General Lesson Information

Title: **Freshwater mussel biodiversity: How do different species fit together in a river to improve environmental health?**

Overview/Annotation- *A short summary or description of the lesson including activities and science concepts.*
The southeast USA has the highest diversity of freshwater animals in North America. One of these taxonomic groups, the freshwater mussels, plays a critical role in our river ecosystems through their filter-feeding. Alabama hosts 180 species of freshwater mussels. How can so many species co-exist and how is this diversity important for a healthy ecosystem?

In this lesson, students will learn about the astounding diversity of freshwater mussels and their incredible life history. After an introduction to this diversity, students will be presented with 3D models of mussels and information on their traits and how they impact water quality. Students will play a game to match the mussels to their habitats and learn about how mussels clean their water. They will apply this knowledge to how biodiversity may impact water quality. The students will have the option to draw a diagram highlighting how mussels interact with their environment.

Keywords: Freshwater mussels, biodiversity, animals, aquatic ecology, organisms, ecosystem, form and function, adaption,

Setting or format (outdoors, in groups, lab, etc.): Indoors
Intended group size (if groups are used): Multiple groups of 2-4

Intended grade level(s): 6-8th (Middle School)

Approximate Time of Lesson (*Ideally break down into 20-50 minute periods*):
50 minutes (could likely be modified for shorter units)

Researcher Biography

Name & Professional Title: Dr Carla Atkinson, Dr Jeff Lozier

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Brief Description of Research Interests:
Carla: My lab is interested in patterns and processes in aquatic ecosystems. Through our work, we contribute to the understanding of freshwater ecological systems and the interaction and feedbacks between the surrounding terrestrial landscape. We are particularly interested in how species traits, especially stoichiometric traits and thermal preferences, influence structure and function within aquatic systems. To do this, we employ combinations of field observational and mesocosm studies to understand how body stoichiometry, trophic ecology, threshold elemental ratios, and growth efficiencies respond under various conditions and state of physiological distress. Furthermore, we study how these organismal rates link to community- and ecosystem-level processes. The research is strongly oriented towards the advancement of both basic scientific understanding as well as better conservation prioritization of biodiversity and the ecosystems.

Jeff: The Lozier lab uses molecular data to address basic and applied questions about evolution and ecology in wild populations, with topics ranging from conservation of bumble bees, genetics of biological invasions, speciation, and the origins of phenotypic diversity. Our work investigates the role of spatial and abiotic variation in structuring neutral and adaptive genetic variation across species ranges, and linking genetic variation to phenotypic variation to obtain a complete picture of adaptation. We are particularly interested in applying genomic tools to investigate phylogeography, adaptation to challenging environments, and ways to predict the future effects of habitat fragmentation. Much of this work involves exploring methods to generate large numbers of genetic markers from high-throughput sequencing to enable strong inferences about evolutionary patterns in wild populations.

https://alex.state.al.us/standardAll.php?grade=7&subject=SC2015&ccode=LSC7&summary=2

Associated Standards and Objectives

Content Standards- *List Alabama Course of Study Standards that connect to lesson*

Grade 7 standards targeted by this lesson plan

6) Analyze and interpret data to provide evidence regarding how resource availability impacts individual organisms as well as populations of organisms within an ecosystem.

7) Use empirical evidence from patterns and data to demonstrate how changes to physical or biological components of an ecosystem (e.g., deforestation, succession, drought, fire, disease, human activities, invasive species) can lead to shifts in populations.

9) Engage in argument to defend the effectiveness of a design solution that maintains biodiversity and ecosystem services (e.g., using scientific, economic, and social considerations regarding purifying water, recycling nutrients, preventing soil erosion).

11) Analyze and interpret data to predict how environmental conditions (e.g., weather, availability of nutrients, location) and genetic factors (e.g., selective breeding of cattle or crops) influence the growth of organisms (e.g., drought decreasing plant growth, adequate supply of nutrients for maintaining normal plant growth, identical plant seeds growing at different rates in different weather conditions, fish growing larger in large ponds than in small ponds).

Related Alabama Alternate Achievement Standards

SCI.AAS.7.5- Distinguish between abiotic and biotic parts of an ecosystem.

SCI.AAS.7.6- Use data as evidence that the availability of natural resources (e.g., food, light, water) influences the growth of organisms

SCI.AAS.7.9- Identify human behaviors that are harmful to the environment; compare the effectiveness of various solutions to these problems (e.g. recycling, preventing soil erosion, organic gardening).

SCI.AAS.7.18- Recognize that healthy specimens of organisms live longer and reproduce in larger numbers than unhealthy specimens; recognize that natural selection may lead to the successful survival of a population by supporting certain traits and suppressing others.

Related NAEP Statements

L8.5a: All animals, including humans, are consumers that meet their energy needs by eating other organisms or their products.

L8.5b: Consumers break down the structures of the organisms they eat to make the materials they need to grow and function.

L8.7: The number of organisms and populations an ecosystem can support depends on the biotic resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.

L8.8a: All organisms cause changes in the environment where they live.

L8.10a: For some characteristics, inheritance is more important; for other characteristics, interactions with the environment are more important.

L8.10b: The characteristics of organisms are influenced by heredity and environment.

L8.11a: Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring.
L8.11b: When an environment changes, the advantage or disadvantage of characteristics can change.
L8.11c: Extinction of a species occurs when the environment changes and the characteristics of a species are insufficient to allow survival.

Primary Learning Objectives- *Sentences beginning with "Students will be able to…" that describe what students will do in the lesson that relates to how students will be assessed.*

- Students will understand that the southeast USA is a biodiversity hotspot, especially for aquatic organisms
- Students will be able to understand how biodiversity is maintained and contributes to ecosystem services.
- Students will learn what a mussel is and why they are important
- Students will that different animal species have different characteristics
- Students will be able to describe the idea that different characteristics are adaptive and can increase their chances of surviving and reproducing in particular habitats.
- Students will learn that environmental variation partly determines what organisms can survive and reproduce in a particular place
- Students will be able to understand linkages between biodiversity, trait diversity, and ecological functions (e.g., filter-feeding = clean water)

Knowledge:
Students know:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living (biotic) things and with nonliving (abiotic) things.
- The completeness of the biodiversity of an ecosystem is often used as a measure of health.
- Changes in biodiversity can influence humans' resources and ecosystem services.
- Growth of organisms and population increases are limited by access to resources.
- Changes in the growth of organisms can occur as specific environmental and genetic factors change.
- Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- Changes in the physical or biological components of an ecosystem (e.g., rainfall, species introduction) can lead to changes in populations of species. Evidence about performance of the given design solution. Biodiversity describes the variety of species found in the earth's ecosystems.

Skills:
Students are able to:

- Organize the given data to allow for analysis and interpretation of relationships between resource availability and organisms in an ecosystem.

- Determine whether the relationships provide evidence of a causal link between factors.
- Interpret the organized data to make predictions based on evidence of causal relationships between resource availability, organisms, and organism populations.
- Organize given data on how both environmental and genetic factors influence the growth of organisms to allow for analysis and interpretation.Demonstrate the scientific idea that changes to physical or biological components of an ecosystem can affect the populations living there.
- Identify and describe the given evidence needed to demonstrate the scientific idea that changes to physical or biological components of an ecosystem can affect the populations living there.
- Evaluate the given evidence, identifying the necessary and sufficient evidence for supporting the scientific idea.
- Use reasoning to connect the evidence and support an explanation using patterns in the evidence to predict the causal relationship between physical and biological components of an ecosystem and changes in organism populations.
- Analyze the data to identify possible causal relationships between environmental and genetic factors and the growth of organisms.
- Interpret patterns observed from the data to provide causal accounts for events and make predictions for events by constructing explanations.

Teacher Vocabulary:

- Evidence
- Scientific Reasoning
- Biodiversity
- Population
- Ecosystem
- Ecosystem service
- Trait
- Evolution
- Adaptation
- Natural Selection
- Specialization
- Variation
- Probability
- Constraint
- Recycling nutrients
- Water Purification

Additional Learning Objectives- *Any learning outcomes that are not directly related to the content standards but may relate to other local or national standards*

Students will learn about their local biodiversity by focusing on freshwater mussels

They will learn about the bizarre, but fascinating life histories of these animals.

Preparation Information

Total Duration- *How many minutes will the lesson last?*
Total activity should last ~50 minutes. 15 minute brainstorming discussion about diversity and introductory presentation. 5 minutes of game introduction. 15 minutes of playing the game. 5 minutes to tabulate results. 10 minutes of discussion of student results and what diversity contributes.

Materials and Resources- *List of materials teacher will need to gather or prepare for lesson*
Teachers will need access to the game pieces and playing boards for each group.

Technology Resources Needed- Computer and a projector

Background and Preparation- The teacher should be familiar with basic biological concepts scaling from individuals to ecosystems. Biodiversity describes the number of species within a given area and Alabama hosts the highest biodiversity of freshwater animals in North America.

Procedures and Activities

Step-by-step description of lesson that would allow another teacher to successfully complete the lesson (suggest possible reflection or comprehension questions along with examples of correct answers or common misconceptions)

Engagement (sparking interest, introducing phenomenon, engage students' everyday experiences)

The first activity will include brainstorming about where the highest amount of species is found in the USA.

After brainstorming, the instructor will start a PowerPoint that shows that Alabama has the highest diversity of freshwater mussels, fish, crayfish, etc, introduces the distinction of freshwater organisms and what "ecosystem services" are. The powerpoint slides will have basic statistics (i.e., patterns of diversity) and show pictures of different mussels and different kinds of rivers and habitat in which species occur, and diagrams/videos of interesting mussel behaviors (e.g., videos of mussels using fish hosts to move around).

Highlight that despite a "generally similar appearance", different mussels actually do different things (have different traits) so they can co-exist in different parts of the ecosystem (the niche). The teacher can ask students to also speak up about what features/differences they see in the pictures on the slides. Discuss how different features may allow different individuals of various to fit into different parts of the river together

Main activity (suggest possible reflection or comprehension questions along with examples of correct answers or common misconceptions)

Game playing: Where do they live (habitats)?
The main activity will center on a game that utilizes a game board for each group, different mussel models (3D printed from real mussels) game pieces, fact cards about each mussel type, and environment cards that the students use to select which mussel best fits a particular environment. The students will attempt to accumulate a diverse set of mussel models on their game board by getting challenges correct. At the end of the game the students will use provided data on mussel "filtering" traits to calculate a "river health" metric based on their assembled community: students with more diversity will have "cleaner water".

More specifically, students are given a "fact sheet" for the mussel models that outline the different traits and habitat preferences for each different model type and a "river map" with different spots ("niches") to put each mussel model type, with the goal of accumulating models to fill the available niche spaces. Environment cards are used to challenge the student to choose the model with traits that best "fit" to the particular stress/challenge/habitat, and students will gain or lose mussels based on whether they choose the right model/species. If a student gets a challenge correct, they can select another model from a source pool to fill another spot on their map. At the end of the exercise

students will tally up the number of mussels of each type, and using the filtering traits, can get an assessment of their river's water quality (illustrating "ecosystem services" from biodiversity).

Wrap up and Reflection (wrap up activity, reflecting on learning, informal assessments of student learning)

- Let the students try to explain first how Biodiversity = insurance for the healthy functioning of ecosystems = Ecosystem Services. Mussels are important for river ecosystems because they clean the water, but different species filter different components and filter more efficiently at different temperatures.
- Show the class a Youtube time lapse video of mussel filter-feeding: https://www.youtube.com/watch?v=vrEyHo3SuZI
- Ask the students to predict what happens to the ecosystem when species are lost? They will discuss what types of interactions they see and have while at school and try to use the vocabulary to the best of their ability in their story. This will be with or without the vocabulary sheet dependent on how the students are doing earlier in the lesson.

Final product/Summative evaluation (e.g. quiz, presentation, essay, etc., may occur during a later class period)

We will evaluate the students' understanding by asking them basic vocabulary after the lesson. Additionally, student will be asked to draw a conceptual diagram showing how a mussel or mussels interact with the environment. Run them through the Mighty mussel website as an example.

Bonus: Matching quiz to evaluate if the students understood the concepts and vocabulary that were highlighted in this lesson plan.

Attachments- *Any materials for the lesson such as video links, worksheets, etc., listed here*

Mussel filter-feeding: https://www.youtube.com/watch?v=vrEyHo3SuZI

Interactive website on ecosystem interactions: http://mightymussel.com/