LESSON

Deep Space Genomics

Project Details

COURSE
Life Science, Biology, Anatomy and Physiology

GRADE SPAN
9–12

DURATION
Three forty-five to sixty-minute session

CONCEPT
Genetics and genomics in space

OVERVIEW

Time has flashed forward, and students now work at a genome technology company. The company intends to shift its focus to deep space exploration in order to help astronauts function optimally in outer space. It will be looking to its employees as it determines what to tackle first, and employees will be able to present their thoughts at an upcoming forum. To get up to speed, students will first review the process of gene editing including: What is a gene? What are the differences between germ-line therapies and somatic therapies? In small groups, students will then be assigned a particular area of concern in outer space, including space radiation, gravity fields, psychological effects of isolation, and the physiological consequences of closed environments. Each group will research their topic and prepare a short presentation, using technology to explain their subject. The teacher will then facilitate the employee forum, in which students will debate/discuss the pros and cons of venturing into each of the deep space focus areas. Students will ultimately be responsible for writing a final decision, and a vote will decide the next phase of their company.

THIS LESSON FOCUSES ON:

Engineering Design Process

- Defining the problem
- Designing Solutions
- Creating or Prototyping
- Refine or Improve
- Communicating Results

21st Century Skills

- Collaboration
- Communication
- Critical thinking
- Creativity

OBJECTIVES

Students will be able to:

- **Summarize** and **discuss** the concept of the human genome and the differences between various types of gene editing.
- **Research** an area of deep space exploration concern and **evaluate** if/how gene editing could help astronauts overcome this issue.
- **Analyze** each of the deep space concern focus areas in order to **develop** their own opinion about which one could most benefit from genomic intervention.
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MATERIALS

- Computer or device with the ability to project, one
- Computers or devices with internet access, enough for at least half the class
- Genome Background Document, one per student
- "How is Genome Editing Used?" Info Sheet, one per student
- Genome Background Document, one per student
- Deep Space Genomics Research handout, one per student
- Employee Forum Criteria handout, one per student
- The Human Body in Space handout, one per student
- Employee Forum Notes handout, one per student
- Employee Forum Ballot, one per student

HAVE YOU EVER WONDERED...

Are scientists actually considering how the genomics field may help astronauts?

Yes, absolutely! One way in which this is happening is through NASA's GeneLab, which NASA describes as "Open Science for Life in Space." GeneLab is an open-source resource for scientists, which means that scientists can search, upload, download and share their data with others. It is NASA's goal that discoveries made with the help of GeneLab "will continue to deepen our understanding of biology, advance the field of genomics, and help to discover cures for diseases, create better diagnostic tools, and ultimately allow astronauts to better withstand the rigors of long-duration spaceflight." [1]

Does space travel affect astronaut's genes?

NASA was able to explore this concept during a research study involving twins: one who traveled to space for a year and one who stayed on Earth. The study found that seven percent of the space-traveling twin's genes remained changed even after returning to Earth. These longer-term gene changes affected his bone formation, immune system, his DNA's ability to repair itself, and the levels of oxygen and carbon dioxide in his blood stream.[2] Interested in learning more about the study? Click here.

Sources:
1 – "About GeneLab." NASA. genelab.nasa.gov/about.
2 – "NASA Twins Study Confirms Preliminary Findings." NASA. nasa.gov/feature/nasa-twins-study-confirms-preliminary-findings.

MAKE CONNECTIONS

How does this connect to students?	How does this connect to careers?	How does this connect to our world?
As the field of genomics is growing and a focus on space travel is again in the limelight, the intersection of genomics and space exploration becomes increasingly important. As one of the larger barriers to deep space travel is its effect on the human body, genomic developments have the potential to alter the frequency and scope of what realistic space travel entails. Chances are also likely that an increasing number of career opportunities in this area will become available, and it is important for students to have an understanding of this topic as they consider what path to take in the future.	**Geneticist** Geneticists are scientists who study genes. They investigate everything from inheritance and mutations to genes' role in health and disease. **Research Scientist** Research scientists analyze information that they learn after they design and perform investigations and experiments. Research scientists may study any science topic, including genomics and/or its intersection with space! **Astrobiologist** Astrobiologists study life in the universe. This includes studying the processes, adaptations and mechanisms that enable organisms to survive in extreme conditions, both on Earth and in outer space.	The potential impact of genomics on space travel affects not only the United States, but the world at large. Space Policy Directive 1, which President Trump signed in 2017, calls for a program that brings humans back to space. It also mandates that the United States form international partnerships to enable this exploration. As countries around the world seek to increase mankind's presence in space, knowledge about any and all factors that could positively impact space travel will be of the utmost importance!

BLUEPRINT FOR DISCOVERY

DAY 1

Note: Depending on the background knowledge your students have regarding the human genome, you may or may not be able to accomplish all of Day 1's activities in one day. If not, simply shift the remaining activities to Day 2!

Directions

1. Begin class by telling students that time has flashed forward. They have graduated high school, earned a technical certification, bachelor's degree or a master's degree, and they now work at a genome technology company. The president of the company has just announced a new initiative involving space travel, and the company needs help as they decide how to move forward. But before the students can provide any substantial assistance, they must get up to speed on genomics.
2. With a partner, ask students to discuss what they already know about genomics. Allow a few students to share their ideas.
3. Pass out a Genome Background Document to each student. Stress the necessity of learning about the concept of genes, genomes, and gene editing given the "career" the students now have.
4. Show the two videos below and instruct students to record notes on their Genome Background Document as they watch.
   - Video 1 (until 1:41): Investigates genes and genomes
   - Video 2: Explores gene editing
5. Discuss the notes that students have taken and arrive at the following understandings:
   - A gene is a section of DNA that contain instructions for life. Most genes tell your cells how to build proteins. These proteins are responsible for a range of functions. For instance, some genes determine physical characteristics, while others influence the risk we have for developing different conditions. Humans have about 20 thousand genes.
   - A genome is an organism's full set of DNA, including all of its genes. A copy of the entire genome exists in all cells that have a nucleus, which is nearly every cell in the body.
6. Move on to the Genome Background Document's third category: Gene Editing. Explain that there are two different categories of gene editing called germline therapies and somatic therapies. In order to fully understand gene editing, it is important to understand both. Distribute one "How is Genome Editing Used?" info sheet to each student, and instruct them to annotate the article for similarities and differences between the two therapies.
   - Circle ideas or facts that you already knew
   - Underline ideas or facts that are new learning for you

- Questions that you still have
- Summarize what you have learned
- Make a prediction about what you might learn next

7. When students have finished reading, divide the class into small groups. Students should work together to compare and contrast the two types of gene editing and fill in the chart on their Genome Background Document.
8. Once students have a basic understanding of what gene editing entails, share more details about the company's space travel initiative. Tell students: The CEO of your company has recently announced that she intends to shift the company's focus to deep space exploration in order to help astronauts function optimally in outer space. The management team will be looking to you—its employees—as it determines what to tackle first, and all employees will be able to present their thoughts at an upcoming forum.
9. Explain that this change in focus has occurred because the United States is putting an increased emphasis on returning to the Moon and then continuing to Mars. But in order for this to happen, we must be able to better deal with the harsh effects of space on the human body.
10. Project this NASA webpage and call on volunteers to read the first four paragraphs aloud. Explain that you will be providing students with the rest of the document as they prepare for the forum.
11. Distribute a Deep Space Genomics Research handout to each student. Explain that small groups of students will be assigned a particular area of deep space travel concern. Review the directions on the handout and ensure students understand that they will be responsible for researching details about their focus area as well as if/how genomics may be able to positively impact this issue.
12. Go on to explain that each group will ultimately work together to present their findings to the rest of the "company." Distribute an Employee Forum Criteria handout to each student, and review the requirements so students know what they are working towards.
13. Divide the class into four groups, and assign each group one of the following deep space concerns:
    - Space radiation
    - Gravity fields
    - Psychological effects of isolation
    - Physiological consequences of closed environments

    Note: Depending on the size of your class, it may be helpful for groups to divide into pairs for the research portion of this activity. Groups can then reassemble once their research is complete.
14. Lastly, pass out the Human Body in Space Handout and explain that groups can use this information as a starting point for their research. From there, they will use the internet to perform the research necessary to prepare for their presentations.

15. Groups should confer quickly before they begin to research in order to delineate who will research each subject. If time remains in the period, direct students to begin their research.

Day 2

1. Inform students that today will be a research day. They should use the majority of the class period to research their focus area and record notes on their Deep Space Genomics Research handout. Any time remaining will be used to begin their presentations.
2. Students should continue to work together to perform internet research. If needed, direct students to the following general sources, where they can then fine-tune their search.
   - NASA.gov
   - Space.com
   - Genetic Literacy Project
   - Live Science
3. When there are 15 minutes left in the period, instruct students to regroup, discuss their research, and begin planning for their presentations. Tell students that each group's presentation should be short: No more than 3 minutes in length. From there, questioning will occur to help the employees dig deeper into the subject area.
4. When the period is coming to a close, tell students that they will have 15 minutes to prepare for their presentations next class period before the forum begins. If groups anticipate that they will need more time, they should prepare at home.

Day 3

1. Allow groups to spend the first 15 minutes of class preparing for their employee forum presentation. Remind them to review the Employee Forum Criteria Handout to make sure their presentation includes all of the requirements.
2. Once 15 minutes have passed, bring class back together. Take on the role of the CEO and welcome everyone to the employee forum. Express that they will help dictate the path of the company, and you are excited to hear what they have to say. Remind the employees that once all ideas have been presented, a discussion will be held around which issue the company should consider tackling first.
3. Distribute the Employee Forum Notes handout to each student and review the directions. Tell students that questions will be asked only once all groups have presented, which is why there is space provided for students to record questions they hope to ask later.
4. Call on groups to present in any order. In between each presentation, allow students a moment or two to finish jotting their notes.

5. Once each group has presented, open the floor to questions. If needed, help guide the discussion with questions such as:
    - Which area of space concern seems to carry the most risk?
    - Which area of space concern seems to possess the most potential for our company?
    - In what area could our company make the biggest impact?
    - Is an area worth pursuing if the benefits have the potential of outweighing the risk?
    - Is there an area of space concern that might make sense to tackle eventually, but not first?
6. When there are about 10 minutes left in the class period, wrap up the discussion, and announce that it's decision time! Distribute the Employee Forum Ballot to each student, and instruct students to read the instructions carefully before recording and submitting their decision. (If there is not enough time for students to finish, they may complete it at home and turn it in the next day.)
7. Once all ballots have been returned, tally the results and announce the future direction of your company!

EXTEND

Once an area of deep space concern has been selected, students can develop a company action plan. Students should consider the research that has already been performed in this area, any research gaps that will need to be studied further, and what the company should focus on first as they create a step-by-step plan for how the company can begin to move forward in this area.

NATIONAL STANDARDS

Next Generation Science Standards

- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- 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.

Common Core ELA Standards

Grades 9–10

- CCSS.ELA-LITERACY.RST.9-10.2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- CCSS.ELA-LITERACY.SL.9-10.1.D Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.
- CCSS.ELA-LITERACY.SL.9-10.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Grades 11–12

- CCSS.ELA-LITERACY.RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- CCSS.ELA-LITERACY.SL.11-12.1.D. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.
- CCSS.ELA-LITERACY.SL.11-12.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Name_____ Date_____

Genome Background Document: For Internal Circulation Only

What is a gene?

_____

_____

_____

_____

What is a genome?

_____

_____

_____

_____

What does gene editing entail?

_____

_____

_____

_____

Somatic Therapy Details	Similarities	Germline Therapy Details

Name_____ Date_____

Genome Background Document: For Internal Circulation Only

Deep Space Focus Area:

_____

_____

_____

_____

Background Information	**Genomics Tie-In**	**Considerations**
Why is this an issue? How and why does it affect astronauts?	Do genes play a role in this issue? Could genomic technology possibly help? Why and how?	What is the potential for success in this area, as well as possible risks to keep in mind?

Name_____ Date_____

Employee Forum Criteria: Company Expectations

Share, compare, and contrast your research notes with your group members. You will then work together to create a presentation that accomplishes the criteria listed below. Use the checklist to help keep track of what you have included.

Content Criteria:

1. A brief overview of your focus area, including how and why this is an issue for astronauts when they travel in deep space. ☐
2. An explanation of *if* and *how* your group believes genomics could help this issue. You can be creative, but your idea must be rooted in research and facts. You will need to explain what genomics could do, as well as how this could be accomplished. ☐
3. Any additional information that could help your company decide whether or not to pursue this focus area. What are the potentials for impact? What potential risks or implications must be considered? ☐
4. A consensus of whether your group believes this area should be tackled first and why. are two different categories of gene editing called germline therapies and somatic therapies. In order to fully understand gene editing, it is important to understand both. Distribute one “How is Genome Editing Used?” info sheet to each student, and instruct them to annotate the article for similarities and differences between the two therapies. ☐

Presentation Criteria:

1. Each group member must participate during the presentation. ☐
2. A digital presentation (Prezi, Key Note, Google Slides, PowerPoint, etc.) that highlights your key points must support your verbal presentation. ☐

DNA decoded

Name_____ Date_____

Employee Forum Notes: For Internal Circulation Only

Directions: As you learn about each of the deep space focus areas, take notes on the following categories. Remember, you will ultimately have a say in which focus area your company tackles first!

Potential Opportunities	Potential Risks	Clarifying Questions
Topic:		
Topic:		
Topic:		

Name_____ Date_____

Employee Forum Ballot

I, _____, believe the company should first pursue the following deep space issue:

___Psychological effects of isolation ___Physiological consequences of closed environments

___Space radiation ___Gravity fields

I have come to this conclusion for the following reasons: [Be sure to cite specific examples of how genomics could benefit this area, acknowledge potential risks, and explain why you believe the opportunities outweigh the risks.]

_____

_____

_____

_____

_____

_____

Employee Forum Ballot

I, _____, believe the company should first pursue the following deep space issue:

___Psychological effects of isolation ___Physiological consequences of closed environments

___Space radiation ___Gravity fields

I have come to this conclusion for the following reasons: [Be sure to cite specific examples of how genomics could benefit this area, acknowledge potential risks, and explain why you believe the potential of this area outweighs the risks.]

_____

_____

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_____

_____

_____