

Lesson Plan: Abiotic Stress on Plants due to Climate Change

Teacher-contributed lesson plan by Dr Neeti Mehla and Dr Aditi Kothari Chhajer, Sri Venkateswara College (University of Delhi), India

As a **high school** or **undergraduate Biological Sciences** teacher, you can use this set of computer-based tools in teaching about **plant physiology**, **abiotic stress** in plants, **climate related stress factors** and their influence on plant growth and development.

This lesson plan discusses abiotic stress in plants and their effect on plant physiology. Students will learn about plant stress responses like acclimation and adaptation to environmental changes due to 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 abiotic stress? How does abiotic stress affect plant physiology?
- What is phenotypic plasticity in plants?
- How does stomatal conductance change in heat-stressed plants?
- Describe physiological plasticity in plants in response to climate related abiotic stress factors.
- What is the difference between acclimation and adaptation in plants, in response to abiotic stress?
- How does vegetation growth respond to climate change?

About the Lesson Plan

Grade Level: High School, Undergraduate

Discipline: Biological Sciences

Topic(s) in Discipline: Abiotic Stress, Stress Physiology, Temperature Variation, Heat Stress, Phenotypic Plasticity, Acclimation in Plants, Adaptation in Plants, Physiological Plasticity, Range Shift

Climate Topic: Climate and the Biosphere

Location: Global

Access: Online

Language(s): English

Approximate Time Required: 45-150 mins

1 Contents

1. Video lecture (~27 min)

An extract from a video lecture that introduces the topic of plant physiology and abiotic stress in plants. It explains how plants respond to these stresses phenotypically and physiologically. The suggested video extract can be viewed from the beginning of the video till 27 minutes of the full-length video lecture (~78 min).

<https://www.youtube.com/watch?v=YfS3XoPc8h0>

Note: Following this introduction, teachers can choose to use either one or both of the following tools to discuss plant responses to abiotic stress due to climate related factors.

2. Laboratory activity (~105 min)

This hands-on laboratory activity allows students to explore the role of stomata in regulating leaf temperature and water loss from plants under different environmental and climate conditions. Students will observe the nature and distribution of stomata of plants growing under such varied abiotic stresses and use the data to quantify differences in these plants.

https://www.windows2universe.org/teacher_resources/withering_crops_activity.html

3. Video lecture (~18 min)

This video lecture gives an overview of how vegetation responds to climate change in terms of phenotypic plasticity, range shifts, phenology, and population changes.

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

4. Suggested questions/assignments for learning evaluation

- What is abiotic stress? How does abiotic stress affect plant physiology?
- What is phenotypic plasticity in plants?
- How does stomatal conductance change in heat-stressed plants?
- Describe physiological plasticity in plants in response to climate related abiotic stress factors.
- What is the difference between acclimation and adaptation in plants in response to abiotic stress?
- How does vegetation growth respond to climate change?

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 this video lecture, "[BIOPL3420 - Plant Physiology - Lecture 28: Plant Stress Responses](#)", by Associate Prof. Thomas Owens, Cornell University, to explain what plant stress is and to define abiotic stressors as the external factors that affect plant physiology. Then, list the factors that may

affect plant growth and development by perturbing its physiology. Further, discuss the types of responses shown by plants due to changes in their environment like immediate responses, acclimation and adaptation. Use this tool to explain phenotypic plasticity in plants that enable them to extend their range or region of optimal growth. Finally, use the lecture to distinguish short term phenotypic plasticity from evolutionary adaptations exhibited by these plants in response to long term environmental changes.

This can be accessed at <https://www.youtube.com/watch?v=YfS3XoPc8h0>

Note: Following this introduction, teachers can choose to use either one or both of the following tools to discuss plant responses to abiotic stresses due to climate change related factors.

2. Hands-on laboratory activity to assess plant responses to climate related abiotic stress

Use this laboratory activity, "[Changing Planet: Withering Plants- Stressing Over Lost Water](#)", by Missy Holzer, Jennifer Bergman and Roberta Johnson of the NESTA/Windows to the Universe team, to enable students to explore the role of stomata in plants in regulating leaf temperature and controlling water loss from leaves under different environmental conditions. This includes a complete laboratory activity plan with background information in the form of a reading and links to other relevant readings and videos. A materials list and a link to download student worksheets is also provided.

Follow the directions, as mentioned in the laboratory activity plan. This will firstly, enable students to gain background information- through a reading and a short video- about the climate related factors like high temperatures and low water availability due to changing precipitation patterns, that can affect plants. Then, the students will prepare slides and microscopically observe the stomata in leaves and study their differences in plants grown in diverse conditions of temperature and water availability. Students can use the data from their observations to represent and compare the distribution of stomata using graphs, in different plants of the same species but grown under varying environmental conditions. Finally, discuss other plant physiological parameters that may be affected by climate related factors.

This can be accessed at https://www.windows2universe.org/teacher_resources/withering_crops_activity.html

3. Use this resource to summarise on plant responses to climate change

Use the video lecture, "[Lecture 4c- Vegetation Response to Climate Change](#)", by Dr Lawrence Venable, University of Arizona, to summarise plant responses to climate change by discussing their impacts on native vegetation in Arizona. Reinforce student understanding about observed climate factors that could affect vegetation growth such as increased CO₂ levels, higher global temperatures and changing precipitation patterns. Then, emphasize how plants respond to such environmental perturbations in the short and long term by showing phenotypic plasticity, acclimation and adaptation. Encourage a discussion on how these climatic factors nudge vegetation growth in other regions than where previously found and therefore, cause a 'range shift'. Finally, discuss how climate change can cause changes in phenology and affect percentages of different species in a population by influencing plant growth and development.

This can be accessed at <https://www.coursera.org/lecture/biosphere-science-future/lecture-4c-vegetation-response-to-climate-change-A4vXP>

4. Questions/Assignments

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

- What is abiotic stress? How does abiotic stress affect plant physiology?
- What is phenotypic plasticity in plants?
- How does stomatal conductance change in heat-stressed plants?
- Describe physiological plasticity in plants in response to climate related abiotic stress factors.
- What is the difference between acclimation and adaptation in plants in response to abiotic stress?
- How does vegetation growth respond to climate change?

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- define abiotic stress in plants and describe the factors causing it
- understand plant stress physiology
- describe the role of stomata in plants under abiotic stress like high temperature and low water availability
- distinguish between acclimation and adaptation responses to abiotic stress in plants
- understand how plants respond phenotypically and physiologically to climate related factors

4 Additional Resources

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

1. Laboratory Activity (7-9 weeks)

This long duration laboratory activity, "[Activity 7: Effect of Environment on Plant Growth](#)", by the American Phytopathological Society (APS) will enable students to demonstrate the effect of environmental changes on the growth and development of some landscape and crop grasses.

This can be accessed at <https://www.apsnet.org/edcenter/K-12/TeachersGuide/PlantBiotechnology/Pages/Activity7.aspx>

2. Video lecture (~53 min)

This lecture, “[01: Introduction to stress physiology of plants](#)”, by Dr Nadine Rühr, Karlsruhe Institute of Technology (KIT), Germany, can be used as an alternative to introduce the topic of plant stress physiology.

This can be accessed at <https://www.youtube.com/watch?v=S5CYPwk4YN8>

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. Video lecture; “[BIOPL3420 - Plant Physiology - Lecture 28: Plant Stress Responses](#)”

Lecture by [Associate Professor Thomas Owens, Cornell University](#) and developed by [The Science Media Production Centre at Cornell](#).

2. Laboratory Activity; “[Changing Planet: Withering Plants- Stressing Over Lost Water](#)”

Developed by Missy Holzer, Jennifer Bergman and Roberta Johnson of the [NESTA/Windows to the Universe](#) team.

3. Video lecture; “Lecture 4c- Vegetation Response to Climate Change”

A [Coursera](#) lecture by [Dr Lawrence Venable, University of Arizona](#).

4. Additional Resources

[American Phytopathological Society \(APS\)](#)

Dr Nadine Rühr, [Karlsruhe Institute of Technology \(KIT WEBCAST\)](#)