IBI* SERIES WINNER

How We Got Here: An Inquiry-Based Activity About Human Evolution

How We Got Here, an IBI prize–winning module, utilizes iterative cycles of inquiry to help students learn about evolution.

Rebecca M. Price

Show your students the face of a baby chimpanzee, and they will be startled and amazed by how human she is (see the photo). The image intrigues and primes students for a scientific inquiry cycle in which they will engage with, explore, explain, elaborate, and evaluate data [the 5e inquiry cycle (*1*)]. Through inquiry, they will reconsider one of the most common misunderstandings about evolution (*2*), that humans evolved from chimpanzees. The class is ready for a conceptual change (*3*) based on evidence the students will gather.

Students spend the majority of class time testing the hypothesis that the evolution of skull shape within the human lineage took place largely by truncating the development of a chimpanzee-like ancestor. They work collaboratively, mimicking the creativity in scientific practice (*4*), by collecting data from the casts of skulls of fetal, infant, juvenile, and adult chimpanzees, as well as adult skulls of *Homo sapiens*, *Homo erectus*, *Australopithecus afarensis*, and *Ardipithecus ramidus*. They recognize that developmental changes in shape are a source of heritable variation on which evolutionary processes can act.

This learning module is flexible; one can choose learning goals that are appropriate to the course content (see the table). Elsewhere, I described one approach that focused on learning about evolution (*5*). Here, the approach emphasizes goals for learning about the nature and process of science through three cycles of inquiry (see the chart).

Step 1. The instructor shows students a picture of a baby chimpanzee (such as the one in the photo). The students spend 1 minute writing (*6*) about why humans and chimpanzees look so similar; this brainstorming sets the stage for the instructor to introduce the testable hypothesis—that our evolutionary ancestor looked like a chimpanzee.

Step 2. Pairs of students observe casts of chimpanzee skulls and identify several characteristics, such as how protuberant the eye brow ridges are, or how long a skull is, that describe the changes that occur during development. Having students identify the characteristics they will study involves them in the process of experimental design. They may choose characteristics that the instructor has not considered, such as the curvature of the back of the skull. As with authentic research (*7*), their results are unpredictable.

Chimpanzee. The startling similarities between baby chimpanzees and humans engage students in the scientific process.

PHOTO CREDIT: DANITA DELIMONT/ALAMY

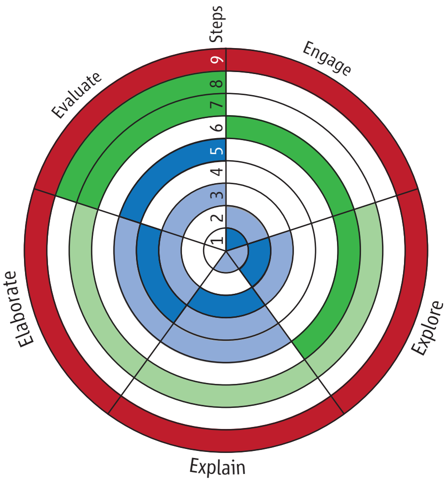
Step 3. Students illustrate what the hypothesis predicts, drawing the skull shapes that they think a new species might have. We discuss how the characteristics that they identified provide evidence to test their hypothesis.

Step 4. Pairs of students choose two characteristics to quantify shape and one measurement, such as skull width, to standardize the others. They evaluate these traits in all the skulls except that of *Ardipithecus ramidus* and graph their results [e.g., (*5*)].

Step 5. Pairs of students answer questions provided by the instructor (*5*). Whole-class discussion helps clarify confusing points.

Step 6. Students begin a second inquiry cycle (see the chart) when they analyze *Ardipithecus ramidus*, also known as "Ardi." This second cycle models a paradigm shift from the original hypothesis to a more sophisticated one. The original hypothesis that the hominin ancestor looked like a chimpanzee was widely accepted by experts until recently (*8*). Students focus on skull measurements, but consider other anatomical features. Ardi demonstrates that our species retains a host of primitive traits and that chimpanzees evolved a number of derived traits (*8*). From their analysis, they infer that Ardi appeared much later, evolutionarily, than she actually did. The paradigm shift begins when I tell the students Ardi's true age, and we work, as a class, to reconstruct the evolutionary relationships of the species in the activity.

Step 7. Additional questions (*5*) provided by the instructor complete the paradigm shift, and students revise their hypotheses. By answering the questions in small groups and then discussing them with the whole class, students recognize that chimpanzees undergo more shape change before reaching sexual maturity than Ardi did, whereas humans undergo less shape change by the time we reach maturity.



Three different inquiry cycles. The steps targeting the 5e inquiry cycle (dark colors) are shown; they may also include secondary foci (light colors). In the first cycle (steps 1 to 5, blue), students test the hypothesis that humans evolved from the truncated development of a chimpanzee-like ancestor by identifying characteristics, graphing data, and interpreting results. In the second cycle (steps 6 to 8, green), students revise their conclusion from cycle 1 after considering *Ardipithecus ramidus*. Students' understanding of inquiry is more sophisticated and they navigate the cycle with less scaffolding. In the third cycle (step 9, red), students test the hypothesis that Piltdown man is ancestral to humans. At this stage, they understand the inquiry cycle well enough that they need little guidance from the instructor.

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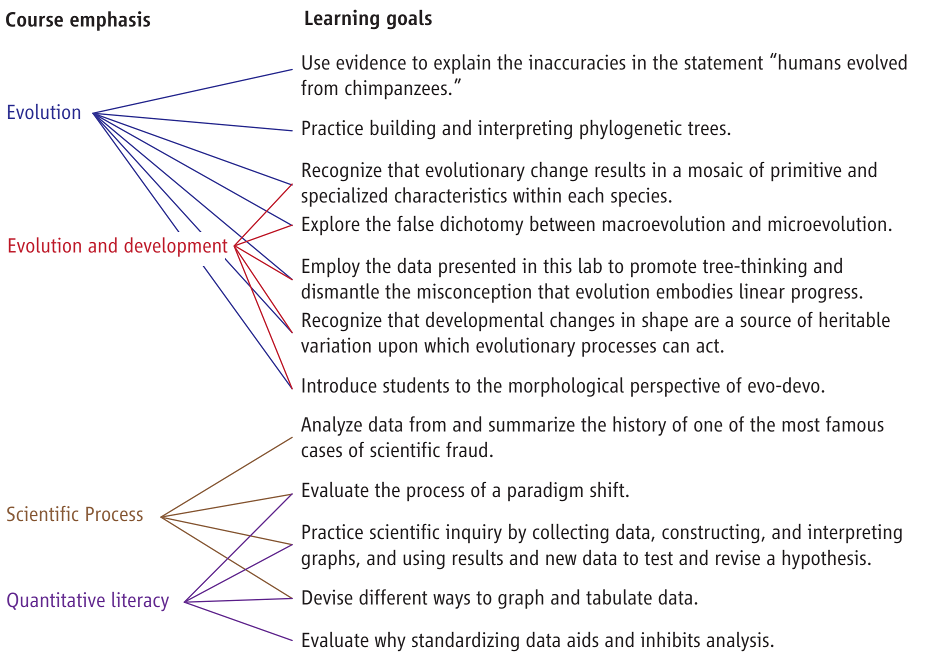
Step 8. Students return to step 1 in pairs to reevaluate their original ideas and to consider how the characteristics they chose affected their outcome. Then, the whole class discusses the results for each pair of characteristics. Some combinations support the hypothesis that the hominin ancestor looked like a chimpanzee; others cause it to be rejected. For example, the location of Ardi's foramen magnum is more similar to a chimpanzee's, whereas her canines are more like ours (*8*). When we seek consensus among all the students' data, we always conclude that we should reject our initial hypothesis.

Step 9. In the third inquiry cycle (see the chart), students test the hypothesis that Piltdown man is ancestral to hominins. They infer that the cranium is *Homo sapiens*, rejecting the hypothesis. This step brings ethics, scandal, and the history of science into the conversation.

Steps 1 to 9 are framed by testing a hypothesis about the morphology of the human ancestor. Students ultimately reject the first hypothesis and formulate an alternative: that the ancestor shared human and chimpanzee characteristics. Framing this activity around hypothesis testing forestalls debate about whether evolution is occurring, focusing instead on how scientific conclusions are formulated. By acknowledging that science is one of many ways of knowing (*9*), I emphasize that some students may personally prioritize faith over science, but that I expect them to recognize the scientific reasoning supporting evolution and the lack of scientific evidence rejecting it.

Experts read deep meaning into symbols within their area of expertise (*3*). Our students do not know how to gain an overview of the scientific process from activities that are written without ambiguity, even though experts recognize that recipe-based labs are symbolic representations of science. Inquiry-based learning makes explicit the dynamism and creativity in science (*1*).



A modifiable learning module. Different goals can be emphasized to suit course content.

The development of this activity mirrors my development as an educator. When I used a recipe-based approach, I dictated which characteristics students should measure, ensuring that everyone achieved the same results. But after researching effective pedagogy and gaining experience, I realized that my students were not engaged in the scientific process. Moreover, it was difficult to distinguish between students who achieved a deep understanding of the material and those who had memorized the answers they knew I wanted. I learned about inquiry [e.g., (*1*)], recognizing it as a formal pedagogical approach and then reframed this activity. The most transformative insight was learning to emphasize engagement. Most students do not share our scientific passions and are bored unless they see a reason for doing an activity. But an engaging activity inspires passion. The intrigue borne from looking into the face of a baby chimpanzee opens their eyes to discovery.

About the author

When **Becca Price** was a little girl, a museum exhibit about the famous australopithecine Lucy inspired her to become an evolutionary biologist. She completed a Ph.D. at The University of Chicago, where her research focused on how and why sea shell shapes have changed through deep time. She participated in the Seeding Postdoctoral Innovators in Research and Education (SPIRE) Postdoctoral Fellowship Program at the University of North Carolina at Chapel Hill, which introduced her to the scholarship of teaching and learning. Now an Assistant Professor at the University of Washington, Bothell, Becca's primary research focus is studying effective methods for helping students understand evolution. She is coprincipal investigator of a working group at the National Evolutionary Synthesis Center that is developing a series of concept inventories to measure students' understanding of different aspects of evolution. In her teaching practice, she uses interdisciplinary strategies that help students relate classroom knowledge to the real world.

PHOTO CREDIT: MARC STUDER

References and Notes

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10. This activity was inspired by another activity written by D. Jablonski and M. Foote. C. Tzou introduced me to the 5e Inquiry Cycle. Thanks to B. Burgett, G. Kochhar-Lindgren, and M. Servetnick for their support, to S. Rosenthal, and to the many students who have participated in this activity. M. Groom, J. Peters, and editors at *Science* offered valuable advice for improving this piece.

Supplementary Materials

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