Why Space Biology & An Introduction to the NASA Twin Study

Worksheet
Student Materials

Instructions:

ANSWER sheet version!

To make of copy of this document use this LINK🔗

ENGAGE
Before you start this section, you will learn a little bit about the National Aeronautics and Space Administration (NASA) and why biology is important for NASA. Watch NASA's "We are Going" video as an introduction to the topic. 👀 **Watch the NASA "We Are Going" (4 min)** video [https://youtu.be/vl6jn-DdafM?si=yigfcQWRJ4rtVU82] **Reminder**: Get a template for your vocabulary book from your teacher if you have not already!

EXPLORE - GOING TO SPACE!	
👀**Watch NASA Explorers: Artemis Generation (11 min)** **OR** **Yo Soy Artemis (6 min, Español)**	https://plus.nasa.gov/video/nasa-explorers-season-5-episode-1/ https://plus.nasa.gov/video/yo-soy-artemis/
✏️Where are people planning on traveling to in space? Have we reached that destination yet?	Answer: NASA anticipates people will return to the moon in the Artemis missions by 2025 at the earliest. Answers may vary as students may cite the Apollo missions or they may say people have not traveled to the moon yet on the Artemis missions.
1. 🔗Check out this website https://www.nasa.gov/image-of-the-day/ and look at the pictures. 2. 🖼️Pick 1-2 pictures and include a link and screenshot in your answer. Describe what you are seeing.	Answer: Answers will vary. Should include a screenshot and link to the relevant picture, as well as two facts.

3. 💖What do you like about the pictures? 4. 📖Click on the “Read More” arrow and read the short article. Share at least two (2) facts that fascinated you. 5. 👥Share your fact with a partner and write down your partner’s favorite fact.	
✏️What interested you about what NASA has done or is working on?	Answer: Answers will vary.
👀 **Watch the video on the Inspiration4 Mission (3 min)** **Or 📖Read the article**	https://youtu.be/D38W150h9a4 https://www.spacex.com/launches/inspiration4/
✏️Would you ever want to go to space? Explain why or why not.	Answer: TEACHER NOTE - Good opportunity to incorporate FlipGrid if you choose to. Answers will vary.
✏️What problems can you think of if you had to live in space for a long time?	Answer: Answers will vary.

EXPLAIN - SPACE BIOLOGY VS ASTROBIOLOGY

As you have read and watched the videos about space missions, you have learned about various reasons why people aim to travel to space. Some are fascinated by just having the chance to experience space, but many are interested in making new discoveries about the universe we live in. In this section, you will learn the difference between space biology and astrobiology in detail.

Answer the questions in the boxes as you read/watch the resources provided. Make sure to read instructions carefully. You can always do more if you have time.

1. 📖**Read** about the difference between astrobiology and space biology from NASA's website HERE.	https://science.nasa.gov/biological-physical/stories/space-biology-and-astrobiology-whats-the-difference/
✏️Write a definition for astrobiology and space biology in your own words. *You can look up any words you don't yet know to figure out their meaning. Work with a partner to come up with a good definition you all understand.*	**Astrobiology**: The answer can be a variation of how astrobiology is the study of the origin of life, how life evolves, and distribution of life in the Universe. **Space Biology**: Space biology should be distinct from astrobiology in that the definition should reference how space biology studies the effects of spaceflight on biological systems. The answer may mention that space biologists study the influence of ionizing radiation, microgravity, isolation, and altered atmosphere.
✏️Do you think astrobiology or space biology is more interesting? Why? *Answering with "neither", "none", or a similar response will not be accepted.*	Answer: TEACHER NOTE - Good opportunity to incorporate FlipGrid if you choose to. Answers will vary.
2. Astrobiology	**Choose (Read & Watch) then respond to the questions in each column.**
📖**Read about how did life form** Read a section of Issue #7 of *Astrobiology: The Story of our Search for Life in the Universe* comic. • Read Pg 20 - 33 (or printed page numbers 18-31) https://astrobiology.nasa.gov/uploads/filer_public/e2/24/e2247808-b5c6-4e49-b2f0-4ce9c89fc43b/issue7_mobile.pdf	👀**Watch** "Astrobiology Case Study: E•NIG•MA" (9 min) • https://youtu.be/DGTPPy2fNyc?si=dQ1qd1vgRYETuGFn **Tips**: • Turn on captions using the CC button on the bottom right of the video. • Click on the settings button⚙️to change languages or adjust speed.

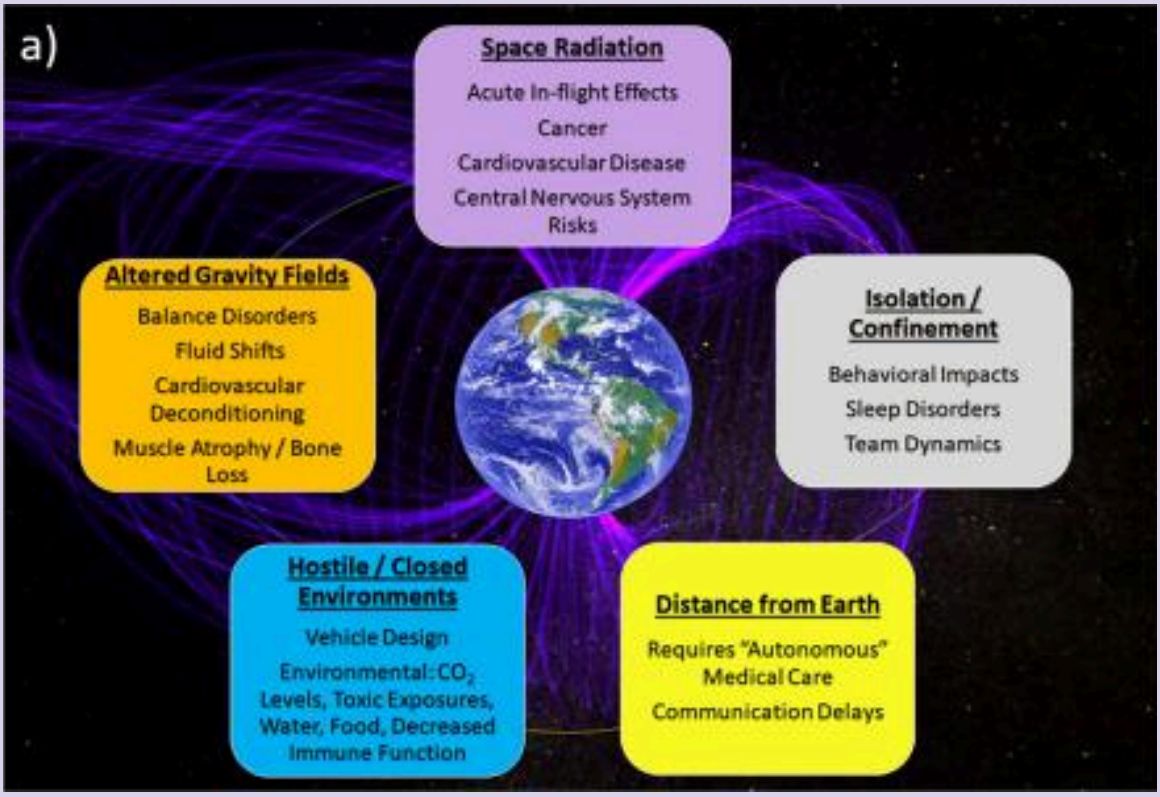
✏️List **5 key ideas** you learned from the comic. Answer: Answers will vary. Potential answers can include: • Astrobiology studies how life could have originated and if it can occur elsewhere • The cell is the simplest unit of life • Many scientists have contributed to learn what are the building blocks of life (Woher found organic compounds can form from inorganic materials, Pasteur isolated bacteria from air, etc.) • Three types of cellular life (eukaryotes, archaea, and bacteria), but archaea and bacteria are unicellular • Microbes can leave chemical signatures in rocks which serve as evidence of life • Environmental conditions of early Earth influenced how molecules like DNA and protein arose • DNA carries genetic information and it can tell the history of how life could have evolved • And more... Some students may find reading this comic more challenging due to vocabulary and unfamiliarity with concepts. This comic can be skipped and students can just watch the video instead as needed.	✏️List **5 key ideas** you learned from the video. Answer: Answers will vary. Potential answers can include: • The big questions in science are “are we alone?” and “where do we come from?” • Ancestors of life began with single celled organisms that have evolved over billions of years • Earth is made of rocks and life is made of proteins • Proteins are responsible for making up life and does everything to keep living things alive • Proteins are like Legos which can be built in different ways with many combinations • There are universal proteins that help form more complex proteins • Proteins probably existed in a primordial soup and looking at protein evolution would tell us how life evolved • People can study proteins by either looking at the earliest universal proteins or by breaking down complex proteins • Evolution of minerals can help research the development of life because certain minerals can’t form without the presence of life • Rocks and life are connected so the timeline found in rocks can be matched to the timeline of protein evolution
	✏️What surprised you about astrobiology? Why was it surprising? Answer: Answers will vary.

✏️What makes up living things based on what you know now?	Answer: Answers may vary based on what students understand. Student responses may include how living things are made up of cells, all life relies on proteins to function, life is made up of inorganic materials that can create organic compounds, and etc.
✏️Why are proteins important for understanding life?	Answer: Responses may include these variations: ● Proteins are necessary for every function life needs to do to stay alive. ● They can be studied to figure out how life could have originated and evolved on Earth. ● Proteins can be broken down to simpler components to trace their origin.

3. Space Biology	
👀**Watch** TED-Ed “Could we survive prolonged space travel?” - Lisa Nip (5 min) ● https://youtu.be/upp9-w6GPhU?si=2ycHVzzpCQuAx_CE	**Tips**: ● Turn on captions using the CC button on the bottom right of the video. ● Click on the settings button⚙️to change languages or adjust speed.
✏️What does “adaptation” mean? How long would it take for humans to adapt naturally?	Answer: Adaptation means a characteristic that has evolved in an organism that is beneficial for its survival and heritable. It could take tens of thousands of years for humans to naturally adapt.
✏️What does Lisa Nip mean by “gene therapy”? Why would this process be helpful?	Answer: Gene therapy is a way to edit genes to be able to treat genetic diseases. It can be used to build in ways to avoid DNA damage such as using fungal melanin to convert harmful radiation to useful energy.

✏️What challenges were mentioned in the video about space travel? Why are they a problem?	Answer: • Microgravity can impair bone and muscle growth which causes weakness • Radiation can damage DNA and cause mutations
👀**Watch** "Introduction to Omics: 360 Degree View of You" - NASA Video (5 min) • https://youtu.be/m7X6mugpijQ?si=Z4wTdta4BXUjo714	If you want a visual of what omics look like, see this NASA poster. (https://www3.nasa.gov/sites/default/files/atoms/files/omics_poster.pdf)
✏️From the "Introduction to Omics: 360 Degree View of You" video, how did they define "Omics"?	Answer: Omics is seeing the collection of molecules that make up "you", such DNA, proteins, and metabolites.
✏️What did they say "omics" is similar to a puzzle?	Answer: We need to put all the individual pieces of omics-related information to see the whole picture of what makes up an individual.
✏️What is the purpose of the Twin Study mentioned in the video?	Answer: The study supports our understanding of space effects on human bodies. Knowing the potential health effects allows us to determine treatments and means to manage health in space for longer space missions, such as a trip to Mars.
✏️What is the benefit of studying omics?	Answer: Understanding omics could mean a better understanding of health to a level where it can be possible to maintain good health in people long before they get sick.

Here is a figure of the core concepts of space biology. It shows the 5 main hazards of spaceflight in different colored squares. Use this figure to answer the next questions.



"The five main hazards of spaceflight and the space exposome" CC by 4.0 / Cropped from original from Patel ZS, Brunstetter TJ, Tarver WJ, Whitmire AM, Zwart SR, Smith SM, Huff JL. Red risks for a journey to the red planet: The highest priority human health risks for a mission to Mars. NPJ Microgravity. 2020 Nov 5;6(1):33. doi: 10.1038/s41526-020-00124-6. PMID: 33298950; PMCID: PMC7645687. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7645687/

🔎**Use the figure above to answer the questions below. You can use outside resources to research.**

✏️Looking at the figure, what are the 5 main hazards of spaceflight?	Answer: • Space Radiation • Isolation/ confinement • Distance from Earth • Hostile / closed environments • Altered Gravity Fields
✏️Choose a hazard and explain why it is dangerous on a Google slide. *Copy-paste the link in the answer box. Make sure your share settings are "Public".*	Answer: Answers will vary, but they should accurately summarize a spaceflight hazard. Encourage students to thoroughly explain why exactly the hazard is so dangerous.

EXPLAIN - NASA TWIN STUDY

You have learned a little about NASA's missions and the research done in space biology. Now you will use what you learned to understand one of NASA's most significant human studies in space: the Twin Study. Have fun and explore the amazing science!

Use your vocabulary books to keep track of new words. Work with a partner to come to a conclusion about what these new words could mean and ask for help when you need it.

👀**Watch these 2 videos** "NASA's 4-year Twin Experiment Takes Us Closer To Mars Than Ever Before" **AND** "Three Key Findings from the NASA Twins Study"	https://youtu.be/ZVRft7r8-Ds https://www.youtube.com/watch?v=hU0cD3kWnKY
✏️Why did NASA use twins in their research? Are there any limitations to this?	Answer: Twins are genetically identical which allows for the perfect control. Any differences observed in Scott Kelly can reasonably be attributed to spaceflight. The limitation is that the findings are based on only a small sample of one astronaut.
✏️Describe at least 3 things scientists found out from the study?	Answer: • Telomeres have lengthened in space • Immune system responds to vaccines normally in space • Gene expression variability increased in certain genes after spaceflight but most returned to normal after returning to Earth • Chromosome mutations
✏️What happens to gene expression in space?	Answer: Some genes became more expressed and some were less expressed in space. These genes did not change back to baseline until the return to Earth, but some of the gene changes did not go back to normal.
✏️What are telomeres? What happened to them in the study?	Answer: The telomere is a cap at the end of a chromosome that protects it and they shorten due to stresses. However, in space, the telomeres are lengthened.

✏️Were any of the changes in Astronaut Scott Kelly permanent?	Answer: The changes were not permanent.
✏️Why was this research important? Optional resource: Twin Study Results at a Glance Poster (https://www3.nasa.gov/sites/default/files/thumbnails/image/pinwheel_041119_me-01_0.png)	Answer: The research done in the NASA Twin Studies advances what we know about the effects of space on human health. It could potentially lead to new treatments and better understanding about cancer as well.
📖**Read** the official NASA news article about the Twin Study HERE (https://www.nasa.gov/humans-in-space/nasas-twins-study-results-published-in-science-journal/)	**Recommended**: You can use this video series "OMICS: Exploring Space Through You" to help you define each omics term. https://youtube.com/playlist?list=PLiuUQ9asub3TReMNgv6kDFwNsRuCWAVcw&si=NRiBJ1ETAM1wLMP0
✏️**Define** these omics terms and add them on your vocabulary book: • Gene • DNA • RNA • Gene expression • Genomics • Epigenomics • Metabolomics • Proteomics • Transcriptomics • Microbiomics **Attach a link** to your vocabulary book if it is digital. Make sure the share settings are set to "**Public**".	(Make sure share settings are "Public") Link to Vocabulary Book: Answers will vary.
APPLY & SHARE YOUR KNOWLEDGE Before starting the next section, check in to make sure you understand what to do.	**DUE DATE**: _____
💼Make a product to explain why space biology and omics research is important for future human space travel.	Upload your product as a URL link or picture if it is a physical object.

Your product can be a slide presentation, artwork, song, or any way to creatively teach someone about what you have learned. <u>Your content MUST include the following:</u> • What are the 5 hazard of space • Reasoning for why omics-related research is needed (use 3 omics terms) • Use supporting details from the NASA Twin Study or other provided resources to strengthen your reasoning • Why (or why not) you would want to go to space • Proper citations Audience: Peers, teacher, school community Presentation: May be in-class or a video recording. Aim for 5-8 minutes.	Link or Image: Answers will vary.

Hooray you have completed the assignment! 🎉👏

For your interest!	
Hispanos de la NASA (en Español)	https://plus.nasa.gov/playlist/hispanos-de-la-nasa-2/
Astrobiology Comics	https://astrobiology.nasa.gov/resources/graphic-histories/
NASA Twin Study Full Research Paper	https://www.science.org/doi/10.1126/science.aau8650
Explore the Open Science Data Repository (OSDR) where scientists share all their omics data	https://osdr.nasa.gov/bio/repo/search?q=&data_source=cgene,alsda&data_type=study
Newsletters from Gene Lab	https://genelab.nasa.gov/newsarchive

---

AUTHOR
Stephanie Tsai, Saddleback High School (Santa Ana, CA)
Edited by GL4HS Staff