Lab Handout

Lab 4. Habitable Worlds: Where Should NASA Send a Probe to Look for Life?

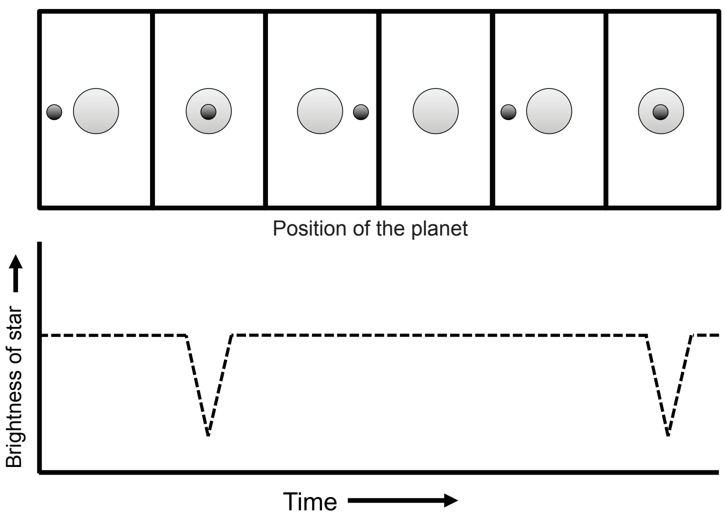
Introduction

Our solar system consists of the star we call the Sun, the planets and dwarf plants that orbit it, and the moons that orbit the planets or dwarf planets. It also contains much smaller objects such as comets, asteroids, and dust. The Sun is one of many stars that have several objects orbiting around it in our Milky Way galaxy. As far as we know, Earth is the only planet that supports life. Earth has several unique properties that allow life to exist; it is solid, it is warm enough to allow liquid water, and it is not too cold to freeze its inhabitants. However, we have only extensively studied the planets and dwarf planets within our own solar system. We know some information about planets outside of our solar system, called *exoplanets,* but exoplanets are difficult to study because they are so far away.

Space scientists with the National Aeronautics and Space Administration (NASA) are currently looking for exoplanets as part of a long-term project called Kepler. To find exoplanets, space scientists aim powerful telescopes at stars outside of our solar system and then measure the brightness of the light that the star emits over long periods of time. They then look for the brightness of the star to dim in a pattern because it indicates that an object is orbiting that star. Figure L4.1 shows what happens to the brightness of a star over time as a planet moves around it. The top row shows what a star would look like to us from Earth as a planet orbits around it. The second row shows how the brightness of the star remains constant except when the planet crosses in front of it—at those moments, the brightness of the star decreases. Kepler space scientists describe this instance as a transit event, and they use computers to identify potential transit events. These potential transit events are classified as *Kepler objects of interest* (KOIs). Kepler space scientists then investigate each KOI to determine if the change in brightness of a star was caused by an exoplanet or something else. So far, space scientists working on the Kepler project have identified over 4,000 exoplanets using this method.

FIGURE L4.1

An example of how Kepler space scientists identify exoplanets. The top panels show how the position of a hypothetical exoplanet changes over time as it orbits a hypothetical star when viewed from Earth. The bottom graph shows how the brightness of the star will decrease only when the exoplanet passes between the star and the Earth.



Once the Kepler space scientists have identified an exoplanet, they attempt to determine if it can support life. To accomplish this task, the space scientists look to see if the exoplanet shares three important characteristics with Earth:

1. It must be terrestrial (composed primarily of rocks and metals).
2. It must have an atmosphere.
3. It must orbit within the habitable zone around a star, which is the minimum and maximum distance from a star where the temperature of a planetary surface can support liquid water given sufficient atmospheric pressure.

Space scientists can determine if an exoplanet is terrestrial or not based on its size, because any exoplanet that is more than twice the size of Earth is likely to be a gas giant. Space scientists can also use the size of an exoplanet to determine if it has an atmosphere or not. Any exoplanet that is less than half the size of Earth most likely does not have enough gravitational pull to keep an atmosphere around it. Finally, space scientists can determine if an exoplanet orbits a star within the habitable zone by measuring its orbital period. The location of the habitable zone around a star, however, is not the same for every exoplanet because some stars emit more energy than others.

These three characteristics are important because they are needed to be able to sustain liquid water on the surface of the exoplanet, and liquid water must be present to support life as we know it. Currently, the Kepler space scientists have identified 12 exoplanets that have all three of these characteristics, so it is possible that these 12 planets could support life.

Scientists are interested in finding exoplanets with life on them because learning more about the life found on these exoplanets will help us better understand the evolution of life on Earth. Information about the characteristics of life on exoplanets could either corroborate existing theories about how life began and changes over time or result in new theories. However, it would cost too much money and waste too much time to send exploratory probes to every exoplanet they find to look for life. So scientists must be able to identify the exoplanets with the highest chance of supporting life. In this investigation, you will have an opportunity to use data about several different exoplanets to determine which ones, if any, have the potential to support life.

Your Task

Use what you know about the Earth-Sun system, patterns, and how scientists need to consider different scales, proportional relationships, and quantities during an investigation to examine the characteristics of several exoplanets orbiting around distant stars. Your goal is to determine which exoplanet, if any, is most likely to contain life based on its physical properties, the properties of the star it orbits, and the size and shape of its orbit.

The guiding question of this investigation is, ***Where should NASA send a probe to look for life?***

Materials

You will use the Lab 4 Reference Sheet: Kepler Project Information Packet during your investigation.

Safety Precautions

Follow all normal lab safety rules.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will need to analyze an existing data set. To determine *how you will analyze the data,* think about the following questions:

- Which data are relevant based on the guiding question?
- What type of calculations will you need to make?
- What types of patterns might you look for as you analyze your data?
- Are there any proportional relationships that you can identify?
- How will you determine if the physical properties of the stars and their planet candidates are the same or different?
- How could you use mathematics to determine if there is or is not a difference?
- What type of table or graph could you create to help make sense of your data?

Connections to the Nature of Scientific Knowledge or Scientific Inquiry

As you work through your investigation, be sure to think about

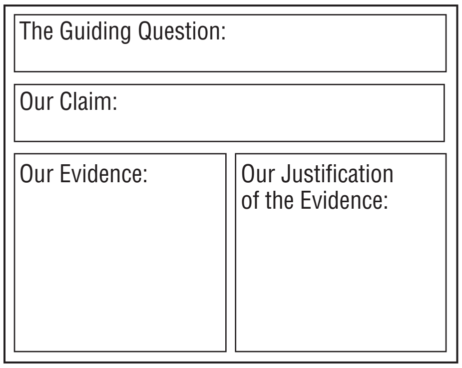
- the difference between data and evidence in science, and
- the assumptions made by scientists about order and consistency in nature.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The *claim* is your group's answer to the guiding question. The *evidence* is an analysis and interpretation of your data. Finally, the *justification* of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence

FIGURE L4.2

Argument presentation on a whiteboard



to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L4.2.

Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

Critiques about our initial argument and suggestions for improvement:

If you are critiquing your classmates' arguments, your goal is to look for mistakes in their arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways to make your initial argument stronger by looking for things that the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

Interesting ideas from other groups or questions to take back to my group:

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. You should write your report using a word processing application (such as Word, Pages, or Google Docs), if possible, to make it easier for you to edit and revise it later. You should embed any diagrams, figures, or tables into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.