Lesson Plan: Phenotypic Plasticity: Coping with Climate Change

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As a **high school** or **undergraduate Biological Sciences** teacher, you can use this set of computer-based tools to teach about **phenotypic plasticity** in living organisms, as a response to **environmental fluctuations**.

This lesson plan allows students to understand the concept of phenotypic plasticity and to differentiate between **acclimation** and **adaptation**, in response to climate related **abiotic factors**. The lesson plan emphasizes how climatic conditions affect the morphology, physiology and behavior of organisms. It includes learning material that enables them to understand how phenotypic plasticity in plants help them to cope with climate change.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in Biological Sciences.

Use this lesson plan to help your students find answers to:

- What is phenotypic plasticity?
- What is the difference between adaptation and acclimation? Illustrate with examples.
- How does phenotypic plasticity in plants help them to cope with climate change?
- How do changes in climatic conditions affect the morphology, physiology and behavior of organisms? Give examples.

About the Lesson Plan

Grade Level: High School, Undergraduate

Discipline: Biological Sciences

Topic(s) in Discipline: Phenotypic Plasticity, Adaptation, Acclimation, Abiotic Factors, Genetic Variation, Range Shift

Climate Topic: Climate and the Biosphere

Location: Global

Access: Online, Offline

Language(s): English

Approximate Time Required: 60-120 min

1 Contents

1. Reading and Associated Video (~25 min)

A reading that explains what phenotypic plasticity is and how it helps an organism to survive under variable environmental conditions. It also explains the difference between adaptation and acclimation by organisms in response to a changing environment.

The reading can be accessed at:

https://evolution.berkeley.edu/evolibrary/news/090501_climatechange

An associated video that reiterates the distinction between acclimation and adaptation and the role of phenotypic plasticity in helping an organism cope with changing climatic factors, with suitable examples.

The associated video can be accessed at:

https://www.youtube.com/watch?v=DRZ_PD7e3XA&feature=youtu.be&list=PLEC34ED558101B182 (up to 10.22 min)

2. Laboratory Activity (~35-95 min)

A lab activity that teaches students how the amount of available light for plants affects the phenotypic characteristics of their leaves.

This can be accessed at:

https://www.radford.edu/~jkell/sunshadeleaves.pdf

3. Suggested questions/assignments for learning evaluation

- What is phenotypic plasticity?
- What is the difference between adaptation and acclimation? Illustrate with examples.
- How does phenotypic plasticity in plants help them to cope with climate change?
- How do changes in climatic conditions affect the morphology, physiology and behavior of organisms? Give examples.

2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Topic introduction and discussion

Use the reading, 'Coping with climate change', by University of California Museum of Paleontology and National Center for Science Education, to teach your students how animals and plants respond to a changing environment by modifying their morphology, physiology and behavior. Explain what adaptation to a changing environment means for a living organism. Introduce the concept of phenotypic plasticity and explain how this enables an organism to cope with variable environmental conditions. Use the text to distinguish between acclimation and adaptation. Emphasize that adaptation is based on genetic variation in organisms and that the trait is passed on in successive generations to adapt to long term environmental changes. Explain that phenotypic plasticity enables organisms to cope with short term changes in the environment and do not have a genetic basis.

Use the associated video, 'Coping with Climate Change- Evolution in the News', by Dr. George Gilchrist, Professor of Biology, College of William and Mary, Virginia, to reiterate the concepts of phenotypic plasticity, acclimation and adaptation in organisms in response to a changing environment by discussing specific examples of plants and animals. Using examples from this video, explain how 'range shift' and 'plasticity' by organisms in response to climate change has limitations and can threaten the survival of several species.

The reading can be accessed at:

https://evolution.berkeley.edu/evolibrary/news/090501_climatechange

The associated video can be accessed at:

https://www.youtube.com/watch?v=DRZ_PD7e3XA&feature=youtu.be&list=PLEC34ED558101B182 (up to 10.22 min)

OPTIONAL: (30-50 min)

Extend your students' understanding of the topic by using the end of text 'Discussion and extension questions' from the reading resource, to enable a classroom discussion. Use the links to readings given here to assess the adaptation or phenotypic strategies adopted by specific plant and animal species. Explore the topic further using the links to 'related lessons and teaching resources'.

2. Laboratory Activity

Use this hands-on laboratory activity, 'Developmental and Phenotypic Plasticity in Leaves', by Radford University, Virginia, to study leaf morphology and phenotypic plasticity in plants. Download and print the activity worksheets for the students. Use the introductory text to remind students that despite being genetically identical, variations are observed in different plants of the same species due to phenotypic plasticity. Follow the instructions given in the worksheet to conduct the activity of collection and analysis of leaf morphology from plants in two different micro-environments: sun and shade. Use the data collected to compare the morphologies of leaves of plants exposed to these different light intensities. Encourage a classroom discussion using the questions given in the worksheet, to enable students to understand the role of phenotypic plasticity in helping plants cope with environmental differences: in this case, light intensity. Extend the discussion to include climatic factors such as rising temperatures and atmospheric carbon dioxide levels, that can result in phenotypic changes as a coping strategy in plants.

This can be accessed at:

https://www.radford.edu/~jkell/sunshadeleaves.pdf

3. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- What is phenotypic plasticity?
- What is the difference between adaptation and acclimation? Illustrate with examples.
- How does phenotypic plasticity in plants help them to cope with climate change?
- How do changes in climatic conditions affect the morphology, physiology and behavior of organisms? Give examples.

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- define and describe phenotypic plasticity in plants and animals
- differentiate between adaptation and acclimation
- describe how phenotypic plasticity helps organisms to cope with climate change

4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

1. Video micro-lecture

An engaging video micro-lecture, 'Phenotype Plasticity', by Sal Khan, Khan Academy, to introduce the concept of phenotypic plasticity, using an example of human identical twins exposed to different environments.

This can be accessed at:

https://www.khanacademy.org/science/ap-biology/heredity/environmental-effects-on-phenotype/v/phenotype-plasticity

2. Video lecture

A video lecture, 'Lecture 4c- Vegetation response to climate change', by Dr Lawrence Venable, University of Arizona, to summarize plant responses to climate change- such as phenotypic plasticity, range shifts, phenology, and population dynamics- by discussing their impacts on native vegetation in Arizona.

This can be accessed at:

https://www.coursera.org/lecture/biosphere-science-future/lecture-4c-vegetation-response-to-climate-change-A4vXP

5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and
ownership details for each tool by following the individual links provided.
We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. Reading; 'Coping with climate change'

By University of California Museum of Paleontology and National Center for Science Education.

2. Associated video; 'Coping with Climate Change- Evolution in the News'

Presented by Dr. George Gilchrist, Professor of Biology, College of William and Mary, Virginia.

3. Laboratory Activity; 'Developmental and Phenotypic Plasticity in Leaves'

Made available by Radford University, Virginia.

4. Additional Resources

'Phenotype Plasticity', by Sal Khan, Khan Academy.

'Lecture 4c- Vegetation response to climate change', by Dr Lawrence Venable, University of Arizona. Hosted by Coursera.