Adaptation and Climate Change

ND EPSCoR Lesson Plan

Lesson Title: Adaptation and Climate Change

Lesson Overview:
The lesson will introduce students to the evolutionary mechanisms underlying adaptation to climate (natural selection, gene-flow, drift, and mutation). Following this lesson students will be able to answer the question: how do organisms adapt to environmental change? and make linkages between genotypic and phenotypic variation. The lesson will include two group activities and one hands-on activity.

Topic(s): Adaptations, climate change, genetics, evolutionary change

Grade or Grade Band: 6-8

Lesson Objectives:
Students will:

- Identify plant traits that may have evolved to adapt and persist within their native environment.
- Describe how random allele combinations result in different phenotypes.
- Extract DNA and tie together genetics, adaptations, environment and species success or decline.
- Calculate change in allele frequencies and associated phenotypic variation across generations in response to natural selection and genetic drift simulations.

National Next Gen Standards:

- **MS-LS4-4:** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
- **MS-LS4-6**: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

North Dakota Standards:

- **MS-LS4-4:** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
- **MS-LS4-6**: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Time Needed (estimate) Three 50-minute class periods

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Dr. Brittany D. Hagen is an Associate Professor of Education and CAEP Accreditation Coordinator at Mayville State University in Mayville, ND. Dr. Hagen teaches courses related to foundations of education, educational technology, educational assessment, and elementary methods. Additionally, she has developed both online and classroom curriculums for a variety of age groups, including teach-the-teacher programs, assessment data

modules, and high school aviation facilitator guides and interactive student activities. Dr. Hagen is also a proud Mayville State alumnus, dedicated to developing highly effective teachers who share a passion for educating young learners.

Scientist/K12 Collaborator & University: Pamela Puppo & Jill Hamilton

Scientist Bio/Research:
Jill Hamilton (NDSU): The Hamilton Lab broadly focuses on understanding the mechanisms that contribute to local adaptation within natural and managed plant populations. Research in the Hamilton lab broadly aims to understand the factors influencing the distribution of genetic variation across species' ranges in both natural and managed plant populations, focusing on those mechanisms that contribute to local adaptation. We take an interdisciplinary approach to these challenges; combining population and landscape genomics with experimental quantitative and functional genomics. Our goal is to understand how genetic and environmental variation influence the expression of complex traits important to adaptation. Through this work we aim to increase our predictive power regarding the adaptive potential of populations for species management under climate change.

Pam Puppo: My name is Pam and I currently work as Assistant Professor of Botany at Marshall University in West Virginia. I used to work as a researcher at North Dakota State University in Fargo when I co-developed this lesson. I am Latino, I grew up in Peru, then moved to the US to study, lived in Missouri for a couple of years, and then moved to Europe where I lived for ten years. I came back to the US a couple of years ago. I always knew I wanted to be a biologist though by the time I graduated from high-school I was torn between science and art. I decided to get a degree in Biology and keep the arts as a hobby, until I took my first Botany class at the university and fell in love with plants. I realized I could also draw the different features of plants, merging my passion for arts with science. I love looking at plants with a magnifying lens and see a world of details, colors, spots, hairs, and so many incredible things that can't be seen with the naked eye. I have traveled to many different countries for collecting and studying plants, I have lived in different continents while studying, and have learned different languages. As a Professor I teach about the fascinating things we can find in nature, I focus on plants, but I also teach Introduction to Biology, Evolution, Ecology and other classes. As to research, I study how different species of plants form in different places like the Andes of Peru and the Canary Islands in the Atlantic Ocean, I have discovered many new species of plants that were not known before, I study how genes help us to differentiate among species, and more recently I have started studying the different plants bees use for feeding their young and constructing their nests.

Preparation/Materials

Background knowledge students must have to be successful

- Students need to know the difference between weather and climate; weather is from day to day/ hour to hour and climate is the overall average weather patterns for an area.
- Students need to know that different climates have different species that live there.
- Students need to know that DNA is the backbone of life containing all of its information changes in it can possibly lead to changes in organisms both good and bad. Accumulation of these changes can lead to evolution and creation of new species.
- Students need to know climate can play a role in which animals have the traits to survive and which ones do not.

Differentiation and accommodation to support learning for all students:
When designing any lesson, it is important to address the needs of all learners. Please refer to the following resource for ideas on how to adjust your lesson to accommodate your students' particular learning needs: https://www.understood.org/en/learning-thinking-differences/treatments-approaches/educational-strategies/common-classroom-accommodations-and-modifications

Essential Terminology

- **Traits**: genetically determined characteristics
- **DNA**: short for deoxyribonucleic acid; the material that carries all the information about living things look and function
- **Mutation:** change in base order of DNA
- **Genotype**: genetic makeup of an organism
- **Phenotype**: observable characteristics of an individual resulting from the interaction of its genotype with the environment.
- **Adaptation:** the process by which a species becomes fit for its environment. Occurs due to natural selection's influencing heritable genetics over several generations.
- **Allele:** variant of a gene
- **Natural Selection:** organism with desirable traits for an environment will survive passing down those traits
- **Gene-Flow:** the introduction of genes from one population to another, thereby changing the composition of the gene pool.
- **Genetic Drift:** a change in the gene pool of a small population that happens by chance

Resources

- Optional: Explore Learning- Gizmo- has a couple great natural selection due to environment lab simulations. Could be done to introduce the topic, extension, or even a modification for students as the lab can be modified (https://www.explorelearning.com/)
- Pepper moth case study and game (https://askabiologist.asu.edu/peppered-moths-game/natural-selection.html)

Websites:

- https://www.explorelearning.com/
- https://askabiologist.asu.edu/peppered-moths-game/natural-selection.html
- https://courses.lumenlearning.com/boundless-biology/chapter/population-genetics/
- https://www.ndepscor.ndus.edu/ndep/nature/sunday-academy/stem-module-topics/

Materials needed:

- Computer
- Activity cards on index cards
- PowerPoint projector
- M&Ms or similar colored candy
- Ziploc bags
- Immersion blender
- Knives
- Plastic Cup
- Paper towels
- Paper clip
- Spoon
- Ice
- ½ onion
- 2 tbsp. dish detergent
- 1 tsp. salt
- ½ cup of water
- 1 coffee filter
- ¼ cup Ice-cold alcohol
- PowerPoint – found as separate attachment

Procedure/Activities

Lesson 1: Defining Adaptations (50 minutes)

Engage:

1. To introduce students to the topic of adaptations consider beginning with one of the following Gizmo lessons: Natural Selection Gizmo, Evolution: Mutation and Selection Gizmo, Rainfall and Bird Beaks. These activities can be found on the Gizmos website: https://www.explorelearning.com/. Another option is pepper moth case study and game found at: https://askabiologist.asu.edu/peppered-moths-game/natural-selection.html. The options lessons can be used as an extension activity or even modified to students who need extra practice or support on the topic. The following lessons are designed to stand alone without students having experienced the Gizmo activities or pepper moth case study.
2. To engage students, ask them the following question: What is an adaptation? Allow time for them to discuss with a partner and share their ideas with the class. Consider jotting their ideas down on the board.
3. Then, display PPT Slide 2 and see how many similarities can be found between the definition on PPT Slide 2 and the definition students came up with that is written on the board.

Explore:

4. Display PPT Slide 3 and lead a discussion about how plants adapt to their environment. Explain that different plants have developed a set of characteristics that allow them to live in different environments.
5. Display PPT Slides 4 and 5 to explore an example of how cacti adapt to their environment. Explain that cactus have spines instead of leaves, open the stomata at night (to avoid losing too much water), accumulate water in the stems, and stems have ridges to expand.

Explain:

6. Split the class into small groups of two or three students. The Activity 1 document has a list of 15 example plants that can be assigned to students. The document titled “Adaptation Activity Cards” also lists each of the plants. Cut up the cards and hand one to each group to assign them a specific plant.
7. Review the Activity 1: Phenotype to Environment directions with students. Page 1 of the document can be shared with students. The remaining pages can be used by the teacher to assign different plants to students. The teacher can also use the information found on the remaining pages to assist the students in their research.
8. In this activity, students will research and learn about a particular type of plant and answer the following questions:
    a. Does this plant have a ‘common name’?
    b. Is this plant used by Native American communities? How?
    c. Is it an herb, bush, tree? How does it reproduce?
    d. What is its distribution and habitat preferences?
9. Students will also create a three-slide PowerPoint to display their findings, a picture, and make a hypothesis about what type of stresses the plant might experience.

Extension of learning more about this topic:

10. Allow time for students to work on their presentations. This will take the remaining time of this lesson and perhaps another class session. The teacher should plan according to what works best for their students and their schedule.

Evaluation

11. When it's time for students to share, allow them time to present their findings to their peers. The students who are watching the presentation will complete the Phenotype to Environment Graphic Organizer that accompanies this lesson. The graphic organizer will allow students the opportunity to be actively engaged in their peers' presentations as they record essential information related to plants and their adaptations. Consider collecting the graphic organizers for points or it could also be used simply as an active processing activity.

Lesson 2: Allele Frequency Game (50 minutes)

Engage:

1. Create new index cards that list each of the plants that were presented by students in the last lesson. Display and read the scientific names of the plants aloud. Ask students (who didn't present on that plant) to identify the common name of the plant listed. See if students can remember any facts shared about the plants. This activity will help students review plant adaptations.

Explore:

2. Review the term "adaptation" and its definition. Display PPT Slide 7 to remind students there are several mechanisms involved in the process of adaptation including: natural selection, gene flow, and genetic drift. All of these are mechanisms of evolutionary change.
3. Have students do a brief search on the computer or their phones to find examples of natural selection, gene flow, and genetic drift. Allow time for students to share what they found.

Explain:

4. Use PPT Slides 8 and 9 and corresponding visuals to explain the process of natural selection. The genes responsible for the particular characteristic are passed along the next generation, making the new generation better adapted to the environment
5. Use PPT Slides 10 and 11 to explain the importance of diversity for natural selection. More information on this topic can be found at: https://courses.lumenlearning.com/boundless-biology/chapter/population-genetics/
6. Use PPT Slides 12-15 to explain the movement of an individual (and the genetic material they carry) from one population to the other. Also explain that if different genes are transported, it can be a source of genetic variation
7. Use PPT Slides 16- 19 to explain genetic drift and how changes in the gene pool happen by chance.
8. Further adaptation discussions can be explained using PPT Slide 20. Ask students "how is this genetic variation generated?"
9. Review mutation vocabulary found on PPT Slides 21-22 using the words and visuals. Explain that all DNA is made with only four "building blocks" called nucleotides: ACGT: adenine, cytosine, guanine, and thymine. Mutation is a change in DNA and are random**.** Also review allele, traits, phenotype, and genotype vocabulary when introducing PPT Slides 21-22.
10. Finally, review PPT Slides 23-25 to introduce genes vs. phenotypes.

Extension of learning more about this topic:

11. To extend the learning, introduce Activity 2: Allele Frequency Game using PPT Slide 26 and the Activity 2 document that accompanies this lesson. Pages 1-3 of the Activity 2 document can be shared with students while pages 4-5 are reference for the teacher (answer key). Use PPT Slide 27 to record the group's results.

Evaluation

12. Lead a class discussion based on the results of the Allele Frequency Game. Review PPT Slide 28 and compare to the results students found in the game. To evaluate learning, review the correct responses to the questions found in the Activity 2 document (pages 4-5).

Lesson 3: Climate Change (50 minutes)

Engage:

1. To engage students in the lesson and activate prior knowledge review the vocabulary from the previous lesson. List the following vocabulary words on the board: traits, DNA, mutation, genotype, phenotype, adaptation, allele, natural selection, gene flow, and genetic drift.
2. Assign point totals to each word and allow groups of students to state the definition of each word. Consider keeping track of point totals and provide a small reward (extra credit points, suckers, etc.) to the winning team.

Explore:

3. Once students have reviewed vocabulary, make sure to emphasize the definition of DNA. Make the point that DNA is where mutations occur and it is what leads to changes in organisms thus adaptations/evolution.
4. Break students into small groups. Hand each student an onion. Ask, "how can you extract DNA from this onion?" Allow time for student responses.

Explain:

5. Use PPT Slide 30 to share a few fun facts about DNA with students.
6. Then, use PPT Slide 31 and Activity 3: DNA Extraction to guide students through the DNA Extraction lab. The materials list and step-by-step directions are found on page 1.

Extension of learning more about this topic:

7. To extend the lesson, ask students the following question, found on PPT Slide 32: Compare your DNA extraction with groups that have extracted a different variety of onion. Do you see any differences? Why or why not? Answer: The students will not see any differences between the DNAs. They must conclude that the DNA molecule is the same for the different onions and thus common to all living organisms.
8. Another extension of the adaptations lesson can be related to adaptations in landscape and climate. Explain to students that we have all heard about climate change, but what is it? Climate has been changing for millions of years. Explain the graph on PPT Slide 33.
9. Display PPT Slide 34. Explain that since the industrial revolution (around 1950), when humans started burning fuels and producing in mass, the climate has changed faster than ever before. Ask students, how does this relate to the vocabulary term: natural selection?

Evaluation

10. To evaluate student learning, ask students to reflect on activity 1 and the research they presented. The hypothesis they were asked to make was to guess what type of stresses might plants experience in a rapidly changing environment (found in the red box on PPT Slide 35). Discuss students' hypotheses and ask them what they have learned from the last three lessons.
11. To wrap up the lesson display PPT Slides 36 and 37 and highlight the key concepts students should have learned as a result of the lesson.

Additional Lesson Resources / Materials

References:

Puppo, P. and Hamilton, J. “Adaptation and Climate Change”. Web. 16 July 2020. https://www.ndepscor.ndus.edu/ndep/nature/sunday-academy/stem-module-topics/

Websites for purchasing materials

For general supplies:

- Nasco: https://www.enasco.com/c/Education-Supplies/Science
- Flinn: https://www.flinnsci.com/
- Carolina: https://www.carolina.com/lab-supplies-and-equipment/science-lab-supplies/science-lab-classroom-supplies/10300.ct
- School Specialty: https://www.schoolspecialty.com/science-supplies-and-products
- Amazon: www.amazon.com