Session 6
Evolution and the Tree of Life

What makes a snake a snake and a lizard a lizard? What distinguishes one type of lizard from another? And how did so many types of reptiles come to be? Session 6 focuses on questions like these as we continue our study of the fundamentals of evolution. Building upon key ideas introduced last session—variation and adaptation through natural selection—we focus upon what defines a species and how new species evolve.

The Video

Deep within the basement of the Museum of Comparative Zoology at Harvard University, there is a treasure trove of life forms ready for study. The program opens inside the reptile and amphibian collection, where we begin to see part of what informs the work of evolutionary biologists.

Dr. Karen Worth, representing the Insights curriculum from the Educational Development Center (EDC), describes how the study of evolution can begin in the elementary grades. Gail Modugno's fifth-grade classroom in Springfield, Massachusetts gives us a glimpse of what this might look like as her students begin to connect similarities among life forms to the possibility of relatedness. Our fourth and fifth graders in the Science Studio ponder some of the same ideas throughout the program, as they share their ideas about species, adaptation, evolution, and relatedness.

Dr. Jim Hanken, from the Museum of Comparative Zoology, helps us dig deeper by using snake and lizard specimens to explore the meaning of "species." Dr. Douglas Causey, also from the museum, presents us with a collection of Darwin's finches to propose a scenario for how new species might evolve through natural selection.

The tree of life is introduced as a model that portrays how scientists think life on Earth evolved. And Dr. Paul Williams updates us on the progress of Bottle Biology, highlighting the results of an experiment that explores the fundamentals of evolution.

Learning Goals

During this session, you will have an opportunity to build understandings to help you:

- Define what is meant by "species"
- Describe how new species evolve as a result of variation and adaptation through natural selection
- Comprehend the tree of life as a model for depicting evolution and the relatedness of species

On-Site Activities

Getting Ready (60 minutes)

Activity One—Problem Set and Reading Discussion (20 minutes)

Work in small groups.

1. Begin the session by reviewing questions 1–4 from the problem set for Session 5. For each question, select a single group member's response and discuss. Use this as an opportunity to clarify understandings of content.
2. Each group member was to identify an idea in the reading assignment that they consider useful in teaching evolution. As a group, discuss these ideas.

Activity Two—Species and Evolution (25 minutes)

1. What is a species? Discuss this question with a partner.
2. To prepare for today's session, you were asked to choose one type of vertebrate animal and to bring it (or some representation of it) in. Consider this animal to represent a species. You were asked to describe external features of this animal and suggest how these features adapt it to its habitat and habits. Share your description with your partner.
3. For one of the two animals described above, imagine a change in the physical environment that surrounds it (e.g., climate, soil, water, air, etc.). Using what you understand about evolution from Session 5, create a scenario in which this species of animal evolves into a new species. Describe this animal after it evolves.
4. For the other animal, imagine a change in the living environment that surrounds it (e.g., food sources, predators, competitors, etc.). Create a scenario in which this species evolves into a new species. Describe this animal after it evolves.
5. How did your scenarios involve the following:
   - variation
   - adaptation
   - natural selection
   - survival
   - reproduction
   - genes
   - time

   What makes these animals new species?

Activity Three—Modeling Relatedness (15 minutes)

1. Display all of the group's animals. Which general features suggest that all of these animals are related? Which specific features suggest that certain animals are more closely related than others?
2. On the floor, a table, or some other surface, arrange the animals to hypothesize how they might be related. Use string to create a visual model for portraying this relatedness.

On-Site Activities, cont'd.

Watch the Video (60 minutes)

As you view the video, think about the following focus questions:

1. What distinguishes members of one species from another?
2. The children in the Science Studio generate scenarios in which new species of turtles evolve from an existing species. What do they think causes evolution to begin? Do you agree or disagree?
3. In our Featured Classroom, a group of students compares the skeletons of vertebrates and reasons which animals might be more closely related. Upon what are they basing their ideas? How would you determine relatedness?

Going Further (60 minutes)

1. As a whole group, look once again at your set of animals. Incorporate any new ideas from the video to check your understanding about what makes each of these animals a different species. If you used DNA as evidence, what would have to be true in order for your model to hold up?
2. Briefly review the scenarios generated by members of the group to describe how these animals might evolve into new species. Make a list of the causes. How realistic are these causes? How do they compare to the cause of:
   - turtle evolution described by the children
   - the evolution of Darwin's finches
   - the evolution of the modern horse
3. As a whole group, pick two causes—one physical (e.g., climate, soil, water, air, etc.) and one living (e.g., food sources predators, competitors, etc.) —and critique the scenarios for evolution. How accurately does each scenario incorporate the fundamentals of evolution?
4. Rejoin your partner. Discuss the difference(s), if any, in the way the group modeled relatedness and a tree of life. On paper, try to create a tree of life that best portrays relatedness among the group's animals. Try to incorporate any new understandings about the evolution of the different lineages of vertebrates by placing examples on different main branches. Within these lineages, start with the two animals that you estimate to be most closely related and "work backwards," one animal at a time. Don't worry about being right—the process of creating the model is what is important. Keep track of the difficulties you have in estimating relatedness or constructing the tree.
5. Reconvene the whole group. How did the various trees of life differ from the group's original model? What were the challenges in building a tree of life? Visit the Web site for more information on building a tree of life (A Closer Look: Vertebrate Evolution; Building a Tree of Life):

   http://www.learner.org/channel/courses/essential/life/session6/

Between Sessions

Homework (* = required)

Reading Assignment*

Driver, R., et al. (1992). *Life and Living Processes.* Leeds National Curriculum Support Project, Part 2. Leeds City Council and the University of Leeds, UK.

Research Summary: Children's Ideas About Nutrition (pp. 1–4, 8–14: Food: What it is; dietary components; plant nutrition; gas exchange in plants; food chains and ecological cycles)

Research Summary: Children's Ideas About Ecosystems (pp. 1–6: Nutrition and energy flow; food chains and webs; communities, populations, and competition between organisms)

As you read:

1. Identify several children's ideas that compare to your own, represent some uncertainty to you, or are particularly prevalent among your students.
2. For each idea, form a question about the content involved and try to answer it.
3. Note what evidence you are using to support your answers.

Life Science Problem Set*

(Suggested answers are listed in the Appendix.)

1. In the video, P.J. and Michael remark that they think it's possible for a tiger and a lion to produce offspring, but not a frog and a human. What do you think their reasoning is? Think of two forms of evidence that might convince them that their ideas are inaccurate.
2. Reproductive isolation—resulting in the inability of two species to interbreed—is considered to be a condition for the evolution of new species.
   - What caused reproductive isolation in the case of Darwin's finches?
   - What are some other ways that a population might become reproductively isolated from an originating population?
   - Why does the concept of reproductive isolation break down in species that reproduce asexually?
   - What other forms of evidence might be useful to distinguish among asexually reproducing species?
3. Using DNA, human beings have been estimated to be "98% gorilla" and "97% chimpanzee."
   - What does this mean in terms of relatedness? Common ancestry? Evolution of these three life forms?
   - How would you draw the branches on a tree of life to depict the evolution of humans, gorillas, and chimpanzees?
4. Near the end of the video, Dr. Zook remarks that evolution occurs in a tree-like manner and that this contrasts with a ladder-like view, where one group of organisms replaces another. Dr. Grisham comments that there is no one species or lineage at the "top" of the tree of life and that life forms that arose earlier weren't replaced by those arising more recently. How does a tree of life demonstrate these ideas?

Between Sessions, cont'd.

Ongoing Concept Mapping*

Develop a concept map around the central concept of evolution of new species. Be sure to include variation, adaptation, natural selection, reproduction, survival, relatedness, common ancestry, and tree of life in your map. Try to make connections between this map and previous maps (i.e., to life cycles in Sessions 3 and 4; to variation in Session 5).

Guided Journal Entry

The tree of life is a model for portraying current thinking about how life on Earth has evolved. Imagine that you are in the position of explaining the tree of life to a colleague who isn't familiar with this model. How would you explain it? Create a journal entry to answer this question. For more information, visit the Web site (A Closer Look: Building a Tree of Life):

http://www.learner.org/channel/courses/essential/life/session6/

Guided Channel-TalkLife Posting

Both the National Science Education Standards and Benchmarks for Scientific Literacy propose standards or goals for understanding big ideas in evolution starting in the elementary grades. Of the ideas addressed in Session 5 (variation, genes, mutation, adaptation, natural selection, artificial selection) and Session 6 (species, evolution of new species, relatedness, common ancestry, tree of life), which do you consider appropriate to introduce at the grade level you teach? Why? Discuss this with your colleagues in your Channel-TalkLife posting for this session. Be sure to share any experiences you've had.

Textbook Reading Suggestions

- species
- evolution
- adaptation
- reproductive isolation
- Darwin's finches
- tree of life
- relatedness
- speciation
- variation
- natural selection
- selective pressure
- eohippus
- phylogenetic trees
- common ancestry

Between Sessions, cont'd.

Preparing for the Next Session*

For "Getting Ready"

In Session 7, you will begin to explore life at the level of communities. A community is a stable assemblage of populations living and interacting together in a specific habitat. Familiar communities include forests, deserts, grasslands, wetlands, ponds, and tide pools. For this session, you'll need to make a "community poster" portraying a community. You'll use this poster in Sessions 7 and 8.

To make the poster, decide upon a community. Select print specimens from the group's collection or locate new specimens that you believe represent key populations in your community—populations that are important in sustaining the community. You should include at least 8–10 specimens. Design your poster and attach the specimens in a way that helps illustrate your community.

Next, identify the links in a food chain that is four links—specimens—long. Use arrows to indicate the links.

Bring your poster to Session 7.

Materials Needed for Next Time

- Your community poster

Ongoing Activities

Bottle Biology

Continue work on your Bottle Biology system. To accompany Sessions 5 and 6, the "Field Population System" has been designed to demonstrate the fundamentals of evolution: variation, adaptation, and natural selection. What happens when an herbivore is introduced to three intermixed populations of plants? How might new species arise in this way? Check out Bottle Biology Spotlights on our Web site to see how our experiment turned out, and for more information on experimenting with your own Bottle Biology system.

Bottle Biology Spotlights: Session 6

System	Activity
Field Population System	Selective Feeding Experiment

Graduate Credit Activities

Continue your work on the annotated bibliography and action research.