

Out of This World

Activity 4.2.3. Reading a year of one astronaut's health data and designing around it

Astronaut Paul Adams is on a Mars mission and everything about his body is being logged to a portal you can open. You read six streams of data, pick the five health problems you think matter most, and design a spaceship that answers them.

WORTH 5 POINTS

DOES NOT HELP ON THE WEBXAM

AT A COMPUTER, THEN DRAWING

ABOUT 90 MINUTES

What this is and why it is worth doing

A Mars mission is at least nine months out, time on the surface, and at least nine months back. Two to three years, with no resupply, no evacuation, and no hospital.

The Space Exploration Lab at Innovation, Inc. recruited Paul Adams to wear remote monitoring devices and log his health for the whole mission. You work with the medical team: read the data, find what is going wrong, and feed it into the design of the next ship.

The reason to do it is that it is the only place in PBS where you are handed a genuinely messy pile of longitudinal data across six different measurement types and asked to say what it means. Not one graph. Six streams that have to be read against each other.

DOES THIS HELP ON THE WEBXAM? NO

WebXam 072110 weighs handling, preparation, storage and disposal, and biotechnology research and experiments. This activity is analysis and design. There is no bench, no protocol, no method. It will not move your exam score.

It is here because reading several data streams against each other and defending a prioritisation is a real professional skill, and because it is one of the two or three most interesting things in the course.

How long it takes and what you need first

- **About 90 minutes**, and it splits: roughly 45 minutes reading the portal, roughly 45 minutes on the two blueprint sheets.
- **A computer with a browser** for Paul's Patient Portal.
- **Two Innovation, Inc. Spaceship Blueprint sheets** and one **Health Concerns Related to Long-term Space Travel** sheet, from Mr. Mendoza. You need two blueprints because the first one is for brainstorming and the second is the clean final.
- Coloured pencils or pens if you want them. The final sketch is supposed to look professional.
- A partner is useful for the design half. Working alone is fine.
- No safety equipment.

The six data streams

STREAM	WHAT IT MEASURES	WHERE IN THE PORTAL
Vital signs	Basic body functions as indicators of the body's ability to hold homeostasis. Paul's device logs blood pressure, heart rate, respiratory rate, temperature and oxygen saturation.	Current vitals on the left, plus the Vitals Record and the History tab
Blood work	Gene expression changes, metabolism, nutrient levels, protein and hormone levels. Complete blood counts, cholesterol panels and metabolic panels.	Lab Results tab, and Genetic Data for expression levels
Cardiovascular imaging	Ultrasound of the carotid artery, turned into 3D diagrams, showing the structure of the vessels and how well blood moves through them.	Lab Results tab, click each label on the left
Dosimetry	Radiation exposure, measured by a dosimeter Paul wears.	Radiation Exposure tab
Diary and logs	Sleep amount and quality including deep sleep, exercise time by muscle group, muscle strength, emotions, stress, and cognition.	Exercise Log, Sleep Log and Cognition tabs
Medical history	What Paul was like before he left.	History tab

READ THE HISTORY TAB FIRST, NOT LAST

Every trend you are about to find is a change from something, and the something is in the History tab. A value that would be alarming in one person is that person's normal. Reading the history first turns your findings from *this number is high* into *this number has risen*, which is a completely different and much stronger claim.

THINGS YOU WILL NEED TO KNOW TO READ IT

Biomarker

A measurable signal that predicts or indicates disease or injury. Proteins and hormones are the usual examples.

Heat shock proteins

HSPs. Proteins produced in response to stressful conditions, so their level acts as a biomarker for stress.

Ghrelin and PYY

Hormones released in the digestive tract. Ghrelin says you are hungry and runs high during fasting, low after eating. PYY says you are full and does the opposite, low during fasting, high after eating.

Gene expression

Using the information in a gene to direct protein synthesis. Cells turn on the genes for the proteins they need, so expression levels shift as the body's situation shifts.

Radiation

Energy carried as waves or high-energy particles. It can cause genetic mutation, immune dysfunction, nervous system damage and raised cancer risk. On Earth the average exposure is about 3 millisieverts a year. In space it is far higher, because the atmosphere and the magnetic field are no longer in the way.

HDL and LDL

Two kinds of cholesterol. HDL removes excess cholesterol from the bloodstream and carries it to the liver. LDL carries cholesterol to cells. A high LDL level indicates raised heart disease risk.

Metabolic panel

A blood test measuring substances such as nutrients and waste products, to see how well the body is carrying out its chemical reactions. Glucose, measured on this panel, is the diabetes indicator.

Complete blood count

CBC. Measures white blood cells, red blood cells, hematocrit, hemoglobin and platelets.

THE GENE FAMILIES, WHICH IS WHAT THE GENETIC DATA TAB IS SHOWING YOU

Regulatory: proteins that drive cellular reactions and control cell growth and division. **Immune system:** defence proteins such as antibodies. **Transport:** proteins that carry materials, such as hemoglobin carrying oxygen. **Motor:** proteins that make cells move, such as actin and myosin. **Signal transducing:** proteins that coordinate cellular activity, including hormones such as insulin and the sensory proteins behind taste, smell and sound. **Other:** structural proteins such as collagen, elastin and keratin.

Which families are switched on tells you which processes are running. A rise in one family is a clue about what Paul's body is currently dealing with.

The steps

- 1 Brainstorm and write down possible medical hazards of space travel before you open any data. Weaker gravity and no free oxygen are the two obvious ones. Get to at least eight.
Done when: a written list exists, made before you looked at anything.
- 2 Work through the Life in Space presentation so you know what Paul's days involve: the CEVIS stationary bicycle, the COLBERT treadmill with its bungee harness that loads the bones, the aRED resistance device, the Life Sciences Glovebox, data entry, dehydrated food rehydrated in pouches, and a sleeping bag strapped to a wall.
Done when: you can name what each exercise device is for.
- 3 Note which of the six data streams are **qualitative** and which are **quantitative**, and write one sentence on why collecting both is worth doing.
Done when: each stream is labelled and the sentence is written.
- 4 Open the History tab first. Then the vitals. Record notes on any trend you see, and note what it is a trend *from*.
Done when: trends are written as changes, with the baseline named.
- 5 Read the Genetic Data tab, then Lab Results including the cardiovascular imaging. Click every label on the left of Lab Results. Record trends.
Done when: notes exist for gene expression, blood work and imaging separately.
- 6 Read the Radiation Exposure tab. Record trends. Compare against the roughly 3 mSv per year an average person receives on Earth.
Done when: a comparison to the Earth baseline is written down, not just the raw numbers.
- 7 Read the Exercise Log, the Sleep Log and the Cognition tab, which holds Paul's diary entries and charts his emotions. Record trends.
Done when: notes exist for all three.
- 8 **Choose the five issues** you think Innovation, Inc. should focus on. This is the graded judgement and there is no key. Different defensible selections exist. What is assessed is whether each of your five is supported by data you can point at.
Done when: five issues are named and each one has at least one specific data observation attached.

- 9 Fill in the Health Concerns Related to Long-term Space Travel sheet. For each of the five: a clear title, a description of the issue and how it affects human body systems, and a labelled drawing on Paul's body outline showing where and how he is affected. Research more if you need to.

Done when: all five have a title, a description and a labelled drawing.

- 10 Take your **first** blueprint sheet and brainstorm on it. Sketch and annotate ways to monitor and reduce these risks. Messy is correct at this stage.

Done when: the first blueprint is covered in options, including ones you will not use.

- 11 Narrow to your strongest ideas, checking that **all five issues are addressed**. Then take the **second** blueprint sheet and draw and label your final innovations neatly.

Done when: every one of the five issues can be traced to something on the final blueprint.

- 12 Write notes explaining what each innovation addresses and how it works, with the reasoning that connects it to the data.

Done when: each innovation has an issue, a mechanism and an evidence link.

What finished looks like

1. Your pre-reading hazard brainstorm.
2. Trend notes for all six data streams, kept separate rather than merged.
3. The completed Health Concerns sheet: five issues, each with a title, a description and a labelled drawing.
4. Your messy first blueprint and your clean final blueprint.
5. Written justification for each innovation: what it addresses, how it works, and which data observation sent you there.
6. Two conclusion answers: given your innovations, is it safe for humans to go to Mars, and what health data did you wish you had?
7. Your response to the ethical scenario below.

THE ETHICAL SCENARIO

Space tourism is growing. Astronauts are in peak condition and train extensively. Tourists are not put through any of it. What screening and training should be required, and how should tourists be monitored in flight? And for people who are not in good health, or who have a terminal condition, and for whom spaceflight is a last item on a list: should they be allowed to go, and what would have to be in place first?

WORKED EXAMPLE OF THE FORMAT. INVENTED FINDINGS, NOT PAUL'S ACTUAL DATA

Issue 3 of 5. Bone loading falls off in the second half of the mission.

Description. The exercise log shows treadmill sessions dropping from most days early in the mission to roughly half as often by the later months, while resistance sessions hold steady. The treadmill is the device that loads the skeleton, because the bungee harness pulls the body down hard enough to create impact. Resistance training strengthens muscle but does not load bone the same way. Without loading, bone is not stimulated to rebuild, so density falls. That affects the skeletal system directly and the muscular system through the joints it changes the mechanics of. The diary entries over the same span mention fatigue more often, which may be a reason the treadmill sessions were the ones dropped.

Drawing. Labelled on Paul's outline at the hips, femurs and lumbar spine, the weight-bearing sites, with an arrow to the exercise log excerpt.

Innovation. A loading sensor built into the treadmill harness that logs actual impact load per session rather than session count, plus a shorter default session so that a tired crew member has a version they will still do. Reasoning: the log currently records that a session happened, not how much load it delivered, so a shortened or half-hearted session looks identical to a full one. Measuring the thing that matters is a prerequisite to fixing it.

What I am unsure about. I inferred the fatigue link from diary entries near the same dates, which is a correlation I noticed rather than a cause I established. It could equally be schedule pressure. I would want the workload log alongside it before I claimed the reason.

WHAT THAT EXAMPLE DOES THAT YOU SHOULD COPY

- It quotes what the data actually showed before saying what it means.
- It names the body systems affected, which the sheet asks for and most people skip.
- The innovation is aimed at a specific mechanism, not at the general topic.
- It separates a correlation it noticed from a cause it can support.

Where people get stuck

Reading one data point as a trend.

A single high reading is a reading. A trend is a direction across time. Say which one you have.

Picking five issues from general knowledge about space rather than from Paul's data.

Bone loss and radiation are the famous ones and they may well be in your five. They still have to be supported by something you actually saw in the portal, with a note saying where.

Skiping the History tab.

Without a baseline you cannot tell an abnormal value from that person's normal one, and every claim you make gets weaker.

Drawings with no labels.

The sheet asks for a labelled drawing. An unlabelled outline with shading on it does not say what it is showing.

Using only one blueprint sheet.

Brainstorming and the final drawing are different jobs. Doing both on one sheet means either the brainstorm was thin or the final is messy, and the final is supposed to look professional.

Innovations that do not connect to a named issue.

Every one of the five issues has to be addressed. Check that mapping explicitly before you draw the final.

Mixing up HDL and LDL.

HDL removes excess cholesterol from the blood and takes it to the liver. LDL takes cholesterol to cells. High LDL is the one that indicates raised heart disease risk.

Answering the space tourism scenario with only one side.

Both answers have real costs. Take a position and deal with the strongest objection to it.

How to submit and how it is credited

THIS ITEM IS WORTH 5 POINTS

Seven deliverables including two blueprint sheets and a completed health concerns sheet. Remember the 20 point per semester cap across all extra credit.

- **Where it goes.** The same place as everything else. Your class form on the portal, or handed to Mr. Mendoza in person. Nothing about extra credit needs a different route.
- **What to hand in.** Photographs of your work where the handout asks for them, plus your written pages. Photographs of handwritten pages are fine. A photograph you cannot read is not.
- **Put your name and period on every page and every photograph filename.** Unlabelled work cannot be credited and it is the single most common way points get lost.
- **When.** Any day after the pack opens, right up to the last week of the semester. There is no deadline inside that window and no penalty for going slowly.
- **Feedback.** You get it back with a note. If a piece is short of full credit you may fix the named thing and resubmit once.