Genes in Space
Space biology and scientific method lesson plan

Lesson Overview:
The goal of these lessons is to engage students in using the scientific method under authentic research scenarios. Through three sequential activities, students will research problems, formulate hypotheses and design original experiments to address yet unanswered scientific questions. No actual experimentation is needed to complete these activities—the goal is to engage students through to the point of experimental design. This lesson plan aligns with NGSS and the Common Core standards (see page 4).

Because Genes in Space focuses on space biology research, the thematic thrust of these lessons is how life adapts to space conditions, with an emphasis on the role of DNA. At the culmination of these lessons, students will have developed the core of a submission to the Genes in Space contest.

With a little more work, students may be able to complete a submission to the Genes in Space contest, and enter for a chance to see their own experiment performed on the International Space Station!

Summary:
We present 3 lessons. Each lesson builds on the previous, culminating in the production of an originally designed space biology experiment. Depending on time available and course objectives, teachers may choose to do one, two, or all three of these lessons as a small unit exploring the scientific method, experimental design, DNA science, and space exploration.

Lesson 1: *Students watch short videos describing current research in the field of space biology. Students work in groups to summarize scientists' research and then share those findings with their classmates.*

> ***Time required:*** *One 45-60 minute period. Optional second period if including more formal presentations.*

Lesson 2: *Students, individually or in pairs, will build on their work in Lesson 1 to develop their own space biology question that could be investigated by astronauts on the International Space Station.*

> ***Time required:*** *One to two 45-60 minute periods with internet access or other research methods available.*

Lesson 3: *Students will design an experiment that could answer the question developed in Lesson 2.*

> ***Time required:*** *One to two 45-60 minute periods with internet access or other research methods available.*

Lesson 1.

Objectives:
Students will describe space conditions and their impacts on biological systems.
Students will identify a key challenge or opportunity of engaging in a manned deep-space mission such as a mission to Mars.

Part 1:
Divide students into groups and have each group watch one of the Genes in Space educational videos focused on ongoing space biology research or have the students select a video:

- DR. GIOIA MASSA - FRESH FOOD FOR THE RIDE TO MARS
- DR. MICHAEL ROBERTS - MICROBES ON THE INTERNATIONAL SPACE STATION
- DR. LIZ WARREN - SKELETONS IN SPACE
- DR. ARUN SHARMA - HEART CELLS BEATING IN ORBIT
- DR. SYLVAIN COSTES - GENETIC DATA FROM SPACE

Students should complete *Worksheet 1* after watching the video.

Optional flipped classroom approach: *Part 1 can be assigned as homework.*

Part 2:
In their groups, students should share their answers to the questions from part 1. Students will present this information to the class. Each group should agree on a consensus answer to each question. Have students as a group choose their 3 best questions.

Optional: Have each group develop a short Google Slides presentation or poster summarizing their video and their discussion.

Part 3: Share out
Each group presents a short summary of their video, the key points from their discussion, and their 3 questions to the rest of the class. Allow time at the end of each presentation for questions from other groups.

Time required: One 45-60 minute period. Optional Second period if including more formal Presentations.

Lesson 2:

Objectives:
Students will develop a question about space biology.
Students will use previously conducted research to refine and focus their question.

In class:
Students develop their own questions and use the scientific method to devise a DNA analysis experiment that addresses their question. After the group presentations done during Lesson 1, students will select the video whose topic interests them the most. Students will work either individually or in pairs to research a challenge or opportunity related to space biology.

Students will find three relevant resources to their question or opportunity. They will then summarize these resources.

From the information they find through their research and based on the original Genes in Space video, students will pose a question that could be answered through experimentation on the International Space Station.

Students should use *Worksheet 2* for this activity.

Time required: One to Two 45-60 minute periods with internet access or other research methods available.

Lesson 3:

Objectives:
Students will conduct research to develop an original hypothesis
Students will apply the scientific method to develop their own original experiment

In class:
Students will use the scientific method to develop a hypothesis and design an experiment to answer the question they developed in lesson 2.

Developing an experimental design requires an understanding of basic DNA experimentation techniques, such as PCR and DNA sequencing. For resources including worksheets and educational videos to help your students master these techniques visit: https://www.genesinspace.org/classroom-resources/

Students should use *Worksheet 3* for this activity.

Optional: Have each student or pair develop a short Google Slides presentation or poster summarizing their hypothesis and experiment.

Time required: One to two 45-60 minute periods with internet access or other research methods available.

Submitting a proposal to Genes in Space

When complete, students can use these worksheets as the basis for a Genes in Space proposal. Students will wish to refine their question, hypothesis, and experimental design further before submitting to the contest. To submit proposals and for a chance to have their DNA experiment conducted on the International Space Station, visit www.genesinspace.org!

Next Generation Science Standards Alignment

Students who demonstrate understanding can:

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Science and Engineering Practice	Disciplinary Core Ideas	Crosscutting Concepts
• Asking Questions and Defining Problems • Planning and Carrying Out Investigations • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information	LS1: From Molecules to Organisms: Structures and Processes LS3: Heredity: Inheritance and Variation of Traits HS-LS4 Biological Evolution: Unity and Diversity	– Cause and Effect – Structure and Function – Stability and Change – Interdependence of Science, Engineering, and Technology

Common Core ELA/Literacy Standards

CCSS.ELA-LITERACY.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCSS.ELA-LITERACY.RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

*For simplicity, this activity has been aligned to high school NGSS and grades 9-10 Common Core standards. For information aligning this activity to other grade levels or standards, namely middle school or Advanced Placement, please contact Genes in Space (genesinspace@minipcr.com).

Worksheet 1

Genes in Space Educational videos – Current Space Biology Research Topics
Study Questions

Answer the following questions based on the video you watched.

1. What challenge or opportunity of space flight was the research in your video addressing?

2. What organism(s), organ system(s), or technology is the subject of the video?

3. What space condition(s) most affect the subject of the video?

4. How has the International Space Station (ISS) aided our understanding of the subject of your video?

5. What experiments from the ISS were described in the video?

6. How might we use what we've learned on ISS to conduct a successful manned deep-space mission such as a mission to Mars?

7. What would you like to know about this organism or system prior to sending humans on a deep-space mission such as a mission to Mars? List at least two questions:

1.

2.

Worksheet 2

Genes in Space Proposal – Developing a Question

Identifying a problem

Now that you are familiar with some areas of current space research, what do you find most interesting?

1. What challenge or opportunity for life in space are you most interested in studying?

Research:

Before you can ask a meaningful question, you need to know more information about your topic. This involves research. Find three resources online that relate to challenge or opportunity you are interested in studying.

2. List the resources that you found:	**3. In one sentence summarize the main idea or finding from this resource as it relates to your challenge or opportunity:**
A.	**A.**
B.	**B.**
C.	**C.**

4. What is *YOUR* question? Focus in on one aspect of this challenge or opportunity and try to re-phase it as a question (ex. What is the effect of microgravity on [*your idea*]?). A good question should be focused enough to be at least partly answerable through a single experiment.

Worksheet 3

Genes in Space Proposal – Designing an Experiment

Part 1: Developing a hypothesis

1. State the question you developed in worksheet 2.

2. From your research or the Genes in Space video, is there any information that relates directly to your question? This information doesn't need to answer your question, just be related to it. List it below:

A.

B.

C.

3. List the resource where you found that information. You may use the same resource more than once:

A.

B.

C.

4. Building on your knowledge and the evidence you have in found your research, state your original hypothesis:

5. Is your hypothesis testable? In a short paragraph, describe evidence that would either support or refute your hypothesis. In this lesson, we are interested in how DNA analysis techniques might be used to address your idea so you may wish to list some evidence that could be generated by such an experiment.

Worksheet 3

Genes in Space Proposal – Designing an Experiment

Part 2: Develop your experimental plan.

A good experiment will obtain evidence that supports or refutes a hypothesis. On the previous page you described this evidence. Now think of an experiment that would produce such evidence. Remember that as part of Genes in Space you need to use the Genes in Space Toolkit as part of your procedure.

1. Restate your hypothesis.

2. What system (organism, cell type, *in vitro* model, etc.) will you use to test your hypothesis?

3. What gene(s) will you investigate?

4. What is your independent variable? (What condition/variable do you plan to test in this experiment?)

5. What is your dependent variable? (What will you *measure* in the end?)

6. Describe your experimental group(s):

7. Describe your control group(s):

8. If your hypothesis is supported, what results would you expect to see in each group?

9. If your hypothesis is not supported, what results would you expect to see?

Worksheet 3

Genes in Space Proposal – Designing an Experiment

Part 3: Genes in Space experiment requirements – OPTIONAL

To prepare your idea to be submitted to the Genes in Space contest, explain how you will use the Genes in Space Toolkit to carry out your experiment. You will also need to explain why the unique environment aboard the ISS is required to test your hypothesis.

1. Genes in Space requires the use at least one of the following tools from the Genes in Space toolkit. Mark which tool(s) you will use in your experiment.

- ☐ **Polymerase chain reaction (PCR):** a technique used to replicate a genetic sequence of interest in a DNA or RNA sample
- ☐ **Fluorescence Viewer:** use fluorescence to visualize biomolecules like DNA, RNA, or proteins
- ☐ **BioBits:** manufacture proteins on demand

2. Explain how your experiment will make use of the tool(s) you circled in #1.

3. Are there any other experimental tools you will need to use to carry out your experiment? Name them and explain how they fit into your plan.

4. Describe the type of data you will be able to collect using the tool(s) you identified in #2 and #3.

5. What aspect(s) of the unique environment on the International Space Station are required for your experiment?

Congratulations! You are on your way to developing an experiment to submit to the Genes in Space contest for a chance to have it conducted aboard the International Space Station. To enter the contest, you must submit your proposal electronically. The electronic submission form is available on January – April at www.genesinspace.org