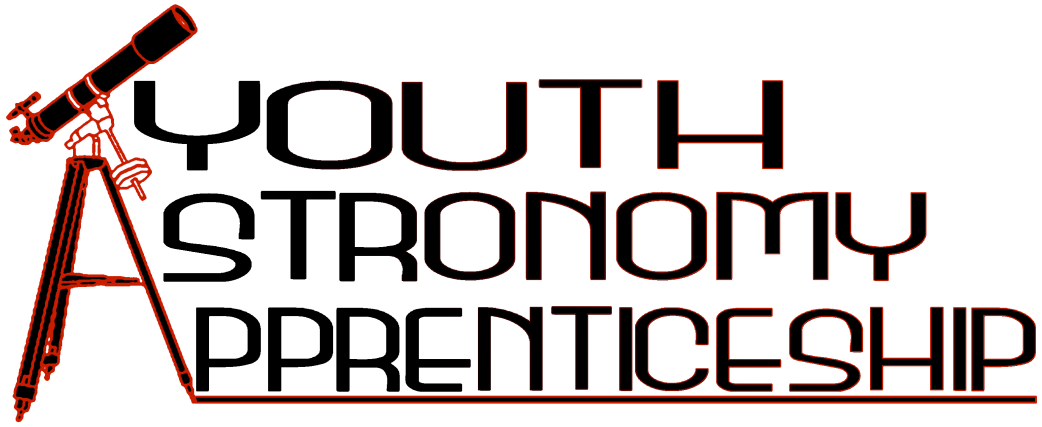

Activity Book

Introduction

Youth Astronomy Apprenticeship

The Youth Astronomy Apprenticeship (YAA) program is an out-of-school time initiative that uses an apprenticeship model to promote science learning among urban teenage youth and their communities. One of the primary goals of YAA is to broaden the awareness of science education as an effective way of promoting overall youth development and of practicing the skills needed to compete for today's science and technology professional opportunities.

Following the apprenticeship model, youth in YAA first participate in an after-school astronomy-training program. After the training is completed, the successful participants become astronomy apprentices who work with educators and other professionals to create astronomy outreach initiatives directed at their own communities. Through the youths' work and their presence among their communities as science ambassadors, YAA aims to promote involvement and support for science learning among the general public.

During the YAA after-school program, youth engage in a variety of astronomy explorations using a combination of hands-on and computer-based that are collected in the YAA Activity Book. As they engage in these activities, youth learn to use a network of educational telescopes called MicroObservatory, which are controlled via the Internet. Youth learn to use software tools to process astronomical images, produce reports and presentations about their project that they share among their peers and the an online community of MicroObservatory users. In the process, youth develop important skills, including logical reasoning, inquiry, completing self-directed tasks, collaborating with others, oral and written communication, and other employable skills used in the sciences and in many other professional fields.

What is MicroObservatory?

MicroObservatory is a network of automated telescopes that can be controlled over the Internet. The telescopes were developed at the Harvard-Smithsonian Center for Astrophysics and were designed to enable youth nationwide to investigate the wonders of the deep sky from their classrooms or after-school centers.

Users of MicroObservatory are responsible for taking their own images by pointing and focusing the telescopes and selecting exposure times, filters, and other parameters. They may select a target from a list or enter its coordinates. The educational value lies not just in the image returned by the telescope, but in the satisfaction and practical understanding that comes from mastering a powerful scientific tool. Observations can be set up in advance and run automatically.

How to Use This Activity Book

YAA was originally designed as a project-oriented program to be covered over 14 weeks, during 2-hour long after-school sessions held twice a week. However, the same program can be adapted to other situations – after-school programs with less time, summer camps, week-long school vacation programs, etc.

The YAA Activity Book is a collection of activities, grouped into three main categories (Hands-On, Computer and Observing Projects) and further into small clusters that focus on one main theme or are complimentary in some way. The first cluster is considered the base for all the other clusters – it contains the introductory activities needed for later activities, and all programs should include that cluster at the start. Other cluster can however be chosen by the facilitators after considering time available, youth interest and personal background knowledge of the facilitator. We encourage all programs to always include at least two observing projects in their implementation of YAA activities.

All of the supplemental materials referred to in the activities are found in the appendix, available online: http://epo.mit.edu/curriculum/Appendix.zip

Why Use Ice Breakers?

Icebreakers can be a great and effective way to start of the day's activities. They help for getting participants motivated and act as an attention getter to help encourage everyone to contribute to the group. Icebreakers can be particularly useful when working with a group of participants that are unfamiliar with one another. Also since icebreakers are typically not related to the subject matter of the day's activities, they are a great way to break up a cluster of more intense activities.

The following are some websites for icebreaker activities we have found useful for getting the group more comfortable with each other encourage communication amongst groups, help motivate participants and energize the group:

- Tennis Ball Activity:

http://www.leadersinstitute.com/teambuilding/team_building_tips/tennis_balls.html

- ❑ Cup Stack: http://eslcafe.com/idea/index.cgi?display:967310805-599.txt
- ❑ Human Knot: http://wilderdom.com/games/descriptions/HumanKnot.html
- ❑ Group Juggle: http://wilderdom.com/games/descriptions/GroupJuggle.html
- ❑ Categories: http://wilderdom.com/games/descriptions/Categories.html
- ❑ 2 Truths and a Lie: http://wilderdom.com/games/descriptions/TwoTruthsAndALie.html
- ❑ On all sides: http://www.niu.edu/orientation/firstyear_conn/Res_Icebreakers.shtml

We encourage you to use these before jumping into the Hands-On, Observation and Computer Activities, or if you notice that your group is struggling to maintain its energy.

Included Icebreakers

In this Activity Book, you will notice we have included some icebreakers in the flow of the activities. For instance, the following are activities that are strategically placed in the Activity Book with their own write-ups, and serve as a precursor for the following activity.

- ❑ Astropoetry
  - o Tour of the Universe
- ❑ What's Different?
  - o Observing Project #1
- ❑ Observation vs. Inference
  - o Observing Project #2
- ❑ Comets and Asteroids
  - o Can be used at any time. See activity write-up for ideas.

Activities, listed by category

Hands-On Activities

Modeling the Universe Activity
Cosmic Cast of Characters
From Starlight to Image
Cosmic Survey
Modeling the Earth-Moon System
Moon Phases Activity
Toilet Paper Solar System
Group Portrait of the Solar System: Taking Images
Group Portrait of the Solar System: Making Sense of Images
Telescopes and Light
Tour of the Universe
A Journey through the Universe: Presentation
Group Portrait of the Universe: Taking Images
Group Portrait of the Universe: Making Sense of Images
Light, Color and Astronomy
Filters Puzzler
Introduction to Models

Computer Activities

MicroObservatory Guest Portal
Introduction to MicroObservatory
Image Processing and Contrast
Images as Data
Investigation of Jupiter and Its Moons: Taking Images
Investigation of Jupiter and Its Moons: Making a Movie/Making Sense of Images
Advanced Image Processing
Group Portrait of the Universe in Color: Taking Images
Creating Color Images

Observing Activities

Did You Notice?
Observation or Inference?
Sharing & Publishing
Introduction & Planning
What does your data mean?
Giving Feedback
Creating Posters
Presenting Posters

Activities, listed by category

The Base Cluster

- Modeling the Universe
- Cosmic Cast of Characters
- MicroObservatory Guest Portal
- Introduction to MicroObservatory
- Image Processing and Contrast
- Observing Project #1

Size and Scale of Solar System

- Toilet Paper Solar System
- Modeling the Earth-Moon System
- Group Portrait of the Solar System: Taking and Making Sense of Images
- Investigation of Jupiter and its Moons Computer Activities

Size and Scale of the Universe

- Cosmic Survey
- Tour of the Universe
- Group Portrait of the Universe: Taking and Making Sense of Images
- Journey Through the Universe

The Universe in Color (digital imaging)

- Light Color and Astronomy
- From Starlight to Image
- 3-Color Image Processing
- Filters Puzzler

Modeling Systems

- Toilet Paper Solar System
- Modeling the Earth-Moon System
- Moon Phases Activity
- Investigation of Jupiter and its Moons
- Tour of the Universe

Light and Color (no computer activities)

- From Starlight to Image
- Telescopes and Light
- Light, Color and Astronomy
- Filters Puzzler

Image Processing (computer activities)

- From Starlight to Image
- Images as Data
- Advanced Image Processing
- 3-Color Image Processing

Observing Projects

- Project #1
    - Did You Notice?
    - Observation or Inference?
    - Sharing & Publishing
- Project #2
    - Introduction & Planning
    - What Does Your Data Mean?
    - Giving Feedback
- Project #3
    - Creating Posters
    - Presenting Posters

Credits

The YAA program and the YAA Activity Book were developed by the MIT Kavli Institute for Astrophysics and Space Research (MKI), in collaboration with the Smithsonian Astrophysical Observatory (SAO), the Timothy Smith Network (TSN), and the Institute of Learning Innovation (ILI) - the external evaluator.

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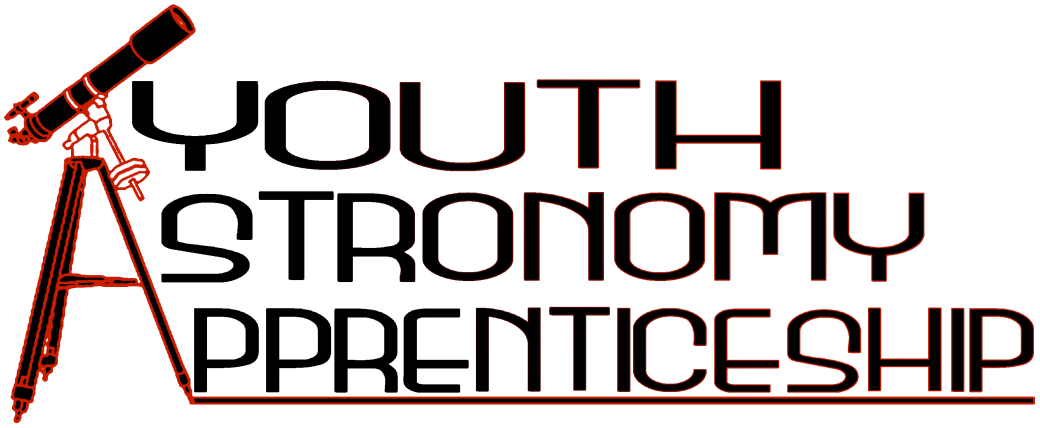

Glossary

absorb: To retain (radiation or sound, for example) wholly, without reflection or transmission.

aperture: A usually adjustable opening in an optical instrument, such as a camera or telescope, that limits the amount of light passing through a lens or onto a mirror.

asteroid: Asteroids, also called minor planets or planetoids, are a class of astronomical objects. The term asteroid is generally used to indicate a diverse group of small rocky celestial bodies in the solar system that orbit around the Sun. Most asteroids in our solar system orbit in a belt between Mars and Jupiter.

astro: A prefix used in English that refers or attaches the meaning of a star or stars, a celestial body or outer space to the name. "Astro" is derived from the Greek word "astron" meaning star.

automated telescope: An automated or robotic telescope provides a way for observers to collect data (images) without actually "observing." An automated telescope can be programmed to take a picture (or many pictures) of stars or other objects in the night sky. It can be useful for many types of projects. Examples might be photographing Jupiter every day, or capturing images of objects that are visible only at inconvenient hours, like the third quarter moon.

axis: A straight line about which a body rotates.

billion: The cardinal number equal to 10^9, or a one with nine zeroes after it. The number that is represented as a one followed by 9 zeros: 1,000,000,000.

black hole: A region in space where gravity is so strong that not even light can escape from it. Black holes in our galaxy are thought to be formed when stars more than approximately ten times as massive as our Sun end their lives in a supernova explosion. There is also evidence indicating that super-massive black holes (more massive than ten billion Suns) exist in the centers of some galaxies.

bookmark: A file within a browser in which an Internet user can save the addresses of interesting or frequently used websites, so that they are readily available for re-use.

browser: A program that allows a user to find, view, hear, and interact with material on the World Wide Web. Netscape Navigator and Microsoft Internet Explorer are examples of popular browsers.

Callisto: The second largest of Jupiter's satellites. Callisto is not geologically active and has a thin atmosphere. This combination means it has a very “old” surface, remaining almost entirely unchanged except for accumulating craters, much like our own Moon. Its diameter is about 2980 miles (4800 km) and takes about 16.7 days to orbit Jupiter.

Cat’s Eye Nebula: Three thousand light-years away, the Cat’s Eye Nebula is a dying star throwing off shells of glowing gas.

causation: The relationship that results when a change in one variable is not only correlated with but actually produces a change in another variable.

CCD: CCD stands for charge-coupled device. A CCD is a detector made on a silicon wafer. Due to the physical nature of silicon, photons of light that hit it generate electrons in the silicon. The job of the CCD is to collect these electrons in its "light buckets" (called **pixels**) during the length of the exposure to light. The more light falling on a particular "light bucket" or pixel, the more electrons that pixel will contain. The buckets then transfer their electrons (think of a "water bucket brigade") out to the CCD controller (which contains the electronics to control the CCD) and on to the computer. The computer then regenerates the image.

celestial object: A natural object, like a star, planet, comet, galaxy, etc. that is observable in the sky.

Centaurus A: This galaxy is situated in the M83 group of galaxies. It is one of the most interesting and peculiar galaxies in the sky. It is of intermediate type between elliptical and disk (spiral) galaxies: the main body has all characteristics of a large elliptical, but a pronounced dust belt is superimposed well over the center, forming a disk plane around this galaxy.

color-blind: Color blindness in humans is the inability to perceive differences between some or all colors that other people can distinguish. It is most often of genetic nature, but might also occur because of eye, nerve, or brain damage, or due to exposure to certain chemicals.

color filter: A sheet of dyed glass, gelatin or plastic, or dyed gelatin cemented between glass plates, used in photography to absorb certain colors and transmit others. The filters used for color separation by MicroObservatory are red, green and blue (RGB).

comet: Comets are loose collections of ice, dust, and small rocky particles in the Solar System that orbit the Sun and, when close enough to the Sun, exhibits a visible coma (or atmosphere) and/or a tail — both primarily from the effects of solar radiation upon the comet's nucleus. The nucleus itself measures a few kilometers or tens of kilometers across, and is composed mostly of rock, dust and ice. Comets are nicknamed 'dirty snowballs.

cones: The specialized photoreceptors in the human eye that allow us to discriminate between different wavelengths of light. Our eyes contain three distinct types of cones, designated the L, M, and S cones because they are primarily sensitive to long, medium, and short wavelengths of light. (The other type of photoreceptor in the eye is known as rods. They are primarily used in low-light and peripheral vision and do not contribute to color vision.)

contrast: Contrast is the difference between the darkest and lightest areas in an image. The greater the difference, the higher the contrast.

corona: The outer part of the Sun's atmosphere.

correlation: A measure of how two variables are related.

crater: A hole caused by an object hitting the surface of a planet or moon.

dark frame: A dark frame is an image taken with the CCD's shutter closed. This image records only the electronic noise due to the detector

itself. When a picture is taken of the night sky it records both the object in the sky as well as the noise. The dark frame is subtracted from this image to leave only a clear image of the object.

data: A collection of facts or information from which conclusions may be drawn. In computer science, data is used to describe information that is stored and/or processed digitally.

detector: A device used to show that something is present.

diffraction grating: An optical component that acts like a prism when it is illuminated with white light. A diffraction grating disperses a beam of light (or other electromagnetic radiation) into its wavelengths to produce its spectrum.

diameter: The length of a straight line through the center of a circle or sphere.

digital: Of, pertaining to, or using data in the form of numerical digits. Available in electronic form; readable and able to be manipulated by a computer.

inference: A conclusion based on observations.

dwarf planet: A celestial body that is in orbit around the Sun, having sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a nearly round shape, and is not a satellite.

The Early Universe: Galaxies like colorful pieces of candy fill the Hubble Deep Field image - humanity's most distant yet optical view of the Universe. The dimmest, some as faint as 30th magnitude (about four billion times fainter than stars visible to the unaided eye), are the most distant galaxies and represent what the Universe looked like in the extreme past, perhaps less than one billion years after the Big Bang.

To make the Deep Field image, astronomers selected an uncluttered area of the sky in the constellation Ursa Major (the Big Bear) and pointed the Hubble Space Telescope at a single spot for 10 days accumulating and combining many separate exposures. With each additional exposure, fainter objects were revealed. The final result can be used to explore the mysteries of galaxy evolution and the infant Universe.

Earth: The third planet from the sun, and our home planet.

eclipse: The blocking of all or part of the light from one object by another. For example, a "lunar eclipse" occurs when the Earth's shadow falls on the Moon, preventing Sunlight from illuminating all of its surface. Lunar eclipses can occur only when the Moon is on the opposite side of the Earth from the Sun (at Full Moon), while solar eclipses can happen only at New Moon. A "solar eclipse" occurs when the Moon passes directly between us and the Sun, blocking part or all of the Sun’s light from reaching us.

electromagnetic spectrum: The full range of frequencies, from radio waves to gamma rays, that characterizes the different “colors” of light. There is a relationship between the amount of energy electromagnetic radiation (light) carries and the frequency. Radio waves are low frequency and low energy radiation while gamma rays at the other

end of the spectrum are high frequency and high-energy radiation. Visible light, that our eyes can see, is also part of the electromagnetic spectrum.

e-mail (electronic mail): Messages sent through an electronic (computer) network to specific groups or individuals. Though e-mail is generally text, users can attach files that include graphics, sound, and video. E-mailing requires a modem to connect the telephone line to the computer, and an e-mail address. E-mail addresses include the @ symbol.

emit: To give or send out (matter or energy).

Europa: The fourth largest of Jupiter's satellites. Europa is a large, dense, icy moon of Jupiter. Its surface is covered with long, crisscrossing track ways (but few craters) and frozen sulfuric acid. Its diameter is less than 2,000 miles (3,138 km), smaller than the Earth's moon. It takes Europa 3.55 days to orbit Jupiter. Its mean distance from Jupiter is about 420,000 miles (670,900 km). It was discovered by Galileo and Simon Marius (independently) in 1610.

exposure time: The period of time a telescope's light-sensing camera collects light coming from the source one wants to take an image of. The longer the exposure time, the more light that the telescope can gather to make an image. The recommended exposure time varies for various targets: faint targets, such as far away galaxies, require long exposure times; bright targets, such as the Moon, require short exposure times.

false color: Assigning colors to an image in order to bring out specific qualities or details of the image. False color can be applied to images taken in visible or invisible light.

favorite: In Internet Explorer, a favorite is a collection of Web addresses selected by the user. Favorites are stored in a folder and are accessed by selecting the Favorites menu. Favorites provide an easy way to organize the Web addresses of interesting sites.

field of view: The area of the sky visible through the telescope.

filter: A filter is a device that removes something from whatever passes through it. In optics a filter is a device, which selectively transmits light having certain properties (often, a particular range of colors), while blocking the remainder. They are commonly used in photography, in many optical instruments, and to color stage lighting.

FITS-format: FITS stands for Flexible Image Transport System, and is an image file format widely used by the Astronomical community. It's great advantage over more familiar image file formats, is that it can, and often does, contain information about the imaging device used to capture the image, and more importantly, the time, date, and location of the telescope used. Additionally, each pixel of a FITS file will often be linked to the Right Ascension and Declination of the portion of the sky imaged. Moving a cursor across such a calibrated image enables an astronomer to determine the positions and names of the stars in the filed of view.

focal plane: The imaginary plane perpendicular to the path of light passing through a lens or mirror where an image can be projected at its sharpest focus. For astronomical objects, it is one focal length away from the optical element.

focal point: Two parallel beams of light passing through a lens or reflecting from a curved mirror come together at a "focal point." The distance between the focal point and the lens or mirror is its focal length.

galaxy: Any of many very large groups of stars, gas, and dust that constitute the Universe, containing an average of 100 billion (10^{11}) stars and ranging in diameter from 1,500 to 300,000 light-years.

Ganymede: The largest of Jupiter's satellites, with a diameter slightly larger than Mercury's. It is the only moon known to have a liquid core generating its own tiny "magnetosphere." A compass would probably work on Ganymede. It is 3,270 miles in diameter (5262 km) and takes 7.15 days to orbit Jupiter.

gas giant: Jupiter, Saturn, Uranus, and Neptune are known as gas giants. This is because they are basically gigantic gas balls compared to Earth and the other three rocky inner planets. The four giant planets are comprised mostly of an outer layer of molecular hydrogen and helium. However, each may have a small solid core as large as several Earth masses at their center. Sometimes they are called the "Jovian planets" because Saturn, Uranus, and Neptune are considered to be very similar to Jupiter ("Jove" is variation of Jupiter in Latin).

globular cluster: A system of stars, generally smaller in size than a galaxy, that is more or less globular (like a globe) in shape.

Great Nebula in Orion: The Nebula's glowing gas surrounds hot young stars at the edge of an immense interstellar molecular cloud only 1500 light-years away. The Great Nebula in Orion can be found with the unaided eye just below and to the left of the easily identifiable belt of three stars in the popular constellation Orion.

gravity: The force of attraction between all masses in the universe; for example the attraction of bodies near or on the earth's surface to the Earth.

Hubble Space Telescope: The Hubble Space Telescope (HST) is a space-based telescope that was launched in 1990 by the space shuttle. From its position 350 miles above the Earth's surface, the HST has expanded our understanding of star birth, star death, and galaxy evolution, and has helped move the existence of black holes from theory to fact. It has recorded over 100,000 images in the past eight years.

Hubble Deep Field Galaxies: A remarkable image taken by the Hubble Space Telescope that covers a speck of the sky only about the width of a dime 75 feet away. Gazing into this small field, Hubble uncovered a bewildering assortment of at least 1,500 galaxies at various stages of evolution.

inference: A deduction or conclusion made from facts that are suggested or implied rather than overly stated. To draw meaning from a combination of clues in a given context without explicit reference to that context.

in-focus: The state of maximum distinctness or clarity of such an image.

internet: A "network of networks" linking millions of computers worldwide for communications purposes. The Internet was originally developed in 1969 for the U.S. military and gradually grew to include

educational and research institutions. Today commercial industries, corporations, and residential users all communicate using the Internet. The World Wide Web is a collection of interactive documents accessible via the Internet.

Io: The third largest of Jupiter's satellites and the closest to the planet. Io is the only body in the Solar System, other than Earth, to currently have active volcanoes. Photographs taken by visiting unmanned spacecraft have revealed smoke plumes hundreds of miles high. Unlike Callisto, these volcanoes are constantly changing the surface of the planet.

Jupiter: Jupiter is the fifth planet from the Sun and by far the largest. Jupiter is more than twice as massive as all the other planets combined (the mass of Jupiter is 318 times that of Earth). Jupiter is composed of mostly hydrogen and helium gas.

Kepler's relation: Also known as Kepler's third law. Kepler's third law of planetary motion says that the average distance of a planet from the Sun cubed is directly proportional to the orbital period squared. Newton found that his gravity force law could explain Kepler's laws. Since Newton's law of gravity applies to any object with mass, Kepler's laws can be used for any object orbiting another object.

light-year: The distance that light travels in one year.

link: A word, phrase, or image highlighted in a hypertext document to act as a navigation aid to related information. Links may be indicated with an underline, a color contrast, or a border.

M51 Galaxy: Also known as the Whirlpool Galaxy, M51 is a classic spiral galaxy. At only 30 million light years distant and fully 60 thousand light years across, M51 is one of the brightest and most picturesque galaxies on the sky.

M15 Globular Cluster: M15 is perhaps the densest of all (globular) star clusters in our Milky Way galaxy. The Hubble Space Telescope has photographically resolved its super dense core, as shown in this HST image.

Mars: The fourth planet from the Sun in the solar system, named after the Roman god of war (the counterpart of the Greek Ares), on account of its blood red color as viewed in the night sky.

Mercury: The innermost and smallest planet in the solar system (since Pluto was re-labeled as a dwarf planet), orbiting the Sun once every 88 days.

meteor: The visible event that occurs when a meteoroid or asteroid enters Earth's atmosphere and becomes brightly visible.

Milky Way: The galaxy which is the home of our Solar System together with at least 200 billion other stars and their planets.

million: The number equal to 10^6, or a one with six zeroes after it.

model: A simplified imitation of something that helps us explain and understand that something better. Models can take different forms, including physical devices or sculpture, drawings or plans, conceptual analogies, mathematical equations and computer simulations.

moon: A natural satellite revolving around a planet. The Moon is the natural satellite of the Earth.

neutron star: A compressed core of an exploded star made up almost entirely of neutrons. Neutron stars have a strong gravitational field and some emit pulses of energy along their axis. These pulsing neutron stars are known as pulsars.

nebula: A cloud of gas and/or dust in interstellar space (The word *nebula* in Latin means "cloud"; its plural is "nebulae"). A nebula can be visible as luminous patches or areas of darkness depending on the way the dust and gas absorbs or reflects light given off either inside or outside the cloud.

Neptune: The eighth planet from the sun.

nova: A cataclysmic nuclear explosion caused by the accretion of hydrogen onto the surface of a white dwarf star.

observation: The process of using one's senses to perceive and record information about some aspect of the natural world. Also the act of making and recording a measurement.

observable universe: The region of space that it is theoretically possible for us to observe, small enough that light from the furthest regions has had sufficient time to reach us since the Big Bang. Both popular and professional research articles in cosmology often use the term "universe" to mean "observable universe". This can be justified on the grounds that we can never know anything by direct experimentation about any part of the universe that is causally disconnected from us, although many credible theories, such as cosmic inflation, require a universe much larger than the observable universe. No evidence exists to suggest that the boundary of the observable universe corresponds precisely to the physical boundary of the universe (if such a boundary exists); this is exceedingly unlikely in that it would imply that Earth is exactly at the center of the universe, in violation of the cosmological principle. It is likely that the galaxies within our visible universe represent only a minuscule fraction of the galaxies in the universe.

Oort Cloud A huge spherical "cloud" that extends from beyond the orbit of Neptune and Pluto, half way out to the nearest star. It contains a trillion or more comets orbiting the Sun. This is a source of long-period comets.

opaque filter: This is not a real filter. When using MicroObservatory you select “Opaque” in the filters selections when you want to take an image with the camera’s shutter closed.

optics: The branch of physics that deals with light and vision, chiefly the generation, propagation, and detection of electromagnetic radiation having wavelengths greater than x-rays and shorter than microwaves.

outer planets: Any of the five planets, Jupiter, Saturn, Uranus, Neptune, and Pluto, with orbits outside that of Mars.

orbit: The path followed by an object in space as it goes around another object; to travel around another object in a single path.

overexpose: To allow too much light to come into contact with film or a CCD (detector). Overexposing a film or CCD produces an image that is too light.

Period: The amount of time it takes for a planet to complete one revolution, or one orbit about the sun.

phases of the Moon: The changing appearance of the Moon as it orbits around the Earth. At "New Moon," the Moon is on the same side of the Earth as the Sun is, and we see only the part of the Moon that is in shadow (another term for New Moon is the "dark of the Moon"). A quarter of an orbit later (about a week after New Moon), we see the Moon illuminated by Sunlight from the side. Thus one-half of the disk of the Moon which faces us is in Sunlight — the right side as seen from Earth's northern hemisphere: this phase is called "First Quarter." About two weeks after New Moon, our satellite has traveled around to the other side of its orbit, and the side facing us also faces the Sun and is fully illuminated as we see it; that phase is called "Full Moon." Three-quarters of a lunar orbit after New Moon, at "Last Quarter," the Moon is again illuminated from the side (the left side as seen from the northern hemisphere). About a week after that, the Moon is New again, and the cycle starts over. Between First Quarter and Last Quarter, when more than half of the side of the Moon facing us in Sunlight, the Moon is said to be "Gibbous." From Last Quarter to First Quarter, when more than half of the side of the Moon facing us is in shadow, the Moon is said to be a "Crescent."

photon: Colloquially, a photon is a "particle of light." Light can be created or absorbed only in discrete amounts of energy, known as photons. The energy of a photon is greater the shorter the wavelength--smallest for radio waves, increasingly larger for microwaves, infrared radiation, visible light and ultra-violet light. It is largest for x-rays and gamma rays.

pixel: The smallest individual component of an image or picture—the greater the number of pixels per inch the greater the resolution.

planet: A spherical ball of rock and/or gas that orbits a star. The Earth is a planet.

Pleiades: A group of stars (technically called an open star cluster) in the constellation Taurus, consisting of several hundred stars, of which six are visible to the naked eye. The Pleiades are named for the seven daughters of the mythological god Atlas (Maia, Electra, Celaeno, Taygeta, Merope, Alcyone, and Sterope), who were thought to have metamorphosed into stars.

Pluto: The second-largest known dwarf planet in the Solar System (after Eris) and the tenth-largest body observed directly orbiting the Sun. Originally classified as a planet, Pluto is now considered the largest member of a distinct region called the Kuiper belt.

pulsar: Exceptionally small and very dense star (about double the sun's mass but only a few miles in radius) that is spinning at very high speed. This spinning star emits energy that is seen as pulses as the star rotates.

reflection: The reflection of light follows certain definite laws. A ray of light striking a reflecting surface at right angles to it is returned directly along the path it has followed in reaching the surface. When, however, a ray strikes a reflecting surface at any other angle, it is reflected at an angle in an opposite direction.

resolution: An optical system's resolution is a measure of the smallest detail it is able to resolve. An instrument through which one can see the stitches on a baseball from some distance away would be said to have greater resolution than another through which one can only see the shape of the baseball. Seeming counterintuitive, this attribute is independent of magnification! Two different telescopes may be pointed at the same object at the same magnification, however the one with greater resolution will present a "sharper" image than the "blurrier" picture offered by the other.

retina: The sensory membrane that lines the eye; it is composed of several layers and functions as the immediate instrument of vision by receiving images formed by the lens and converting them into signals which reach the brain by way of the optic nerve.

rotate: To turn around a center point, or axis, like a wheel turns on a bicycle.

satellite: An object that revolves around a larger primary body. Satellites may be naturally occurring, such as the Moon, or they may be man-made, such as a telescope.

Saturn: The sixth planet from the sun and the second largest in the solar system. Saturn is a gas giant made primarily from hydrogen and helium, and has a beautiful system of rings.

scale: The ratio between the size of something and a representation of it; "the scale of the map"; "the scale of the model"

silicon chip : A wafer-thin slice of silicon that contains thousands of microscopic electronic circuits.

solar eclipse: A "solar eclipse" occurs when the Moon passes directly between us and the Sun, blocking part or all of its light from reaching us.

Solar System: The system of the Sun and the planets, their satellites, the minor planets, comets, meteoroids, and other objects revolving around the Sun.

spectrum: The distribution of energy emitted by a radiant source, as by an incandescent body, arranged in order of wavelengths.

star: A ball of material, mostly hydrogen, in dynamic equilibrium between gravity tending to collapse it and fusion reactions in the core tending to expand it. Our sun is a star.

star cluster: A group of stars which are held together by their mutual gravitational attraction. In the Milky Way, there are two different kinds of star of star clusters: ones called "open" (or "galactic") star clusters which are generally sparsely populated and exist only in the disk of the Galaxy, and the larger, older "globular" clusters.

starburst: A generic term to describe a region of space with an abnormally high rate of star formation.

The Sun: The star at the center of our solar system.

supernova: A special event at the end of the life of a massive star in which the star explodes and shines millions of times brighter than it had during its lifetime. Only stars about 10 times the mass of our sun will die

in this way. At peak light output, these supernova explosions can outshine a galaxy.

Supernova 1987A: In 1987 a supernova (designated SN1987A by astronomers) was observed in a nearby galaxy called the Large Magellanic Cloud. This was the first "nearby" supernova in the last 3 centuries, and for the first time astronomers were able to directly observe the incredible light show.

Subaru: Japanese name for Pleiades, stars in the constellation Taurus.

system: a group of independent but interrelated elements comprising a unified whole.

target: In astronomy the celestial object one takes a picture of is called target.

Taurus (The Bull): This is one of the 13 constellations of the Zodiac.

telescope: A device which allows us to see far away objects even when we cannot see them with the naked eye.

terrestrial planet: The four innermost planets in the Solar System (Mercury, Venus, Earth, and Mars) are sometimes called the "terrestrial" planets because of their proximity to Earth ("Terra" in Latin) and their similarity as solid bodies with compact, rocky surfaces.

trillion: The number that is represented as a one followed by 12 zeros: 1,000,000,000,000.

underexposed: To allow too little light to come into contact with film or a CCD (detector). Underexposing film produces an image that is too dark.

universe: All matter and energy, including the earth, the galaxies, and the contents of intergalactic space, regarded as a whole.

upload: Copying or sending files or data from one computer to another. A Web developer, for example, could upload a document to a Web server.

Uranus: The seventh planet from the Sun.

Venus: The second-closest planet to the Sun, orbiting it every 224.7 Earth days.

waning: The act or process of gradually declining or diminishing.

waxing: To increase gradually in size, number, strength, or intensity.

web interface: A window screen that can be access through the Internet. Through this window you can interact or communicate with another device usually located away from you. In our case an observer can communicate with the MicroObservatory telescopes through a web form – the web interface - found on the MicroObservatory web site.

world wide web: A vast collection of files, including text, graphics, and other data linked through the Internet.