Connected Experience: Evolution and the Galápagos Tortoise

GRADE LEVELS	6th-8th; California Content Standards for 7th and High School Biology
SUBJECTS	Life Sciences
DURATION	Pre-Visit: 30 minutes Academy: 15 minutes Post-Visit: 15 minutes
SETTING	Classroom; Islands of Evolution exhibit at the Academy

Objectives

Students will:

1. learn how natural selection played a role in the diversification of tortoises on the Galápagos Islands.
2. collect data on Galápagos tortoise morphology of specimens on display at the museum.
3. connect a tortoise's physical adaptations with the island habitat most likely to support it

Materials

world map or globe
tortoise and habitat visual aids, printed on paper or overhead transparencies
Galápagos Tortoises museum worksheet (one per student)
pencils and writing surfaces

Vocabulary

- adaptation: a particular structure or behavior that helps an organism survive better in its habitat
- natural selection: a process by which individuals that are better adapted to their environment are more likely to survive and reproduce than others of the same species
- evolution: the gradual change in a species over time

Teacher Background

The Galápagos Islands and their Tortoise Residents

The Galápagos Islands are an archipelago consisting of sixteen volcanic islands located 600 miles west of Ecuador in the Pacific Ocean. They formed about 4 million years ago when a series of underwater volcanoes erupted, spewing up magma that cooled to form the cone-shaped islands. When the islands first formed they were devoid of life, but over time animal and plant species colonized them, producing the ecological communities that exist there today.

Colonization of the islands took place over time by several modes of transportation. Most of the reptiles and mammals that made it there (without the help of humans) probably rafted there on pieces of driftwood or vegetation. Plant seeds may have floated there by sea, drifted in the wind, or arrived in the guts of birds that could fly there. Transportation by any of these methods was certainly difficult. Only the strongest of seabirds could have made the flight, and anything that rafted or drifted there had to survive for several weeks on the open ocean.

One example of a creature that made the journey to the Galápagos is the tortoise. Tortoises from the mainland of South America (most likely relatives of the Chaco tortoise *Geochelone chilensis*) drifted to the Galápagos Islands and colonized almost every island in the archipelago. Each island has a unique habitat because of differing climate patterns, topography (number and size of volcanoes, other terrain anomalies) and species compositions. Some islands are dry and desert-like while others have extremely wet and lush highlands. At the time of colonization, the tortoises on each island were similar. However, over time, the tortoises with traits favoring survival and reproduction on their island were selected for (natural selection) and each island's population of tortoises evolved into a new species so that fourteen species lived on fourteen different islands.

The Galápagos tortoises underwent severe population declines when humans colonized the islands. Not only were the tortoises killed for food and collected for pets and scientific specimens, but humans introduced rats, dogs, goats, and disease that all contributed to their demise. Only about 5-10% of the original population remains today. There are currently eleven different species, and they are distributed among nine islands. On a positive note, the Galápagos Islands are now a wildlife preserve and the tortoises are making a comeback.

Natural Selection as a Mechanism for Evolution

While evolution may be intimidating to some, the concept boils down to a simple truth: populations of organisms change gradually over time in response to genetic and environmental factors, such that species become differentiated from their ancestors. As a result, the diversity of life on the planet has differed throughout Earth's history. Accepted almost universally by scientists today, the idea was a novel one in the mid-19th century. Although several mechanisms for evolution exist (random mutation, genetic drift, etc.), natural selection is by far the easiest to observe. Developed by the naturalist Charles Darwin in the decades following his expeditions to the Galápagos, the process of natural selection can be broken down into the following five basic steps, easily recalled using the acronym "VISTA":

- **Variation:** Individuals in a population often have unique mixtures of traits, be it size, color, ability to ward off disease, or talent at attracting a healthy mate.
- **Inheritance:** Some of these traits are encoded in one's DNA, and therefore passed from parents to offspring.
- **Selection:** If some parents have traits that better help them survive and reproduce, their variations will be the ones passed on to future generations.
- **Time:** As generations of successful offspring are reared, advantageous traits will become more common.
- **Adaptation:** As a result of this evolution (change over time in a population), some feature of the species makes it better suited to inhabit its environment.

As you teach natural selection to your students, keep this acronym in mind. Use the sequential nature of the steps to clarify the process or reverse misconceptions. It is important to remind the students that organisms don't change or evolve during their lifetime. Evolution occurs over generations due to the inheritance of DNA passed on from parent to offspring.

Tortoise Specimens on Exhibit at the California Academy of Sciences

Island Name	Resident Tortoise
Santiago Island	Santiago Tortoise: *Geochelone darwini*
Rábida Island	Rábida Tortoise: *Geochelone wallacei*
Santa Cruz Island	Santa Cruz Tortoise: *Geochelone porteri*
Española Island	Española Tortoise: *Geochelone hoodensis*
Isabela Island, Wolf Volcano	Volcán Wolf Tortoise: *Geochelone becki*

Before Your Visit

Preparation

1. Make overhead transparencies or print copies of the visual aids, generously made available by the Manzanita Project.

Introduction

Tell your students that when they visit the California Academy of Sciences they will see an exhibit called Islands of Evolution. What comes to mind when they hear the word "evolution"? What does it mean, how does it occur, and why might islands be involved? Accept any ideas and keep a list on the board to track misconceptions. Explain that in today's activity, the class will learn about the process of evolution using some famous tortoises that live on the Galápagos. Is anyone familiar with this group of islands?

Procedure

1. Indicating the location of the Galápagos on a map, tell your students the story of how the Galápagos were formed and how various plants and animals managed to colonize the islands. Make sure students realize this did not all happen in a single day, but slowly over thousands of years.
2. Next, explain that one creature that rafted to the islands is the tortoise. Showing the picture of the Chaco tortoise from Ecuador (*Geochelone chilensis*), explain that a tortoise *similar* to this one arrived on the islands long ago.
3. Now, introduce the variety of tortoises currently inhabited the Galápagos. Link the habitat types to resident tortoises by posing questions to your students while showing the provided visuals. The pictures point out the variable characteristics that you might want to highlight.
    - ❖ Lush habitat: What are the habitat characteristics of this island? What do you think the climate is like here? (*warm, lots of plants, plenty of water*)
    - ❖ Short-necked tortoise: Using the visual aid, explain how the short-necked tortoises that live in the lush habitat eat the grass and flowers on the ground, and have a very large and dome-shaped shell.
    - ❖ Dry desert habitat: What are the habitat characteristics of this island? What do you think the climate is like here? (*dry, hot, cactus spread here and there*) Tell the students that the tortoises that live here like to eat the cactus. Point out that the cactus is high off the ground. What traits might a local tortoise have? (*a long neck*)

- ❖ Long-neck tortoise: What traits of the tortoise are different? (*the long neck and saddleback shape of the shell*) Look at the habitat photo again. Point out that the tortoises eat the cactus that is high off the ground, and so their necks evolved to be able to reach the food. Why might their shell shape have changed? (*it helps their necks reach even higher*)

4. Explain that these are two types of tortoises that live here, but there are now eleven different species! All of these species are 1) short-necked and dome-shelled, 2) long-necked and saddle-back shaped, or 3) somewhere in between.
5. Return to the photo of the Chaco tortoise. Lead a discussion about the differences between the Chaco tortoise and the tortoises that live on the islands presently.
   - ❖ How are the tortoises different?
   - ❖ Why have they changed?
   - ❖ Did this happen during a tortoise's lifetime, or several generations?

Wrap-Up

Tell the class that at the California Academy of Sciences, they will see specimens of Galápagos tortoises collected by Academy scientists way back in 1906!

At the Academy

Preparation

1. Make a copy of the museum worksheet for each student.
2. Have students bring a pencil and a hard surface.

Procedure

1. Find the display of tortoise specimens at the entrance to the Islands of Evolution exhibit.
2. Have students study the characteristics of the specimens. Using this observable evidence – and the information they learned in class about the islands and the shapes of the tortoises that live there – have students predict what the habitat might be like on the native islands of the species highlighted on the worksheet.
3. Encourage students to spend at least 10 minutes writing conclusions. Then, they should head off to find one more family of animals from the Galápagos that seems to have branched into a similarly diverse group!

Back in the Classroom

Procedure

1. Have students reflect on their trip by reviewing the worksheets, prompting them to provide explanations for their conclusions based on observable evidence.
2. By questioning students, review how any one form of tortoise become the most common on any particular island. (*The tortoises that have the most fitting traits for their island's habitat will be more likely to survive and reproduce. For example, the tortoises with longer necks on the island with food that is high off the ground are more likely to survive and reproduce than the short-necked tortoises. The traits for neck length were passed on to offspring over countless generations.*

Because of natural selection acting over thousands if not millions of years, the tortoises evolved. Today each island has a distinct species of tortoise that looks and functions differently from the other species.)

3. Have students share any discoveries of other famous Galápagos families. (*finches and mockingbirds are examples.*)

Extensions

Read more about Charles Darwin's trip to the Galápagos. Explain how he noticed that organisms looked different depending on the habitat that they lived in and, based on those observations, wrote the theory of natural selection. Present a slide show of the different finches in the Galápagos. Explain that some finches have big bulky beaks to crack big seeds and nuts, some finches have long slender beaks to eat insects, etc. Discuss how this is similar and different from the tortoise situation, and be sure to reinforce the VISTA steps.

Resources

Galápagos Conservation Trust. (2008). "Galápagos Giant Tortoise." Retrieved July 28, 2008, from http://www.gct.org/tortoise.html.

American Museum of Natural History. (2005). "Darwin." Retrieved August 8, 2008, from http://www.amnh.org/exhibitions/darwin/.

References

Caccone, A, et al. (1999). Origin and evolutionary relationships of giant Galápagos tortoises. *Proceedings of the National Academy of Sciences*. Vol. 96, 23:13223-13228.

American Museum of Natural History. "Galápagos Giant Tortoise." Retrieved July 18, 2008, from http://www.amnh.org/nationalcenter/Endangered/tortoise/tortoise.html.

Correlated California Content Standards

Grade Seven

Life Sciences

3a. Students know both genetic variation and environmental factors are causes of evolution and diversity of organisms.

3b. Students know the reasoning used by Charles Darwin in reaching his conclusion that natural selection is the mechanism of evolution.

3e. Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

Grades Nine through Twelve

Biology/Life Sciences

8a. Students know how natural selection determines the differential survival of groups of organisms.

8b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.

8d. Students know reproductive or geographic isolation affects speciation.