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No. 14 & 15 - Spring 1990

Introductory Astronomy Glossary

Editor's Note: In response to requests from a number of readers, we have put together two resource lists that educators at all levels can use in their teaching, lecturing, and study assignments: an Introductory Astronomy Glossary and a Basic Astronomy Library. Like everything else that appears in this newsletter, we are happy to grant you unliminted permission to reproduce these resources for any noncommercial purpose. We welcome requests from our readers for other resource materials you would like to see us assemble.

— Andrew Fraknoi, editor

Asteroid: Any of the thousands of small rocky objects that orbit around the Sun, most of them between the orbits of Mars and Jupiter (although some pass closer to the Sun that Earth does and others have orbits that take them well beyond Jupiter). The largest asteroid is one called Ceres; it's about as wide as the state of Texas.

Astronomical Unit: A unit of distance equal to the average spacing between the Earth and the Sun. Usually abbreviated *A.U.*, it is equal to about 150 million kilometers (93 million miles), and is a distance that light takes about 8 minutes to cover. It is a handy size for use for expressing distances in the solar system. For example, the diameter of the orbit of the most distant planet, Pluto, is about 80 A.U.

Big Bang: The primeval explosion which most astronomers think gave rise to the universe as we see it today, in which clusters of galaxies are moving apart from one another. By "running the film backward'' — projecting the galaxies' motions backward of time — astronomers calculate that the Big Bang happened about 10 to 15 billion years ago.

Binary Star: A system of two stars, orbiting around one another. Binary (and triple and even higher multiples) stars are very common; astronomers estimate that about half of all stars are members of multiple-star systems. The nearest star to our solar system, Alpha Centauri, is actually our nearest example of a multiple star system — it consists of three stars — two very similar to our Sun and one dim, small, red star — orbiting around one another.

Black Hole: An object whose gravitational pull is so strong that — within a certain distance of it — nothing can escape, not even light. Black holes are thought to result from the collapse of certain very massive stars at the ends of their lives, but other kinds have been postulated as well: "mini black holes,'' for example, which might have been formed in turbulance shortly after the Big Bang. "Supermassive black holes'' — with masses millions of times the Sun's — may exist in the cores of large galaxies.

Comet: A small chunk of ice, dust, and rocky material (only a few miles across) which, when it comes close enough to the Sun, can develop a tenuous "tail.'' Tails of comets are made of gas and dust that have been driven off the comet's surface by the Sun's energy and they always point away from the Sun (no matter what direction the comet is moving). Comets spend most of their time very far from the Sun, and are active only for a short period (a few months at most) as they move quickly around the Sun on their elongated orbits.

Constellation: A pattern of stars on the sky, named for a person, animal, or object (usually from mythology). Astronomers use constellations to designate directions in space; for example the great galaxy "in Andromeda" lies in the direction from us marked by the pattern of stars we call Andromeda (the Princess of Ethiopia in Greek mythology). Just as patterns we see in the clouds are not permanent, neither are the star-patterns of constellations, since the stars move (albeit very slowly on the timescale of a human lifetime). The constellations of 100,000 years ago were quite different from today's. Astronomers now divide the sky into 88 sectors, each of which is named after the traditional constellation in that sector.

Cosmology: The branch of astronomy that deals with the origin, large-scale properties, and the evolution of the observable universe.

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

Equinox: Either of the two instants during the year when the Sun is directly over the Earth's equator. In the spring in the Northern Hemisphere, the vernal equinox occurs around March 21st, and in the fall the autumnal equinox happens around September 21st (although the specific dates vary slightly from year to year.) At the time of the equinoxes, the length of day and night are very nearly equal all over the world. In the United States, spring and fall officially begin at the instants of the vernal and autumnal equinoxes, respectively.

Galaxy: A large assemblage of stars (and sometimes interstellar gas and dust), typically containing millions to hundreds of billions of member stars. A galaxy is held together by the gravitational attraction of all its member stars (and other material) on one another. Most galaxies are either of a flattened, spiral form or a fatter ellipsoidal shape without a spiral pattern. The "Milky Way'' galaxy, of which our Sun is a part, is a spiral galaxy with a disk about 100,000 light-years across containing roughly 400 billion stars. Our Sun is in the disk, about 2/3 of the way out from the center, and orbits around the center for the Milky way taking about 200 million years to go around once.

Globular Cluster: A large congregation of stars (containing hundreds of thousands to about a million stars) which is spherical in form. About 150 globular clusters are members of our Milky Way galaxy, distributed in a round halo around the Galaxy's disk. Globular clusters, which can also be detected in other galaxies, are made up of very old stars (twice the age of the Sun or more).

Light-Year: The distance light travels in one year in a vacuum. Light travels at a speed of about 300,000 kilometers per second (186,000 miles per second) in a vacuum. A light-year is about 9 1/2 trillion kilometers (6 trillion miles) long.

Local Group: The relatively small cluster of galaxies of which our Milky Way is a part. It is known to contain about two dozen member galaxies, but most of those are 'dwarf'' galaxies, considerably smaller than our own. There are only two large galaxies in the local group: the Milky Way and the Andromeda Galaxy (about two million light-years away from us in the direction of the sky marked by the constellation Andromeda.) The Local Group is about 3 million light-years across, and is itself part of a "supercluster'' of clusters of galaxies which is centered on a huge aggregate called the Virgo Cluster.

Magnitude: A way of expressing the brightness of astronomical objects inherited from the Greeks. In the magnitude system, a lower number indicates a brighter object (for example, a 1st magnitude star is brighter than a 3rd magnitude star). Each step in magnitude corresponds to a brightnesss difference of a factor of about 2.5. Stars of the 6th magnitude are the faintest the unaided human eye can see.

Magellanic Clouds: The two closest galaxies to us which are satellites of our own Milky Way. They are each irregular in form and relatively small (only about 1/5th as broad as the Milky Way's disk). They are roughly 100,000 light-years away from our galaxy in a direction such that they can be seen easily only from Earth's southern hemisphere. The first Europeans to record their existence were Ferdinand Magellan's crew in the early 1500s; to them, the two galaxies looked like small clouds separated from the Milky Way.

Meteor: A bit of solid debris from space, burning up in Earth's atmosphere due to friction with the air. (The luminous streaks they trace across the sky are commonly called "shooting stars,'' although they have nothing to do with stars!) Before entering Earth's atmosphere (with a typical speed of about 25,000 mph) the body is

called a *meteoroid*. If any of the object survives its fiery passage down through the air, then those parts which hit the ground are called *meteorites*.

Milky Way: A faint band of hazy light that can be seen from clear, dark locations and which stretches all the way around the sky. When looked at using binoculars or a small telescope, it is seen to be composed of vast numbers of individual, faint stars. It is actually the disk of our own galaxy — seen from our perspective (within the disk), the flat lens- shape of the Galaxy appears to surround us. Astronomers often use the term "Milky Way'' to refer to our entire galaxy, rather than to just its appearance in our sky. [See galaxy]

Nebula: A cloud of gas and/or dust in interstellar space. (The word *nebula* in Latin means "cloud"; its plural is "nebulae.'') Nebulae can make themselves apparent by glowing (as "emission nebulae''), by scattering light from stars within them (as "reflection nebulae''), or by blocking light from things behind them (as "obscuration nebulae'').

Neutron Star: A crushed remnant left over when a very massive star explodes. Made almost entirely of neutrons (subatomic particles with no electric charge), these stellar corpses pack about twice as much mass as there is in the Sun into a sphere only about 10 kilometers across. A teaspoonful of their material would weigh more than all the automobiles in the United States put together. Some neutron stars are known to spin very rapidly, at least at the beginning, and can be detected as "pulsars'': rapidly flashing sources of radio radiation or visible light. The pulses are produced by the spinning of the neutron star, much like a spinning lighthouse beacon appears to flash on and off.

Nova: A star that abruptly and temporarily increases its brightness by a factor of hundreds of thousands. Unlike supernovae (much more violent explosions which destroy the stars that produce them), stars that "go nova'' can do so more than once. Novae are thought to occur in binary stars in which one member is a compressed dwarf star (such as a white dwarf or a neutron star) orbiting close to a much larger star. According to this theory, material from the larger star's outer layers accumulates on the dwarf's surface, becoming ever hotter and more compressed by the dwarf's strong gravity, until the ~stolen'' material explodes. [See supernova, binary star, white dwarf, and neutron star]

Parsec: A unit of distance equal to about 3.26 light-years (or, more precisely, equal to 206,265 Astronomical Units). Technically, a *parsec* is defined to be the distance from which the Earth and Sun would appear to be separated from one another by 1 second of arc (about the size a dime would appear to be if seen from a distance of 2 miles).

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 which 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.''

Planet: A major object which orbits around a star. In our solar system, there arenine such objects which aretraditionally called "planets'': Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. (There are no "official'' specifications for how big an object must be to be called a planet rather than, for example, an "asteroid.'') While no individual planet has ever been seen orbiting around another star, we wouldn't expect to see them, given the limits of current technology. It is suspected, though, that planets are common companions of stars.

Planetarium: A domed theater in which a special device in the center of the room projects a simulation of the nighttime sky onto a dome above the audience. Planetariums generally can show how the nighttime sky looks from anywhere on the Earth's surface at any time (for thousands of years into the past and future).

Quasar: One of a class of very distant (typically billions of light-years away), extremely bright, and very small objects. The term "quasar'' means "quasi-star'' — that is, something that looks like a star but can't

actually be a star. A typical quasar produces more light each second than an entire galaxy of stars does, and it does so from a region of space which is perhaps as small as our solar system. Precisely how they produce their prodigious amounts of energy is not known, but astronomers suspect that their brilliance may be connected with the violent effects of very massive black holes at the centers of distant, dim galaxies on material right around them. [See black hole]

Radio Astronomy: The study of radio waves from objects in the universe. Radio and visible-light waves are the only kind of light-like radiation which can reach the ground easily from space. Partly because of this, radio astronomy became the first non-visible branch of astronomy, with large radio telescopes (instruments which can gather and focus radio waves from space) being first developed in the 1950s.

Red Giant: A very large, distended, and relatively cool star which is in the final stages of its life. A typical red giant, if placed where the Sun is in our solar system, might extend past the orbit of Mars. The relatively cool temperature of its outer layers (perhaps only 2,000 degrees Celsius as compared to the Sun's 6,000 degrees) would make it look orange or red instead of yellowish-white. (The Sun is predicted to become a Red Giant about 5 billion years from now.)

Red Shift: The lengthening (or "stretching") of light waves coming from a source moving away from us. If a source of light is moving toward us, the opposite effect — called a "Blue Shift'' — takes place. Light from all galaxies outside the Local Group is "red-shifted,'' indicating that they are moving away from us (and from each other). This phenomenon is called the "expansion of the universe.''

Second of Arc: A very small angle which is equal to 1/60th of a minute arc (which, in turn, is 1/60th of a degree). A line on the sky from horizon to horizon extends 180 degrees. A U.S. 10-cent piece seen from a distance of 2 miles has an apparent diameter of about 1 second of arc.

Satellite: An object orbiting around another, larger one. For example, smaller bodies orbiting around planets are called those planets' "satellites'' (or, occasionally, "moons'' — but some astronomers frown on this use of the word "moon,'' which they feel should be reserved for Earth's natural satellite exclusively.) Probes we launch into orbit around the Earth are called "artificial satellites.''

Solar System: The Sun and all things orbiting around it, including the nine major planets, their satellites, and all the asteroids and comets.

Solstice: Either of the two instants during the year when the Sun, as seen from Earth, is farthest north or south of the equator. The summer solstice (when the Sun is over the Tropic of Cancer) occurs around June 21st; the winter solstice (when the Sun is over the Tropic of Capricorn) happens around December 21st. In the Northern Hemisphere, summer and winter officially begin at the instants of the summer and winter solstices, respectively.

Spectrum: The band of colors, from violet through red, obtained by passing white light through a prism (or another device that spreads light out into its component colors). Astronomical "spectroscopy,'' the study of the spectra of astronomical objects, is a very powerful tool in determining many characteristics of stars, nebulae, etc., since details of their spectra can reveal the materials they're made of and many of the physical conditions (temperature, pressure, and so on) within them.

Star: A large hot ball of gas which generates energy in its core by nuclear reactions. (The Sun is our local example of 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. [See globular clusters]

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

Supernova: An explosion which marks the end of a very massive star's life. When it occurs, the exploding star can outshine all of the other stars in the galaxy in total for several days and may leave behind only a crushed core (perhaps a neutron star or black hole). Astronomers estimate that a supernova explosion takes place about once a century in a galaxy like our Milky Way. While most supernovae in our Galaxy are probably

hidden from our view by interstellar gas and dust, astronomers can detect supernova explosions in other galaxies relatively frequently. [See neutron star, black hole]

Telescope: An instrument designed to gather light (or other kinds of radiation) from a large area and bring it to a focus, where the radiation can be analyzed. The primary purpose of most astronomical telescopes is to provide the brightest possible images, since most things that astronomers study are very faint. Thus, the "size'' associated with a telescope (such as the "200-inch'' on Palomar Mountain) refers to the diameter of its light-gathering area.

Universe: In astronomy, the sum total of all things which can be directly observed or whose physical effects on other things can be detected.

Variable Star: A star that changes its brightness. There are several classes of variable stars, including "periodic'' variables (which change their brightnesses on a regular schedule, ranging from hours to many years) and "irregular'' variables (which abide by no fixed schedule). Careful, long-term monitoring of variable stars is one major way in which amateur astronomers have made important contributions to research astronomy.

White Dwarf: The collapsed remnant of a relatively low-mass star (roughly 1 1/2 times the Sun's mass and less), which has exhausted the fuel for its nuclear reactions and shines only by radiating away its stored-up heat. A typical white dwarf might have as much mass as the Sun, but have a size equivalent to the Earth's. Its density is roughly equivalent to that of a soda can into which a 747 airliner has been squeezed. (The Sun is expected to become a white dwarf at the end of its life.)

A Basic Astronomy Library

A Basic Astronomy Library

Books on Astronomy in General

Bartusiak, M. *Thursday's universe.* 1986, Times Books. Frontier areas of astronomy, as explained by a skilled science journalist.

Chaisson, E. *Cosmic Dawn.* 1981, Berkley paperback. An eloquent primer on the evolution of the universe and our place in it. (A sequel, called The Life Era, was published by Atlantic Monthly Books in 1987.)

Ferris, T. *Galaxies.* 1980, Stewart, Tabori & Chang. Lavishly illustrated introduction to the large-scale cosmos by a noted science writer.

Goldsmith, D. *The Astronomers.* 1990, St. Martin's Press. Focuses on the work of two dozen key astronomers. (Ready in late 1990.)

Hartmann, W. & Miller, R. *Cycles of Fire.* 1987, Workman. Over-sized paperback with gorgeous color illustrations, introducing the realms of the stars and galaxies.

Jastrow, R. *Red Giants and White Dwarfs,* 2nd ed. 1979, Warner paperbou nd. Good, basic book on the evolution of the universe and humankind.

Preiss, B. & Fraknoi, A., eds. *The universe.* 1987, Bantam. Collection of introductory articles by noted astronomers and science fiction stories inspired by good science.

Preston, R. *First Light.* 1987, Atlantic Monthly Books. Eloquent introduction to modern astronomy through the life and work of a few of its finest practioners.

Sagan, C. *Cosmos.* 1980, Ballantine paperback. A superbly-written, highly personal tour of the universe; based on the PBS TV series.

Trefil, J. *Space Time and Infinity.* 1985, Smithsonian Press. A beautiful coffee table book introducing modern astronomy.

Books about our solar system as a Whole

Chapman, C. & Morrison, D. *Cosmic Catastrophes.* 1989, Plenum. Fascinating introduction to impacts, collisions, and solar system violence.

Eliott, J. & Kerr, R. *Rings.* 1984/7, MIT Press. Introduction to the rings around Jupiter, Saturn, and Uranus.

Frazier, K. *solar system.* 1985, Time-Life. Profusely illustrated guide to the planets by a fine science writer.

Miller, R. & Hartmann, W. *The Grand Tour.* 1981, Workman paperbound. A guide to the solar system, illustrated with photos and paintings.

Morrison, D. & Owen, T. *The Planetary System.* 1988, Addison-Wesley. A fine up-to-date textbook that can be read for pleasure.

Preiss, B., ed. *The Planets.* 1985, Bantam. A collection of authoritative articles about each planet and some science fiction based on them.

Books About Specific Planets

Burgess, E. *Venus: An Errant Twin.* 1985, Columbia U. Press.

Cattermole, P. & Moore, P. *The Story of the Earth.* Cambridge U. Press.

Davis, J. Flyby. 1987, *Atheneum.* Mainly about Uranus, but with sections on Jupiter and Saturn.

Hockey, T. *The Book of the Moon.* 1986, Prentice Hall.

Littmann, M. *Planets Beyond: The Outer solar system.* 1988, Wiley. Good introduction to Uranus, Neptune, and Pluto.

Moore, P. *The Planet Neptune.* 1988, Horwood/Wiley.

Morrison, D. & Sams, J. *Voyage to Jupiter.* 1980, NASA Special Publication #439, US Gov't Printing Off.

Morrison, D. *Voyages to Saturn.* 1982, NASA Special Publication #451, US Gov't Printing Off.

Strom, R. *Mercury: The Elusive Planet.* 1987, Smithsonian Inst. Press.

Washburn, M. *Mars at Last.* 1977, Putnam's.

Tombaug h, C. & Moore, P. *Out of the Darkness: The Planet Pluto.* 1980, Stackpole Books. (Out of print; but worth searching for.)

Books About Asteroids, Comets, and Meteorites

Chapman, R. & Brandt, J. *The Comet Book.* 1984, Jones & Bartlett paperbound. Introduction to comets by two noted experts in the field. Should soon be available in a revised edition from W. H. Freeman & Co.

Dodd, R . *Thunderstones and Shooting Stars: The Meaning of Meteorites.* 1986, Harvard U. Press.

Kowal, C. *Asteroids: Their Nature and Utilization.* 1988, Horwood/Wiley. Best introduction.

McSween, H. *Meteorites and their Parent Planets.* 1987, Cambridge U. Press. What meteorites are and where they come from.

Sagan, C. & Druyan, A. *Comet.* 1985, Random House. Beautiful book of comet science and lore, with good background on the solar system.

Whipple, F. *The Mystery of Comets.* 1985, Smithsonian Inst. Press. Personal account by the scientist who first explained the nature of comets.

Books about the Sun

Frazier, K. *Our Turbulent Sun.* 1983, Prentice-Hall. A science writer reviews the modern picture of our local star.

Friedman, H. *Sun and Earth.* 1986, Scientific American Library. Very nice primer on the Su n and its relationships with our own planet.

Noyes, R. *The Sun, Our Star.* 1982, Harvard U. Press. Good introduction to the astronomy of the Sun by a Harvard astronomer.

Wentzel, D. *The Restless Sun.* 1989, Smithsonian Institution Press. Excellent and up-to-date.

Books about Stars and Their Evolution

Cohen, M . *In Darkness Born: The Story of Star Formation.* 1988, Cambridge U. Press. Introduction to stellar infancy and youth.

Greenstein, G. *Frozen Star.* 1983, Freundlich. Eloquent book about the death of stars and what it is like being an astronomer today.

Kaler, J. *The Stars and their Spectra.* 1989, Cambridge U. Press. Definitive book on what we can learn about stars by decoding their light. (Somewhat more advanced.)

Kaufmann, W. *Black Holes and Warped Spacetime.* 1979, Freeman paperbound. Best introduction to black holes and the theories behind them.

Kaufmann, W. *Stars and Nebulas.* 1979, Freeman paper-bound. Brief primer on stars and their lives.

Kippenhahn, R. *100 Billion Suns: The Birth, Life, and Death of the Stars.* 1983, Basic Books. Nontechnical review of stellar evolution.

Marschall, L. *The Supernova Story.* 1988, Plenum. Excellent introduction to exploding stars and Supernova 1987A.

Moore, P. *Astronomers' Stars.* 1987, Norton. Profiles of individual stars whose understanding was crucial to the progress of astronomy.

Verschuur, G. *Interstellar Matters.* 1989, Springer-Verlag. A history of how we learned about the gas and dust between the stars.

Books about Galaxies and Quasars

Harrington, S., et al. *Learning About Quasars.* 1990, Astronomical Society of the Pacific information packet. Collection of articles about observations of quasars and theories about what they might be.

Hodge, P. *Galaxies.* 1986, Harvard U. Press. A thorough introduction to our modern understanding of galaxies.

Kaufmann, W. *Galaxies and Quasars.* 1979, Freeman paperbound. Clear basic guide to what lies beyond our Milky Way Galaxy.

Wright, A. & H. *At the Edge of the universe.* 1989, Horwood/ Wiley. Searching for the most distant objects, especially quasars.

Books about the Origin and Evolution of the universe

Barrow, J & Silk, J. *The Left Hand of Creation: Origin and Evolution of the Expanding universe.* 1983, Basic Books. A good up-to-date discussion of modern theories and observations.

Cornell, J., ed. *Bubbles, Voids, and Bumps in Time.* 1989, Cambridge U. Press. Excellent articles on mapping and understanding the universe.

Ferris, T. *The Red Limit*, 2nd ed. 1983, Morrow/Quill paperbound. Good history of how large-scale properties of the universe were discovered.

Gribbin, J. *In Search of the Big Bang.* 1986, Bantam paper-bound. Thorough, readable introduction to our quest for the universe's origin.

Harrison, E. *Cosmology.* 1981, Cambridge U. Press. A superb, literate textbook on large-scale questions about the universe.

Pagels, H. *Perfect Symmetry.* 1985, Bantam. A readable introduction to the science of the universe beginning, from the perspective of a physicist.

Trefil, J. *The Moment of Creation.* 1983, Macmillan paper-bound. Fine introduction to our modern understanding of the Big Bang. (See also his The Dark Side of the universe, 1988, Scribner's.)

Tucker, W. & K. *The Dark Matter.* 1988, Morrow. On the quest for the "hidden mass'' of galaxies and the universe.

Books about Invisible Astronomy

Field, G. & Chaisson, E. *The Invisible universe.* 1985, Birkhauser. About the many interesting phenomena revealed by modern instruments but not visible to the eye, and about plans for future telescopes.

Friedlander, M. *Cosmic Rays: Tracking Particles from Space.* 1989, Harvard U. Press.

Tucker, W. & Giacconi, R. *The X-Ray universe.* 1985, Harvard U. Press. Fine introduction to cosmic phenomena that produce X-rays.

Verschuur, G. *The Invisible universe Revealed.* 1987, Springer-Verlag. A fine introduction to the discoveries and techniques of radio astronomy.

Books about the Search for Life Elsewhere

Goldsmith, D. & Owen, T. *The Search for Life in the universe.* 1980, Benjamin/Cummings. A basic introductory text in this field.

McDonough, T. *The Search for Extraterrestrial Intelligence.* 1987, John Wiley. Good-humored, basic book.

Rood, R. and Trefil, J. *Are We Alone?* 1981, Scribners paperbound. Popular-level introduction to life out there and the search.

Books about Telescopes and Other Instruments

Cohen, M. *In Quest of Telescopes.* 1980, Cambridge U. Press. Nice book on what it is like to use big telescopes and be an astronomer today.

Cornell, J. & Gorenstein, P. *Astronomy from Space.* 1983, MIT Press. Chapters by various astronomers on the results from and plans for exploring the universe with instruments in space.

Davies, J. *Satellite Astronomy.* 1988, Horwood/Wiley.

Field, G. & Goldsmith, D. *Space Telescope: Eyes Above the Atmosphere.* 1990, Contemporary Books.

Krisciunas, K. *Astronomical Centers of the World.* 1988, Cambridge U. Press. History of major observatories from ancient days through today.

Tucker, W. & K. *The Cosmic Inquirers.* 1986, Harvard U. Press. Well-written stories of some of the biggest telescopes on Earth and in space.

Books on Computers and Astronomy

Burgess, E. *Celestial Basic.* 1982, Sybex.

Duffett-Smith, P. *Astronomy with Your Personal Computer*, 2nd ed. 1987, Cambridge U. Press.

Duffett-Smith, P. *Practical Astronomy with Your Calculator*, 3rd ed. 1988, Cambridge U. Press.

Genet, R. & Hayes, D. *Robotic Observatories.* 1989, AutoScope Corp., P.O. Box 40488, Mesa, AZ 85274.

Lawrence, J. *Basic Astronomy with a PC.* 1989, Willmann-Bell.

Books on the History of Astronomy

DeVorkin, D. *Race to the Stratosphere: Scientific Ballooning.* 1989, Smithsonian Inst. Press.

Evans, D. *Under Capricorn: A History of Southern Hemisphere Astronomy.* 1988, Adam Hilger. Astronomical developments in Australia & elsewhere.

Ferris, T. *Coming of Age in the Milky Way.* 1988, Morrow. Eloquent, poetic book on the development of our ideas about the universe.

Gingerich, O., ed . *Astrophysics and 20th Century Astronomy to 1950.* 1984, Cambridge U. Press. Excellent collection of articles; the first in a series of historical collections from Cambridge.

Krupp, E. *Echoes of the Ancient Skies.* 1983, NAL paper-bound. Introduction to the astronomy of earlier civilizations around world.

Osterbrock, D., et al. *Eye on the Sky.* 1988, U. of California Press. The history of the Lick Observatory, the first of the major astronomical observing centers in the U.S.

Sheehan, W. *Planets and Perception.* 1988, U. of Arizona Press. History of progress and reversals in understanding the planets.

Introductory Manuals for Sky Observing

Berry, R. *Discover the Stars.* 1987,Harmony/Crown. A fine introduction by the editor of Astronomy magazine, with clear maps.

Beyer, S. *The Star Guide.* 1986, Little Brown paperbound. A guide to the 100 brightest stars for beginners; good charts.

Chartrand, M. *Skyguide.* 1982, Golden Press paperback. Good compact handbook for beginners, with good illustrations.

Cherrington, E. *Exploring the Moon Through Binoculars and SmallTelescopes.* 1984, Dover paperbound. Good guide to a variety of lunar observations.

Harrington, S. *Selecting Your First Telescope.* 1983, Astronomical Society of the Pacific. Pamphlet on what telescope do, different types of instruments, and what to do with a new telescope.

Mayer, B. *Starwatch.* 1984, Putnam paperbound. An eccentric but clever guide on constructing star-finders from simple household materials.

Menzel, D. & Pasachoff, J. *A Field Guide to the Stars and Planets*, 2nd ed. 1983, Houghton-Mifflin paperback. Updated edition of a classic guide, full of information and with good new maps.

Moore, P. *Exploring the Night Sky with Binoculars.* 1986, Cambridge U. Press. A friendly introduction with clear instructions.

Muirden, J. *Astronomy with Binoculars.* 1984, Arco paperback. A pleasant and useful book for scanning the sky with binoculars.

Ridpath, I . & Tirion, W. *universe Guide to Stars and Planets.* 1984, universe paperback. Compact guide to sky with constellation maps.

Schaaf, F. *Wonders of the Sky.* 1983, Dover. An amateur astronomer's enthusiastic guide to the joys of naked-eye observing.

Whitney, C. *Whitney's Star Finder*, 4th ed. 1985, Knopf paperbound. Clear, basic primer on sky phenomena & constellations. (Updated regularly.)

Books for Serious Amateur Astronomers

Berry, R. *Build Your Own Telescope.* 1985, Scribners. A good step-by-step manual for making telescopes, by the editor of Astronomy magazine.

Jones, K. *Webb Society Deep Sky Observer's Handbook* (5 volumes) 1982, Enslow. Background info and rich catalogs of objects to observe.

Levy, D. *Observing Variable Stars: A Guide for the Beginner.* 1989, Cambridge U. Press.

Newton, J. & Teece, P. *The Guide to Amateur Astronomy.* 1988, Cambridge U. Press. Thorough primer by two Canadian amateurs.

Sherrod, P. *A Complete Manual of Amateur Astronomy.* 1981, Prentice-Hall paperbound. Excellent guide to observing techniques and projects.

Texereau, J. *How to Make a Telescope*, 2nd ed. 1984, Willmann-Bell. A wealth of detailed information on making a telescope from scratch.

A Few Selected Books for Children

Apfel, N. *Astronomy Projects for Young Scientists.* 1984, Arco paperbound. Good, simple astronomy activities for junior high level and up.

Asimov, I. *Isaac Asimov's Library of the universe.* 1988-90, Gareth Stevens. Beautifully produced, basic astronomy series for ages 8-12.

Berger, M. *Bright Stars, Red Giants, and White Dwarfs.* 1983, Putnam. Brief introduction to stars and their evolution. [Ages 10-15]

Branley, F. *Saturn: A Spectacular Planet.* 1983, Crowell. Picture book summarizing our knowledge of the ringed planet. [Ages 7-11]

Branley, F. *Space Telescope.* 1985, Crowell. Illustrated introduction to telescopes and the big one to go in space. [Ages 8 -11]

Burnham, R. *The Star Book.* 1983, Astromedia/Cambridge U. Press. Book of cardboard star maps & instructions for beginners. [12 to adult]

Hatchett, C. *The Glow-in-the-Dark Sky Book.* 1988, Random House. [All ages.]

Krupp, E. & R. *The Big Dipper and You.* 1989, Morrow. A delightful illustrated book on stars and constellations. [Ages 6-12.]

Parker, E. *The Universe.* 1983, Cambridge U. Press. Picture book on astronomy for very young children.

Poynter, M. & Klein, M. *Cosmic Quest.* 1984, Atheneum. A nice introduction to the search for life elsewhere in the universe. [Ages 13 and up]

Taylor, G. *Volcanoes in Our Solar System.* 1983, Dodd, Mead. Discussion of volcanoes on Earth and on other planets & moons. [13 and up]