

Introduction

This lesson explores the topic of telomere lengthening and shortening during spaceflight. Students develop a model that represents how telomeres protect DNA. Then students will use their model to show how environmental factors, such as cosmic radiation, affect telomere length. Students discuss the strengths and limitations of their model and how changes to telomeres may affect astronauts' health.

Learning Objectives

After the lesson, the students should be able to:

- Explain the role of telomeres in protecting chromosomes.
- Describe how environmental factors, such as cosmic radiation, can affect DNA.
- Develop and use a physical model to show structural changes in chromosomes before, during, and after spaceflight.
- Make evidence-based claims about how spaceflight could affect human health.

Necessary Prior Knowledge

Before starting this lesson, students should have a basic understanding of the following concepts:

- Cells are the basic unit of life.
- DNA is the genetic material found inside the nucleus of cells.
- Chromosomes are the organized structures of DNA.
- Environmental factors, like cosmic radiation, can damage DNA.

These concepts will help students understand how telomeres function to protect chromosomes and why changes in telomere length might affect health.

Key Terms

- chromosome
- DNA
- telomere
- cosmic radiation

Time Requirement

2 to 4 class periods, depending on age and additional reading or writing assignments

Grade Level

Grades 6-8

Materials

- Shoelace (1 per group)
- Tape
- Scissors (1 per group)
- Ruler (1 per group)
- Small zip-top plastic bag (1 per group)
- Aluminum foil (1 sheet per group)
- Coins, paper clips, rubber bands, or other small objects

Lesson Plan

1 GETTING STARTED

Duration: 25-35 minutes

- Begin by showing a short video that introduces students to astronauts in space. Play the [spinning in space](#) video. Or play a bit of the [FIRST Interview with SpaceX Inspiration4 Crew](#). Ask students to think about how spaceflight might affect the human body. Then invite students to Think-Pair-Share to respond to the following questions:
 - What do you think happens to the human body in space?
 - Why might space be a dangerous place for living things?
 - What parts of the body or cells might be especially vulnerable?
- Introduce the concept of DNA and telomeres by playing a [short video about telomeres](#) from the Jackson Laboratory. Highlight the comparison of telomeres with shoelaces.
- Show students a shoelace and point out the plastic tips (aglets). Tell students that the aglets represent telomeres, a part of the chromosome that protects DNA from damage.
 - What do you think might happen if the tips of your shoelaces wore out?
 - How can we relate that to what happens to telomeres inside your cells?
- Explain that scientists have discovered that telomeres change length in space, which is surprising. In this lesson, students will explore this phenomenon by designing a model that shows how telomeres change before, during, and after a trip to space.

2 READING ASSIGNMENT

Duration: 30-40 minutes (can be assigned as homework)

- Individually or in pairs, have students read the article “What Happens to Astronauts’ DNA in Space?” from *Science Journal for Kids*.
- After students finish the reading, have them answer the assessment questions provided at the end of the article. (A teacher’s key is available on the article’s webpage.)
- Bring the class back together for discussion. Allow students to discuss their answers to the assessment questions, or ask questions such as the following to guide discussion:
 - What was surprising about the results?
 - Why might telomeres get longer in space?
 - What are the possible risks of shortened telomeres back on Earth?

3 HANDS-ON ACTIVITY

Duration: 30-45 minutes

Students work in groups and use the provided materials to model the effects of spaceflight on telomeres. Students should construct their initial model (before spaceflight) and then physically adjust the model to show what they think happens during and after spaceflight.

- Divide the class into groups and provide each group with a set of materials.
- Read the following prompt to students:
 - Your job is to create a model that visually represents how telomeres change. You’ll choose how to show environmental effects using physical changes in the DNA (shoelace) and telomeres (aglets/tape). You get to decide when and how telomere length should change in your model.
- Tell students that their model should show telomeres before an astronaut goes into space, during spaceflight, and after the astronaut returns to Earth.
 - Instruct students to document their model before, during, and after spaceflight. Students should draw diagrams or take photographs of their model during each stage to record their observations.
 - Clarify that students may cut their shoelaces, but emphasize that they should plan their model carefully before doing so.
- Use questions such as the following to guide students as they work:
 - What change will you make to represent telomeres getting longer or shorter?
 - Which materials or actions will represent harmful conditions?
- Have students compare their model with other groups’ models in a Gallery Walk. Instruct students to evaluate how well each model explains the concept. After students finish working, have a few groups present their models and explain the following:
 - What each material in the model represents.
 - How the model shows the changes in telomeres.

4 DISCUSSION

Duration: 25-30 minutes

- Distribute the Discussion Questions worksheet and have students work individually or in pairs to respond to the questions.
- After students finish responding to the questions, lead a class discussion, and invite students to share their responses.
- Next, focus the discussion on the strengths and limitations of using models to represent science concepts.
 - What was one strength of your model?
 - What was something your model couldn't represent well?
 - What other types of science ideas are difficult to observe directly? How can models help us understand them?
 - If you could do this activity again, how would you improve your model or change the materials to make it more accurate?

5 CONSOLIDATION: WRITING ASSIGNMENT

Duration: 30 minutes or longer

- Review the main ideas of the lesson:
 - Telomeres protect DNA like aglets protect shoelaces.
 - Environmental stress during spaceflight, (e.g., cosmic radiation, microgravity) can cause telomeres to change.
 - In space, telomeres may lengthen temporarily but shorten rapidly after returning to Earth.
 - Telomere damage is linked to aging and disease.
- Have students choose one of the following writing prompts to complete in class or as homework.
 - **Option 1:** You are part of a team designing a mission to Mars. One of your jobs is to help protect astronauts' DNA during the trip. Write a short proposal (1–2 paragraphs) explaining:
 - Why protecting telomeres is important.
 - What environmental risks in space might affect telomeres.
 - One or two creative ideas for how you might reduce telomere damage during the mission (e.g., shielding, nutrition).
 - **Option 2:** Write an explanation for younger students that describes what telomeres are and how time in space affects telomeres. Draw a diagram or model to support your explanation.
 - **Option 3:** Scientists use models to better understand things they can't directly see. Write a reflection explaining how your group's model helped you understand telomeres. How could you improve your model? What would you change if you did it again?

Additional Resources

Are Telomeres the Key to Aging and Cancer. Learn Genetics.

<https://learn.genetics.utah.edu/content/basics/telomeres/>

Even Short Trips to Space Can Change DNA. The Conversation.

<https://theconversation.com/even-short-trips-to-space-can-change-an-astronauts-biology-a-new-set-of-studies-offers-the-most-comprehensive-look-at-spaceflight-health-since-nasas-twins-study-232967>

Data from all-civilian crew details health effects of space travel.

<https://www.reuters.com/technology/space/data-all-civilian-crew-details-health-effects-space-travel-2024-06-11/>

Astronauts may have 'baby feet,' get shorter, face strange health problems after return.

<https://www.today.com/health/news/nasa-astronauts-return-possible-health-problems-rcna196862>

Video Resources

VideoFromSpace: Spinning Fast In Space Make You Dizzy? Astronaut Experiment

<https://www.youtube.com/watch?v=GPNLSHiJ-t4>

CNET Highlights: FIRST Interview with SpaceX Inspiration4 Crew! (From Dragon's Cupola)

https://www.youtube.com/watch?v=xMUL_3Ci0yU

The Jackson Laboratory: What are telomeres? | Telomere animation

<https://www.youtube.com/watch?v=U0fRAr-ZHCo>

Worksheet

1 What did you notice about how telomeres changed in your model?

2 How did your group choose to represent spaceflight or radiation exposure?

3 Which part of the model was the hardest to represent?

4 Think about the strengths and limitations of your model. What does your model help explain well? What are some limitations of your model?

5 Why might shortening telomeres after space travel be a concern?

6 What situations on Earth might cause telomere damage?

7 Would you go to space knowing it could damage your DNA? Why or why not?
