

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

Student 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 response to space flight.

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.

AUTHOR

Erin Tubolino, Broken Arrow Early College High School (Broken Arrow, OK)

Edited by GL4HS Staff

1: SPACE FARMING- INTRODUCTION TO PLANTS IN SPACE

OVERVIEW

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.

Driving Question: Why do we need plants in space?

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

<https://nasaclips.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?

What factors were the scientists trying to control or replicate?

Why are scientists interested in these factors?

Remember- What do plants need to live?

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			
Soil			
Nutrients			
Gases			
Gravity			
Radiation			

Questions:

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.

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:	
Factors in choosing the right plant	
Systems to grow and monitor plants in space:	
Importance of light:	
Influence of Gravity	
Watering plants in space	
Propagating plants in space:	
Plant genetics	
Human impact	

Use the information from Graphic Organizer 2 to complete column 3 of Graphic Organizer 1.
Practice the Think-Pair-Share: Comparing Notes protocol described on the last page.

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.

Write 3-5 sentences explaining the connections you believe exist between microscopic changes in the plant and the space environment.

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.

REMEMBER-

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:

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).

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.

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

READ AND ANNOTATE ON PAPER

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 al, 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.
- **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.

DIGITAL READING AND ANNOTATING 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/co>
[py](#)

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 al, first.

Tips for reading and annotating on paper:

- o Read the entire section only using the underline tool at this time to underline information you want to remember, research, or record as evidence.
- o 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.
 - o 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.
 - o Use the same methods used for the previous sections.
- **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.

NEXT STEPS

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

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.

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:

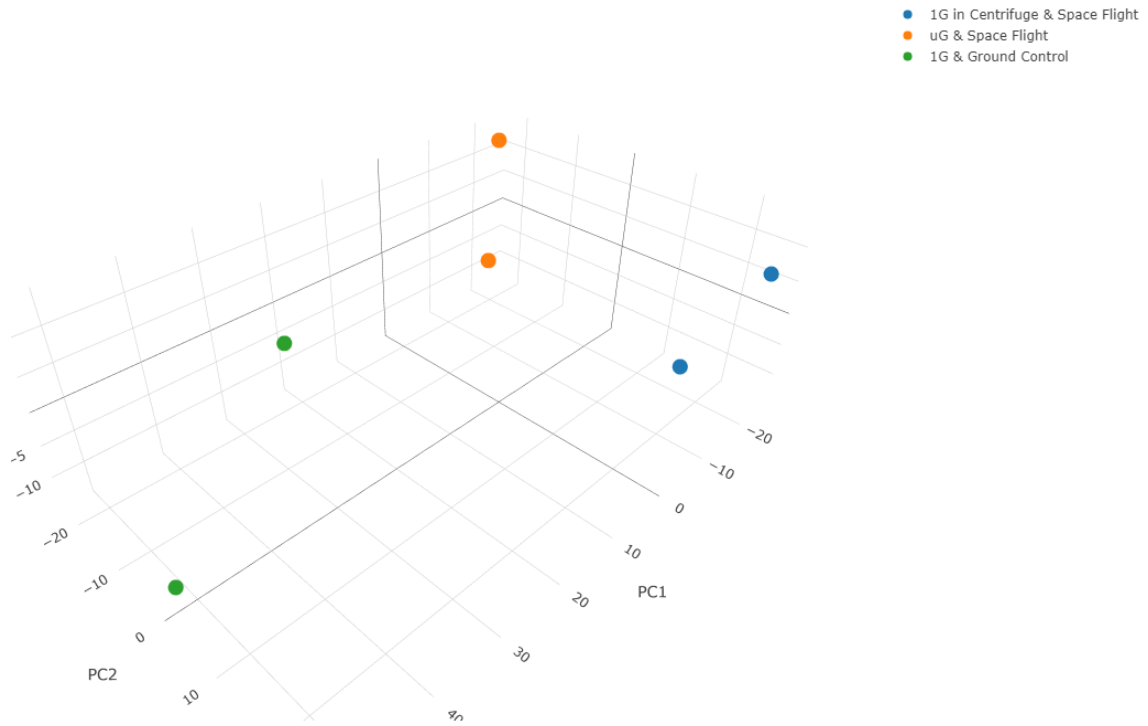
Directions: Work in pairs. One student should be using a Chromebook to navigate the internet and conduct the investigation, while the other records information on the student data sheet. Take turns-students should swap roles.

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:

What I see:	What it means:

Next, view the Volcano Plot

Record the following information as you analyze the Volcano Plot:

The name of your gene of interest:

Is your gene up or downregulated?

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.

Name of the gene:

Acts upstream of or within:

Involved in:

Located in:

Enables:

Expressed during:

Expressed in:

Has gene product:

BAR eFP notes:

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).

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.

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.

ACTIVITY

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:

- 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.

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:					

