What does the universe look like?

The purpose of this exploration is to use the telescopes to create images of different celestial objects, and to begin to pose and answer questions about what the images can tell us about the objects.

- Almost everything we know about the universe comes from studying and interpreting the light that comes to us from space.
- MicroObservatory telescope images are all taken at the same scale (or "magnification"). The relative size of an object in the image contains information about how large it is or how far it is.
- Astronomers adjust the brightness and contrast of the images they take, but must be careful when intrepreting features of the image.
- The more we learn about the universe, the more questions we have. Science is the art of asking, as well as answering, questions.

GRADE LEVEL:
7-12

TIME OF YEAR:
Anytime

SCIENCE STANDARDS:
Various

MATERIALS NEEDED:
✔Online telescopes
✔ Software, free from Internet
✔ Printer (optional)

TIME NEEDED:
2-3 class periods

TEXTBOOK LINK:

In this introduction to using the telescope, students assemble a "group portrait" of the universe. This activity enables students to gain facility with using the telescope. They have "early assured success," but can also choose to image challenging objects as well. The activity provide the "big picture" of the universe and what's in it. Students are encouraged to pose questions that will motivate their own future projects.

The activity enables you to:

- ✔ Sort out students' prior conceptions about what's in the universe.
- ✔ Introduce the concept of angular size and its connection to size and distance.
- ✔ Introduce image processing, if desired.

Materials Needed

	For each team of students
	Optional: Rulers for measuring printed images
	For the class
	Internet access to the MicroObservatory online telescopes
	Image-processing software (MOImage) on your local computer
	Printer (black-and-white)
	For the teacher
	Optional: Video projector for demonstrating Internet use

Organizing student work

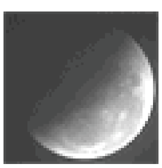
1. Demonstrate how to use the online telescopes. If you have an overhead projector that can project a Website onto a large screen, then you can demonstrate the procedure to the whole class. If not, the class can gather around a computer station connected to the telescope Website for the demonstration. See the QuickGuide, "How to Use the Online Telescopes" for full instructions.

2. Students should work in teams of five or six. Each team is responsible for imaging one collection of images, including the Moon; the planet Jupiter or Saturn; a nebula such as the Orion nebula: stars or a star cluster: and a galaxy.

3. Emphasize to students that good work habits with the telescopes will save headaches further along. For example:

> Download and save image files as soon as possible after the images are taken. Images remain on the Web for only a few days; once gone, they cannot be retrieved.
>
> Make sure to download faint images in FITS format so that you can bring out fine details through image-processing.
>
> Name the image files clearly. The images may be needed again for future explorations or student projects.
>
> If it is important to conserve your printer's toner, then have students *invert* their images before printing them—that is, print them as black against a white background rather than white against the dark night sky. To invert images, open them in MOImage (or any image-processing program) and choose the Invert command on the menu. Then save the images in inverted form.

Part 2: Making sense of the images



The Moon:

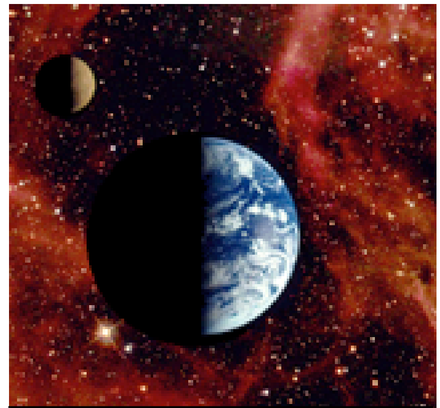
Which direction is the Sun in your image? Why do you think that?
The Sun is the source of light for the Moon. The Moon is shining by reflected light.

What do you think caused the craters on the Moon?
Impacts of asteroids, early in the solar system's history.

Why isn't the Earth covered with craters too?

Over billions of years, wind and water have eroded almost all of Earth's craters. But a few are still visible.

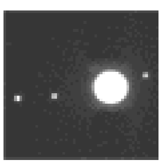
A tough one: If the Moon craters are from impacts, then why are there mountains in the centers of some of the craters?
See Exploration 3, student projects, and compare with Harold Edgerton's famous "milk drop" photo. An asteroid impact melts the underlying rock.



An image of the Earth and Moon, seen from space, is superimposed on a separate Hubble telescope image of the background sky. Two very different exposure times

Why did you have to use a deep grey filter?
To block some of the light: The moon is so bright, you would need an exposure time shorter than the telescope can handle.

Why don't you see stars in the background of your Moon image?
The moon is so bright that the exposure must be short. Therefore, the stars are underexposed.



Jupiter

If Jupiter (or Saturn) is a big planet, why does it appear so much smaller than our Moon?
Because it is much further away.

Why don't you see any stars in the image of Jupiter?
Jupiter is so bright that the exposure must be short. Therefore, the stars are underexposed.

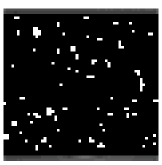
Can you detect any of Jupiter's moons?
Your image should contain two to four Jupiter's innermost four moons.

If you took several exposures of Jupiter over time, would you expect to see the moons moving?
Yes, over four or five hours you will see the innermost two moons move detectably in that time. (See Exploration 5, Voyage to Europa.)

What is the source of light for Jupiter and its moons? Why do we see them?
Like all planets and moons, Jupiter and its moons REFLECT light from the Sun. They don't produce their own visible light.

What are those bright vertical bands coming out of Jupiter. How do I get rid of them? Are they part of the planet?

If you overexpose an image of Jupiter or other bright object, you'll see vertical "flares" coming from the object. These are not part of the actual scene; they are created in the silicon chip that images the scene. To get rid of them, you'll have to reduce the exposure time. But then it will be harder to see Jupiter's moons, which are fainter than the planet.



Stars

Why do the stars appear as tiny dots?
Almost all stars are so far away that they appear as dots even in the most powerful telescopes — even the Hubble Space Telescope! (One of the closest large stars—Betegeuse in the constellation Orion—has been resolved into a tiny, almost featureless disk.)

Then why are some of the dots wider than others? Are those stars larger?
No. If stars could be imaged exactly, then EVERY star would be less than 1 pixel wide, because they're so far away. But because the telescope is an imperfect machine, the stars get imaged into disks. The largest dots correspond to the BRIGHTEST stars, not the largest stars.

Could I ever see planets around those distant stars, using the telescope?
Planets around distant stars are so faint and so small that no telescope in the world can yet image them. But there are indirect ways of telling they're there. (See Exploration 4, "Distance to a Star" student project, "Extra-Solar Planets".)

Do the stars emit their own light, or are they reflecting light from some other source?

Stars emit their own light, the same as our Sun, the closest star.

In ancient times, people thought the stars were on a giant sphere, all at the same distance from Earth. Do you think that the stars are all at the same distance from Earth? Can you tell whether they are just by looking at your images?

The stars are at different distances from Earth, but you can't tell that just by looking at your images. Some stars look dimmer than others so they SEEM further away; but those stars may be inherently dimmer, like a lower wattage bulb. (See the investigation, "To the Stars!")

What would it look like if you live near the center of one of the globular clusters of stars?
There would be so many nearby stars that the sky might never get dark at night.

Do you see more stars in certain directions of the sky than others? Why do think?
Images taken in the direction of the center of the Milky Way (low declinations) should show many more stars than images taken towards, say, the North Pole. That's because the visible part of our galaxy is shaped like a giant pinwheel.

Nebulae

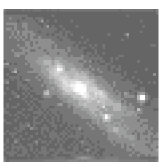
How do the nebulae in your images compare in size to the Moon's image?
The Orion nebula and others can be as large as, even larger than, the width of the Moon.

If the nebula appears as large as the Moon, then why don't we see it in the night sky?
It's too faint. Many beautiful objects in the sky — such as nebulae and galaxies—would be large enough to see with our naked eye, if only they weren't so dim! The telescope aids us by gathering light from dim objects:

How does your exposure time for the nebula compare to the exposure time for the Moon?
The nebula takes a longer exposure time, because it is so faint. And not only is the Moon's exposure so short, you also need a deep grey filter to cut down even more of the Moon's light!

Tough one: Does the nebula glow with its own light, or reflected light?
Some nebula emit their own light, while some we see only because they reflect light from nearby stars. See the activity, "Universe in Color".

Why do you think there are so few nebulae compared to stars?
Nebulae are scenes from either the birth or death of stars. These processes take relatively little time, compared to the lifetime a star. In fact, one of the ways astronomers can tell how long the stars live is by comparing the numbers of stars they see to the number of star births and star deaths they see.



Galaxies

Does your galaxy image also contain stars in the field of view?
Most galaxy images should also contain stars in the field of view.

Which do you think is further away, the galaxy or the stars? Can you tell from your image?
Many students think the stars are further away, because they appear smaller. But all the stars we see with the telescope are in our own Milky Way galaxy. They are MUCH closer than the galaxies in your image. But you can't tell this just from looking at an image. A century ago, even the world's greatest astronomers were debating whether the galaxies were inside our own Milky Way, or were outside.

If the galaxies are further away than stars in our own galaxy, then why do they appear so large?
Each galaxy is an enormous collection of billions stars, as is our own Milky Way galaxy. It took additional information, beyond the actual images, for astronomers to conclude that galaxies are huge collections of stars.

Why can't I see the individual stars in the galaxies that I've imaged?
At the scale of your image, each individual star in the galaxy would be smaller than a single atom! It is truly amazing that the combined light of the stars can form the beautiful galaxy images you have created.

Why do the galaxies have such different shapes?
The shapes depend on how the galaxies were formed, whether they have collided with other galaxies in the past, and also on what angle you are viewing them from.

Are the galaxies all the same distance? If not, how far out do they go?
See the investigation, "In Search of Infinity."

When I look at a galaxy, am I looking at a place where other creatures live?
No one knows!