tackle such concerns more openly, pointing out that while evolution does not (and cannot) explain the “final cause” of why we are here on Earth, it can address the secondary causes or mechanisms that explain how we got where we are.

**Related readings**


**Living Evolution:**

A Passion for Science Communication

By Gail Jennes

Evolution has been a topic of investigation at the Museum of Science, Boston (MOS) ever since Harvard geologist Louis Agassiz critiqued Charles Darwin's *On the Origin of Species* at an 1860 meeting of the museum's precursor, the Boston Society of Natural History. (For the record, Agassiz disagreed with Darwin's conclusions.)

Recent polls showing the level of public misunderstanding about Darwinian evolution were thus no surprise to museum staff. Since 2003, they had been planning to upgrade an existing exhibit on the topic. The result, *Human Evolution*, opened in late 2005. With more elements still to come, the exhibition allows visitors to explore the evidence for the development of our own species through interaction with fossils, genetic research, and living animals.

The driving force behind the project is MOS manager of discovery spaces Lucy Kirshner. As a child growing up in Massachusetts, Kirshner was encouraged to pursue her own inquiries, she says. "We lived outside as much as possible and scrutinized the size, shape, and changes in all sorts of living things." The experience taught her that asking good questions is as important as finding answers. After beginning her museum career at Michigan's Ann Arbor Hands-On Museum in 1981, she came to MOS in 1985.

Kirshner's inspiration for *Human Evolution* was the many breakthroughs achieved in genetic research over the past decade, including the Human Genome Project. "Evolution and the genetic mechanisms at its heart are challenging to teach and difficult to grasp," she says, "but public understanding is critical."

Housed in the museum's Human Body Connection discovery space, the exhibition features a variety of interactive exhibits. Museum-goers learn more about themselves as they compare similarities and differences between newly hatched chicks and humans and observe the behavior of live primates (in this case, a family of cotton-top tamarin monkeys). "This is not dusty, but living history," Kirshner says. "Visitors who

Lucy Kirshner, manager of discovery spaces at the Museum of Science, introduces visitors to the PTC taste test, a harmless indicator of genetic inheritance.

Photo by Eric Wehunt/Museum of Science, Boston.

watch our tamarins care for their children will relate to other species in a whole new way."

At the Hominid Skull Field Station, museum-goers can play a computer-based game to learn about differences among our extinct early relatives—exploring where each skull was found, who discovered it, and what each reveals. In a related component, they can also learn what jaws and teeth reveal about an early hominid's diet, age at death, and relationship to modern humans.

In the genetics area, computer-generated animations demonstrate how DNA turns into proteins in real time. A taste experiment with the harmless but bitter chemical PTC lets visitors explore their own genetic inheritance, and with a spin of a 4-foot dial, they can choose an organism and follow its branching evolution to see how it is related to others. Throughout, the exhibition presents the evidence for evolution and shows how scientists have interpreted it, allowing visitors to draw their own conclusions. But the museum stands clearly for the science. When people ask about intelligent design, Kirshner says she explains the difference between ID, a "philosophical construct," and scientific theories, "well-documented explanations that have grown out of careful experiments, supported by evidence that is open to scrutiny and test."

Gail Jennes is communications officer at the Museum of Science, Boston. The Human Evolution exhibition is part of an institution-wide natural and life sciences initiative that will include hosting the Darwin exhibition in 2007.