

Lesson Plan: Metabolic Rate and Climate Change

Teacher-contributed lesson plan by Dr. Subhash Rajpurohit, Ahmedabad University, India.

As a **high school** or **undergraduate Biological Sciences** teacher, you can use this set of computer-based tools to teach about **metabolism** in living organisms, **metabolic rate** and **factors affecting metabolic rate** including the **impact of increasing global temperatures** due to climate change.

This lesson plan will enable students to understand the role of metabolism in living organisms and the various factors that influence it. Students will be able to understand how climate change could influence the metabolic rate of organisms and affect their physiology and survival. A hands-on lab activity will enable students to assess temperature driven changes in metabolic rate of ectotherms and endotherms.

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 metabolism?
- What are the factors that influence the metabolic rate of an organism?
- How does the metabolism of organisms respond to climate change?
- Discuss the impact of increasing global temperatures on metabolic rate.
- Climate change could exert negative effects on reproduction in Ectotherms. Explain.

About the Lesson Plan

Grade Level: High School, Undergraduate

Discipline: Biological Sciences

Topic(s) in Discipline: Metabolism, Metabolic Rate, Factors affecting Metabolic Rate, Ectotherms, Endotherms, Homeotherms, Heterotherms, Thermoneutral Zone (TNZ), Lower Critical Temperature (LCT), Upper Critical Temperature (UCT)

Climate Topic: Climate and the Biosphere

Location: Global

Access: Online, Offline

Language(s): English

Approximate Time Required: 90-120 min

1 Contents

1. Reading (15 min)

A reading that introduces the topic of metabolism and metabolic rate in living organisms and describes the factors influencing it.

The reading can be accessed at:

<https://www.khanacademy.org/science/biology/principles-of-physiology/metabolism-and-thermoregulation/a/metabolic-rate>

2. Reading (15 min)

A reading that describes the impact of increasing global temperatures on the metabolic rates of cold-blooded animals- ectotherms.

The reading can be accessed at:

https://www.researchgate.net/publication/47370860_Global_metabolic_impacts_of_recent_climate_warming

3. Video (~1.45 min)

A short video that shows why climate related melting ice forces polar bears to invest five times more energy in swimming rather than walking and thus, impacts their survival rates.

The video can be accessed at:

<https://www.youtube.com/watch?v=-C8EyOjShk4>

4. Classroom/Laboratory Activity (60- 90 min)

A classroom/laboratory activity to measure the metabolic rate in living organisms and note changes under diverse temperatures; to gain insight on the possible effect of rising temperatures due to climate change on the metabolic rates of these organisms.

This can be accessed at:

<https://www.saddleback.edu/faculty/steh/bio3afolder/Animal%20Energetics%200309.pdf>

5. Suggested questions/assignments for learning evaluation

- What is metabolism?
- What are the factors that influence the metabolic rate of an organism?
- How does the metabolism of organisms respond to climate change?
- Discuss the impact of increasing global temperatures on metabolic rate.
- Climate change could exert negative effects on reproduction in Ectotherms. Explain.

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

Introduce the topic of metabolism and metabolic rate using the reading, '[Metabolic rate](https://www.khanacademy.org/science/biology/principles-of-physiology/metabolism-and-thermoregulation/a/metabolic-rate)' by Khan Academy. Discuss the various factors that influence the metabolic rate in animals. Use the text to describe endotherms and ectotherms. Explain how they are affected by the ambient temperature of their surroundings. Use this reading to define basal metabolic rate (BMR) in living organisms and how it affects energy expenditure by them. Define thermoregulation and discuss the various strategies employed by endotherms and ectotherms to thermoregulate their bodies.

The reading can be accessed at:

<https://www.khanacademy.org/science/biology/principles-of-physiology/metabolism-and-thermoregulation/a/metabolic-rate>

2. Discuss the impact of climate change on metabolic rate

Use the reading, '[Global metabolic impacts of recent climate change](#)' by Dillon et al, October 2010, Nature 467(7316):704-6, to explain to your students how tropical ectotherms that constitute a large percentage of Earth's biodiversity, could be more severely affected by rising temperatures due to climate change.

The reading can be found at:

https://www.researchgate.net/publication/47370860_Global_metabolic_impacts_of_recent_climate_warming

3. Discuss further implications of climate change

Play the video, '[When ice melts, polar bear use 5x more energy to swim instead of walk](#)' by Blaine Griffen, Brigham Young University, to explain the possible influence of climate change- melting ice caps due to rising temperatures- on the metabolic rate of the polar bear leading to higher energy expenditure and resultant body weight loss. Use this video to explain how this effect on metabolism lowers the reproductive rates and affects the survival of the species.

The video can be accessed at:

<https://www.youtube.com/watch?v=-C8EyOjShk4>

4. Classroom/Laboratory Activity

Use this laboratory activity, '[Animal Metabolism](#)' by Saddleback College, California, to enable students to test the effect of varying temperatures on the metabolic rates of an endotherm (mouse/rat) and an ectotherm (goldfish). Firstly, use the information given in the worksheets to explain to the students the thermoneutral zone (TNZ), lower critical temperature (LCT) and upper critical temperature (UCT) for all organisms. Explain why it differs for different types of organisms. Use the worksheet instructions to explain the different ways in which the metabolic rates for these organisms is determined and to set up the experiments. Instruct the students to make graphs of the results and to compare the changes in metabolic rates of the organisms in response to changing temperature. Discuss the results of these experiments in the context of global temperature rise due to climate change.

This can be accessed at:

<https://www.saddleback.edu/faculty/steh/bio3afolder/Animal%20Energetics%200309.pdf>

5. Questions/Assignments

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

- What is metabolism?
- What are the factors that influence the metabolic rate of an organism?
- How does the metabolism of organisms respond to climate change?
- Discuss the impact of increasing global temperatures on metabolic rate.
- Climate change could exert negative effects on reproduction in Ectotherms. Explain.

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- define metabolism and metabolic rate of living organisms.
- list the various factors that influence metabolic rate.
- understand what ectotherms and endotherms are.
- describe thermoregulation in animals.
- discuss the possible effects of increased temperature due to climate change on ectotherms and endotherms.

4 Additional Resources

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

1. Reading

A paper, 'Physiological Optima and Critical Limits', Miller, N. A. & Stillman, J. H. (2012). Nature Education Knowledge 3(10):1, that explains how species distribution and responses to climate change are determined by the optimal performance efficiency of the organisms in the given environmental conditions.

This can be accessed at:

<https://www.nature.com/scitable/knowledge/library/physiological-optima-and-critical-limits-45749376>

2. Reading

A review, 'The effects of temperature on aerobic metabolism: towards a mechanistic understanding of the responses of ectotherms to a changing environment', by Patricia M. Schulte, University of British Columbia.

This can be accessed at:

<http://jeb.biologists.org/content/jexbio/218/12/1856.full.pdf>

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; 'Metabolic rate'

By [Khan Academy](#).

2. Reading; 'Global metabolic impacts of recent climate change'

Authored by Michael E. Dillon, George Wang and Raymond B. Huey, October 2010, Nature 467(7316):704-6. Hosted on [researchgate.net](#).

3. Video; 'When ice melts, polar bear use 5x more energy to swim instead of walk'

Presented by Blaine Griffen, [Brigham Young University](#).

4. Laboratory Activity; 'Animal Metabolism'

By [Saddleback College, California](#).

5. Additional Resources

Reading; 'Physiological Optima and Critical Limits', Miller, N. A. & Stillman, J. H. (2012). [Nature Education Knowledge](#) 3(10):1.

Reading; 'The effects of temperature on aerobic metabolism: towards a mechanistic understanding of the responses of ectotherms to a changing environment', review by [Patricia M. Schulte](#), University of British Columbia. Published by the [Journal of Experimental Biology](#).