Space Farming: Space Biology, Plants, and using the GeneLab Data Repository

Teacher Materials

OVERVIEW

As humans seriously consider leaving the Earth behind for a time, to explore our solar system, we must deal with the reality of growing food while traveling and once we get to our destination. Humans are working towards understanding the challenges to grow plants in space and the important molecular changes that occur in plants in response to the space environment. To help us understand the observations seen in plants grown in space, students will eventually use the GeneLab Data Repository to analyze a model organism's transcriptomic response to space flight.

This activity reinforces NextGeneration Science Standard *HS-LS-1-6 Molecules to Organism: Structures and Processes*. Students will need to have a prior basic understanding of photosynthesis, cellular respiration, genetics, epigenetics, and homeostasis. Students are also expected to have become familiar with navigating the GeneLab data repository in a previous activity and be familiar with the tools and research strategies outlined in the lesson *Introduction to Omics Using GeneLab* by Elisheva Bailey.

CONTENT OBJECTIVES

- Discover some of the important scientific research being conducted (or that will be conducted) in space to help humans live off of our world.
- Review scientific literature and draw conclusions from the findings.
- Use the GeneLab Data Repository to analyze a dataset and select genes to investigate further.
- Use a gene database to research the function of a specific gene.
- Draw conclusions about the change to a gene and its effects on the organism's structure and/or function.
- Present findings to peers for review through a class presentation.

PACING AND SCHEDULING

This unit is designed to be taught in 90-minute block sessions. Lessons could be divided roughly in half for shorter class periods. This unit should take a total of five 90-minute block sessions (or ten 50-minute class periods).

TEACHING METHODS

- Each lesson will have components of independent work, partner work, and group work.
- Each lesson will require a computer with internet access.
- The general flow of the lessons will be Engage and Remember, followed by a

short class discussion. Then the teacher will give directions and students work on an activity. At the end of the lesson, the students will “quick write” for the next lesson and the lesson closes. Lesson 4: Presenting your Findings is really two lessons in one because one day is for making the presentations and the second is for the students to actually present their work to the class.

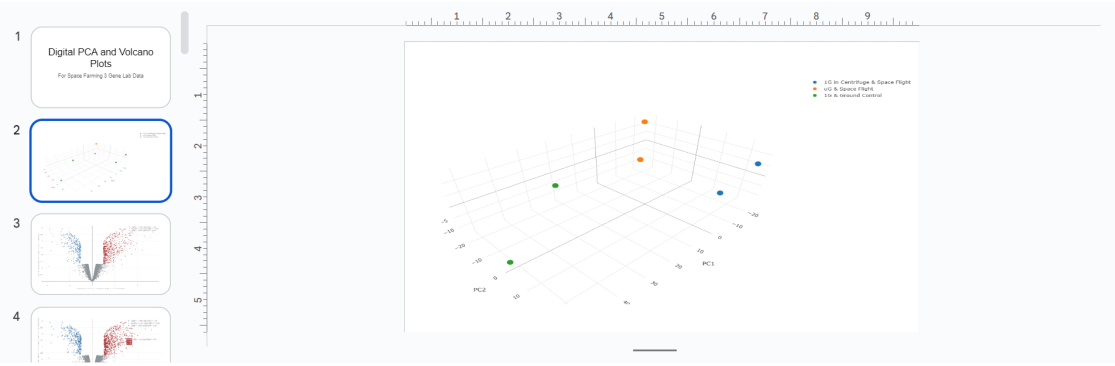
- Each lesson has detailed notes and tips in the teacher's materials.

CURRICULAR CONTENT

Day 1: Space Farming Part 1 – Introduction to Plants in Space
Students will watch videos about space biology and space innovations to begin generating ideas about what excites them about space. Then we investigate a case study of the plants on the International Space Station (ISS). Students will explore a website to learn what we have learned so far about plants in space.

Day 2: Space Farming Part 2 – Evaluating the Metadata
OPTIONAL Student Materials: DIGITAL JOURNAL TO ANNOTATE
Students will use the GeneLab Data Repository website to investigate plants that have been in space flight. We will use OSD-213 as a case study for the activities. After investigating the GeneLab Data Repository website, students will review the scientific literature associated with the study to learn more about what genetic impacts spaceflight may have had on the plants.

Day 3: Space Farming Part 3 – the GeneLab Data Repository Data
OPTIONAL Teacher Printable: OSD-213 PCA AND VOLCANO PLOTS
This link provides teachers with slides that can be printed for classroom distribution, as shown in the example below.



Students will use the GeneLab Data Repository Visualization tool to analyze the data set and choose a gene to research in-depth using TAIR.org genetic database for Arabidopsis. Students will take notes to create a presentation to share their findings with their peers in class.

Day 4: Space Farming Part 4a – Preparing Your Findings
Students will create a presentation to share their findings with the class.

Day 5: Space Farming Part 4b – Presenting your Findings
Students will present their findings to their peers and be evaluated using a rubric by their peers and the teacher.
Rubric and Peer Review Score Card are in the teacher materials for Day 4.

REFERENCES TO DATA SETS

OSD-213, available at https://osdr.nasa.gov/bio/repo/data/studies/OSD-213
Original study citation: Fengler S. "A whole-genome microarray study of Arabidopsis thaliana cell cultures exposed to microgravity for 5 days on board of Shenzhou 8", NASA Open Science Data Repository, Version 3, http://doi.org/10.26030/6hk1-qw49

STANDARDS ALIGNMENT

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

DAY 1: SPACE FARMING- INTRODUCTION TO PLANTS IN SPACE

OVERVIEW

This activity reinforces HS-LS-1-6 Molecules to Organism: Structures and Processes. Students will need to understand photosynthesis, cellular respiration, genetics, epigenetics, and homeostasis. Students are also expected to have used Gene Labs in a previous activity and be familiar with the tools and research strategies outlined in Introduction to Omics Using GeneLab by Elisheva Bailey.

The lesson is designed to be taught in a 90-minute class period.

KEY CONCEPTS

- Plants are a necessary component to sustaining life away from Earth.
- Plants are affected by space at a molecular level.

OBJECTIVES

- Investigate how the ISS (International Space Station) is helping humans understand how to grow plants in space.
- Determine many of the factors affecting plants in space.

TEACHING TIPS

- Students should use note-taking skills to write information using the student worksheet.
- Teachers will need access to the Internet to show videos.
- Lessons are designed for students working both independently and in pairs at different points in the lesson.
- Additional tips are provided throughout the teacher materials.

ENGAGE

Teacher: If teaching in person, write the driving question on the whiteboard in a place all students can see the question. Allow students 2-5 minutes to respond to the question and lead a short class discussion to determine students' prior knowledge. The teacher could also collect all answers to the question in one document or on the whiteboard for all students to view as they work. The document could be printed after class for students with IEP accommodations.

Driving Question: Why do we need plants in space?

Teacher: If possible, show the video to the entire class at one time. Students may want to watch the video a second time. Allow students 2-3 minutes after the video to record their responses to the three questions below. Lead a class discussion and record student responses in a document or on the whiteboard in a place that is visible to all students. These observations should turn into investigation topics for future lessons.

Watch the following video clip, and interview from Subject Matter Expert, Dr. Jabob Torres:

https://nasaeclips.arc.nasa.gov/videosingular/asksme/technical-horticultural-scientist-jacob-torres

After watching the video answer the following questions:

What type of technology was being developed?

Answers will vary but should include: water delivery systems, pillows for holding soil, and circuit boards with seeds.

What factors were the scientists trying to control or replicate?

Answers will vary but should include ideas about- Gravity and equipment used on the space station

Why are scientists interested in these factors?
Answers will vary but should include ideas about- To help us grow the food we need to travel longer and further in space.

Remember- What do plants need to live?
Teacher: Students should complete this part independently first. If students are struggling after 5-7 minutes, you may want to allow students to work in pairs. If working in pairs, each student should use a different color writing utensil to write and pass one paper back and forth. For example, one student could use a blue pen and the other could use a black pen.
In total students may need 10-15 minutes to complete the first two columns of Graphic Organizer 1.
Directions: Using your prior knowledge about photosynthesis and nutrient cycles, complete the first 2 columns of the following graphic organizer. (If you are unsure of an answer you may research if time permits, be sure to use a reliable resource, not a Wiki or Encyclopedia/Dictionary):

GRAPHIC ORGANIZER 1:

Factor:	Needs:	Makes:	Changes in Space:
Photosynthesis	Sunlight, carbon dioxide, water	Oxygen and glucose	No sunlight
Soil	Nutrients (NPK), water	Distributes nutrients and water to roots	No soil or gravity to hold the soil down.
Nutrients	Provided by the soil and biota in the soil	NPK	No soil or soil microbes or fungi
Gases	Carbon Dioxide	Oxygen	No circulation in space
Gravity	1g	Gravitropism	microgravity
Radiation	Solar energy	Glucose	Space radiation

Questions:

Questions will vary.

Teacher: For this activity, students will be working in pairs to compare notes and clarify their understanding. If students were partnered for part of the last activity, pair them with a different partner for this part of the activity.

Think-Pair-Share: Comparing Notes

Work in pairs. Each person must use a different colored writing utensil for this activity. For example, if you wrote your notes in black pen, complete this activity in blue pen.

Directions:

1. When it is YOUR turn, share one term, idea, or question you wrote down in your notes. (From this point in the protocol forward, "idea" refers to an idea, unfamiliar term, or question)
2. Your partner will listen while you speak if your partner
    a. Has the same idea, they will give you a thumbs-up. Then you both make a checkmark next to that idea.
    b. Does not have the same idea, they will make a flat hand. Then they can add your idea to their notes. Do not simply show your partner your paper, you must verbally give them the idea to add to their notes.
3. Your turn is over, switch roles.

Continue until the time is called.

Teacher: Before moving to the next section, lead a class discussion to discuss all student findings, and add these ideas to the class notes list begun in the previous sections (if using class notes).

EXPLORE:

Teacher: Students should complete this section independently, by exploring the web page linked below. I have provided some sample, very basic answers, but student responses will vary.

What changes in space for plants?

Complete Graphic Organizer 2 as you explore this website:

https://www.nasa.gov/mission_pages/station/research/news/Ways-the-ISS-Helps-Study-Plant-Growth

GRAPHIC ORGANIZER 2 (Use a piece of paper to record additional evidence if necessary.)

Factor:	Evidence:
Benefits to the astronauts:	Astronauts can grow their own food, psychological mood improvement
Factors in choosing the right plant	Grow well on Earth in same equipment used on space station
Systems to grow and monitor plants in space:	Veggie- holds six plants in soil pillows, PONDS- Passive Orbital Nutrition Delivery System- no pillows but automatically delivers water/nutrients and requires astronaut maintenance, Advance Plant Habitat- fully automated, requires little human intervention.
Importance of light:	Plants need red and blue light, provided by LED not the sun
Influence of Gravity	Use calcium to sense gravity. PESTO- found that wheat grows differently but not detrimentally in space, the space plants were taller, but their development was changed in the leaves, cells, and chloroplasts.
Watering plants in space	Need enough water w/o drowning. PONDS and other automated systems help. Hydroponic and aeroponic techniques are being investigated.
Propagating plants in space:	We are learning about how long seedlings remain viable in space. It is possible to re"pot" seedlings in space.
Plant genetics	The genome is epigenetically changed, we are trying to understand if the changes lead to adaptations to space over time.
Human impact	Contributes to the circadian rhythms, behavior, and well-being of astronauts. Engages creativity.

Use this information to complete column 3 of Graphic Organizer 1.
Practice the Think-Pair-Share: Comparing Notes protocol described on the last page.
Teacher: Pair students with different students than previous activities. Allow students to work for 5-7 minutes depending on how productive the conversations sound as you monitor the room.
Before moving to the next activity, lead a short class discussion allowing several students to share out their answers to ensure all groups have the same basic concepts before attempting to craft a claim, evidence, and reasoning response to the "explain" question.
EXPLAIN:
Teacher: Students should complete this activity independently. Allow students 10-15 minutes to write their 3-5 sentence explanation. If they finish early, they should check their work for errors and Claim, Evidence, and Reasoning components.
How does the ISS help humans study plants in space?
Write 3- 5 sentences explaining your understanding of how the ISS helps humans study plants in space.
Answers will vary.

EXTEND:
Teacher: This is a closing assignment to get students thinking about the next lesson in which we will use the GeneLab Data Repository to investigate flight investigations and genetic changes. Students should be allowed to write for as long as time allows, most students should finish in 3-7 minutes.
How can understanding microscopic changes in the plant help us understand how to compensate for these changes?
Write 3-5 sentences explaining the connections you believe exist between microscopic changes in the plant and the space environment.

DAY 2: SPACE FARMING-EVALUATING THE METADATA

KEY CONCEPTS

- The model organism for studying plants is the genus Arabidopsis.
- Reviewing scientific literature and metadata is essential for understanding the purpose and findings of the original experiment.
- Gene regulation involves complicated chemical pathways to maintain homeostasis.

OBJECTIVES

- Use the GeneLab Data Repository to research the metadata for OSD-213.
- Read, annotate, and analyze scholarly journals.
- Build on the ideas of other scientists through research and asking questions.

TEACHING TIPS

- Teachers and students will need access to the internet and an internet-enabled device capable of running the GeneLab Data Repository website and downloading files.
- Students may work alone, in pairs, or in groups of up to 4 students.
- This lesson is designed for a 90-minute block schedule with students working independently. If the teacher were to jigsaw the paper and use an expert chairs

approach to sharing the information among the group members the activity could be completed by a group of 4 in 55 minutes.

- More teacher instructions are throughout the Teacher Materials.

ENGAGE:REMEMBER-

Teacher: Allow students 2-5 minutes to quick write about the last lesson. Lead a short class discussion allowing students to share out ideas they remember from the last lesson. If you started class notes during the last lesson, you may want to display them after everyone has shared and allow students to determine if they "forgot" anything from the last class period. This should take 5-10 minutes in total including student work time.

In the last lesson, we learned all of the ways in which astronauts aboard the ISS are helping humans understand the potential problem and challenges of growing plants in the space environment.

List 3-5 of those challenges:

EXPLORE: Now, let's get a deeper look at what we've learned from space flight.

As you may recall, when scientists conduct experiments, they often use a model organism. In the case of plant studies, the most common model organism is Arabidopsis thaliana. Scientists often refer to this plant as simply Arabidopsis (uh-rabid-op-sis).

Teacher: If you have not discussed model organisms with your class before this point, you may want to give a mini-lesson on the topic of what makes a good model organism. Some examples are available in the teacher resources for Gene Labs for High School.

As a case study, today we will begin conducting an analysis of the metadata associated with OSD-213.

You may either- use this link:
https://osdr.nasa.gov/bio/repo/search?q=OSD-213&data_source=cgene,alsda&data_type=study OR go to NASA.genelabs.org and search for OSD-213.

Use the skills you learned the last time you worked with the GeneLab Data Repository to browse the metadata associated with this study.

Teacher: Please note there are two versions of the same assignment below, one is for annotating on paper and the other is for annotating digitally. Please delete the directions you do not need before sharing them with students. Allow students 30-60 minutes to read an annotate the article (depending on if you are allowing them to work in groups and jigsaw the activity they could finish in 30 minutes, if the students are working alone it may take an hour or more.)

Now it is time to dig deep into the scientific literature.

Teacher: If you will have the students annotate on paper, please print from the link below, then delete the link and the digital document instructions that follow the on-paper instructions before sharing with students.

Here is a link to the journal associated with this study:

https://drive.google.com/file/d/1WFp5bG_cJJ37BJ7wvT0WSeiF0wMAV5K1/view?usp=sharing

READ AND ANNOTATE ON PAPER DIRECTIONS

Read and annotate the abstract, introduction, and conclusion section of the paper, "A Whole-Genome Microarray Study of Arabidopsis thaliana Semisolid Callus Cultures Exposed to Microgravity and Nonmicrogravity Related Spaceflight Conditions for 5 Days on Board of Shenzhou 8" by Svenja Fengler et all, first.

Tips for reading and annotating on paper:

- Read the entire section one time through with only a pencil in hand.
    - With the pencil, underline information you want to remember, research, or record as evidence.
- Read the section a second time through, with only a pencil in hand.
    - This time as you read-
        - Circle unfamiliar words or terms to research later.
        - Draw an asterisk at the beginning and end of important ideas
        - Erase the line under anything you have underlined more than once (you don't need to have every instance of an unfamiliar word circled or underlined).
- Read the section a third time through. This time you need a highlighter and sticky notes.
    - This time as you read-
        - Write each unfamiliar word or term on its own sticky note
        - Write each underlined idea you want to use as evidence for writing your own conclusions on its own sticky note, on the back of the sticky note write the name of the paper and the page you took the note from.
        - Highlight anything you wrote asterisk by.
- Repeat with each section.
- After reading the assigned sections, write your own 5-7 sentence summary of the study that was conducted in OSD-213 and the original scientists' conclusions. You may not directly quote the text.
- Now you are ready to read the Materials and Methods, Results, and Discussion sections of the paper.
    - Use the same methods used for the previous sections.

EXPLAIN:

- **FINAL PRODUCT:** In a digital document, type up the two summaries, followed by the unfamiliar terms you wrote down and their definitions, followed by the quotes you wrote on sticky notes and the page numbers of those quotes.

Teacher: If printing the entire journal for each student is not possible, I have made a Google Slides version. If you would like more information about how I made the slides please email me at etubolino@baschools.org. Directions for using Google tools to annotate are included on the first slide of the Google Slides. There is also a teacher message on the first slide- please delete the message before sharing with students. If you are using the digital version of this assignment, please delete the link and the directions for the on-paper version of this activity before sharing it with students.

Reading and annotating a digital document.

READ AND ANNOTATE DIGITAL DIRECTIONS

Please use this modified copy of the original literature- none of the content or graphics have been changed, it has been formatted to allow you to digitally edit the work without changing the work.

Google Slides Research Article:

https://docs.google.com/presentation/d/1ATp8tZVRjz0Dz5e0JC8bzcfnxL6oeIYHOioJ2dge71Y/copy

Directions:

Use the Google Tools to annotate the article in the following slides.

1. You may use the lines tool to draw lines under important words or phrases.
    a. How to use the lines tool:
        i. Click the icon in the Google toolbar.
        ii. Choose a line type.
        iii. Zoom in using the icon.
        iv. Click and drag to draw the line under the text.
        v. You may change the color of the line using the icon
        vi. You may change the thickness of the line using the icon

2. You may use shapes or text boxes with a semi-transparent color to highlight the text.
    a. How to use the Shapes tool as a highlighter:
        i. Click on the icon in the Google toolbar.
        ii. Choose a shape, then click drag to draw the desired shape..
    b. How to use the Text box as a highlighter
        i. Click the icon in the Google toolbar.
        ii. Click and drag your cursor over the area you want to highlight.
    c. For Both Methods:
        i. How to change the fill color to highlight-
            1. With the shape/text box selected click on the icon in the Google toolbar.
            2. Choose "Custom"
            3. Make your custom color- don't forget to slide the Transparency to 75% or more.

3. You may use digital sticky notes to take notes as you read the text.
    a. How to use digital sticky notes-
        i. Copy and paste the sticky notes in the margin of this page to any other page in the document.
        ii. Use the fill (bucket) tool to customize the color of your sticky notes.
        iii. Use the text tools to customize the font.

Read and annotate the abstract, introduction, and conclusion section of the paper, "A Whole-Genome Microarray Study of Arabidopsis thaliana Semisolid Callus Cultures Exposed to Microgravity and Nonmicrogravity Related Spaceflight Conditions for 5 Days on Board of

Shenzhou 8" by Svenja Fengler et all, first.
Tips for reading and annotating on paper:

- Read the entire section only using the underline tool at this time to underline information you want to remember, research, or record as evidence.
- Read the section a second time through, this time as you read-
  - Circle unfamiliar words or terms to research later.
  - Draw an asterisk at the beginning and end of important ideas using a text box.
  - Erase the line under anything you have underlined more than once (you don't need to have every instance of an unfamiliar word circled or underlined).

- Read the section a third time through. This time you need a highlighter and sticky notes.
  - This time as you read-
    - Write each unfamiliar word or term on its own sticky note.
    - Write each underlined idea you want to use as evidence for writing your own conclusions on its own sticky note be sure to write the number of the page you took the note from on the note.
    - Highlight anything you wrote asterisk by.
- Repeat with each section.
- After reading the assigned sections, write your own 5-7 sentence summary of the study that was conducted in OSD-213 and the original scientists' conclusions. You may not directly quote the text.
- Now you are ready to read the Materials and Methods, Results, and Discussion sections of the paper.
  - Use the same methods used for the previous sections.

EXPLAIN:

- **FINAL PRODUCT:** In a digital document, type up the two summaries, followed by the unfamiliar terms you wrote down and their definitions, followed by the quotes you wrote on sticky notes and the page numbers of those quotes.

Teacher- Final products will vary. A rubric can be provided upon request (email address provided above).

NEXT STEPS

Make a list of 3-5 genes, cellular processes, or biological pathways you think may be affected by space flight in Arabidopsis.

DAY 3: SPACE FARMING-The GeneLab Data Repository

KEY CONCEPTS

- Exposure to the space environment can cause genetic changes in an organism.
- Genetic changes often lead to phenotypic changes in the organism.
- Gene expression can impact biological pathways and the ability of the organism to maintain homeostasis.

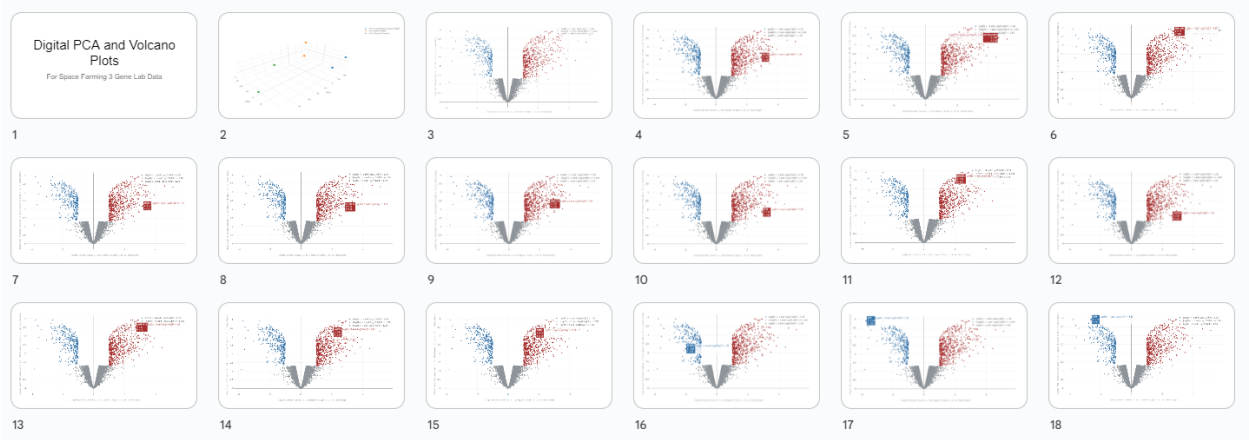
OBJECTIVES

- Analyze the GeneLab Data Repository visual data to determine if a gene is up or downregulated.
- Interpret the GeneLab Data Repository visual data to guide research into the function of a gene, cellular component, or protein.

- Use a gene database to learn more about the function of a gene and the biological pathways associated with the gene.

TEACHING TIPS

- This lesson is designed to be taught in a 90-minute block period.
- This lesson is designed for 6 groups of 3-4 students each.
- Students and teachers will need a device with internet access.
- OPTIONAL: Volcano Plot with Gene ID cards: LINK
    - Within the above-linked presentation are Volcano Plots and heat maps from gene labs. Slides 4-27 are the same Volcano Plot, but each image has a different gene highlighted for students to observe. I created this resource to print out the scatterplots 2 slides per page on cardstock, then laminated. The cards can be reused all day or multiple years.
    - I created this resource because I imagine that in many schools the Gene Labs website might take a very long time to load on Chromebooks and school Wi-Fi, this is a great alternative that still challenges the students to analyze the data and gain direction for further researching the gene.



- Additional teaching tips are throughout the teacher materials.

ENGAGE:

LAST TIME

Review your list of 3-5 genes, cellular processes, or biological pathways you think may be affected by space flight in Arabidopsis. Be prepared to share ideas with the class. Record any ideas you did not have on your original list below:

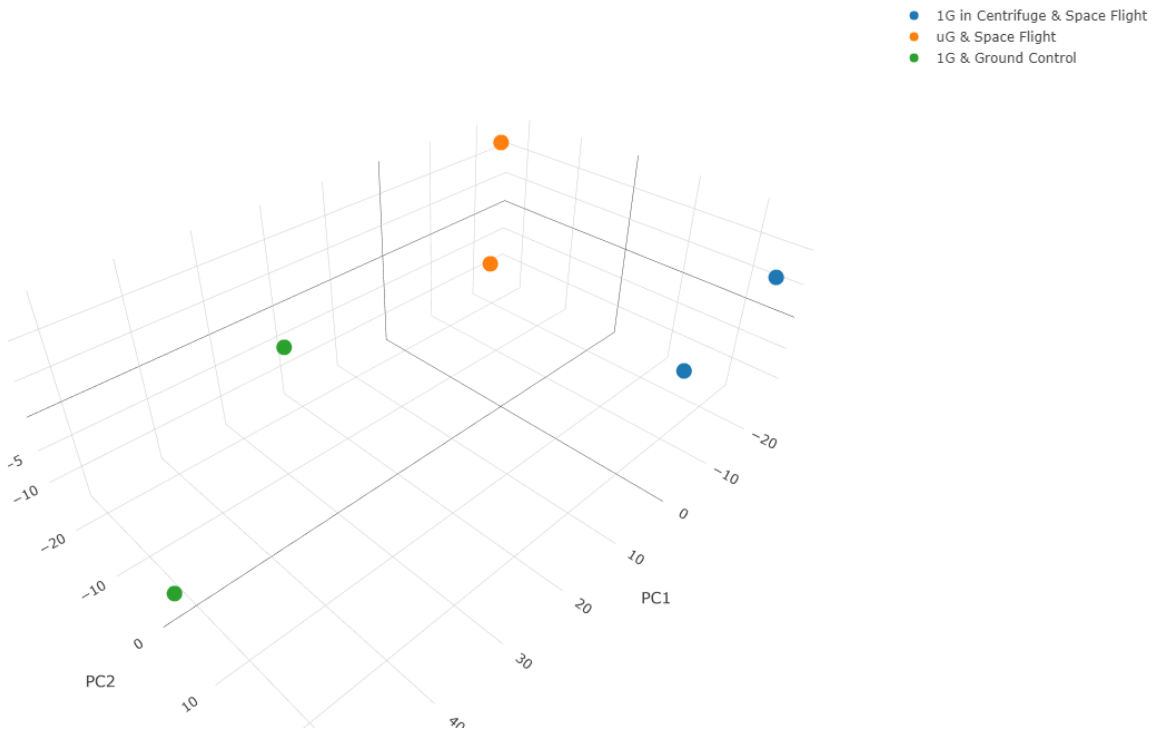
Teacher: Allow students about 1 minute to review their notes from the last lesson and compose an idea to share with the class. Then lead a class discussion to allow all students to share out their ideas. Students may need reminders to record the new ideas students share, and it may be helpful for the teacher to make a “class document” visible to all students for students that do not write as fast to use as a reference.

EXPLORE:

Directions: Work in pairs. One student should be using a Chromebook to navigate the internet and conduct the investigation, while the other records information on the student data sheet.

Take turns-students should swap roles.

Go to https://genelab.nasa.gov/
Click on: Visualize Data button
This tool takes a very long time to load. We are interested in OSD-213 the Arabidopsis study we read about in the last lesson.
First view the PCA plot. It has been imported for you below for you to view while the tool loads.



Complete the following table as you analyze the graph:
Teachers: If students have never analyzed a PCA plot or if they need more practice first, I highly recommend another Gene Labs Lesson: Bioinformatics Bite #3 Intro to PCA plots by Catherine Boileau, Bloomington High School South (Bloomington, Indiana). Allow students 7-10 minutes to analyze the graph and complete the table. Ask students to share out answers to ensure all students are drawing similar conclusions and to help those students that are struggling to see the connections.

What I see:	What it means:
The markers for all the flight plants are clustered closer on PC1	The differences on PC1 are more important than the changes on PC2, so the changes in the flight mice must be more important than the changes in the GC
The markers for all the 1g plants are clustered closer on the PC2 line	The differences between the 1G mice are less important than the differences between the FLT mice.

Answers may vary depending on individual interpretation.	

Next, view the Volcano Plot

Teacher- If students have not analyzed a scatter plot or need a refresher, it is highly recommended that students complete another Gene Labs Lesson: Introduction to Omics Using GeneLab by Elisheva Bailey.

Teachers- If the tool is loading too slowly, or if you decided to cut out the online portion for now, pass out the printed volcano plots now. Allow students 3-10 minutes to analyze the Volcano Plot, depending on whether the students are viewing the printed maps or choosing a gene from the web-based Volcano Plot. If allowing students to self-assign genes, I recommend making students write the name of their gene large on a whiteboard or butcher paper in the front of the room where everyone can see to be sure you don't have students researching duplicate genes. Also, be sure that students are picking an even number of upregulated and downregulated genes. You will be pairing up an upregulated pair with a downregulated pair in the next lesson.

Record the following information as you analyze the Volcano Plot:

The name of your gene of interest: Answers will vary depending on which plot you gave the student.

Is your gene up or downregulated? Answers will vary depending on which gene you assigned the student.

Next, research your gene!

Record notes about your gene as you conduct your research, be sure to focus on biological pathways and/or phylogenetic changes that could result in the organism.

Use the following website to conduct your research: https://www.arabidopsis.org/

Tips on beginning your research:

1. Type the name of your gene into the search box in the upper right corner of the page, then press "enter" or click "search".
2. When your results populate, click on the blue code under the heading "locus".
3. Read the information available about your gene, be sure to scroll all the way through to view all of the available information.

Record your notes below, you may need to modify the list by adding to taking away topics depending on the availability of data for your particular gene.

Teacher- Notes will vary, but should include key information about biological pathways and/or phylogenetic changes that could reasonably be occurring in the organism due to a change in the gene. Allow students 30-40 minutes to conduct their research, depending on how productively students are working.

Name of the gene:

Acts upstream of or within:

Involved in:

Located in:

Enables:

Expressed during:

Expressed in:

Has gene product:
BAR eFP notes:

EXPLAIN: Propose an explanation- How do you think the changes to the gene you studied is changing the phenotype of the plant? (Use 3-5 sentences with evidence to support your claims and scientific reasoning to justify your claims).
Answers will vary, look for reasonable explanations supported by evidence and check that students are applying sound scientific reasoning to their explanations. Allow students 7-10 minutes to develop their conclusions.

4 AND 5: SPACE FARMING-PRESENT YOUR FINDINGS

KEY CONCEPTS

- Genetic material is responsible for both hereditary and repair functions in the body of an organism.
- Genes can be involved with more than one process.
- Proteins have functions related to all stages of the organism's life cycle.

OBJECTIVES

- Use researched data to create a presentation to share your findings with the class.
- Present your finding to the class, be prepared to answer questions and elaborate on your ideas.

TEACHING TIPS

- This lesson is designed to take two 90-minute class periods. One 90-minute session to create the presentations and another to present the presentations the students create.
- Students should be working in groups of 4 students for this activity.
- Each student will need a computer with internet access to create their presentations and conduct any necessary additional research.
- Additional teaching tips are throughout this teacher guide.

ENGAGE: REMEMBER

Last time, we researched specific genes to discover what is known about the gene's function in the plant's body. Retrieve your answer to the "Next Time" question from the last lesson. Summarize the ideas into a single sentence, write that sentence below, and be prepared to share out your answer with the class.
Teacher- Allow 4-5 students to share their sentences with the class, and give the students feedback to help them with any misunderstandings or missed connections.

EXPLAIN: ACTIVITY

Teacher- Split your students into groups of 3-4 for this activity. Groups students together with two students with an upregulated gene and two students with a downregulated gene.
I would go through the directions in detail to ensure all students understand what should go into their presentation and have the opportunity to ask questions- it will probably take 10 minutes to fully explain the directions and the rubric.
Allow students to work on their presentations for 45 minutes or more depending on how productive you feel they are working.

Transition to working in a group of 4 as instructed by your teacher.
In a group of 3-4 you will create a presentation to share your findings. Each person in the group must present at least one slide.
Create a new Google Slides or Canva presentation and share it with all members of your group.

Section Expectations:

Section 1: Title Slide- All students' names and a catchy title for your presentation.
Section 2: An upregulated gene- 2-4 slides explaining the name of the gene, what the gene does, which biological pathways it is involved in, when it is most expressed in the plant's life cycle, your conclusions about what this gene being upregulated is changing in the organism.
Section 3: A downregulated gene- 2-4 slides explaining the name of the gene, what the gene does, which biological pathways it is involved in, when it is most expressed in the plant's life cycle, your conclusions about what this gene being downregulated is changing in the organism.
Section 4: Conclusions- 2-4 slides explaining how you think the condition of space flight might have affected the plants in this data set.

General Guidelines:

Teacher: Feel free to modify these directions and the rubric that follows to work for your students and grading style. These are the guidelines we enforce for presentations at our school, but I know all schools are different. The rubric can be used to grade the presentations. I would recommend giving one copy to each student when they begin making their presentation, and another on the day of presentations. You can make a class set of the rubric and put it in a plastic sheet protector. The students can use a dry-erase marker to score the presentation on the rubric while the other group presents, then transfer the score to the score sheet and erase the sheet before the next presentation begins. This gives the other students something productive to do while one group returns to their seats and the next group sets up their presentations. I usually hand out a score sheet with the rubric on the day of the presentations and ask students to grade each other's work. Sometimes I average all of the scores together (with my grade counting twice) and award the student that grade for their presentation, sometimes I just grade it myself and use the grade sheet as a way to make the other students accountable. I created a scoresheet below the rubric for teachers to use if they wish. (Delete the red text before sharing with students please.)

- Text should be large enough to be read easily from the back of the room when presented at the front.
- Text should be clear and easy to read (including color choices and fonts.)
- Images should be used on each slide; images should explain or add to something on the slide- they are not just decoration.
- Do not put too much text on one slide- your audience should not need to choose between listening to you speak or reading your slide. Keep the notes on the slide short and to the point, elaborate when you speak about the slide and images you chose.

Presenting Tips:

- Dress for the occasion, you will be standing in front of the class avoid wearing PJs or sweats.
- Speak clearly and loud enough for everyone in the room to hear you.
- Do not read from the slides, you may take notecards with you to help you remember what to say or pronounce difficult words, but you should try to speak naturally, not as if you are reading from your notes.

- When you are NOT presenting, actively listen to the other presenters. Take notes, and ask questions- put yourself in their shoes- would you want everyone zoning out and trying to sleep while you are presenting? Be a good audience when you are not presenting, please.

ELABORATE: **Rubric** (Points listed are "per slide" if a section has 4 slides, they can earn up to 20 points for that section)

Criteria	Advanced- 5 points	Mastery- 4 points	Meets Expectations 3.5	Below Expectations - 3	Poorly (or not) Attempted- 0
Title Slide	Engaging title, all team member names present, engaging image	Engaging title, all team members present, an image	Title, All team members present, an image	Missing: Title, a team member's name, or an image	Missing more than one essential element.
Upregulated Genes	4 slides that accurately explain the function and importance of the gene including engaging images to elaborate on the speaker's ideas.	4 slides that accurately explain the function and importance of the gene and images to demonstrate the speaker's ideas.	2 slides meet "Mastered" expectations.	1 slide meets "Mastered" expectations.	No slides meet "Mastered" expectations.
Down Regulated Genes	4 slides that accurately explain the function and importance of the gene including engaging images to elaborate on the speaker's ideas.	4 slides that accurately explain the function and importance of the gene and images to demonstrate the speaker's ideas.	2 slides meet "Mastered" expectations.	1 slide meets "Mastered" expectations.	No slides meet "Mastered" expectations.
Conclusions	4 slides that explain the speakers' conclusions, including engaging images to elaborate on the speaker's ideas.	4 slides that explain the speakers' conclusions and images to demonstrate the speaker's ideas.	2 slides meet "Mastered" expectations.	1 slide meets "Mastered" expectations.	No slides meet "Mastered" expectations.
Presentation:	Text is clear and easy to read, font and color choices are appropriate, and images enhance the presentation instead of distracting.	Text is clear and easy to read, font and color choices are appropriate, and images are present on all slides.	2 slides do not meet "Mastered" expectations.	3 slides do not meet "Mastered" expectations.	No slides meet "Mastered" expectations.
Presenting:	Spoke loudly and clearly for the entire room to hear, spoke in a natural conversational tone, was professional and clear when speaking or asking questions.	Spoke loudly and clearly for the entire room to hear, spoke in a natural conversational tone, and was able to answer questions respectfully.	2 slides meet "Mastered" expectations.	1 slide meets "Mastered" expectations.	No slides meet "Mastered" expectations.
Total:					
Notes:					

Group Name:	Group Score:	Comments/Notes:

EVALUATE: Peer review scorecard.

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