

In the Footsteps of Galileo: Observing the Moons of Jupiter



Activity C13

Grade Level: 6–12

Source: The Lawrence Hall of Science (a science museum and education research center at the University of California, Berkeley) included this activity in the GEMS *Space Science Sequence for Grades 6–8*. Learn more about GEMS at: <http://www.lhsgems.org/CurriculumSequences.htm> and at http://www.carolinacurriculum.com/gems/core_sequences.asp. Versions of this activity have also been published by Lawrence Hall of Science in the *Moons of Jupiter* GEMS guide, and the *Moons of the Solar System* guide in the Planetarium Activities for Student Success (PASS) series. © copyright 2008 by the Regents of the University of California. In 2009, the original GEMS activity was modified to highlight the process of science. It was published in its present form as a cornerstone activity for the International Year of Astronomy celebrations in 2009.

What’s This Activity About?

In 1610, Galileo used his new spyglass (telescope) to observe Jupiter, and found that it had four moons going around it. These were the first moons found around another world, and the first bodies indisputably orbiting something besides the Earth. In this activity, students learn about the scientific method and do a simplified version of Galileo’s pioneering observations of Jupiter’s moons.

What Will Students Do?

Students will look at data showing the positions of the moons of Jupiter over 9 nights and follow the motions of each moon to determine its orbital period around Jupiter. Throughout, the activity emphasizes the process of science and makes students aware of the steps in that process.

Tips and Suggestions

- Some teachers who do this activity regularly like to hand-out or put on the board the diagram at the end of the “Questions That Come Up” section that explains the issue of seeing a moon on the front or back part of the orbit in the same place on observation sheet. Visualizing this is hard for many students and it’s worth making this point early on.
- For additional background on Galileo and his work, see the sheet (3.34) *Galileo: Myths Versus Facts*, on *The Universe at Your Fingertips* disk.
- As the activity mentions at the end, when the Voyager spacecraft went by Jupiter in 1979, Galileo’s moons were revealed as fascinating worlds, each with unique characteristics and features. As a follow up, students can do a research project on one of the moons. See the *Getting to Know the Solar System* (5.8) Resource Guide on *The Universe at Your Fingertips* disk for web and reading materials on Io, Europa, Ganymede and Callisto.

What Will Students Learn?

Concepts

- Moons of Jupiter
- Scientific method
- Telescopes

Inquiry Skills

- Observing
- Modeling
- Recording
- Explaining
- Reasoning
- Predicting

Big Ideas

- Patterns of change
- Models and simulations
- Interactions

In The Footsteps of Galileo: Observing the Moons of Jupiter

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Who is this activity for?

Any group can do this activity together. This write-up offers choices for flexible presentation to a variety of groups. **The instructions for the basic activity on pages 4–7 are simple. Teachers and group leaders without astronomy knowledge can successfully follow them.** The rest of the material is background material and ideas for extending the activity and adapting it for different groups. The activity has been done successfully with mixed age groups and groups grade three through adult. These are some of the groups who should try this activity: school classes, after-school groups, families, home-school groups, scouting groups, and any other group that wants an authentic science learning experience.

Why should our group do this activity?

Four hundred years ago, Galileo made the first significant observations with a telescope. This activity is a simulation of one of the many discoveries that Galileo made. It is an example of the modern evidence-based view of science that really began with Galileo. By doing this activity you will share teaching this understanding of science with large numbers of people all over the world who are also doing the activity. (It was one of the key activities during the 2009 International Year of Astronomy, celebrating the 400th anniversary of Galileo’s first turning the telescope to the heavens.)

What are the goals of this activity?

1) *A positive experience of science*

This activity allows participants to act as scientists and to enjoy the satisfaction of making discoveries from observations.

2) *An accurate portrayal of science and scientists*

Though it is often neglected in the classroom, science standards suggest that students need to learn about the practice of science and what scientists actually do. In their quest to seek explanations about the natural world, scientists give priority to evidence in the form of a cumulative body of data or observations of a phenomenon. Multiple lines of evidence lead to the development of well-tested theories.

This activity allows students to be scientists and practice science as they learn new content. They work in teams as they observe and record data, generate scientific questions, construct explanations based on evidence, and compare and evaluate explanations. Students reflect on what they were doing during the activity and compare it to what scientist do.

3) *An understanding of a key moment in the history of science*

In 1609 Galileo Galilei heard about a Dutch invention that allowed the observation of ships coming into port well before the human eye could see them. After receiving the plans for this telescope, Galileo further improved it and instead of just using it to view objects on Earth, he pointed it at the heavens. Galileo made careful observations of our Moon, the Sun, the moons of Jupiter and the phases of Venus. His careful observations provided the first evidence that the Earth is not at the center of our Solar System, causing a revolution in our thinking about the Universe.

4) *Other concepts in space science*

There are many science concepts to be learned from the activity in addition to those mentioned above. Teachers, activity leaders, students, and other participants should pursue them as far as they are comfortable, concentrating on the examination of evidence and the reasoning process. This list starts with concepts that all learners can gain from this activity. Items near the end of the list are for more advanced learners.

- Aside from Earth, some other planets have moons.
- Without a telescope or binoculars, Jupiter is visible as a star-like object in the sky.
- With binoculars or a small telescope, Jupiter is visible as a small disc of light with four nearby moons (which appear as tiny spots of light).
- Stars, planets, and moons have different movements in the night sky.
- Moons orbit planets. Different moons orbit at different speeds.
- There is a mathematical relationship between the distance of a moon from a planet and the time it takes to orbit the planet.

When should our group do this activity?

This activity can be done any time. You do not have to actually observe Jupiter to do this activity, but if the activity sparks interest, it's nice to point out Jupiter in the night sky, if it happens to be visible.

Where did this activity come from?

This activity originated from Galileo himself; starting with observations he began in 1609. His observations of Jupiter have been repeated by professional and amateur astronomers for hundreds of years.

The Lawrence Hall of Science (a science museum and education research center at the University of California, Berkeley) began using a simulation of Jupiter observations as a learning tool in the 1970s. It has been presented in the planetarium at Lawrence Hall thousands of times. Lawrence Hall has included this activity in the GEMS *Space Science Sequence for Grades 6–8*. Learn more about GEMS at: <http://www.lhsgems.org/CurriculumSequences.htm> and at http://www.carolinacurriculum.com/gems/core_sequences.asp Versions of this activity have also been published by Lawrence Hall of science in the *Moons of Jupiter* GEMS guide, and the *Moons of the Solar System* guide in the Planetarium Activities for Student Success (PASS) series.

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LEADING THE MOONS OF JUPITER ACTIVITY

Materials

- One transparency of *Jupiter Observations* and an overhead projector (see Pages A1 & A2)
 - OR
- The “In The Footsteps of Galileo” PowerPoint and a computer with a projector.
(See page 9 for downloading information and for other options for displaying the Jupiter observations.)
- For each student, an *Observing Jupiter* activity sheet and a pencil (see Page A3).

OPTIONAL

- One hula hoop and ball (to help students model moon motion)

Preparation and Set-up

Arrange a computer with projector to display the downloaded PowerPoint,

OR

Copy the page of Jupiter Observations onto a transparency and set up an overhead projector. If you make a black and white copy, use red, blue, and yellow markers to color the moons according to the Color Key Chart. (Use permanent markers or markers made for transparencies.) Practice displaying the observations one night at a time. Use a piece of paper to cover up the nights above and below the observation you are making.

Step-by-Step Presentation:

Setting the Stage

1. The new invention. Just about 400 years ago, a Dutch man named Hans Lippershey invented something that could make distant objects look closer and brighter. At first, it was called a “spyglass”. Ask the group what they would want to look at if they had an invention like that. Accept all answers.

2. Introduce Galileo. Galileo was a scientist and teacher in Italy. He was excited about the new invention and he soon figured out how to make them himself. The invention was eventually renamed the “telescope.” Other people looked across the land and the oceans with telescopes. Galileo was one of the first to use it to look into space.

3. What Galileo saw. Galileo looked at many things with his telescopes, including the stars, moons and planets. But one of his biggest surprises came when he found what looked like four stars close to Jupiter. Night after night, as Jupiter moved through the sky, the four stars stayed with it. Show students the view of Jupiter and explain that Galileo was curious about the four specks of light that looked like stars next to Jupiter.

Making Observations

1. Display Observing Jupiter, Night 1 and explain the colors of the spots. Galileo would have only seen white spots. We have color coded them to help us track different spots*.

*For the moment, DO NOT refer to the spots as ‘moons’. At the end of the activity, you may wish to tell the students the names of each moon. They are:

Red=**Io** (EYE-oh)

Yellow= **Europa** (your-OPE-ah)

Blue=**Ganymede** (GAN-ee-meed)

White=**Callisto** (ca-LIST-oh)

2. Explain the numbers on either side of Jupiter. This view of Jupiter has a scale of numbers so that you can describe the position of each spot. For instance, the white spot is near the “2” on the right side of Jupiter and the red spot is between Jupiter and the “-1” on the left side of Jupiter.

3. Assign a spot to each student. Divide the group into four smaller groups. Each group gets to become an expert on one of the color coded spots of light by watching it over the next few days and keeping track of what it does.

4. Distribute the Jupiter Observation Sheets. Each student should write the color of the assigned spot on the sheet.

5. Explain how to record observations. For Night 1 each student puts a mark (a small “x” or a dot) on the top line of the chart in the position of the assigned spot. Students may show each other their marks and help each other to record them accurately.

6. Display Night 2 and have students record on the second line of the chart. Allow students enough time to record carefully and check their work. Remind them to find the same color spot each night and to record each observation on the proper line of the chart.

7. Continue through the nights, with students recording as you go. Invite students to make predictions. Around Night 4 or Night 5 students have become adept at observing and recording. Pause between nights and invite them to predict where they will see their assigned spots of light on the next night.

Asking Questions, Sharing Observations and Making Sense

1. Ask each group of students to generate up to three questions they can answer using their data.

2. Ask each group of students to share the data of their colored spot of light and their three questions with the rest of the class. List the questions on a whiteboard/blackboard or on chart paper.

3. Ask each group to generate additional questions they can answer if they had access to the data for all four colored spots of light.

4. Ask each group to share their additional questions. List the additional questions on the whiteboard/blackboard or on the chart paper.

5. Assign each group a question to answer and challenge them to find support for their answers using only their data as evidence.

6. Ideally, students should realize that they can draw a line connecting the mark that they made for Night 1 to the mark they made for Night 2, and so on down the page. If they don't do this, you can suggest it at this point.

7. Ask each group to share their questions, answers, and evidence that supports their answers.

The Practice of Science

Ask each student to write down what they did as part of the activity. Ask them to think about how they "acted" like scientists. Provide an example if needed, (e.g. observed from the slides, recorded data).

Ask students to share their answers.
List answers on a whiteboard or on poster paper.

Ask the class to compare and contrast what they did with what a real scientist does.

Watch a short 4 minute video about Galileo's observations of Jupiter. The video clip is located on a website called Teachers Domain:

<http://www.teachersdomain.org/resources/ess05/sci/ess/eiu/galileomoon/index.html>

After the students have viewed the video, ask the following questions:

1. Why did Galileo look at Jupiter?

Because it was visible in the night sky when Galileo first started using his telescope.

2. Why did Galileo repeat his observation?

Galileo observed 3 or 4 peculiar spots of light aligned with Jupiter in a straight line.

3. What question did Galileo ask?

What are those spots of light?

4. What did Galileo do that helped to answer his question?

Galileo observed Jupiter again the following night and continued observing Jupiter for weeks.

5. Show Galileo's observing log (slide) and discuss his observations.

6. Why is there different number of spots visible each night?

Sometimes one spot was either in front or behind Jupiter and was therefore not visible.

7. Why did Galileo not observe on each night?

Maybe it was cloudy or he had other things to do.

8. What was Galileo's claim?

After weeks of observations Galileo's claim was that these spots of light were going around Jupiter and that they must be moons like our Moon.

9. What was his evidence?

His evidence was the drawings he made in his observing log.

10. What were the implications of his claim?

If four moons were going around Jupiter, then not everything is going around Earth as claimed by the geocentric model.

If Jupiter can hold on to four moons while moving, then Earth can hold on to its moon if it is moving. The idea at the time was that Earth could not possibly be moving, because it would lose its moon.

11. What did Galileo do with his work?

Galileo published his work both in Latin and Italian, the language of the people.

12. How did society react to his work?

His book in Latin sold out in no time. The Church was not happy with his claim that the Sun, and not Earth, was the center of the Universe.

13. What made Galileo the first modern scientist?

Galileo gave priority to evidence in developing new theories about the world.

Background information and reflection for teachers

The National Science Education Standards (1996) list five essential features of classroom inquiry as:

1. Learners are engaged in scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations.

Which of these features were addressed in the activity? Where? How?

ADAPTING AND SUPPLEMENTING THE ACTIVITY

Other Options for Assigning Moons

In the activity described on the previous pages, students in a group are all instructed to watch the same color spot of light so that they can check each other's work easily. Another option is have members of each group watch a different color spot. That way they can make comparisons more easily as they go along.

Some students may want to watch more than one spot. You may allow this if you judge that they are capable, but have them make a different kind of mark on the recording sheet for each different color spot that they observe.

The Cloudy Night Challenge

If your group seems to be good at observing and recording, and if they are noticing patterns as they are making observations, consider adding one more little challenge to the activity. Around

Night 7 or Night 8 skip a night and tell them it is cloudy. Make sure that they leave this line blank on the chart and continue with the following line. When they are done they can use their observations from before and after the cloudy night to guess where their moons would have appeared. This gives students a taste of what doing astronomy in the real world of cloudy skies is like.

Stretch the activity out over nine days

If you are doing this activity with a family or any other group that meets regularly, you can make the observations a daily ritual instead of doing them all in one sitting. This could be accompanied by stargazing.

Small groups

If you do this activity with a den of scouts, a family, or any other small groups, you do not need to project the simulated observations. You may simply have groups look at a print-out of the observations for each night, or gather around a computer monitor.

Astronomy Club

If you do this activity using a telescope or binoculars, you can observe Jupiter and its moons over the course of several nights if it's visible. To determine which moon is which, use this online applet:

<http://www.skyandtelescope.com/observing/objects/javascript/jupiter>

OPTIONS FOR DISPLAYING MOONS OF JUPITER

There are two versions of the simulated Jupiter Observations data.

Jupiter Observations is the standard one. This version is suitable for most groups. It has been used extensively with participants of all ages and has proved successful in conveying the learning goals of the activity. The simplifications are as follows:

- All four moons are always visible.
- Moons are distinguishable by color.
- The periods of the moons are altered slightly so that each makes a full revolution in a whole number of days. This makes it easier for participants to discover the moons' periodic motion.

Jupiter Observations-Advanced is a version suitable for advanced groups (upper middle school or older) and groups with an astronomically knowledgeable facilitator and lots of extra time to analyze and make sense of data. It is similar to the observations that Galileo and other astronomers have made since the invention of the telescope, but it has not been tested extensively as a teaching tool. You may want to consider running the activity with the simplified observations and then using the more realistic ones as a follow-up activity.

Using simulated observations from Lawrence Hall of Science

You may use either simplified observations or more realistic observations using these methods.

- Copy the attached *Jupiter Observations* sheets (Pages A1 & A2) onto a transparency and display it on an overhead projector, one night at a time in succession, covering the other nights as you go along. If you print out a black and white transparency you can color the moons with colored markers according to the attached key.

- Copy the *Jupiter Observations* sheet (Page A3) onto paper, one for each team of students. Cut apart the observations for each night, and distribute them during the activity one night at a time in succession.
- Download one of the Power Point presentations from (<http://www.astrosociety.org/education/slooh/teachers.html>) and use it to display observations one night at a time on a monitor or with a computer projector.

Sharing observations on an overhead projector

An effective way to share data is to have four students (one for each moon) transfer their data onto transparencies copied from the Observing Jupiter sheet. Students can use markers that match the colors of the moons, using a black marker for the white moon. Layering these transparencies on top of each other allows easy comparison of the motions of the different moons. Do this only after students have had time to consider the data in its more raw form and to think of their own ways to display and compare data.

Using other sources for simulated or real observations

There is no option for using simplified observations using these methods.

- Use a desktop planetarium program that can display the moons of Jupiter. For example, *Stellarium* is a free program that can be downloaded at: <http://www.stellarium.org/> You can display the images for students or you can have students seek and record images.
- Use a telescope to make observations on your own or with your students. If you are not a telescope user yourself, contact a local astronomy group.

Quantitative analysis of the data

Older students and students who want to take the activity further can explore the quantitative relationships of distance and times in the Jupiter system.

Period of Orbit. Most students, even the youngest and least experienced, will notice the different times it takes for each moon to make one full orbit.

Radius of Orbit. The numbers on the data and observation sheets that are to the left and right of Jupiter represent the apparent separation Jupiter in units of one million kilometers. Students can determine the radius or orbit for each of the moons by looking at the moons' maximum apparent distances from Jupiter.

Speed. The speed of each moon is the distance it travels around Jupiter (2π times the radius of orbit) divided by the period of the orbit. Students who compute this for each moon will discover that the closer moons really do move more quickly than the more distant moons. This surprises students who often assume that the moons travel at the same speed and that the closer moons get around more quickly just because the path they follow is shorter. (Whether we are discussing the planets in the solar system or any similar orbiting system, it is true that closer objects move more quickly than the more distant objects.)

Kepler's Third Law of planetary motion states that in an orbiting system like the Jupiter system the cube of the radius of orbit (R^3) divided by the square of the period of orbit (T^2) for each object will be a constant. $R^3 / T^2 = \text{Constant}$. Students are unlikely to discover this relationship on their own, but if you are teaching this law in a high school or higher-level class, you can use the moons of Jupiter as an illustration of this law.

QUESTIONS THAT MAY COME UP

What do I need to see Jupiter and when can I see it?

Jupiter is easily visible without a telescope. It looks brighter than any star. As the Earth and Jupiter orbit the Sun, sometimes the Sun blocks our view of Jupiter. This happens about every thirteen months. The table shows the best times to see Jupiter (assuming clear skies.)

Jupiter Visibility						
	2011	2012	2013	2014	2015	
Jan.	Jupiter is visible sunset to midnight.	Jupiter is visible sunset to early morning.	Jupiter is visible sunset to early morning.	Jupiter is visible all night!	Jupiter is visible late evening to dawn.	Jan.
Feb.	Jupiter is visible only just after sunset.	Jupiter is visible sunset to midnight.	Jupiter is visible sunset to early morning.	Jupiter is visible sunset to early morning.	Jupiter is visible all night!	Feb.
Mar.	Jupiter is not visible.	Jupiter is visible only just after sunset.	Jupiter is visible sunset to midnight.	Jupiter is visible sunset to early morning.	Jupiter is visible sunset to early morning.	Mar.
Apr.	Jupiter is not visible.	Jupiter is not visible.	Jupiter is visible only just after sunset.	Jupiter is visible sunset to midnight.	Jupiter is visible sunset to early morning.	Apr.
May	Jupiter is visible only just before sunrise .	Jupiter is not visible.	Jupiter is not visible.	Jupiter is visible only just after sunset.	Jupiter is visible sunset to midnight.	May
Jun.	Jupiter is visible midnight to dawn.	Jupiter is visible only just before sunrise .	Jupiter is not visible.	Jupiter is not visible.	Jupiter is visible only just after sunset.	Jun.
Aug.	Jupiter is visible late evening to dawn.	Jupiter is visible midnight to dawn.	Jupiter is visible only just before sunrise .	Jupiter is visible only just before sunrise .	Jupiter is not visible.	Aug.
Sep.	Jupiter is visible all night!	Jupiter is visible late evening to dawn.	Jupiter is visible midnight to dawn.	Jupiter is visible only just before sunrise .	Jupiter is visible only just before sunrise .	Sep.
Oct.	Jupiter is visible all night!	Jupiter is visible late evening to dawn.	Jupiter is visible late evening to dawn.	Jupiter is visible midnight to dawn.	Jupiter is visible only just before sunrise .	Oct.
Nov.	Jupiter is visible sunset to early morning.	Jupiter is visible all night!	Jupiter is visible late evening to dawn.	Jupiter is visible late evening to dawn.	Jupiter is visible midnight to dawn.	Nov.
Dec.	Jupiter is visible sunset to early morning.	Jupiter is visible all night!	Jupiter is visible all night!	Jupiter is visible late evening to dawn.	Jupiter is visible midnight to dawn.	Dec.

What do I need to see Jupiter's moons?

A small telescope, or even binoculars, will let you see the moons of Jupiter. They appear as pinpoints of light next to Jupiter. Only space-based telescopes and some of the largest ground-based telescopes can see the moons as ball shaped objects with features.

How could Galileo tell which moon was which night after night?

Galileo had to see patterns over several nights before he could learn tell the moons apart. Callisto may have been the easiest one to start with. Callisto is the slowest one and the farthest one from Jupiter. When Callisto seems to be the most separated from Jupiter it also seems to sit almost still for a few days. During those days, it was easier for Galileo to identify Callisto. This allowed him to concentrate on the motions of the other three. Io, the closest large moon to Jupiter, moves fast enough that over a several hours its motion is detectable. That was also helpful to Galileo. Lastly, remember that Galileo was a very intelligent man. Once he understood what was happening with these moons, he began to predict the moon's motion and he was able to match the moons to his predictions accordingly.

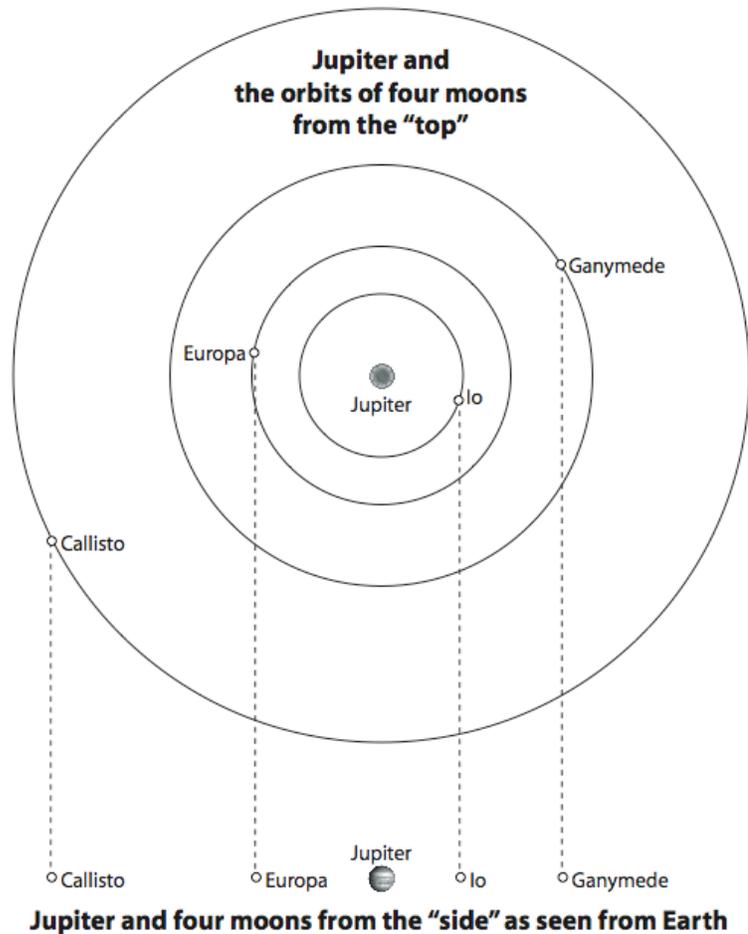
Why do the moons of Jupiter seem to move side to side instead of around in circular orbits?

One of the most difficult parts of leading this activity is assessing whether your students make the connection between the apparent side-to-side motions that they observe and the nearly circular orbits of the moons of Jupiter.

Like most planets and moons, the four largest moons of Jupiter have orbits that are fairly circular. (Not perfectly circular, but close.) They all orbit in the same direction, counter-clockwise as seen looking “down” from above Jupiter’s north pole.

From Earth, we never see the moons of Jupiter follow paths that look like circles because from Earth we see the orbiting system “edge-on,” or from the “side.”

It may help your students to visualize this motion if a student helper holds a hula-hoop “edge-on”, and the teacher moves a ball around the hula-hoop. Students in the class can then see the perceived motion of the moons (in a straight line), while simultaneously understanding that the moons are actually moving in circular orbits.



TIMELINE AND HISTORICAL NOTES

364 B.C.E: Earliest record of a possible sighting of a moon of Jupiter

Gan De was a Chinese astronomer who helped compile the first known star catalog. He also wrote about observations of the planets. In writing about Jupiter, he described a small star that accompanied it. This star could have been Callisto or Ganymede. This is technically possible; a few modern astronomers and stargazers claim to have seen Ganymede without a telescope. The sky was much darker in the time of Gan De, giving him an observational advantage.

1610: Galileo observes the Moons of Jupiter with a telescope

Galileo observed four star-like objects near Jupiter with a telescope. After more observations he concluded that they were satellites of Jupiter. He named the objects the “Medician Stars” to honor the wealthy family of one of his former students. (Terms for objects in space were not yet well defined in Galileo’s time. Even though Galileo called the moons of Jupiter “stars” it is certain he knew that they were in a distinctly separate category from other objects that we call stars.) Galileo used the discovery of Jupiter’s moons as evidence against the Ptolemaic Earth-centered model of the universe.

1614: Names for Jupiter’s moons

Simon Marius published a book in which he claimed to have discovered the moons of Jupiter before Galileo. This could never be substantiated, yet the names that Marius gave to the moons are the names that are used today. Callisto, Ganymede, Europa, and Io are all characters in classical mythology that are associated with the mythical god Jupiter. Galileo himself referred to the moons individually as I, II, III, and IV. Astronomers used Galileo’s designations until the twentieth century and then Marius’s names came into fashion.

1616: Longitude

Galileo proposed using observations of the moons and eclipses of the moons of Jupiter as a method for accurate global time keeping. His purpose was to help navigators and map makers calculate longitude. (Latitude can be calculated fairly easily from the positions and movements of stars, but calculating longitude requires accurate time-keeping). The King Phillip III of Spain had offered a prize to the person who could solve the problem of calculating longitude on a ship at sea, but Galileo’s proposal was turned down because of problems with observing Jupiter at sea and insufficient precision in predicting eclipses of Jupiter’s moons at the time.

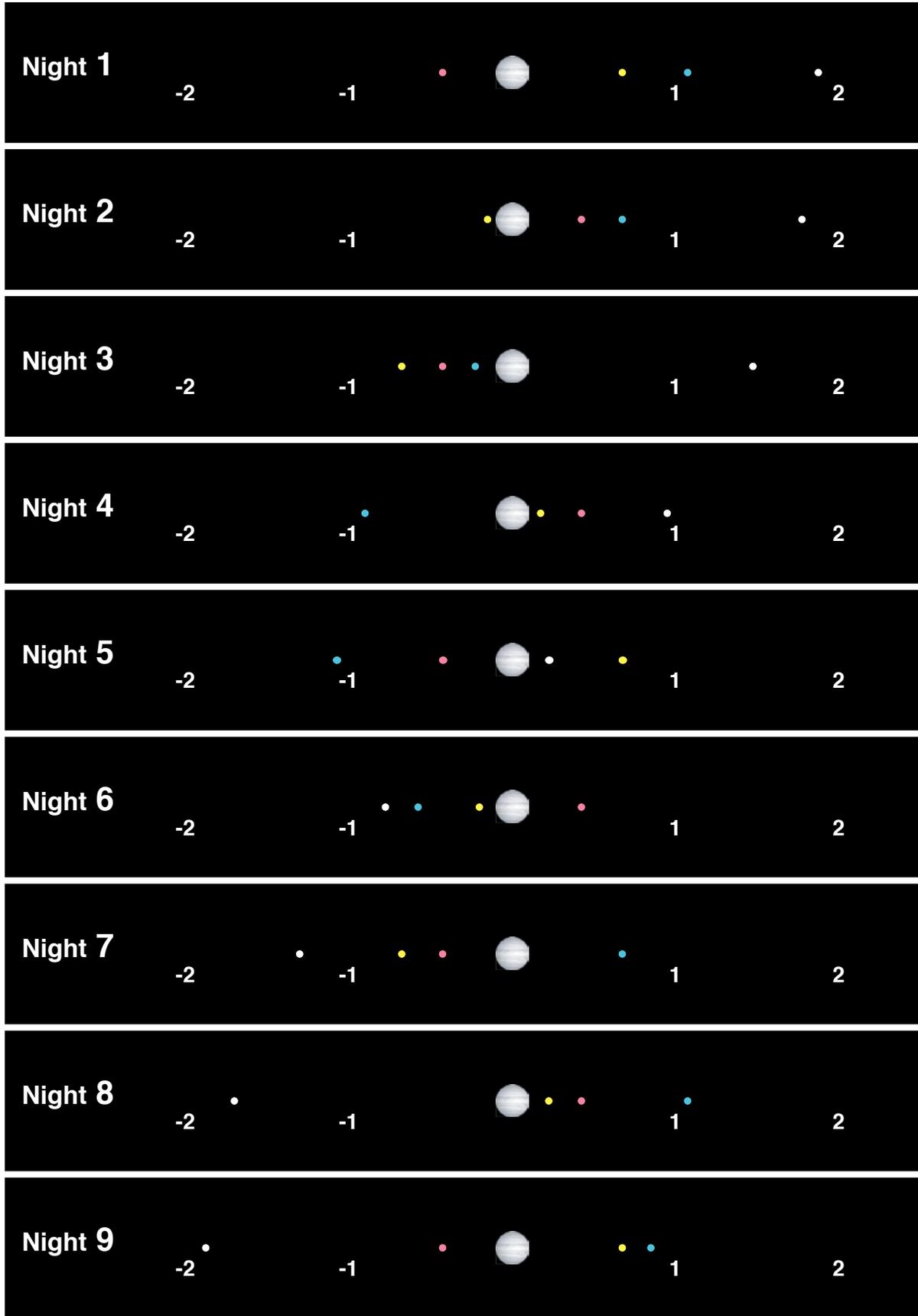
1670s: The Speed of Light

Giovanni Domenico Cassini noticed that observations for the timing of the passage of Jupiter’s moons through the shadow of Jupiter (eclipses) did not match predictions. He attributed this to the differences in the time it takes light to reach Earth from the Jupiter system when Earth and Jupiter are in different positions in their orbits. In other words, light from Callisto, e.g., takes longer to reach the Earth when Callisto is on the back part of its orbit than when it is on the front part. Ole Christensen Rømer, a colleague of Cassini, made further observations that confirmed this hypothesis. Rømer’s work became the basis for the first calculations of the speed of light.

1970s-Present: Spacecraft visit the Jupiter system

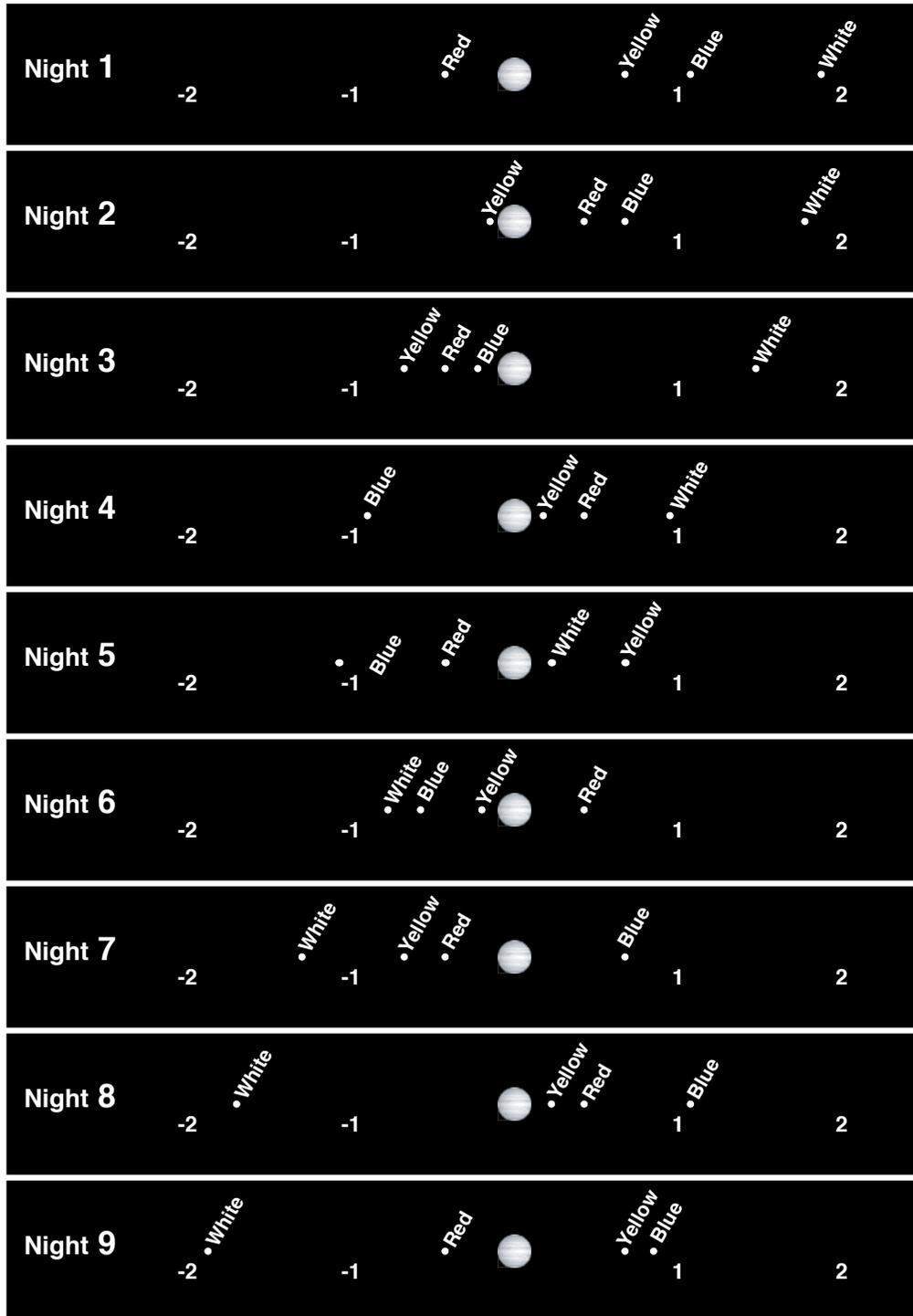
Several missions took photographs and studied Jupiter and its moons: Pioneer 10, Pioneer 11, Voyager 1, Voyager 2, Galileo, Cassini, and New Horizons. Go to <http://www.nasa.gov> for more information about these past and current missions. For nicely organized images from these missions, see: <http://photojournal.jpl.nasa.gov>

Jupiter Observations



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Color Chart for the Jupiter Observations Transparency



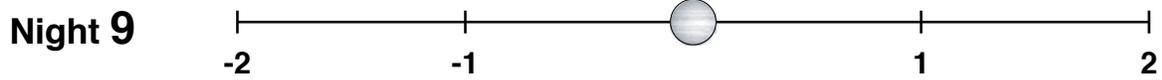
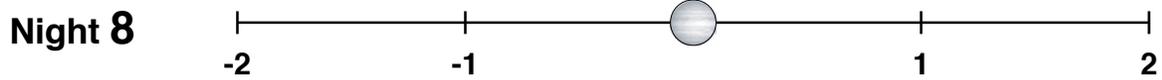
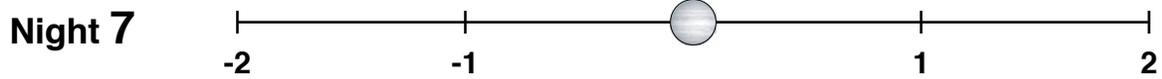
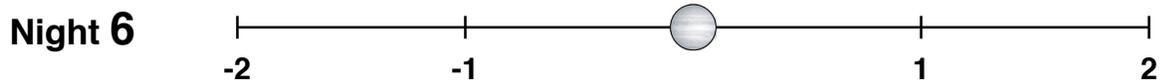
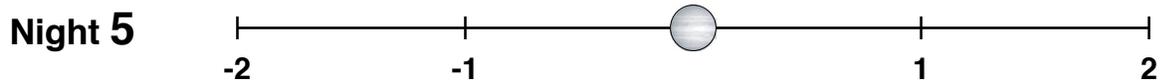
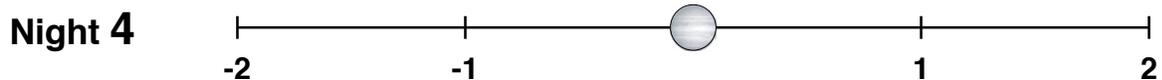
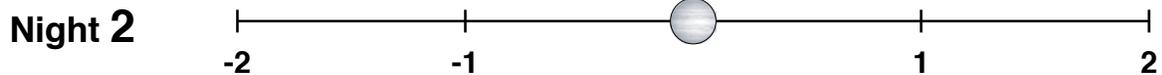
If you make a black and white transparency of the Jupiter Observations you will need to color the moons with permanent markers or pens designed for transparencies. This chart is to help you color them correctly.

Name _____

Your object's color: _____

Observing Jupiter

In 1610 Galileo Galilei observed Jupiter with a telescope. He was curious about objects near Jupiter that looked like small spots of light.



This activity is part of the *GEMS Space Science Sequence* from Lawrence Hall of Science. www.lhsgems.org/CurriculumSequences
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