OVERVIEW

Scientists have recently finished sequencing the full human genome and biotechnology and data analyses are becoming an increasingly important part of scientific research. Many different types of technologies can be used to conduct, analyze and implement scientific studies. One of these new technologies is the study of -omics. These lessons will focus on the discussion of omics, implementation, and use in determining how specific genes can be studied.

Objectives

1. Students will explore how genes potentially change during spaceflight conditions.
2. Students will be introduced to and explore omics as a valuable tool in biotechnology.
3. Students will analyze data using various databases and research specific genes.

Remember When?

Using your notes from the last unit, fill in the chart below using **your own words** to reinforce your understanding of the vocabulary.

Vocabulary Word	Definition
Gene	
DNA	
RNA	
Protein Synthesis	
Traits	
Gene Expression	
Epigenetics	

Part 1. EXPLORE: An Incredible Opportunity

In 2019, NASA and other scientists and academic institutions had an amazing opportunity to study the effects of spaceflight on the human body. Identical twins, Scott and Mark Kelly, became astronauts and were participants of this landmark experiment. There is empirical evidence from studying epigenetics that suggests the environment can change our DNA and cause genetic changes in our body and that we are not necessarily "pre-wired". We will evaluate this study and its evidence during this unit and look at how the science of omics will help advance our understanding of how our genes work.

Together we will watch the following video to get a better understanding of the study. The link to the video can be found here.

With your table group, read the following article together. Note the ten different results that scientists and researchers concluded. **Using your own words**, in the table below add a summary of those changes that were seen in Astronaut Scott Kelly.

Changes	Summary
Telomeres	
Immunome	
Gene Expression	
Cognition	
Biochemical	
Microbiome	
Epigenomics	
Metabolomics	
Proteomics	
Integrative Omics	

With your table group discuss one of the findings above and do research online to learn more about the topic.

For example, if your group chose “Epigenomics”, what does this mean, and how does it relate to the human body. Write your research information below.

What change did you research?	What did you learn?

Now it’s time to dig deeper. With your table group, we are going to read the first nine sections of the official scientific report released by the National Library of Medicine (read down through the paragraph above the first graphic noted Fig. 1.) This is a scientific journal article that will provide more information on the NASA Twins Study. As you go through the article, note various vocabulary words that you may not understand. Also, note areas of interest within the article. Write this information in your notebook. The article can be found here.

Answer the following questions based on the NIH article.

1. What was the main goal of this study?

2. Why was this study unique?

3. What were some of the limitations of this study?

4. List three findings that resulted from the study.

   a.

   b.

   c.

5. List one conclusion your group reached in regards to this study on Scott and Mark Kelly and any physiological changes that differed between ground and spaceflight.

Part 2. EXPLORE: OMICS (Oh My!)

Omics is a branch of science that studies the biological molecules that translate into genes, structure, function, genotypes, and phenotypes. There are several different types of omics. Let's first get a general overview by watching the following video.

This video from NASA shows how we can use the various disciplines of omics to help understand an individual down to their molecular level. With that information, scientists and researchers can potentially tailor medical care to that person before they become sick, instead of treating the onset of diseases as they happen. Utilizing the Twins Study and analyzing omics results, may allow us to personalize medicine toward the individual.

Let's learn more about omics. In your notebook, take notes as we go through the following presentation. Make sure you write down key vocabulary words and then go back as needed to fill in more details. The link to the presentation can be found here.

Let's review! From your notes, answer the following questions.

1. What are omics?

2. List three different types of omics and **on your own**, research what those omics are.

Omics	What are they?
1.	
2.	
3.	

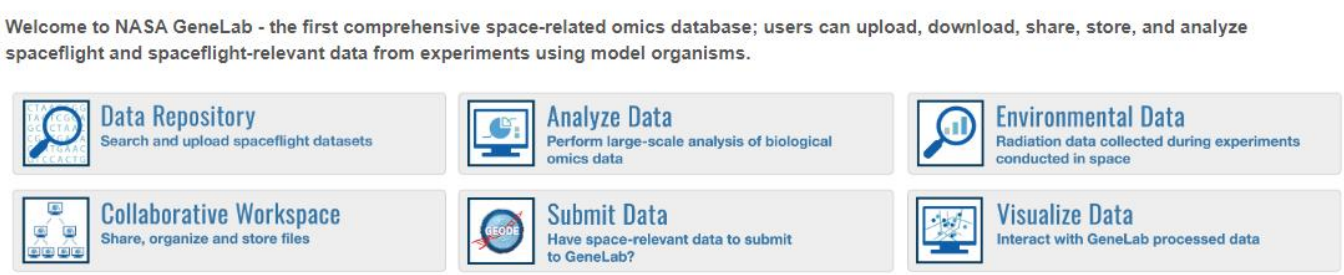
3. What is the human genome project?

4. What is the difference between genome and genomics?

5. How can genomics help our society in the future?

Part 3. EXPLAIN: GeneLab Data Repository

There are hundreds of databases that contain information about omics, genes, and other genetic information. One very special database helps people analyze the results of experiments that have been to space. This database is the **GeneLab Data Repository**. There are over 300 different studies that are included. Let's watch a short video about GeneLab. You can access the video here.



We will now spend some time exploring the GeneLab Data Repository. Make sure you take notes as we go through the database. You will have time to explore on your own.

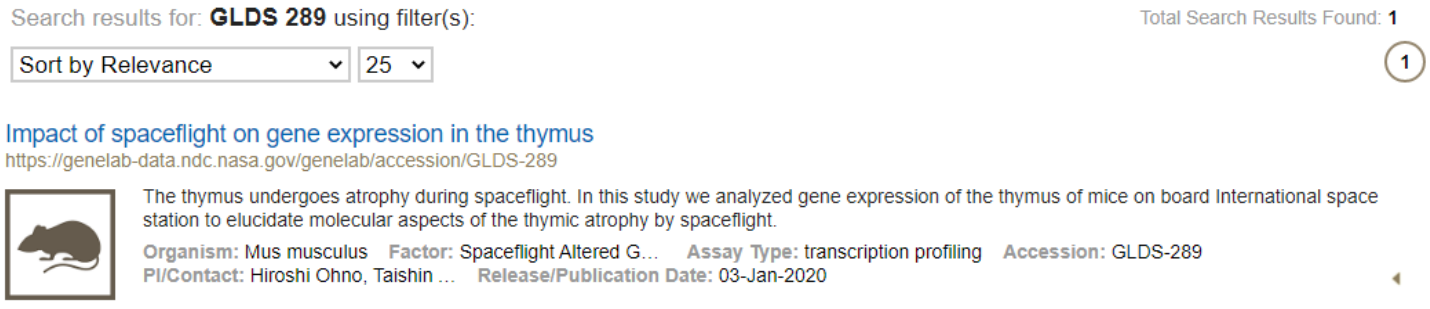
1. Access the GeneLab Data Repository by clicking here.

2. We will now go into the Data Repository. Click on the Data Repository icon on the top row on the left or click the link to go there directly.

3. You will see that there are 378 studies (at the time this resource was published) with a variety of different organisms that were flown and analyzed in this database. Let's take a look at one specific study.

4. In the "Search Data" tool, type the following: **GLDS 289**

5. You will see the following:



6. Click on the title of the experiment. This will take you to the full description of the experiment.

7. On the left side, there are the various parts of the experiment that you will want to view. Start by

reading the description and then scrolling down through the rest of this experiment.

8. Once you have finished, fill in the following table.

Answer the following questions, **using your own words.**	Answers
Describe what was studied in GLDS 289.	
What organism was used in the study? (If you are not sure, you can hover or click on the link and it will bring up the information).	
What were the dates of the studies?	
Look in the protocols area. How old were the mice? (Note: There were two studies: MHU-1 and MHU-2)	
How were the samples collected?	
Scroll down to the Assays/Measurements area. How many samples were collected? (You will need to scroll down along the right side and count them)	
Research what the thymus gland does in humans. Write your answer using **your own words.**	

9. **Now it is your turn**. Go back to the main data repository site and look through the various studies. You can filter on various options including project type, factors, organisms, etc. If you are unclear about what the organisms are, look them up online. Once you have one that interests you, fill in the table below.

Answer the following questions, **using your own words.**	Answers
What is the number and the name of the study you chose to review?	
What organism was used in the study?	
What were the dates (and durations) of the studies?	
What was being studied in the experiment?	
How were the samples collected?	
Scroll down to the Assays/Measurements area. How many samples were collected? (You will need to scroll down along the right side and count them)	

Part 4. ELABORATE: Data Analysis of a graph

Once experiments are completed in space, the samples are returned to Earth and analyzed alongside the samples put through the equivalent ground-based experimental procedures. The data must be sequenced correctly to understand the changes (if any) that take place in spaceflight as opposed to the control samples on Earth. Scientists use data analysis tools to input the information into various machines called sequencers and then analyze the various components of the data which could be DNA, mRNA, tRNA, or other biomolecules. This process is called **Bioinformatics**.

Let's recall the dataset GLDS-289 from Part 3. This experiment had two separate flights and compared the gene expression of the thymus gland with spaceflight and simulated 1G while in flight. The control of the experiment were the mice that stayed on earth with normal 1G.

We will work together to analyze one chart that is the result of previous data analysis. Most of the preliminary analysis of the data has been done for you, therefore we will go through the process of evaluating a graph that highlights the biological pathways that were affected in the thymus gland. You may recall from our genetics unit that there are many genes that affect similar processes in our bodies. The graph below, generated by a tool called GOseq, shows an analysis of the various genes that have been categorized by function. Let's evaluate the graph.

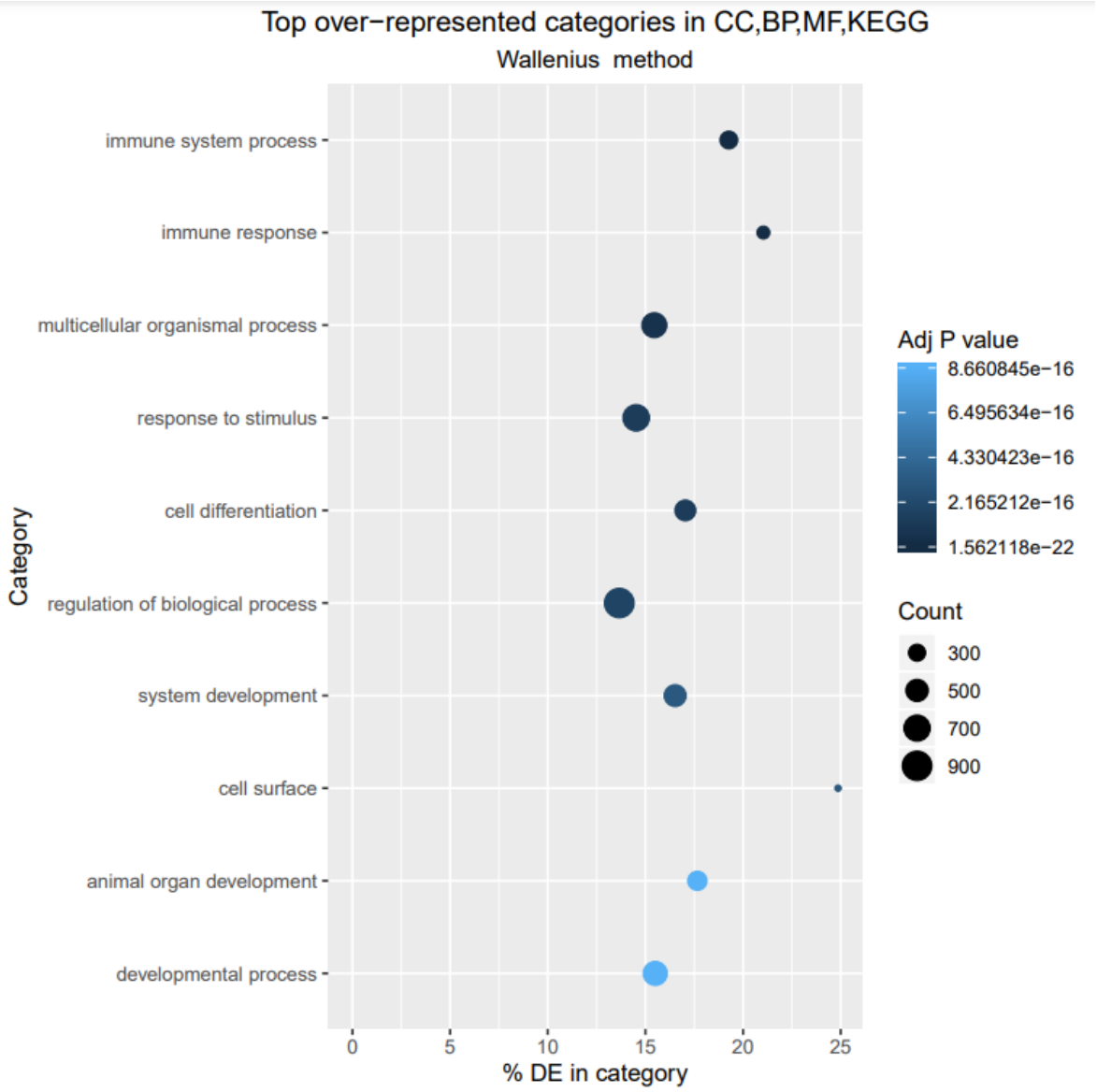


Figure 1. Over-represented GO terms plot - GroundControl (Control 1G) v Simulated 1G (Spaceflight)

With your table group, answer the following questions:

1. What do the colored dots represent?

2. What do you think the graph is showing us?

3. Are any of the pathways related in terms of physiological response?

4. We often use mice as model organisms for laboratory experiments. As we have indicated, this research is a mouse experiment studying the thymus gland. Thinking back to The Twins Study, how might this graph help us understand what could potentially be changing both in mice and humans?

With this graph, we can only see what changes occur in the genes for specific pathways, we cannot isolate specific genes. We will now investigate those next.

Part 5. EVALUATE: Research a gene

Based on the graph above, we can only determine which biological pathways are included in the data. You will now spend some time analyzing the various genes that may be included. However, we cannot necessarily look at all the genes represented in those pathways.

To identify specific genes, there is another graph we can visualize. Using the same data set, GLDS-289, we can see a "Volcano Plot". This identifies specific genes. See Figure 2 below.

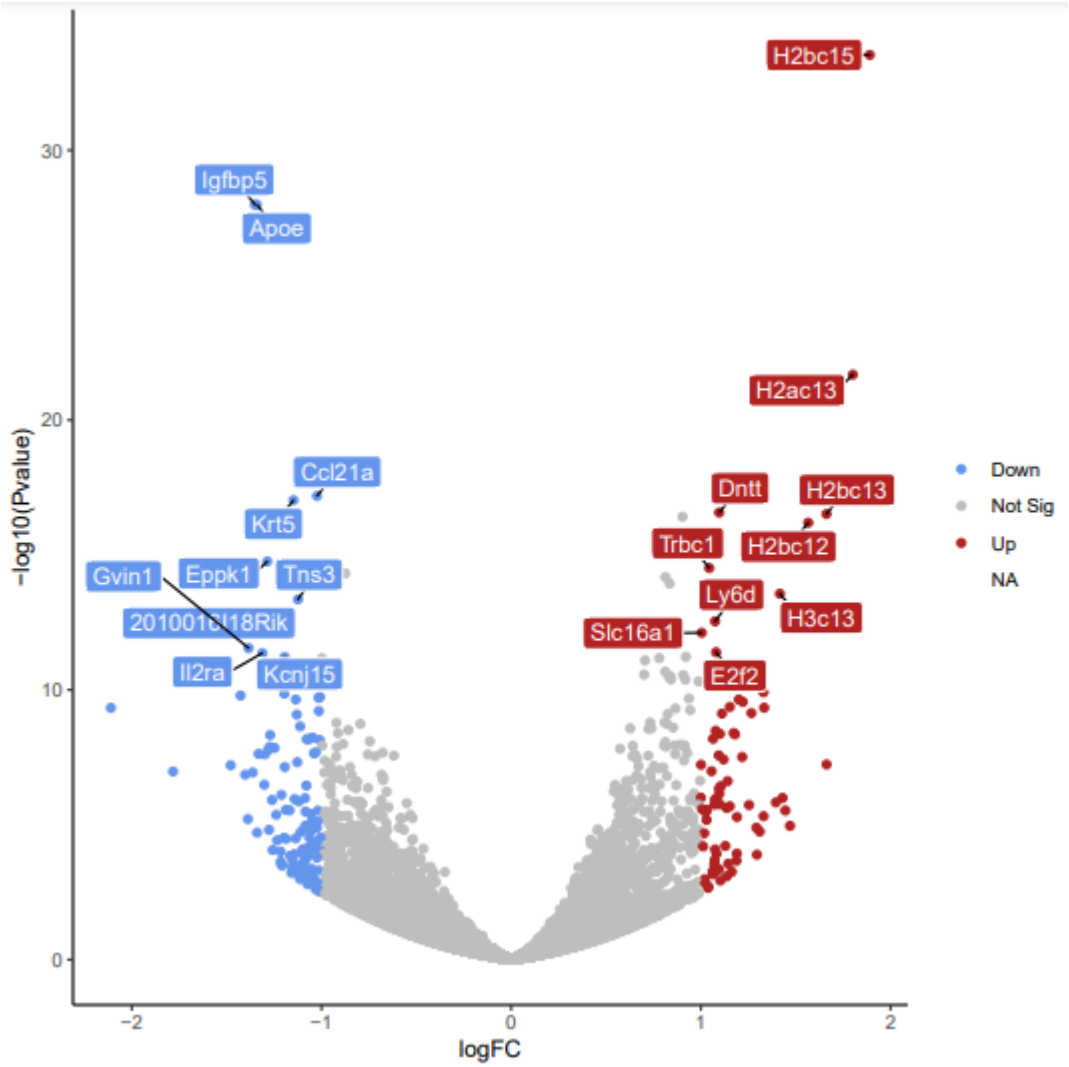


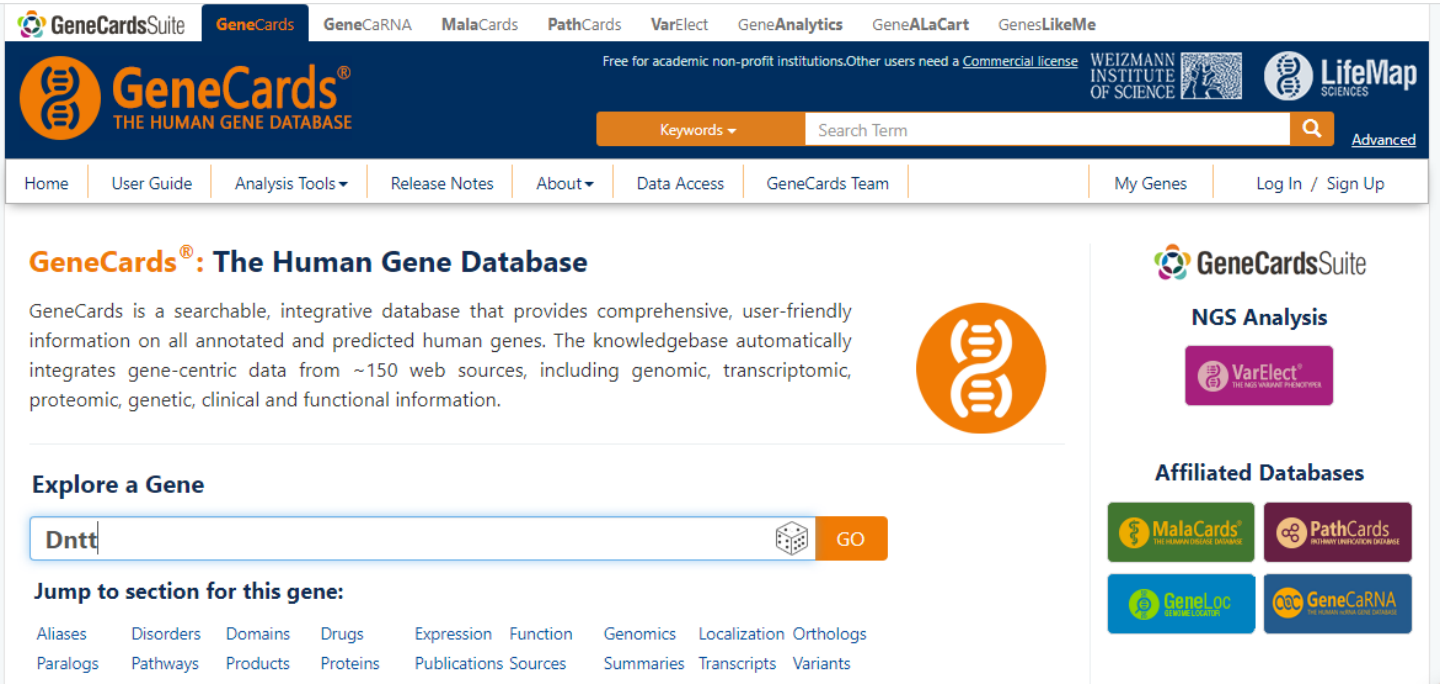
Figure 2. Up and down-regulated genes. Volcano plot - GroundControl (Control 1G) v Simulated 1G (Spaceflight)

What we are seeing are specific genes that are significantly expressed in the biological processes from our previous graph. The grey dots also represent genes but they are not statistically significant for the dataset we are looking at.

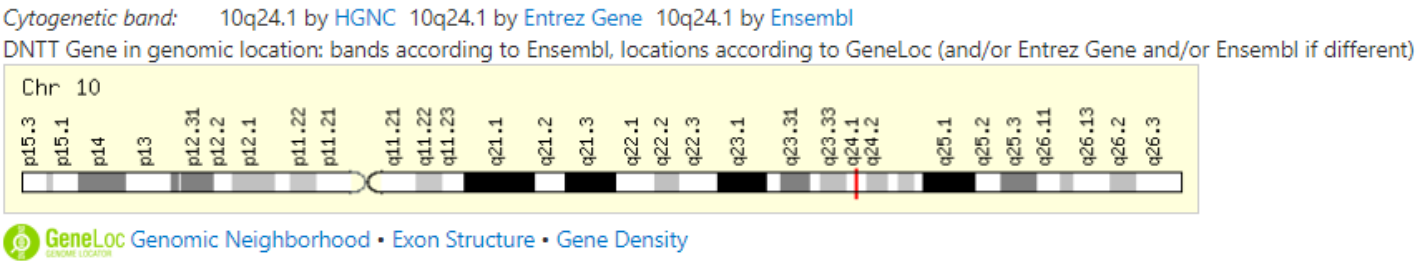
You can now look up specific genes by using web resources. Many databases track genes, gene expression, and what genes do. Let's look at one of these. When researching biological pathways, a good database is GeneCards: The Human Gene Database. Do the following steps.

Step 1. Click on the link or open a new tab in your browser.

Step 2. We can randomly pick any of the genes from the volcano plot to do research. For example, let's research "Dntt". In the search window where it says "Explore a Gene" type "Dntt".



Step 3. Read through the information presented. We can see that this particular gene is DNA Nucleotidylexotransferase. Use Google or another search engine to look up terms that you are unfamiliar with. As you scroll through the information from this website, you will see a picture of a chromosome. Use can then visualize where that particular gene is on the chromosome.



This will be a picture you will want to use within your Infographic which is your last activity of this assignment. As you continue, you will see a "Predicted three dimensional structure from AlphaFold". Click on the link and it will take you to another website that will show you what the protein would look like. Recall our discussion about proteins and protein folding from our biochemistry unit.

Three dimensional structures from PDB for DNTT Gene P04053 IMPROVED!

Filter: (2 results)

PDB ID	PDBe	RCSB-PDB	OCA
2COE	(3D)	(3D)	(3D)
5W4E	(3D)	(3D)	(3D)

Predicted three dimensional structure from AlphaFold P04053

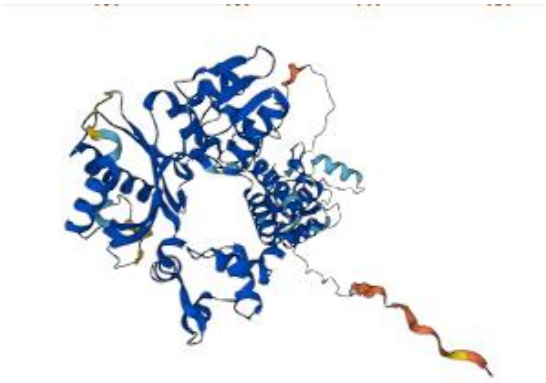
Alternative splice isoforms for DNTT Gene

UniProtKB/Swiss-Prot: P04053-1 P04053-2

neXtProt entry for DNTT Gene

Protein Expression for DNTT Gene

See protein expression from ProteomicsDB, MOPED, PaxDb, and MaxQB



Continue evaluating the information from GeneCards for “Dntt”. Take notes in your notebook on items that you find relevant and interesting. Note all the items that you can jump to at the top including disorders that can occur as a result of problems with this gene. For “Dntt”, disorders that can occur include lymphoma, sarcoma, leukemia, and thymoma. Thymoma is a cancer of the thymus gland which is what the GLDS-289 experiment is studying!!!

Jump to section: Aliases, Paralogs, Disorders, Pathways, Domains, Products, Drugs, Proteins, Expression, Publications, Function, Sources, Genomics, Summaries, Localization, Transcripts, Orthologs, Variants

No data available for Polymorphic Variants from UniProtKB/Swiss-Prot for DNTT Gene

Disorders for DNTT Gene

MalaCards (39) MalaCards diseases for DNTT Gene - From: COP, AKS, and GCD

Filter: (39 results) See all 39 »

Disorder	Aliases	PubMed IDs
Lymphoblastic Lymphoma [1, 21, 64]	Lymphoma, Lymphoblastic Lymphoma Lymphoblastic Precursor Cell Lymphoblastic Lymphoma See all 4 »	
Myeloid Sarcoma [1, 21, 64]	Granulocytic Sarcoma Chloroma Extramedullary Myeloid Tumor See all 10 »	
Mixed Phenotype Acute Leukemia, T/Myeloid [1, 64]	Doid:0081039	
Acute Leukemia [1, 21, 64]	Stem Cell Leukaemia Stem Cell Leukemia Acute Leukemias See all 10 »	
Thymoma [1, 21, 64]	Primary Thymic Epithelial Neoplasm Primary Thymic Epithelial Tumor Thymus Neoplasms	

Part 6. EVALUATE: Infographic

Now that you have an understanding of the specific genes that we can isolate based on the research we have done for this activity, you will now utilize the resources to create an Infographic from one of the genes.

As a group, review the Volcano Plot and pick **ONE** gene to research and create your Infographic. Several online resources can be used including Biorender or Canva. Do a google search for infographics to visualize what one may look like. There are many different ways to graphically represent the information on your gene. You cannot use the same gene as another group, so we will go around the room and list all the groups and their genes on the board.

Your assignment is to create an Infographic on one of the genes your group has researched. The grading rubric will be in Schoology. Make sure the following information is included:

1. Gene name and gene family
2. Chromosome number (and location)
3. Picture of location on chromosome
4. Summary of what gene does
5. Explanation of the biological pathway that is involved
6. Diseases that can occur as a result of dysfunction of the gene
7. Protein folding graphic (or other graphic) based on the gene
8. Supplementary information based on additional research (google search or other)
9. Citations on all your sources including graphics and details about the gene.
10. All group members' names and group number.

Your Infographic will be due at the end of the unit. See Schoology for more details.

Part 7: Conclusion

We have spent the last few weeks learning about how biotechnology and space biology can help us identify how genes – or their expression – may change in spaceflight. Reflecting on what you researched and read about the NASA Twins Study, answer the following questions.

1. Why would researchers use animals (such as mice and rats) to study human physiology?

2. What do you think are some goals for scientific inquiry in space?

3. What connections can we make from studying specific genes that may benefit society as a result of research conducted in space?

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