# Research reveals surprising results about kids' capacity for scientific literacy

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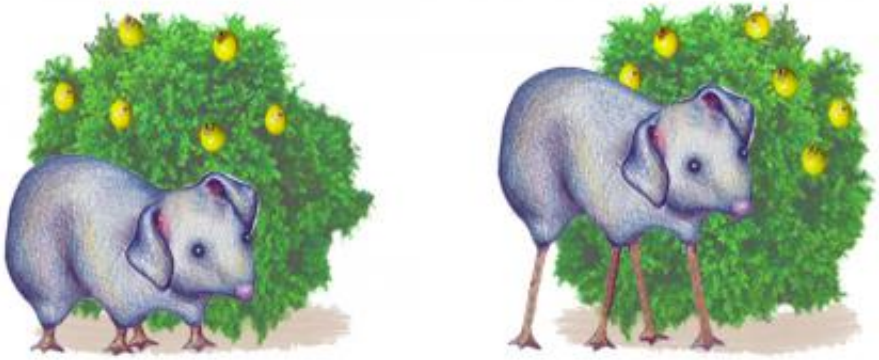

(Medical Xpress)—It turns out kids can understand complex scientific concepts – like natural selection – far beyond what anyone would have expected.

To demonstrate this, Boston University cognitive developmental psychologist Deborah Kelemen and her co-researchers created a 10-page picture storybook about pilosas, a group of fictional mammals with long trunks. Then they read it aloud to five to eight year old's.

The pilosas use their trunks to catch insects. In the past, most of the pilosas had wide trunks. Only a few had thin trunks. Then extreme climate change drove most of the insects underground, into long, narrow tunnels where only the pilosas with thin trunks could reach them.

The drama unfolds around a central question: How did the pilosas evolve over time from a group of animals having trunks of varying widths to those with thin trunks predominating?

It's a story about adaptation by natural selection, which is one of the core mechanisms not just of evolution, but of all biology. It is also one of the most widely misunderstood concepts in science. It is generally viewed as so complex – so beyond the grasp of young children – that educational standards in the U.S. suggest that it should not be taught comprehensively until ages 13 to 18.

The kids who heard the story about the pilosas got it.

"We're still astonished by what we found," said Kelemen, who reports the findings in a study published last week in *Psychological Science*.

"It shows that kids are a lot smarter than we ever give them credit for. They can handle a surprising degree of complexity when you frame things in a way that taps into the natural human drive for a good, cohesive explanation."

"I had one child say to me, 'Wow, I think my head is going to explode I learned so much today,'" said Boston University developmental

psychology postdoctoral fellow Natalie Emmons, an author on the study.

The conventional wisdom is that young children should be taught only piecemeal biological facts, such as that food is needed for survival or that animals have useful body parts, without tying the facts together into an explanation of how the mechanism of natural selection works.

But why bother trying to explain the mechanism to young kids? Kelemen and her colleagues make the case that teaching it earlier may help head off learning problems later on.

Young children are natural explanation seekers, Kelemen writes in the study. Around pre-school age, they start intuitively thinking that natural phenomena exist for a purpose or operate by design. To a five or eight-year-old, it makes perfect sense to think that rivers exist so crocodiles have a place to live or that giraffes got long necks because they needed them to reach leaves high in the trees.

This scientifically inaccurate thinking is known as teleological explanation. While it helps young children's everyday reasoning, Kelemen said, the kind of beliefs associated with it can impede the ability of older students – and, ultimately, adults – to understand the counter-intuitive logic of natural selection. A species evolves over time as animals with certain traits that fit better with their environment survive and reproduce at higher rates than those without the advantageous trait.

Not only did the kids understand how the pilosas evolved in the storybook, but they accomplished one of the most difficult tasks of learning: generalizing the concept. They applied what they learned from the pilosas to another species of novel animals, in some cases, even after three months.

Kelemen's experiment, born amid the growing discussion about the need to improve science literacy in the U.S., began with this question: Was it possible to teach young children a basic concept of adaptation by capitalizing on their efforts to figure out the natural world as well as the fragmentary state of their ideas?

Most storybooks that touch on natural selection only further confuse kids, Kelemen said. They anthropomorphize the animals, skimp on the facts and dispense with explanations altogether.

Or the books are so flashy the kids can't focus on the story. "All kinds of bells and whistles are often built into storybooks," Kelemen said." Everyone thinks that is going to make the storybook fun for the kid."

Kelemen and her co-researchers carefully crafted their book, combining what they knew as developmental psychologists with the research on science education. They invented the pilosas so the children couldn't come into the lab with pre-conceived ideas about the animals. They kept the story and the pictures simple. The narrative about how the pilosas lived and died – and the explanation of how and why they evolved over time – unfolded gradually, with one biological fact logically connecting to the next.

The researchers asked the children questions before and after reading them the storybook to assess their learning of basic biological facts – such as the link between food and health and health and reproduction—and their ability to integrate these facts into a coherent, accurate explanation of why pilosas' bodies changed over time.

Learning was particularly striking among older students; in the second experiment, 100 per cent of the seven and eight year olds understood that the reason why the pilosas or other animals changed over time was because individuals with more beneficial traits out-survived and out-

reproduced others in the group.

Kelemen's study suggests that one way to raise science literacy in the U.S. is to start teaching earlier some key concepts that our natural tendencies of mind make especially hard to understand – and that a good place to start would be with natural selection. The concept, Kelemen said, is an important foundation for children's understanding of other fundamentals, such as the diversity of living things and the origins of species.

"It turns out that if you put the facts into the context of a theory, the kids learn not only the facts, but they also understand the full explanation," Kelemen said. "And they get it beyond a level we ever imagined they would, given how young they are."

She added: "We're not necessarily getting rid of a natural orientation to think everything exists in nature to perform a function. What we are doing is helping children also develop alternatives ways of understanding why some kinds of functions and purposes in nature exist. It is a scientifically accurate way that is going to help them in the science classroom and beyond."

David Klahr, a professor of cognitive developmental psychology and education science at Carnegie Mellon University, who was not involved with the study, said he was " impressed with the results," and with the creativity with which Kelemen and her team conceived and executed the work.

"We've known for years that young children can extract the intended message from a coherent story," he wrote in an email. "Everything from Aesop's Fables to things in the typical 'children's bible stories' volume exploit young children's ability to extract meaning from well crafted tales."

Kelemen said: "Taking insights from developmental research about how children think and applying them to the construction of educational materials can yield incredibly positive results. Early interventions like this might be key to improving scientific understanding of counter-intuitive ideas longer term."

**More information:** The complete study is available online: www.bu.edu/cdl/files/2014/02/K … electionplussupp.pdf

Provided by Boston University