Lab Handout

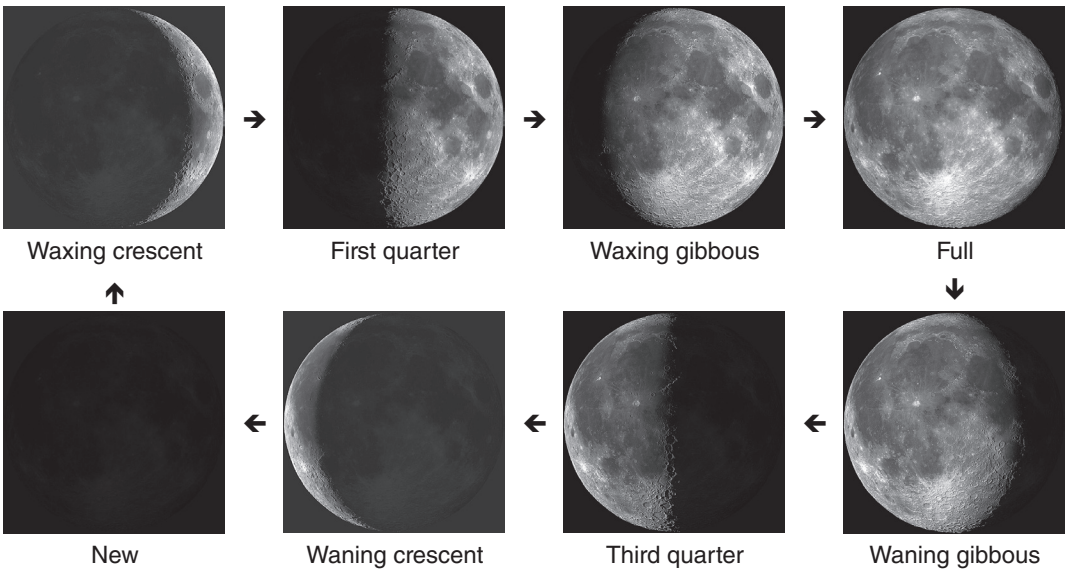
Lab 1. Moon Phases: Why Does the Appearance of the Moon Change Over Time in a Predictable Pattern?

Introduction

We have all seen the Moon in the sky and how it looks different at various times of the month. In fact, differences in the appearance of the Moon over time were the basis for the Chinese, Islamic, Hindu, and Judaic calendars, as well as most of the other calendar systems that were used in ancient times. People can use the appearance of the Moon to mark the passage of time because the Moon's appearance changes in a predictable pattern over a period of 29.5 days. Figure L1.1 shows the pattern that the appearance of the Moon follows. As can be seen in this figure, the portion of the Moon that is illuminated gradually increases until the Moon is full, and then the portion of the Moon that is illuminated gradually decreases until it is completely dark. People often describe this pattern as a lunar cycle. Each phase, or how the Moon looks at a given point in the lunar cycle, has a specific name (see Figure L1.1).

FIGURE L1.1

The phases of the Moon follow a predictable pattern over a period of 29.5 days



There are some other important facts that we know about Moon in addition to the fact that it goes through a series of phases over the course of a lunar cycle. First, the Moon rises in the east and sets in the west once every 24 hours. The Moon, therefore, travels

from east to west across the sky just like the Sun. Second, the time that the Moon rises and sets in the sky changes each day. Sometimes the Moon will rise at dusk and set at dawn, and other times it will rise late at night and set in the morning. The Moon can even rise at dawn and set at dusk just like the Sun. The times that we can see the Moon in the sky therefore change over the course of a lunar cycle. Third, we always see the same light and dark regions on the surface of Moon regardless of its current phase (see Figure L1.1). We always see the same surface features when we look at the Moon because the same side of the Moon is always facing Earth. Finally, we see solar and lunar eclipses from time to time. A solar eclipse occurs during the day. A solar eclipse results in the light from the Sun being blocked for about 5 to 10 minutes (see Figure L1.2). A lunar eclipse, in contrast, occurs at night. A lunar eclipse causes the full Moon to get darker and turn red for a few minutes (see Figure L1.3). All of these different facts about the Moon can be explained if you understand what causes the lunar cycle.

FIGURE L1.2

A solar eclipse

FIGURE L1.3

A lunar eclipse

To explain the lunar cycle and all these different facts about the Moon, it is important to know a little about the types of objects that are found in our solar system and how all these objects move over time in relation to each other. The solar system consists of the Sun, the eight official planets, at least five dwarf planets, more than 130 moons, and numerous small bodies (including comets and asteroids). At the center of the solar system is the Sun. The inner solar system includes the planets Mercury, Venus, Earth, and Mars; the dwarf planet Ceres; and three moons. The outer solar system includes the planets Jupiter, Saturn, Uranus, and Neptune; the four other dwarf planets; and the remaining moons. In our solar system, all the planets and dwarf planets orbit (revolve around) the Sun, and all the moons orbit planets or dwarf planets. All the planets in our solar system travel around the Sun in a counterclockwise direction (when looking down from above the Sun's north pole). All of the planets and dwarf plants, with the exception of Venus, Uranus and Pluto, also spin (or rotate) in a counterclockwise direction.

You can use this information about our solar system to develop a physical model of the Earth-Sun-Moon system. You can then use your physical model to explore how Earth,

the Sun, and the Moon move in relation to each other and how the light from the Sun illuminates the Moon as it orbits Earth. You can also use your physical model to determine how different positions of Earth, the Sun, and the Moon in relation to each other affect the appearance of the Moon over time (as seen from Earth). You will then be able to use what you learned about how the Moon and Earth move in relation to each other over time by working with a physical model to create a conceptual model that you can use to explain the lunar cycle.

Your Task

Develop a conceptual model that you can use to explain the phases of the Moon. Your conceptual model must be based on what we know about system and system models, patterns, the objects that are found in our solar system, and how these objects move in relationship to each other. You should be able to use your conceptual model to predict when and where you will be able to see the Moon in the sky during a lunar cycle.

The guiding question of this investigation is, ***Why does the appearance of the Moon change over time in a predictable pattern?***

Materials

You may use any of the following materials during your investigation:

Equipment

- Safety glasses or goggles (required)
- Physical model of Earth (large ball on a stand)
- Physical model of the Moon A (small ball on a stand)
- Physical model of the Moon B (small ball on a stick)
- Lamp and lightbulb

Other Resources

- Moon phase calendar A (use to develop your conceptual model)
- Moon phase calendar B (use to test your conceptual model)

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

- Wear sanitized indirectly vented chemical-splash goggles throughout the entire investigation (which includes setup and cleanup).
- Use only GFCI-protected electrical receptacles for lamps to prevent or reduce risk of shock.
- Handle the lamps with care; they can get hot when left on for long periods of time.
- Wash hands with soap and water when done collecting the data and after completing the lab.

LAB 1

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

The first step in developing a conceptual model is to design and carry out an investigation to determine how movement of Earth, the Sun, and the Moon over time results in the Moon looking different from our perspective on Earth. To accomplish this task, you will need to create a physical model of the Earth-Sun-Moon system using the available materials. You can then use this physical model to see how light shines on Earth and the Moon when they are in different positions relative to each other. You can also use this model to test your different ideas about the underlying cause of the Moon phases. As you develop your physical model, be sure to consider the following questions:

- What are the boundaries of the system you are studying?
- What are the components of this system?
- How can you quantitatively describe changes within the system over time?
- What could be causing the pattern that we observe?

Once you have used your physical model to test your ideas about the underlying cause of the Moon phases, your group can use what you learned to develop your conceptual model. A conceptual model is an idea or set of ideas that explains what causes a particular phenomenon in nature. People often use words, images, and arrows to describe a conceptual model. Your conceptual model needs to be able to explain why we see the phases of the Moon in the same pattern. It also needs to be able to explain

- why we see the Moon rise in the east and set in the west,
- why the Moon rises and sets at different times of the day,
- why we see the same side of the Moon regardless of its current phase, and
- why there are occasional solar and lunar eclipses.

The last step in your investigation will be to generate the evidence that you need to convince others that your conceptual model is valid or acceptable. To accomplish this goal, you can use your model to predict when and where the Moon will be in the night sky over the next month. You can also attempt to show how using a different version of your model or making a specific change to a portion of your model would make your model inconsistent with data you have or the facts we know about the Moon. Scientists often make comparisons between different versions of a model in this manner to show that a model is valid or acceptable. If you are able to use your conceptual model to make accurate predictions about the behavior of the Moon over time or you are able show how your conceptual model explains the behavior of the Moon better than other models, then you should be able to convince others that it is valid or acceptable.

Connections to the Nature of Scientific Knowledge and Scientific Inquiry

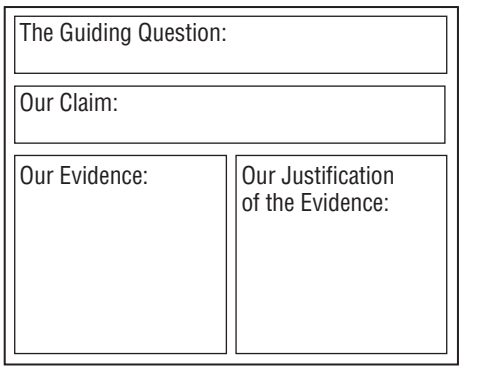
As you work through your investigation, be sure to think about

- the use of models as tools for reasoning about natural phenomena, and
- how scientists use different methods to answer different types of questions.

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 to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L1.4.

FIGURE L1.4
Argument presentation on a whiteboard



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 of 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 session 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.