



## Bioinformatics Bite #2: Intro to Omics

Worksheet  
Teacher Materials

### OVERVIEW

This activity introduces the term “omics”, what it entails, examples of omics studies, and applications of omics.

### KEY CONCEPTS

- Omics are the study of collective sets of molecular information.
- Applications of omics study include the refinement of medical technologies.
- Statistical tools are used to assess omics data.
- Many NASA studies and research include omics data.

### OBJECTIVES

- Students will be able to create a functional definition of the term “omics”.
- Students will be able to define characteristics that define different types of omics.
- Students will be able to list statistical tools relevant to omics studies.
- Students will learn to navigate at last one NASA website with omics resources and data.

### TEACHING TIPS

- Suggested time frame: Approximately one hour-long class period, but can be extended or broken into components spread over a set of days.
- **Recommended Warmup:** Before you pass out the handouts, ask your students to brainstorm on a scrap piece of paper what they think omics is?
- I always love to start off engaging the students in the lesson by bringing students prior knowledge-correct or not- to the surface, so I can make a note of where my students are and what I need to do to make sure they gain a proper understanding of the topic by the end of the lesson.
- Please note that additional teacher tips are integrated into the appropriate sections, and indicated in RED text in the teacher materials.

## BIOINFORMATICS BITE #2: OMICS

Text references are associated with the GeneLab for High Schools Bioinformatics Manual for the Galaxy Platform, available at [ [url](#) ].

Videos are found at <https://www.nasa.gov/hrp/omics-videos>

### Part 1: What IS Omics?

**Interact with the resources listed and linked and take notes on their information in the highlighted portions of the table.**

Resource	Notes---What is Omics?
<p>Watch Videos:</p> <p><a href="#">Introduction to Omics</a></p> <p><a href="#">Omics: Advancing Personalized Medicine from Space to Earth</a></p>	<p>Student answers will vary</p> <ul style="list-style-type: none"> <li>● Omics try to understand all of the individual pieces to make sense of the whole picture</li> <li>● Omics is a field of study that integrates different types of molecular information.</li> <li>● Could lead to personalized healthcare instead of one size fits all.</li> <li>● NASA Twins Study utilizes omics to look at a variety of things</li> <li>● Hope to predict and prevent disease by analyzing omics measurements and genomes</li> <li>● Omics is the collection of measurements of biomolecules</li> <li>● Utilizes big data to manage health</li> <li>● Omics will allow us to see things at a level we have never seen before.</li> <li>● Omics is part of a new era of personalized medicine based on new technologies</li> <li>● A discipline integrating collections of measurements of biomolecules to provide a complete picture of health.</li> <li>● The primary focus of the NASA Twins Study.</li> </ul>
<p>Read Text: <a href="#">What is Omics (Excerpt)</a></p>	<p>Student answers will vary</p> <ul style="list-style-type: none"> <li>● a field of study that ends in –omics</li> <li>● –ome suffix is really used to address the study of the –omics fields, so genomics is the study of the genome</li> <li>● Omic technology adopts a holistic view of the molecules that make up a cell, tissue or organism.</li> <li>● Omics technology can be applied to basic research to help understand the response of organisms to different external stimuli</li> <li>● Used in disease processes where they can play a role in screening, diagnosis and prognosis as well as aiding our understanding of disease progression</li> </ul>

**Using the information you collected in the above table, use your own words to define what is meant by omics.**

**Student answers will vary. Guide students to use the information above and put it in their own words. It is not about sounding fancy or guessing the “right” definition, it is about grounding their definition in facts in a way that is understandable to them.**

## Part 2: Oh-So-Many Types of Omics!

Your teacher will assign you one of the types of omics and you will watch the video/read the resources, and conduct research to fill out your row of the chart (unless you get epigenomics & microbiomics, you need to do detailed notes on both, since there is only one column to research).

When you are done, you will collaborate with other students to get the information you need to fill out the rest of the chart.

Feel free to set a time limit for the individual work, then form groups and set a time for group collaboration to keep students moving. OR you can pre-group students and set a time limit for individual and collaborative work altogether. You can also have students do this solo if needed, but the individual/group jigsaw is the intended method of this lesson.

Student answers will vary on all of this, but here are some sample answers for your use.

Omics Type (& Resources)	Omics Definition	Analytical Tools Used to Conduct Omics Analysis
<b>Genomics</b> <a href="#">Genomics Video</a> <a href="#">Omics Types (Excerpt)</a> <a href="#">Omics Analytical Tools (Excerpt)</a>	The omics study of the total DNA of a cell or an organism.	Genes can be studied individually through PCR and quantitative PCR or they can be studied genome wide with microarrays and RNA sequencing (preferred, more accurate).
<b>Transcriptomics</b> <a href="#">Transcriptomics Video</a> <a href="#">Omics Types (Excerpt)</a> <a href="#">Omics Analytical Tools (Excerpt)</a>	The study of RNA molecules, generally mRNA since they are the template for protein synthesis.	Expression based techniques like microarrays and RNA Sequencing (preferred, more accurate).
<b>Proteomics</b> <a href="#">Proteomics Video</a> <a href="#">Omics Types (Excerpt)</a> <a href="#">Omics Analytical Tools (Excerpt)</a>	Study of expression of proteins in an organism  Aims to study functional relevance of proteins through characterizing information flow through protein pathways and networks.	Mass spectrometry techniques  Physical biochemistry, enzymological, and immunological techniques  Two dimensional electrophoresis  Isotope tags  Liquid chromatography  Protein chips
<b>Metabolomics</b>	Metabolome-small molecule	Mass spectrometry

<p><a href="#">Metabolomics Video (#1)</a></p> <p><a href="#">Metabolomics Video (#2)</a></p> <p><a href="#">Omics Types (Excerpt)</a></p> <p><a href="#">Omics Analytical Tools (Excerpt)</a></p>	<p>chemicals found within an organism and can be produced by metabolic activities or not be naturally produced.</p> <p>Study of global metabolite profiles in a system under a given set of conditions</p>	<p>Gas chromatography</p>
<p><b>Phenomics</b></p>	<p>“Morphological, molecular, physiological and biochemical characterization”</p>	
<p><b>Ionomics</b></p>	<p>“Identification, characterization, and distribution of elements”</p>	
<p><b>Epigenomics</b></p> <p><a href="#">Epigenomics Video</a></p>	<ul style="list-style-type: none"> <li>● Environment has a profound impact on DNA/packaging material around it (and health)</li> <li>● Collection of changes by environment is epigenomics</li> <li>● The changes can be modified by stress</li> <li>● DNA can be changed through habits</li> <li>● Epigenomics is the study of the collection of modifications to your DNA.</li> </ul>	
<p><b>Microbiomics</b></p> <p><a href="#">Microbiomics Video</a></p>	<ul style="list-style-type: none"> <li>● More microbes than our cells!</li> <li>● Make metabolites that can influence our behavior/conditions</li> <li>● Can control through diet and probiotics</li> <li>● Microbiome consists of bacteria, viruses, and fungi and it digests food and makes essential vitamins</li> </ul>	

Read [Omics Statistical Tools \(Excerpt\)](#) and answer the question below.

**What types of statistical tools can be used for omics analysis?**

Encourage students to look at the text and research on the internet as well! They may feel frustrated with this step if they have low statistics knowledge but encourage them to push through it and provide guiding hints to get to the following recommended answers:

- Statistical methods to identify genes or groups of genes that are changing in response to a specific treatment
- Quantitative real time PCR (gene expression methods) to validate if changes are real
- T-statistic (most common type of analysis for two groups of data)
  - Determine false discovery rate

**Part 3: The Twin Study: NASA Omics in Space**

**Watch: [Fireworks in Space: NASA’s Twins Study Explores Gene Expression](#)**

Complete the “True or False” activity about the omics teams’ results of the NASA Twin Study with a partner using this [link](#). Time your partnership, see how fast you can go and get them all right! Check with your teacher if you got it right, and start the clock again if you didn’t!

In the picture, there is differentiation between Dr. and PhD. I have used “doctor” interchangeably, as both are technically doctors. Feel free to set your own parameters for your students or use this as a discussion for what the title “Doctor” means!

Statement	T/F	If F, rewrite the statement so it is true. (Just write N/A if T)	What omics team (Researchers and Topics?)
Scott reacted the same to the flu vaccine before, during, and after the mission, which proved the immune system responded appropriately in space.	T		Immunome Dr. Mignot & Team
Microbiome health was not maintained during space.	F	Microbiome health was maintained during space	Microbiome Dr. Turek & Team
Scott showed signs of inflammation in space.	T		Integrative Omics Dr. Snyder & Team
Scott’s fluids shifted to his lower body and there were structural changes to his eyes.	F	Scott’s fluids shifted to his upper body and there were structural changes to his eyes.	Proteomics Dr. Rana & Team
Scott’s degree of epigenetic changes were	F	Scott’s degree of epigenetic changes were similar to Mark’s on Earth.	Epigenomics

different from Mark's on Earth.			Dr. Feinberg & Team
Scott's carotid artery wall thickened in space.	T		Metabolomics Dr. Lee & Team
Gene expression changed in space and the majority retained that change on Earth. DNA damage was observed.	F	Gene expression changed in space and the majority returned to normal (on return to Earth). DNA damage was observed.	Gene Expression Dr. Mason & Team

Partnership Time to Complete: **Students times will vary.**

**Watch:** [Three Key Findings from NASA's Twin Study](#)

Looking back at all the different omics teams' results from the true/false activity, pick your favorite one and complete the following questions.

**Student answers will vary, so this is just an example of one choice. Encourage detail and research!**

Omics Team: <b>Gene Expression</b>	<a href="#">Picture Link</a> (referenced above)	<a href="#">Article Link</a> (Look for a section on your omics team and read that--and more if you wish!)
General Notes---->	Gene expression changed in space and the majority returned to normal (on return to Earth). DNA damage was observed.	<ul style="list-style-type: none"> <li>• Changes Scott experienced may have been associated with his lengthy stay in space.</li> <li>• Most of these changes (about 91.3%) reverted to baseline after he returned to Earth; however, a small subset persisted after six months</li> <li>• Some observed DNA damage is believed to be a result of radiation exposure.</li> </ul>

**How does your omics team's results could potentially help improve the space experience/health for astronauts?**

Student answers will vary, but continuing with the example--It will enable us to better understand how a human body adapts to the extreme environment of space. This knowledge will help us design treatments, technologies, and protocols that will protect our astronauts' health as they go further into space for longer periods of time.

## Part 4: Bringing the Information to the People: NASA GeneLab

Interact with the resources provided and take notes on their information in the highlighted portions of the table.

Resource	Notes---How does the GeneLab use omics datasets?
Watch Video: <a href="#">NASA GeneLab: Omics database for spaceflight experiments</a>	Student answers will vary <ul style="list-style-type: none"><li>● First comprehensive omics database for space related research.</li><li>● Open access repository for spaceflight data.</li><li>● Datasets are accessible to scientists all around the world for follow on research</li><li>● Help make advances in space research and improve the lives of humans back on Earth.</li></ul>
Read Text: <a href="#">Omics and Gene Lab (Excerpt)</a>	Student answers will vary <ul style="list-style-type: none"><li>● NASA has aimed to examine the fundamental building blocks of life in order to understand the response of living organisms in space and aid in fundamental research discoveries on Earth.</li><li>● Modern biological molecular techniques of omics and the detailed analysis has resulted in significant advances</li><li>● NASA has collected data from omics studies and curated them in GeneLab.</li><li>● GeneLab is an open access system to engage in bioinformatics work and analyze data from government space research.</li></ul>

Go to <https://genelab.nasa.gov> and explore! Write at least three cool things you learned/interacted with AND where you found it on the website!

Encourage students truly to explore the website! Discuss the variety in students' responses.

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

## Part 5: Learning Aims and Evaluation

Please rate where you personally are at, with regards to the learning aims, at the end of the lesson and why.

### Rating Scale

1- I do not understand it at all yet.

2-I understand parts of it, but I need my teacher and/or classmates' support to answer questions.

3-I understand it and can complete an assignment by myself.

4-I understand it so well I can teach others and apply my knowledge to new situations.

Talk to students about the importance of metacognition (“thinking about your thinking”) and reflecting on their learning and where they are at with what they are learning. It may feel strange to students, but it is very important for their growth and helps them see learning aims as not something to simply “glaze over” at the beginning of the assignment but tools to see what they have learned. Encourage them to be honest, letting them know that rating themselves below a 4 for any or all of these learning aims does not correlate with losing points for this section.

**Learning Aim #1:** Students will be able to define what omics means and give examples of some of the main omics fields.

#### My Evaluation of Learning Aim #1 and Explanation:

**Learning Aim #2:** Students will be able to describe some of the analytical and statistical tools used in omics to analyze and interpret data.

#### My Evaluation of Learning Aim #2 and Explanation:

**Learning Aim #3:** Students will be able to explain how NASA (and specifically NASA GeneLab) uses omics datasets.

#### My Evaluation of Learning Aim #3 and Explanation:



## References

GeneLab for High Schools Bioinformatics Manual. Available at [ url ]

Omics - Exploring Space Through You. NASA Video Gallery. <https://www.nasa.gov/hrp/omics-videos>

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NASA GeneLab: Omics database for spaceflight experiments. (October 2018). YouTube. <https://www.youtube.com/watch?v=evPRRuM6KFA>

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