Virtual Venus

Observing Venus Using Slooh Online Observatory in the Classroom

By Vivian White, Astronomical Society of the Pacific © 2007

Ideal for Grades 5–12 and beyond

Welcome to the wonderful world of Remote Telescopes! This activity is designed to give you and your students and introduction to this powerful observing tool. But that is not all. Here you will see how to combine kinesthetic learning, active investigation and this exciting new technology to teach your students about the Solar System we live in. This is presented in a coherent, logical order but you can also use pieces to demonstrate individual concepts.

Class time: Two 40–50 minute class periods with short follow up as needed

Contents

Materials for Activities:

- ❑ Computer (one or more) with Internet Access
- ❑ 4 or more solid white balls (baseballs, softballs, volleyballs, etc)
- ❑ 1 Standing Lamp Without Shade and a room that can be darkened some
- ❑ Extension Cord
- ❑ Copies (originals included here):
  - 1 per 6-8 students: Heliocentric Model Worksheet (two sided)
  - 1 per 6-8 students: Geocentric Model Worksheets (two sided)
  - 1 per student: Predictions and Observation Worksheet (two sided)

1) Before You Get Started: Is It the Right Time of Year for Observing?

Using telescopes has some inherent unpredictability in it. Even with the best preparation, the skies are sometimes cloudy. This is the nature of science, especially astronomy. Apart from these short-term issues, being well prepared is the best way to begin observing. Planets are not visible at all times of the year or all night long and you want to make sure that when you go to look for Venus, it is actually visible. See the bottom of the page for how to use the activity when Venus is not out.

Follow these simple instructions to insure a successful observing project:

A. Is this the right time of year for observing Venus in the classroom with Slooh? You can use this activity during the following months:

✓ 2008 ~ November through March 2009

✓ 2010 ~ May through October

✓ 2011 ~ December through May

If you do not see your dates listed above, you will not be able to see Venus through a remote telescope in the classroom.

B. Make sure you can observe during your class time by finding your time zone on the graph below and **making sure that one of your classes falls within the listed times.**

Approximate Observing Times 2008

(Check the week of observations for more precise times)

Time Zone	November 2008	December	January 2009	February	March
Pacific	9:30–10:30	10:00–11:00	10:00–11:30	10:30–11:30	10:00–11:00
Mountain	10:30–11:30	11:00–noon	11:00–12:30	11:30–12:30	11:00–noon
Central	11:30–12:30	12:00–1:00	12:00–1:30	12:30–1:30	12:00–1:00
Eastern	12:30–1:30	1:00–2:00	1:00–2:30	1:30–2:30	1:00–2:00

You can use photos instead and still do the activities. Photos of Venus’s phases can be found at: http://www.astrosociety.org/education/slooh/teachers.html

2) Slooh Tutorial

Now Let's Get Familiar with the Telescope

You will want an introduction to the Slooh technology before using it in the classroom. The next few lines will get you started with remote observing in no time flat!

Slooh Quick Set-Up

- For a quick, free tutorial to see just how easy Slooh is to use (you don't even have to be a member for this), go to: http://www.slooh.com/schedule/
- Click on the Launch Pad on the bottom right of the screen.
- From the Launch Pad, click "Help & FAQs" on the left side of the screen.
- Then click the Tutorial button to discover all that you can actually see and how much fun it can be taking pictures on remote telescopes.
- Now you are ready to Observe! Go back to the Mission schedule (http://www.slooh.com/schedule/) "Mission Login".
- After you feel comfortable with that, go back to the Help Page and try out Reserve Mission tutorial to see how to pick the object you want to observe.

Remember your Username and Password here:

______________________	______________________
Username (email)	Password

3) In Class Introduction

a. "Galileo Was A Rebel"

Bold words are the main concepts. *Italics are questions to ask the class.*

*An asterisk means there is further exploration in the Teacher Box on the left.

For thousands of years, people believed the Sun and all the heavens orbited around the Earth. *Why?** This is called a **geocentric system** since it is centered on the Earth. *Can you think of other "geo" words?**

In the sixteenth century, Nicolaus Copernicus came up with a new idea. He hypothesized that all of the planets traveled around the Sun. This is called a **heliocentric model**.*

This was a very controversial idea, because it seemed to contradict the Bible and the accepted traditions of the time. The term **"revolution"*** as we use it now comes from the challenge to authority and big change in thinking that happened around this idea!

Galileo was born in Pisa, Italy over 400 years ago. In 1609 he heard about the invention of a telescope in Holland. It was being used to watch for ships coming into ports there. From a simple description, he made a far better telescope for himself. Galileo then pointed his new telescope to the skies. He **made many discoveries** by just watching the skies a lot. He was the first person to see the **moons of the planet Jupiter and the phases of the Venus**.

His job as a professor of astronomy at University of Padua in Italy required him to teach the theory of that time, which said that the universe was geocentric. The idea that we are the center of the universe made people feel special and comfortable. He had heard about Copernicus's heliocentric theory many years before he ever looked through the telescope. **Galileo's observations with his new telescope convinced him of the truth of heliocentric theory*.**

Here's where he took a stand. Galileo published books talking about his observations and how they offered evidence that the Sun was the center of the Solar System. He also published these books in his native language of Italian instead of the usual Latin. Only priests and educated people could read Latin but many people in that area could read Italian. (Power to the People…)

The Roman Catholic Church was a very powerful influence at the time. They thought that Galileo's observations contradicted what the Bible said and tried to make him take it back. He maintained that he was only relying on the evidence presented to him by nature and tried to convince them to look through the telescope. Many of them refused and thought that he was trying to trick them. In 1633 the **Inquisition convicted him of heresy,*** banned his books, and sentenced him to house arrest at his villa outside of Florence, Italy. There, he kept writing about his telescopic observations and the evidence they provided for a heliocentric theory until he died nine years later at the age of 78.

It took another hundred years for the church to recognize publicly that Galileo's science was right and remove the ban on the heliocentric theory. Today, this theory is well established and widely accepted.

If you ***observe*** the Sun, moon and stars for a while, it looks like they are spinning around the Earth.

"Geo" words include geography, geology, geothermal. Geo is Greek for "Earth".

Helios is the Greek god of the Sun. Heliotrope, and helicopter both come from helio.

Copernicus's controversial book was called *On the **Revolution** of the Celestial Spheres* in 1543!

Galileo watched moons going around Jupiter and said something along the lines of, ***"Well, not everything revolves around the Earth anyhow."*** This was just the beginning of mounting evidence that the Earth was not at the center

The ***Inquisition*** was a part of the Catholic Church designed to find witches and heretics. ***Heresy*** is an opinion or doctrine contrary to church teachings. A person who believes these differing views is called a ***heretic***.

b. The Scientific Method

Galileo is sometimes called the father of modern science for the way he went about discovering things. He used what we call today the **scientific method.** *(Does anyone know the steps in the scientific method?)** The way he went about discovering things is often referred in our classroom to as the "scientific method". Although we will follow his method here it is important to know that there is no single "scientific method" universally employed by all. Scientists use a wide array of methods to develop hypotheses, models, and formal and informal theories. They also use different methods to assess the fruitfulness of their theories and to refine their models, explanations, and theories. They use a range of techniques to collect data systematically and a variety of tools to enhance their observations, measurements, and data analyses and representations.

> The scientific method involves
>
> 1) Making observations about the world around you
>
> 2) Inventing hypotheses (or educated guesses) for why things appear as they do
>
> 3) Testing these guesses with experiments or further observations.
>
> 4) Then drawing conclusions from the results of your tests.
>
> When a hypothesis stands up to many tests, it becomes a Theory, like the Big Bang. If, after a very long time, it seems to always work no matter what, it becomes a Law.

Here is what we will do in this experiment:

1) It is observed that the sky appears to move above us. *Give an example of things that travel across the sky.*

2) We will start with two hypotheses, the heliocentric model (maybe we all move around the Sun) and the geocentric model (maybe everything moves around the Earth) of our planetary system. They can't both be right, so we will look at ways of discovering the truth.

3) We will make real models of the two systems and figure out a way to test the differences between the two hypotheses.

4) Then we will make observations of the planet Venus through a telescope and hopefully come to a conclusion about our place in the Solar System.

(Review this and make sure everyone gets why.)

4) Classroom Kinesthetic Activity

The Phases of Venus

Adapted from PASS (Planetarium Activities for Student Success), Vol.11 Astronomy of the Americas. Copyright 1992 by the Regents of the University of California.

This activity is designed to be used in conjunction with a remote observing section, but can also be used independently to illustrate the phases of Venus.

a. Teacher Set Up

Materials Needed for This Activity:

• One white light with no shade or reflector that can be placed about 4 feet off the ground

• Four or more white balls (e.g. volleyballs, baseballs or softballs)

• Five each of the Heliocentric and Geocentric Student Worksheets (two sided)

• One for each student: Predictions Worksheet (two sided)

• Optional: a globe

Day of the Activity:

Set up the white light in a place with enough cleared space all the way around it to fit all of the students so that they will have room to turn around.

Darken the room as much as possible by closing the shades, doors and turning off all lights except the central one. If you do not have shades, you may want to use dark paper to cover some of the windows. Also, the farther away the light is from the walls, the less reflection you will get and the easier it will be to see phases.

b. Phases of Venus In Class

This exercise is to help students understand planetary phases and where in the sky that Venus is observed. If you have already done an activity Modeling Moon Phases (A-3 in Universe at Your Fingertips), this may be a quick review.

This can be read to the students or just go over **major concepts (in bold)**.

Italics are questions to discuss with the class.

An * asterisk denotes more information is offered for the teacher.

> In astronomy, the word **phase** is used to describe the lit-up side of a planet or moon.

You can make a Know, Wonder, Learn chart with 3 categories of ideas. *What do you know already about Venus? Did you know that Venus has phases? What is a phase?* Do phases always look the same? Can you think of anything that shows phases?* (Moon) Let's explore what makes phases.

We learned that Galileo presented **evidence that Solar System was heliocentric (the Sun is in the middle). One of the things that supported this was his observation the phases of Venus.** Let's explore phases and how they would be different in a heliocentric and geocentric Solar System.**To do:** Turn on the central white light and turn off or down the room lights and close the shades. Students should come up to the front of the room and make a semi-circle around the light, but they should stay at least a meter away from the light for the activity to work best.

> These are **not the correct sizes or distances** of the planets in the Solar System, but we want to examine phases close up in this model.

Let's pretend that this **bright white light is the Sun and your head is the Earth**.* People on your "Earth" live on Mt. Nose. *What time of day is it on Mt. Nose when you look directly at the Sun?* (Noon) *What time of day is it when you are facing directly away from the Sun?* (Midnight)

Now, put your hands up to form blinders on the sides of your eyes. Demonstrate as shown in the picture.

Your **hands form an eastern and western horizon** to Mt. Nose. Now turn around and face directly away from the Sun, then start turning slowly ***to your left***. This is the way that the Earth turns. When the Sun "rises" from your eastern horizon, it's morning. You should see the Sun during your day. It is night when the Sun "sets" behind your western horizon and you are facing away from the Sun. *Which hand does your Sun set behind, right or left?* (Right)

On which horizon does the sun set, the West or the East? (West) *Which of your horizon hands represents your western horizon, right or left?* (Right hand) Turn a couple more times slowly to see the Sun rise and set a couple more times, and then stop at your "noon" positions facing the Sun and rest your "horizons." You may put your hands down.

Here you might get some resistance to the positions of East and West. If you have a globe, hold that up to your chest and demonstrate by turning to the left the way that the Earth turns. We are used to looking at a picture of the Earth from the outside. Becoming the Earth takes a little bit of rearranging our mental picture. Think about where the United States would be on the Earth. The sun rises in the east and sets over California. Show how this works with the globe by turning to your left.

To do: Hold Venus about a meter to the right of the Sun (as seen by your students).

Now we will add Venus to our model. This ball represents Venus. As you turn, you will see Venus and the Sun. When the real Sun is above the horizon, it is so bright that it is difficult for you to see the real Venus. So in our model, **imagine you can only see Venus when the Sun is below the horizon** (behind your hand or behind your head). Now, put your horizons back on and start turning slowly (still to the left) to find out when you can see Venus.

Raise your hand if you saw Venus just before sunrise. (Most students will raise their hands.) Now, stop turning and rest your horizons. You can observe Venus in the sky just before sunrise in the east or just after sunset in the western horizon**. It always stays close to the sun in the sky**. Before the invention of telescopes, they called it a star because, although it is very bright, **with your eyes alone it is too small to see that it is a planet**. Without a telescope, it just appears as a point of light like the rest of the stars. People have known that this "morning star" and the "evening star" were the same object for many thousands of years.

To do: Put Venus on the left side of the Sun (as seen by the students).

If you put up you horizon hands and let your Earth turn again, do you think you will be able to see Venus before sunrise or after sunset? (After sunset) Try it. *Raise your hand if you saw Venus just after sunset.* (Most will raise their hands) *Was Venus a "morning star" or "evening star" for you?* (Evening star) Turn around a couple of more times to make sure you can see this "evening star" just after sunset.

Do you think there is any time when you cannot see Venus at all? (Yes) When would you not be able to see Venus? (When Venus is either behind or in front of the Sun from the Earth's perspective. Also when it is the middle of the night.)

We have just finished the first step of the scientific method. We made the observation that Venus is never found very far from the Sun as seen from Earth. This observation is nothing new for humans. People have known about this "star" for a very long time. **What they could not see until the invention of the telescope was that Venus has phases!**

Do you see that the Sun side of Venus is lit up and the other side is darker? If there were no light in this room except for the "Sun," you would not be able to see the dark side of the ball at all. What does that look like from where you are standing? Get students to talk about what they observe. Because the students are in different places, the descriptions will be slightly different. Some may say they see phases, that it looks like the Moon's phases. Talk about this and see if others see the same thing.

To do: Move the Venus ball to different places around the Sun. Make sure that they understand the concept of phases and see different phases as the position changes.

In Galileo's time, many people thought that the Earth was the center of our Solar System. It was not until Galileo pointed his telescope at the heavens that he could finally see the phases of Venus. This was one of his strongest pieces of evidence that we live in a heliocentric Solar System.

Now we will make models to investigate the two ways that Venus, this "morning star" and "evening star" was explained in Galileo's time.

5) Kinesthetic Investigation in Small Groups: “Heliocentric or Geocentric?”

To do: Split the class in half and then make groups of 3-4 students. Half of the groups will make a model of the heliocentric hypothesis and the other half will make a model of the geocentric hypothesis. Hand out one “Heliocentric Model” worksheet or “Geocentric Model” worksheet to each group.

Ask the students to read together in their group the first page of the worksheet. Before they start drawing, ask them to make sure everyone in the group understands this first page. Ask them to explain it as a group if you think they are having difficulties. When they are ready, **let one group from each model come and record their predictions with a ball and the light**. While they are busy with this, other groups may want to look at activity L-3, *Ancient Models of the World* from *Universe at Your Fingertips* (see resources).

> In a Heliocentric Solar System, Venus would sometimes show phases fuller than half if you looked at it through a telescope. In a Geocentric system, Venus’s phases would always be less than half full.

When the students finish, bring the heliocentric groups together to discuss as a large group what a **full cycle of Venus phases would look like**. Ask the geocentric groups to come together do the same. Discuss questions and predictions that students have made. Draw the predictions for the two different phase cycles on the board, clearly marking which prediction goes with which model. (See the back of the Predictions Worksheet for actual phases.) ***How would Galileo have been able to tell the difference between a Heliocentric System and a Geocentric System?**** *Why would no one have noticed before?* (We can’t see phases without a telescope.)

Extra Note:

Outer planets do not go through phases. See if students can show why using the lamp and balls. You can do this as a class. *If you were living on Mars, which planets would show phases?* (Mercury, Venus and Earth because their orbits are closer to the Sun.)

To do: Pass out one “Predictions and Observations” worksheet to each student. One side has the actual difference in the phases between Heliocentric and geocentric systems. If this is not what your students came up with, discuss the differences between the systems. On the side with boxes, ask them to draw a guess of what they think Venus will look like when we look through the telescope. This does not have to be the same as the model they made.

Hint: Venus is in the western sky right after sunset.

6) Classroom Observing with Remote Telescopes

Be sure to do this during the times indicated on the chart in Section 1: Before You Get Started

a. Set Up For Teacher

Up to One Week Before:

Reserve time on a telescope and schedule the objects you would like to see. You will need to reserve time for Venus and also time for at least one of the outer planets. Both Saturn and Jupiter are eye-catching and fun to view through a telescope. Mars has less "wow" factor, but can be used to illustrate the differences between inner and outer planets.

Saturn is available during the entire 2007 observing period, Jupiter is available to view during class time from Mid-April on (you can see it later in the day beginning in March). During 2007, Mars is up too late to be observed with this activity.

Check the weather at the site and make sure that it will be clear the "night" that you will be observing. You can do this right on the Slooh website. If it happens to be cloudy when you would like to do this activity, there are good photos of Venus taken with Slooh telescopes at the end of this activity (see Resources). **Have these ready in case!**

Day of the Activity:

Login to Slooh before class and make sure that it is clear out and your mission is ready to view.

b. In Class Activity

Now let's try to find out what kind of Solar System we live in. We will be **testing these hypotheses in the same way that Galileo did**, by observing! Our observing system is a little more high-tech, though. Thanks to computers and the Internet, we can look through telescopes in different parts of the world and see what they're seeing. It's daytime here right now, so it's not the best time to look at planets for us. *Does anyone have any ideas how to get around this? What about a telescope on the other side of the world? Is it light or dark there now?*

The telescope that we are going to be using is in the Canary Islands, off the coast of West Africa. It is not long after sunset there now, and Venus is up in the western sky. I have told the telescope that we want to look at Venus, so when our time comes up, it will point there and show us what Venus looks like.

To do: Now you are ready to observe! You should be logged on to Slooh.com and from the Launch Pad open the Mission Interface. Remember that your planet will be on the Member Channel (not the Editor Channel). See "Quick Set Up" if you have any questions.

Watch as the image appears. Remember to take pictures to use later! You can take up to three pictures per mission. Have students record their observations in the correct squares on their Predictions and Observations Worksheet. Discuss what is emerging. Indeed, Venus is not always a round dot on the sky. This will probably surprise most students. Common responses are something along the lines of, "It looks like the Moon!" Remember to observe one of the outer planets as well to compare the shapes.

Using the Pictures You Take:

By going to the tab labeled "My Pictures", you can look at pictures you have taken by the type of object it is (Solar System, Planetary Nebula, etc.). If you click on one of the pictures, it will open in a new window. You can then highlight it and save as a PDF file or other image file. Astronomers find these images easier to look at, and it also takes less ink to print if you invert the colors. That way Venus will be black and the background will be white. Print them out and save them somewhere to compare images you will take later.

7) Conclusion and Follow Up

What Did We See?

Depending on when you are observing, Venus may be a crescent or fuller than half (called "gibbous"). Galileo observed over many months found all the phases from almost full to new when he looked at Venus through a telescope. From this, he concluded that the Earth could not be the center of the planetary system. His observations directly opposed the geocentric system. This is how theories are disproved.

This was still considered a theory for many years after his discovery, and not just because the church objected. Theories have to be tested over and over before they become accepted as a good representation of reality. The cool thing about science and scientists is that they are willing to change their minds if evidence shows that their theories are wrong. When theories have been tested for a long time and seem to stand up to many types of experiments, they sometimes become laws. *How sure do you think we are now that we live in a heliocentric Solar System?*

Further Study/Homework:

Ask students to look to the west after the Sun sets in the evening sky and see if they can see a very bright "star." They will be observing again! Get them to make a sketch of the bright star in the West after sunset and include the horizon.

Have students research another of Galileo's discoveries or inventions.

If you did not explore this earlier, discuss why planets that orbit farther away from the Sun than Earth do not go through phases. See if students can show why using the lamp and balls.

To Do:

For the rest of the year, take pictures a week or so apart to further explore the phases. One person can do this each week or the whole class can keep a Venus journal. Keep track of your observations using pictures or drawings with the date marked on each one and display these in the classroom.

The next 6 pages are **three 2-sided worksheets** that can be copied to give to students. You will need one each of the Heliocentric and Geocentric Worksheets for every 6-8 students. Every student will get the Comparisons and Predictions Worksheet.

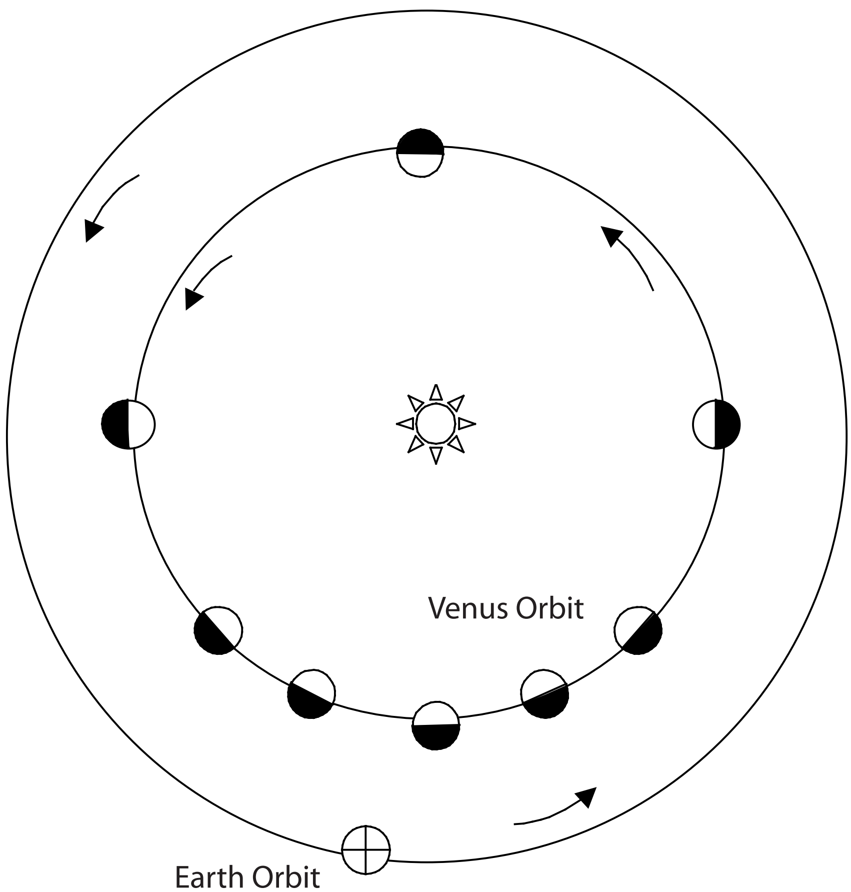
Heliocentric Model

Create a Hypothesis to Make Predictions

Group Members ____

____

Your group is going to examine what Venus would look like from Earth in the heliocentric model. Other groups are looking at the geocentric model and next we will compare the differences. In the Heliocentric model, Venus is about 2/3 the way from the Sun to Earth.

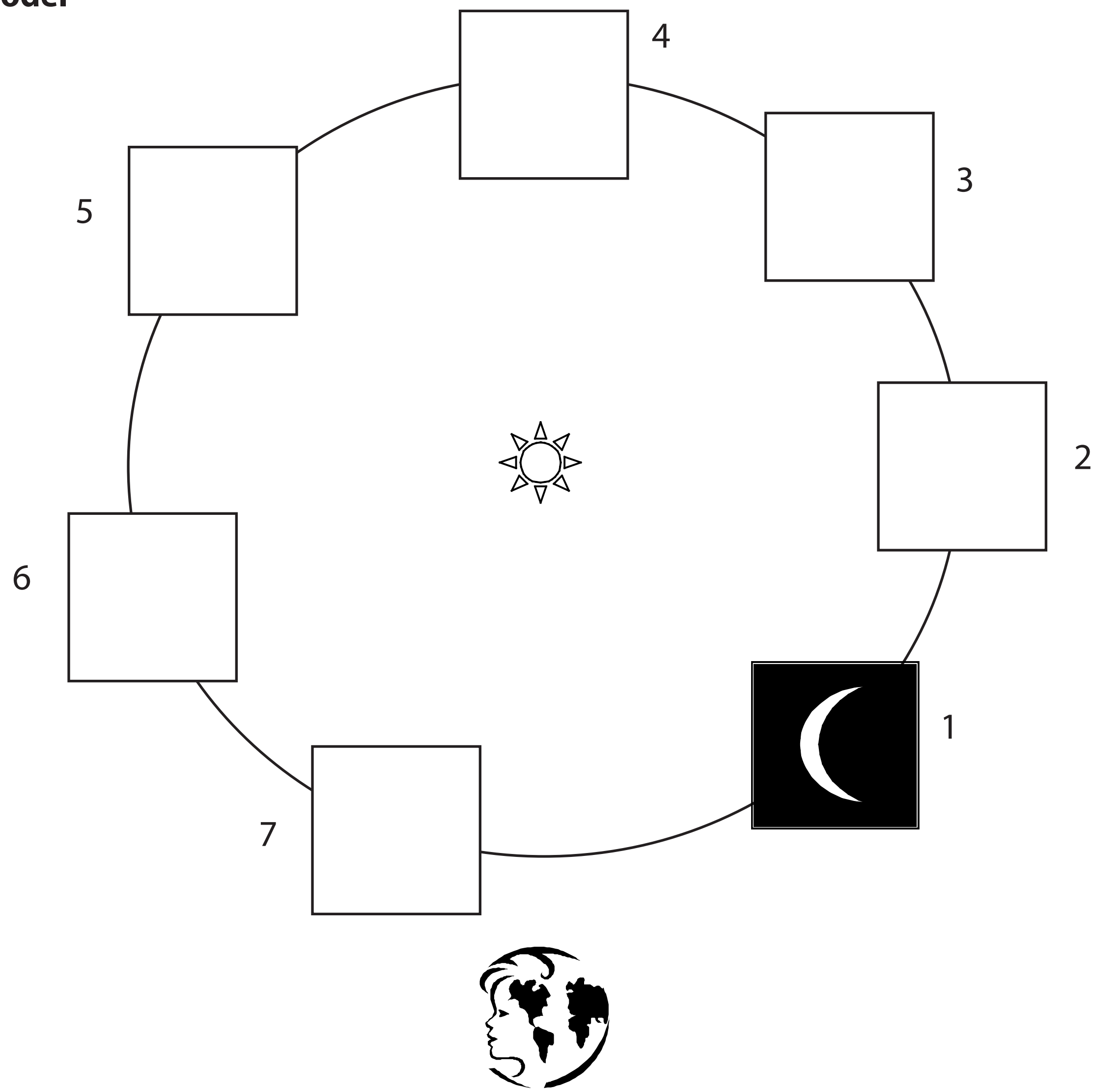


This is what the phases of Venus look like from above a heliocentric system (from the ceiling). The side of Venus that points towards the Sun is lit up. The other side is dark. Here we show what Venus looks like at different places in its orbit. Can you see why Venus never appears very far from the Sun when looking from Earth? Let's investigate further.

Scientists make models like these and then predict what they would see if the model were true. We are going to predict what Venus would look like from Earth in a heliocentric system and come up with some questions to test this hypothesis.

Heliocentric Model

Page 2



To Do in Class:

- Within your group, pick one person to be the first Venus. This person holds the ball about 1 meter away from the Sun at that height. Venus walks counterclockwise slowly around the Sun, making sure other group members can see the Venus model at all times.
- The other group members will be on Earth and stand together about a meter and a half from the Sun. When Venus passes the group, ask him/her to stop a little to your right, where position #1 is above. Does the lit up side look like that picture? Help each other.
- Let Venus walk slowly around the Sun a few times and watch the phases change. When Venus reaches position #2 ask him/her to stop. Record the phase that you see there. Then have another person be Venus. Repeat this with each person holding Venus for two drawings until all boxes are filled. Help each other fill boxes that you have missed.

Be ready to discuss the following questions with the rest of the class:

1) Talk about what you think a full cycle of Venus's phases would look through a telescope if we indeed lived in a heliocentric planetary system. (How full should it get? Will you always see it? Remember that the Sun is much bigger than Venus.)
2) What do you think a planet like Saturn or Jupiter (farther away from the Sun than the Earth is) will look like through a telescope? Will it have phases?

Geocentric Model

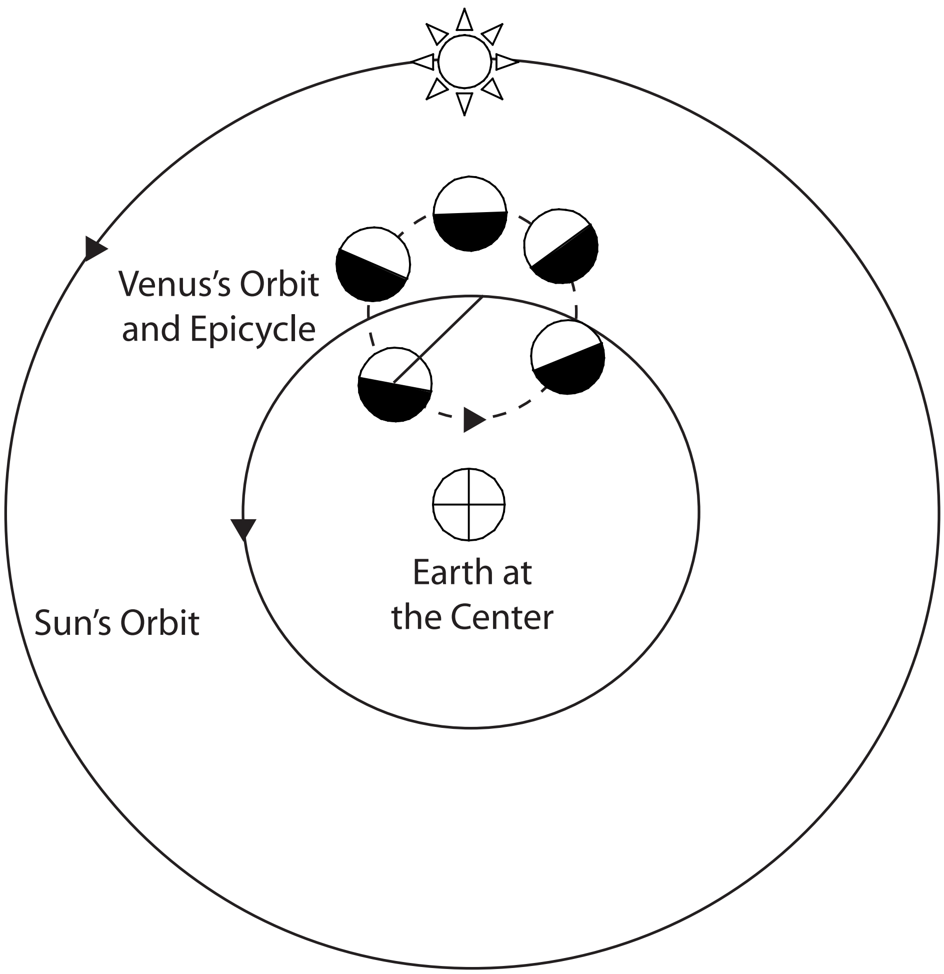
Create a Hypothesis to Make Predictions

Geocentric Members ____

____

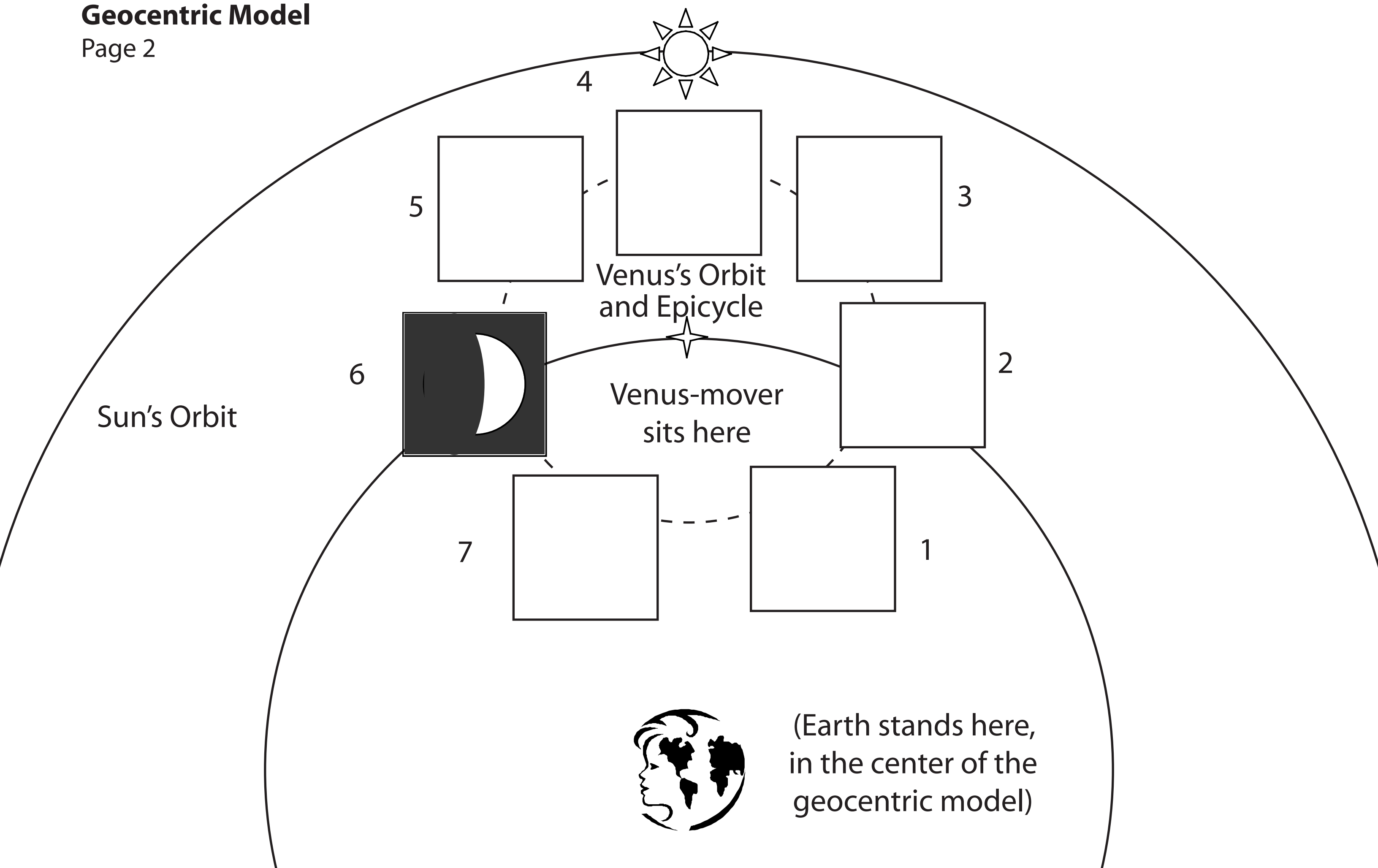
Your group is going to examine what Venus should look like from Earth in the geocentric model. Other groups are looking at the heliocentric model and next we will compare the differences.

From Earth we never observe Venus very far away from the Sun. The geocentric model had to make some adjustments to keep Venus from moving to the other side of the Earth. They had to add circles on top of circles to account for this. These were called epicycles (dashed line). Venus's epicycle always stayed between the Earth and the Sun. It went around on top of Venus's orbit. Here is what a basic geocentric model might look like from above (if you were looking down from the ceiling):



The side of Venus that points towards the Sun is lit up. The other side is dark. The Sun moves around its orbit and Venus goes around its epicycle. In this model, the epicycle stays between the Sun and the Earth.

Scientists make models like these and then predict what they would see if the model were true. We are going to predict what Venus would look like from Earth if this model were correct and come up with some questions to test this hypothesis.



To Do in Class:

- Within your group, pick one person to be the first Venus-mover. You will **kneel or sit about 1 meter from the Sun (light) and hold Venus above you at the same level as the light**.
- Another person will be the first Earth. Bring this worksheet and a pencil with you and stand about 2 meters from the Sun, in line with Venus. (see above)
- Have Venus-mover look at Earth and hold Venus in his/her right hand at arm's length at about the height of the Sun. Does Earth see the same part of Venus lit up as you see drawn above in position #6? If you do not see it, ask another group member for assistance.
- When you see the phase, ask the Venus holder to move the Venus towards Earth **in a counterclockwise circle** (as shown in the picture above) a few times. Ask the Venus mover to stop when Venus gets to position #7 and record what phase you see.
- Then the person playing Earth will become the next Venus-mover and a new person will be the Earth. Keep rotating until everyone in your group has had a chance to record the phases.

Be ready to discuss the following questions with the rest of the class:

1) As a group, talk what you think a full cycle of Venus's phases would look like if we lived in a geocentric planetary system. (How full should it get? Are there any times you won't see it? Remember, Venus is actually much smaller than the Sun.)
2) What do you think a planet that has an orbit on the other side of the Sun, like Saturn or Jupiter, will look like to us in a telescope? (If the Earth were still in the center)

Predictions and Observations

Venus is visible right now in the western sky just after sunset. (That's a hint) Based on what you just saw in the models, **draw a prediction of what you think Venus will look like through a telescope** in the left box below.

Venus Prediction (in a Telescope)	**Venus Observation** (in a Telescope)
Other Planet Observation	**Other Observation**
Planet ____________________	Object ____________________

After sunset tonight, look towards the western horizon, where the sun just set. If it is a clear night, you may see a very bright "star" above the horizon. It may just impress whoever you're with if you look up casually and say, "Look! That's Venus over there in the west." Now you know.

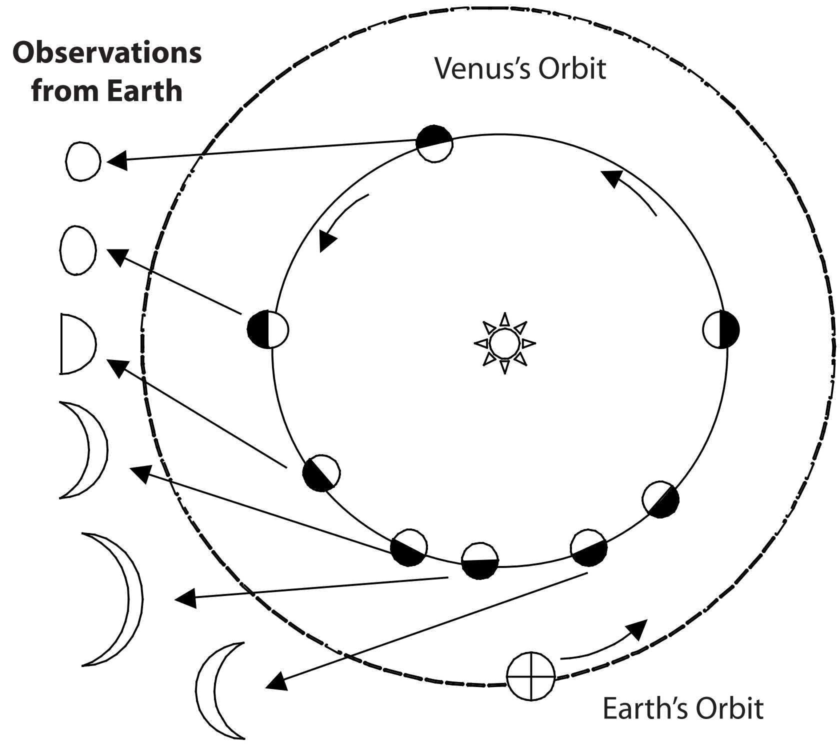
If later in the year, you don't see it in the evening sky, it has probably become a "morning star" and can be seen in the east right before dawn but you have to get up early for that.

What We Observe from Earth

Heliocentric vs. Geocentric Models

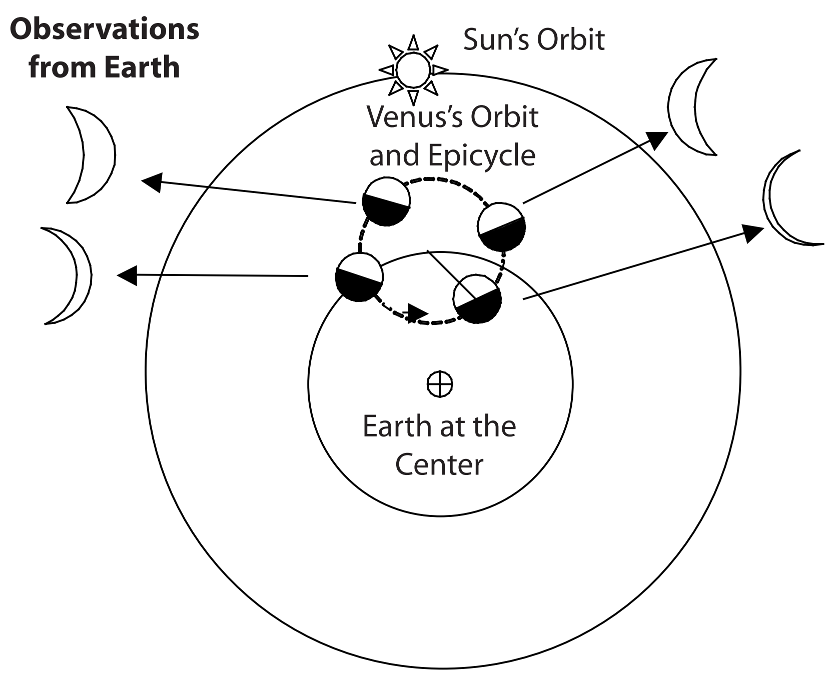
Heliocentric Model:

Here we observe Venus going from almost a circle all the way to thin "crescent" or fingernail as it orbits the Sun. When Galileo pointed his telescope into the night sky, he saw that that bright star was in fact a planet. He also saw that it had phases, including almost "full" or round.



Geocentric Model

If the Earth were in the middle, Venus would appear to stay in the area between the Earth and the Sun. It never goes very far from the Sun as viewed from Earth, so the geocentric model needs epicycles, or circles on top of circles. If this were the case, then from Earth we would only see some of the phases of Venus, not all of them. Venus would never even become half full.



9) California Science Standards Addressed

5th Grade

Earth Sciences

5. The solar system consists of planets and other bodies that orbit the Sun in predict-able paths. As a basis for understanding this concept:

a. Students know the Sun, an average star, is the central and largest body in the solar system and is composed primarily of hydrogen and helium.

b. Students know the solar system includes the planet Earth, the Moon, the Sun, eight other planets and their satellites, and smaller objects, such as asteroids and comets.

c. Students know the path of a planet around the Sun is due to the gravitational attraction between the Sun and the planet.

6th grade

Investigation and Experimentation

7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Develop a hypothesis.

b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

e. Recognize whether evidence is consistent with a proposed explanation.

g. Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions).

h. Identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hillslope).

7th grade

Investigation and Experimentation

7. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

b. Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.

c. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e. g., motion of Earth's plates and cell structure).

8th grade:

Earth in the Solar System (Earth Science)

4. The structure and composition of the universe can be learned from studying stars and galaxies and their evolution. As a basis for understanding this concept:

d. Students know that stars are the source of light for all bright objects in outer space and that the Moon and planets shine by reflected sunlight, not by their own light.

e. Students know the appearance, general composition, relative position and size, and motion of objects in the solar system, including planets, planetary satellites, comets, and asteroids.

Investigation and Experimentation

9. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Plan and conduct a scientific investigation to test a hypothesis.

9th–12th Grades:

Investigation and Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

d. Formulate explanations by using logic and evidence.

f. Distinguish between hypothesis and theory as scientific terms.

g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.

i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).

k. Recognize the cumulative nature of scientific evidence.

l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

n. Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e. g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).

10) Resources and Remote Telescopes

The ability to observe the night sky from your classroom computer is a new and exciting resource. You are encouraged to experiment, see what interests students, and let us know what you find. Please share any ideas and discoveries: bayareaastro@astrosociety.org

Resources:

Pictures of Venus and more taken with Slooh telescopes. These are important to have on hand in case of clouds at the telescope. They can be found on the Bay Area Project ASTRO website under "Partner Resources" at:
http://www.astrosociety.org/education/astro/bayarea/resources.html

The Universe At Your Fingertips and ***More Universe at Your Fingertips*** have useful activities for the classroom that can be easily adapted to use with remote telescopes. Try L-3, *Ancient Models of the World* as a supplement to this activity. C-16, *Tracking Jupiter's Moons* and H-7, *Galaxy Sorting* (also on ASP website, below) can be done with your own images and descriptions that the students write. *G-7, Estimating Star Brightness* explores variable stars. Can be found through the AstroShop:
http://www.astrosociety.org/astroshop.html

Project CLEA, Contemporary Laboratory Experiences in Astronomy has some great labs and free software for high school and undergraduate students. Some of the labs can be done using remote telescopes instead of simulation software, such as *Revolution of the Moons of Jupiter* and *The Height of Lunar Mountains*.
http://public.gettysburg.edu/~marschal/clea/CLEAhome.html

To learn more about **Galileo Galilei**, go to the **Galileo Project** website by Rice University. In the library, there are lesson plans that explore his life and discoveries further.
http://galileo.rice.edu/index.html

More Observing Activities can be found on the following websites

Slooh for Schools Teacher Page:

http://www.slooh.com/schools/

Astronomical Society of the Pacific online activities:

http://www.astrosociety.org/education/activities/handson.html

Introductory Astronomy Clearinghouse Labs:

http://www.astro.washington.edu/labs/

Astronomy Labs 101 from Vanderbilt University:

http://www.physics.vanderbilt.edu/astrocourses/AST101/labs/

Astronomy Education Review (For beginning college classes but many labs also used in high school):

http://aer.noao.edu/cgi-bin/new.pl

Other Remote and Robotic Telescopes:

Slooh Online Observatory is a wonderful remote telescope to use in the classroom because it is user friendly and requires virtually no image processing. There are other telescopes that are also used in the classroom and here we highlight some of our favorite with their features. This list is current as of January 2007 but things do change so check with the individual operations if you have questions.

Hands On Universe provides software to 6-12th grade teachers to do investigative astronomy labs, including image processing.

http://www.handsonuniverse.org/about_hou/index.html

MicroObservatory allows you to ask for a picture of a specific object and they will return the data to you from their telescopes in Cambridge, MA. They also have a great list of activities under the "Challenges" tab on their webpage.

http://mo-www.cfa.harvard.edu/MicroObservatory/

National Schools' Observatory is free to all UK schools and may be expanding internationally soon. They will return your observing request to you in a few days.

http://www.schoolsobservatory.org.uk/

Rent A Scope Observatories have live imaging and good personal help. They are expanding their educational programs at the time of publication.

http://www.ras-observatory.org/ras/index.html

School of Galactic Radio Astronomy has summer teacher institutes that give 8th – 12th grade teachers access to Smiley, the 4.6 meter radio telescope.

http://www.pari.edu/programs/K12Programs/

Research Based Science Education (RBSE) allows 6-12th grade students to write proposals to work with astronomers on the Spitzer Space Telescope.

http://www.noao.edu/education/arbse/top/ro

Telescopes in Education gives students access to live data to use with a dozen great imaging activities.

http://www.ocastronomers.org/ezine/monthly_meetings/meeting_2002_11.asp