Hellbender Education

LESSON PLAN 2: SPECIATION AND DIVERSITY IN APPALACHIA

MIDDLE SCHOOL STANDARDS ADDRESSED (BY STATE):

NGSS (Kentucky, Maryland)	**MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** ***Clarification Statement:*** Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. ***Disciplinary Core Ideas:*** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources. **MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.** ***Clarification Statement:*** Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations. ***Disciplinary Core Ideas:*** • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(secondary)* • (ETS1.B) There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary)*
Pennsylvania	**4.5.7.D. Explain how biological diversity relates to the viability of ecosystems.** • Compare and contrast monoculture with diverse ecosystems. • Explain how biological diversity relates to the ability of an ecosystem to adapt to change. • Explain how an adaptation is an inherited, structure, function, or behavior that helps an organism survive and reproduce.

	4.2.7.C.: Use appropriate tools and techniques to analyze a freshwater environment. ● Interpret physical, chemical, and biological data as a means of assessing the environmental quality of a freshwater environment. **4.2.8.C.: Describe how a diversity index is used to assess water quality.**
West Virginia	**S.6.LS.7: Students will construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** **S.8.LS.2: Students will construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.**
Virginia	**LS.9: The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include** a) differences between ecosystems and biomes; b) characteristics of land, marine, and freshwater ecosystems; and c) adaptations that enable organisms to survive within a specific ecosystem.
North Carolina	**6.L.2: Understand the flow of energy through ecosystems and the responses of populations to the biotic and abiotic factors in their environment.** ● 6.L.2.1: Summarize how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred within food chains and food webs (terrestrial and aquatic) from producers to consumers to decomposers.
Tennessee	**6.LS4: Biological Change: Unity and Diversity** 1. Explain how changes in biodiversity would impact ecosystem stability and natural resources. 2. Design a possible solution for maintaining biodiversity of ecosystems while still providing necessary human resources without disrupting environmental equilibrium. **8.LS4: Biological Change: Unity and Diversity** 1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change in life forms throughout Earth's history. 2. Construct an explanation addressing similarities and differences of the anatomical structures and genetic information between extinct and extant organisms using evidence of common ancestry and patterns between taxa. 4. Develop a scientific explanation of how natural selection plays a role in determining the survival of a species in a changing environment.

HIGH SCHOOL STANDARDS ADDRESSED (BY STATE):

NGSS (Kentucky, Maryland)	**HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** ***Clarification Statement:*** Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. ***Disciplinary Core Ideas:*** ● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. ● A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. **HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** ***Clarification Statement:*** Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species. ***Disciplinary Core Ideas:*** ● Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. ● Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)* ● Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary)*

	● (ETS1.B) When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*
Pennsylvania	**4.1.12.A.: Analyze the significance of biological diversity in an ecosystem.** • Explain how species adapt to limiting factors in an ecosystem. • Analyze the differences between natural causes and human causes of extinction. • Research wildlife management laws and their effects on biodiversity. **4.5.10.D: Research practices that impact biodiversity in specific ecosystems.** ● Analyze the relationship between habitat changes to plant and animal population fluctuations.
West Virginia	**S.10.LS.11: Students will use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** **S.10.LS.13: Students will design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** **S.10.LS.15: Students will create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.** **S.HS.ENV.10: Students will analyze biological diversity as it relates to the stability of an ecosystem.**
Virginia	**BIO.7 The student will investigate and understand how populations change through time. Key concepts include** a) evidence found in fossil records; b) how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations; c) how natural selection leads to adaptations; d) emergence of new species; and e) scientific evidence and explanations for biological evolution.
North Carolina	**Bio.2.1: Analyze the interdependence of living organisms within their environments.** • Bio.2.1.2: Analyze the survival and reproductive success of organisms in terms of behavioral, structural, and reproductive adaptations.
Tennessee	**BIO2.LS2: Ecosystems: Interactions, Energy, and Dynamics**

	1. Plan and carry out an ethology investigation of a simple organism. Gather, analyze, and present data in tabular and graphical formats. Draw conclusions based on data and communicate findings.

STUDENT OBJECTIVE: Students will:

a) Recognize the unique features of Appalachia that make it a global species-diversity hotspot for salamanders.
b) Evaluate several different stressors faced by salamander populations in Appalachia.
c) Understand how speciation can occur through geographic isolation.
d) Differentiate between different methods for measuring species diversity.

LESSON OVERVIEW:

Time	Instructional Sequence	Activity Summary
15 min	Engage	*You Live in the Salamander Capital of the World* video/article (Blue Ridge Outdoors)
20 min	Explore	Speciation Activity
20 min	Explain	*What is a species?* Video (*University of Utah Learn.Genetics)* Teacher PowerPoint: Sky Islands in the Blue Ridge - Speciation and Hellbender Taxonomy
40+ min	Elaborate	**Middle School:** Species Richness and Species Evenness **High School:** Simpson's Index Activity **Extension:** Stream Organism Project
5 min	Evaluate	Exit Ticket: Speciation

LESSON STEP 1: ENGAGE

Objective: Introduce students to Appalachian salamander diversity and conservation.

Materials:

- *You Live in the Salamander Capital of the World* video
- *You Live in the Salamander Capital of the World* handout (article, vocabulary and student questions)

Sequence:

1. Students will watch the video and/or read the article about Appalachian salamander diversity and conservation.
2. *Optional*: Teacher can review "Key Vocabulary" from student handout.
3. Students should answer questions on their handout after watching/reading.
4. *Optional*: Teacher can lead a short class discussion about the "What About You?" question from the handout (asking students to share experiences with Appalachian salamanders that they may have had in the past).
5. *Optional:* Teacher can also provide students with their state list of salamanders as a way to relate to local species.

LESSON STEP 2: EXPLORE

Objective: Students will understand how geographic isolation results in speciation.

Materials:

- Speciation Activity student handout

- For a class of 24:
  - 24 pennies
  - 24 pipe cleaners
  - 6 large opaque bowls or containers
  - About 1000 small plastic craft beads (as many different colors as possible)
  - Colored pencils, markers, or crayons

Sequence:

1. Before class starts:
   - Set up 2 large main stations around which 12 students can gather.
   - Set up 4 small "satellite" stations around which 2 students can gather.
   - At each of the 2 large stations, place one of the bowls or containers, and fill it with ¼ of the beads, with as many colors as possible.
   - At the smaller stations, place the other 4 bowls, and fill the containers with beads of only 2 colors per station (for example, one small station will only have orange and blue beads, while another will have only green and white beads).
2. At the start of the activity:
   - Each student receives one penny and one pipe cleaner.
   - 12 students start at one of the two large stations, and the other 12 start at the other large station.
   - The teacher should go over the instructions for the game with the class (on the student activity handout) prior to starting the activity.
3. During the activity, the teacher should circulate throughout the 2 large groups, and then throughout the smaller breakout groups, to ensure that students are following activity guidelines.
4. Once the activity is over, the teacher should facilitate a class discussion as students answer the questions on their student handouts.

LESSON STEP 3: EXPLAIN

Objective: Students will

a) Understand that species are defined differently, and the species we have identified today represent a "snapshot" of the process of speciation.
b) Be able to explain the "sky islands" concept and how it relates to salamander diversity in Appalachia.
c) Understand the taxonomic relationship between hellbenders and other vertebrates/amphibians.

Materials:

- *What is a Species?* video (University of Utah, Learn.Genetics)
- Student Notes Sheet
- Teacher PowerPoint: Sky Islands in the Blue Ridge – Speciation and Hellbender Taxonomy

Sequence:

1. Teacher begins powerpoint and discusses the pictures of the eastern red-spotted newt, and then the cat and the dog.
2. Teacher shows the What is a Species? Video
3. Students summarize 3 key points from the video, and teacher facilitates class discussion by asking for students to volunteer their responses.
4. Teacher proceeds through remaining slides as students fill in slot notes on their notes sheet.

LESSON STEP 4: ELABORATE

Objective: Students will calculate species richness and evenness of two different communities. (HS): Students will calculate Simpson's Diversity Index to compare biodiversity in two different communities.

Materials:

- Diversity Lab student handout
- Diversity Lab materials
    - 12-flavor gummy bears, randomly sorted into Ziploc bags
    - Calculator (HS)

LESSON STEP 5: EVALUATE

Objective: Students will demonstrate their understanding of speciation and species diversity by completing an **Exit Ticket**.

Materials:

- Paper and pencil
- 3 Exit ticket folders ("Got it!"; "I Think I'm Close"; "I Need Some Help!")

Sequence:

- Teacher asks students to write their name, the most important thing they learned during the lesson, and any lingering questions on a sheet of paper.
- Students submit the "ticket" to the folder that best represents their understanding of the lesson's content.