Contents

Movie Browser
Nightly Grabbag
Tables
Tutorials

January

January 1 : Calendars
January 2 : Earth-closest to the Sun
January 3 : Orion, the Hunter
January 4 : Betelgeuse
January 5 : Rigel
January 6 : Orion Nebula
January 7 : Galileo discovers some moons
January 8 : Project - Galileo discovers something about gravity
January 9 : Camelopardalis, the Giraffe
January 10 : Taurus, the Bull
January 11 : Aldebaran
January 12 : The Pleiades
January 13 : The Hyades
January 14 : Crab Nebula
January 15 : Auriga, the Charioteer
January 16 : Capella, sixth brightest star
January 17 : Three star clusters in Auriga
January 18 : Epsilon Auriga, the strangest star in the sky
January 19 : Eridanus, the river
January 20 : How to become an astronomer
January 21 : Project - Absolute vs. apparent magnitudes
January 22 : Project - Distances to stars
January 23 : What is astrophysics?
January 24 : Voyager 2 and Uranus
January 25 : Volcanos in space
January 26 : Project - How high the mountains?
January 27 : Apollo 1
January 28 : Challenger
January 29 : Caelum , the Chisel
January 30 : Project - Gravity in space
January 31 : Explorer 1

Earth at Perihelion

It is commonly thought that the seasons change due to the Earth's distance from the Sun. After all, if it gets colder, shouldn't we be getting further from the Sun? Makes sense. But it is also very wrong. For on or around January 2, in mid-winter with the winds blowing and 12 feet of snow out the front door (North Dakota residents only), the Earth is actually at its closest point in its orbit. This is called the perihelion, "peri" for closest, "helion", the Sun. Since the Earth's orbit is not perfectly round but an ellipse its distance varies from 91,396,000 miles (145,103,000 km) at the closest out to 94,511,000 miles (152,102,000 km), or about 3%. True, the distance change no doubt affects the climate slightly but is not nearly as significant as the more immediate factors such as the Earth's tilt, cloud cover, etc.

These values do vary slightly as do the dates which can move back and forth a day or two. Click here, and First Light will move you above the solar system letting you peer down upon this sight.

Clavius : One of the largest craters on the near side of the Moon, measuring 140 miles across. This was the supposed location of the great moon base in the film *2001-A Space Odyssey*.

February

February 1 : Gemini, the Twins
February 2 : M35
February 3 : Project - the color of stars
February 4 : Canis Major, the great dog
February 5 : Sirius, the brightest star
February 6 : M41
February 7 : Beta Pictoris, a most unusual system
February 8 : Barnard's star, the runaway
February 9 : Halley's Comet
February 10 : Project : A Comet's Tail
February 11 : Procyon
February 12 : Canopus, the second brightest star
February 13 : Telescopium Herschelii
February 14 : Asterisms
February 15 : Zodiacal Light
February 16 : Project - limits of visibility
February 17 : Ceres, the first asteroid
February 18 : Discovery of Pluto
February 19 : Pluto
February 20 : Friendship 7
February 21 : Celestial coordinate systems
February 22 : Bode's Law
February 23 : Tycho Brahe, the man with the golden nose
February 24 : H-R Diagram
February 25 : Where do the constellations come from?
February 26 : Cosmology
February 27 : Geocentric Universe
February 28 : Author's birthday
February 29 : Holiday

Movies

Earth
Moon
Solar System
Space Shuttle - Hubble Repair Mission

planetary nebula :
A circular expanding shell of gas usually due to a star having exploded ("gone nova") or possibly a result of a slower process of merely casting off excess gases as the star converts from one type to another.

The Roman Calendar

At the start of a new year, I thought we should discuss calendars. No doubt you have many hanging around on the walls, on your desk, in your computer. We've accepted the concept of 12 months of varying lengths, one which changes every four years. But just where did "July" come from? Who named "March"? Why does a month have (about) 30 days?

The first calendars were based on astronomical observations, namely, the motions of the Moon. The Moon had a 29 1/2 day cycle that was familiar to everyone, and was a convenient length of time to deal with. But the Moon's phases were out of sync with the seasons so something more regular such as the Sun and stars were used, hence the origin of the "solar" calendar.

The origin of our calendar is from the Romans, who started with a lunar calendar, but changed over to solar. Originally the "year" was 305 days (10 lunar months) with an extra 51 added to fill in the gaps for a total of 355 days. This became known as the "Roman Republic Calendar", but it still did not keep in step with the seasons. In order to synchronize it with the Sun, an extra month was added between February 23 and 24 every two years. The month of "Mercedonius" finally created a approximate solar year but after several hundreds of years things became unusable by the first century BC.

At that time, Julius Caesar decided to abandon the lunar calendar altogether and adopted a year of 365 1/4 days with twelve months varying between 30 and 31 days and one of 28 days. An extra day was tossed in to February every fourth year to take into account the extra quarter of day.

This "Julian Calendar" was all well and good except the year is NOT exactly 365 1/4 days. It is more like 365.2422 days; in other words, slightly shorter. So over a period of centuries, the error built up and caused the years to slip by several days. By 1545 this figure was a full 10 days and the determination of religious festivals (usually based on astronomical periods) were way off. In 1582 Pope Gregory XIII had a Bavarian Jesuit astronomer named Christopher Clavius develop a new more accurate calender. The year's length was finalized at 365.2422 days. To adjust for this three out of every four century years would be leap years, while the fourth would not (called a "common year"). So the years 1700, 1800 and 1900 were leap years while 2000 will not be. Furthermore, in order to get the calendar back in line, 10 days were dropped in October of 1582. When people went to sleep on October 4 they woke up on October 15. This is called the "Gregorian Calendar", which is what we still use today.

Interestingly enough, not all countries used it at first, so the date and year would change depending on your location! The Catholic countries took to it immediately, but it took Scotland about 15 years, and England ignored it until 1752. Russia never adopted it until the revolution in 1917, a full *335 years* after the fact!

In light of the various irregularities astronomers are more likely to use "Julian dates" to isolate events more accurately. A Julian date is simply the number of days from January 1, 4713 BC. So the for instance, January 1, 1980 was JD 2444240, or about 2 1/2 million days from the beginning date chosen in 1582 by an Italian Protestant scholar, Joseph Scaliger. Since 4713 BC was considered to be the year of creation according to popular interpretations of the time, any day before that time could not possibly be of use to us mere mortals.

ellipse :
One of a set of curves called *conic sections*, roughly a flattened circle and the natural mathematical shape an orbit assumes.

Orion, the Hunter

What can one say about Orion? This is clearly the most sublime and spectacular of all constellations in the sky. As the air grows crisp and the leaves slip silently toward the ground in mid-fall, stately Orion makes its presence known with its distinctive "belt" framed by the brilliant stars of Rigel, Betelgeuse, Bellatrix and Saiph. His uplifted right arm carrying a celestial club, his outstretched left arm draped with a lion's pelt create an imposing sight for the chilly skies of winter. (or for my southern hemisphere customers "the balmy skies of summer").

Orion is one of the most ancient of constellations, his exploits in Greek mythology however are rather vague as he was known simply as a great and powerful hunter and son of Neptune. Apparently quite aware of his good looks and manliness he took on an arrogant nature leading in part to his downfall, according to one of the stories.

Step outside if it is clear and dark and you should see him high in the sky being followed by his two hunting dogs, Canis Major and Canis Minor and depending on what legned you read, he is either after the rabbit Lepus or the great bull Taurus, who can clearly be seen charging him.

One fable states that Orion was interested in the seven sisters known as the "Pleiades", daughters of Atlas and Pleione. Zeus snatched the women up and placed them in the sky to keep them out of his reach, however poor Orion can still be seen pursuing them night after night and century after century never destined to reach them and they never quite within his grasp.

Orion's death varies greatly. According to one story he was boasting how he was the greatest of all hunters. However he made the mistake of stating this to Artemis the goddess of hunting and Leto her mother, claiming that he could kill any creature on Earth. Unwilling to tolerate such presumption, the Earth itself split open revealing a giant scorpion which stung Orion to death. Now he is placed opposite in the sky from Scorpius, so as the great scorpion begins to rise in the east, Orion is able to make his cowardly escape by ducking below the western horizon.

The constellation of Orion is mentioned in the literature of the ages. In the Bible, Job states "Canst thou bind the sweet influence of the Pleiades, or loose the bands of Orion?" or ancient Egyptian texts : "The Great One has fallen...Behold he has come as Orion...".

The right shoulder of Orion is the star Betelgeuse, from the Arabic "Beit Algueze", meaning the decidedly less romantic sounding, "armpit of the giant". It is 520 light years away, meaning that the light that strikes your eyes tonight left a little before Columbus began his journeys. Betelgeuse with a diameter between 480 and 800 million miles making it one of the largest stars visible to the naked eye. If placed where the Sun is it would extend out beyond the *Mars.*

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m42.sbm}Orion's sword hanging from the famous belt is the location of one of the most spectacular of all nebula in the sky, known as either the Great Nebula in Orion, or simply as M42. Here is where stars are being incubated and come to life. M42 is easily seen in binoculars and small telescopes and on clear nights, even with the naked eye.

To the right of Orion is Taurus the bull with his distinctive red eye of Aldeberan, slightly further is the cluster of the seven sisters of the Pleiades. To the left are the constellations Canis Major and Canis Minor, the big and little dogs.

So, as you stare at the hunter you join countless other generations of common or royal, of slave or free, of merchant or artist, of programmers and non-programmers, who stand in awe of the mighty Orion.

Click here  and First Light will center Orion for you.

Betelgeuse

Alpha Orionis, "Betelgeuse", is the brightest variable star, changing between magnitudes 1.2 and 0 with no real period. Betelgeuse is easily seen as the upper left shoulder of Orion below his mighty uplifted arm. This is one of the largest stars known, with size estimates between 480 and over 800 million miles. Were it to replace the Sun, the star's edge could reach out beyond the orbit of Jupiter! While the star has an estimated volume of 160 million suns, its mass is no more that 20 times the Sun. This means that its density is only about .00000005 that of air, prompting some to call Betelgeuse a "red-hot vacuum".

When you are looking at Betelgeuse, , you are looking 520 years into the past; in other words, back in time! Think of it this way : the light that is striking your eyes tonight left a few years *before* Columbus sailed into the history books.

The name comes from the Arabic "Beit Algueze" which literally means "the armpit of the giant".

variable star :
Stars which vary the brightness due to either internal physical processes or eclipses of other nearby stars.

magnitude :
The brightness of a star or other object in the sky. The lower the magnitude the brighter the object. Each magnitude represents an intensity of about 2.5 times less than the next lower value. So a fourth magnitude star is 2.5 times dimmer than a third magnitude star. The dimmest stars visible to the naked eye under the best conditions are around 6.5 rendering up to 3000 total stars visible at any one time.

Rigel

Tonight you may become "podiatrist" (foot doctor) to the stars, literally, by examining the foot of the great hunter Orion. The brilliant star in the lower right of body of Orion is Rigel.

Rigel is a supergiant, the seventh brightest star in the sky and the brightest in all of Orion. It has luminosity of about of 57,000 times the Sun, making it one of the most luminous known stars in the galaxy. Were the star the same distance as Sirius (8 light years, vs. 900 light years), it would blaze away at a magnitude of -10! Rigel is a double star with a 6.7 magnitude companion easily visible in a small telescope.

The name Rigel comes from the Arabic "rijl", meaning foot. Click here and First Light will center Rigel for you.

supergiant :
The very brightest and largest stars formed when stars heavier than the Sun hit old age. Supergiants are rare since they burn out very quickly, but are so bright that most of the patchy areas seen in external galaxies are groupings of them. Sixteen of the one hundred brightest stars are supergiants.

light year ("ly") :
The distance light travels in a year. At 186,000 miles/second, this comes to 5,878,000,000,000 miles, approximately. The closest star next to the Sun is Alpha Centauri at about 4.2 light years away.

multiple stars :
Two or more stars orbiting around each other. Sometimes called "double" or "binary" stars.

The Great Nebula of Orion

Looming over the winter skies is Orion, the mighty hunter. Stately Orion makes his presence known with his distinctive "belt" framed by the brilliant stars of Rigel, Betelgeuse, Bellatrix and Saiph. His uplifted right arm carrying a celestial club, his outstretched left arm draped with a lion's pelt, create an imposing sight for the chilly skies of winter. Hanging down from the belt you will find his sword (no well-dressed hunter should be without one). Go outside with a pair of binoculars and study this great celestial sword. In the center you will notice a fuzzy patch, something that looks like an out of focus star, but the stars are in focus (or should be). What are you looking at? None other than the Great Nebula in Orion.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m42.sbm}The Orion nebula ("M42") is considered without a doubt, one of the most spectacular treasures of the sky. Visible in binoculars, it becomes impressive in large telescopes. At 30 light years across it is known for its distinctive fan shape with a greenish hue in small telescopes and fiery red in large ones. It is thought to be 1700 light years away, so the light striking your eyes tonight began its journey in the third century AD.

The soft glowing light is caused much in the same way as that in your fluorescent lights. The gases are pummeled by ultra-violet radiation from nearby stars. The gases are mainly hydrogen, about 90% worth, 8% helium and the rest being trace elements of the usual suspects, Carbon, Oxygen and so on.

Buried within the soft velvety clouds is the Trapezium, the nebula's energy source, . This is perhaps the best known multiple star system in the sky, made up of 4 main components and several dimmer ones. The Trapezium is clearly visible in standard binoculars and should provide a pleasurable sight on a cold winter's eve.

Galileo discovers some moons

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\galscope.sbm}On a cool January's eve in 1610, Italian mathematician and physicist, Galileo Galilei took a small slender tube of his and aimed it toward the sky. This "telescope" invented by Hans Lippershey a year earlier in the Netherlands, (and improved by Galileo), could magnify distant objects by over 30 times. This opened the window wide on the heavens revealing the beauty and mysteries that lay just beyond the reach of the normal human eye, but not the imagination.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\galnotes.sbm}On this date all those years ago, Galileo made some observations of the planet Jupiter. Nearby he noticed small stars stretching out on either side. Over a period of several nights these "stars" would move back and forth apparently around the massive planet. These observations convinced him of the correctness of the radical views of Copernicus the Polish mathematician who stated that the Earth and other planets all revolved around the Sun (the Heliocentric theory) instead of the Earth being the center of the Universe as was commonly thought (the Geocentric theory). This picture is of Galileo's originals notes from that fateful night.

The latter view was the only one which the Catholic church at the time considered consistent with the biblical teaching. Because of this Galileo was strongly urged to change his heretical opinions. In response he stated that the Bible taught the way to go to Heaven not the way the heavens go. However he was instructed not to teach his views in public.

In 1623 a friend of his became Pope and moderated the church's stance just a bit, but Galileo was still summoned to the court of the Inquisition, thanks to his many enemies, where he was forced to recant his views and forbidden to study any more astronomical problems. Sent home under house arrest he labored until his death in 1642 making important discoveries in statics and dynamics (the science of bodies at rest and in motion) and used that to in a roundabout way to support the Copernican view of the Universe. The results of these studies created the foundation of mathematical physics.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\callist1.sbm}Now use First Light to see the moons of Jupiter as Galileo saw them nearly 400 years ago, . If Jupiter is visible right now from your location, take your binoculars out and see them for real. The moons Galileo saw are called appropriately enough, the "Galilean moons" and consist of Io, Ganymede, Europa and Callisto. These remained merely points of light until the Voyager 1 probe photographed them up close and personal in 1979. And now a newer spacecraft, named "Galileo", is poised to do the same. A fitting legacy to one of the greatest scientists.

Galileo discovers something about Gravity

Project. . .

When one thinks about Galileo (if at all), it is usually in conjunction with his radical views at the time, of the Universe and our place in it. It was Galileo who is primarily credited with proving the Heliocentric (Sun centered) view of the Universe thanks in large part to the new fangled invention known as the telescope. But he wasn't "just" an astronomer, for Galileo was a formidable physicist, mathematician and theoretician, and when banned from further study of the heavens by the Catholic church he made many important observations and discoveries on a more down-to-Earth level. Perhaps one of the most oft repeated experiments his has to do with the speed of falling objects. A classic which is repeated in grade school laboratories around the world, it is wonderful in its simplicity.

The common thought at the time suggested that heavier objects fell faster. The story is told that in order to prove this he performed the following experiment : Taking two balls of different weights he climbed to the top of the Leaning Tower of Pisa. Releasing them at the same time the both hit the ground, *at exactly the same time*!

Now you do the same. If you don't live near the Leaning Tower, you might want to substitute a chair or balcony instead. Take a grape and an orange (or any two objects that are obviously of different weights such as an Oil Tanker and Twinkie) and drop them at the same time from your artificial tower. Observe what happens.

In 1972, astronaut Dave Scott on Apollo 15 actually performed this experiment on the Moon. Click on the film icon to see it for yourself, .

Camelopardalis - the Giraffe

One of the oddest critters to grace the heavenly dome is immortalized in the constellation of Camelopardalis, the Giraffe. Not all constellations are ancient, this one being "invented" in 1613 by Dutch astronomer Petrus Plancius.

It is reasonably large but otherwise rather unremarkable, . One nice item is the face on galaxy called NGC2403. Under dark skies and clear seeing, you might be able to catch this one tonight with your binoculars. With a relatively bright magnitude of 8.8, it should be visible as a fuzzy patch in the left side of the constellation. You might want to print out a star chart from First Light to take out with you as you try to spot it. Amateur telescopes might reveal some slight mottling of the various star clouds.

NGC2403 is about eight million light years away, just beyond the edge of our local group. Astronomically speaking it is the next block over.

Taurus - the Bull

No doubt by now you've seen Orion gracing the winter's evening sky. Orion, the great hunter with his club uplifted in his right hand is forever locked in battle with Taurus the bull. Frozen in time, Taurus' red eye (the star Aldebaran) stares unblinking, straight ahead.

The story is told that Taurus is actually the god Zeus in disguise. He would adopt the form of a bull to try and get near the beautiful Europa so he could abduct her. One day after she befriended this creature she climbed on its back for a ride. Since they were near the sea shore, Taurus/Zeus took her out across the waters and eventually landed at the island of Crete where they lived for many years.

Only the front half of the bull actually forms the constellation, , Aries and Cetus are where the back half should be. Some illustrations show the bull charging out of a cloud of dust, while others have it rising half out of the water to be consistant with the stories. Whatever the case may be, Taurus shares this same unlikely problem with Pegasus the Winged Horse.

The head and face of Taurus are marked by the distinctive V-shaped star cluster called "The Hyades", . Over the ages mythographers have vainly attempted to name the brightest members of this group, however no one could agree on just how many stars should be named nor what exactly they should be. So present day, none of the stars have official names except for Aldebaran the brightest one. There are about a half dozen main stars, but your binoculars should reveal a hundred or more. The cluster is about 150 light years away and contains a total of several hundreds of stars.

A little over to the right of the Hyades is another star cluster, the Pleiades, sometimes called the Seven Sisters, . These were said to be the daughters of Atlas and Pleione. This is a fabulous cluster for binoculars revealing dozens of stars, and in telescopes, hundreds come to light. This is a young cluster, being only a few million years old. There is still faint gases, or nebulosity surrounding the stars visible in photographs, the stuff from which they were born.

Aldebaran

"...I saw on a minaret's tip Aldebaran like a ruby aflame, then leisurely slip into the black horizon's bowl" (Thayer)

Aldebaran ("the Follower"), is the 13th brightest star in the sky, . The star has from earliest days been called "The Eye of the Bull" (Taurus), which makes its distinctive reddish color more significant. The star itself is about 68 times the luminosity of the Sun, and 40 times its diameter.

Taurus is clearly visible, locked forever charging the great Orion. His red eye sits unblinking up against the smooth black of the sky. Aldebaran forms the top part of the V-shaped collection of stars called "The Hyades". Over the ages, mythographers have vainly attempted to name the brightest members of this group. However, no one could agree on just how many stars should be named or what exactly they should be. So, present day, none of the stars have official monikers except for Aldebaran, the brightest of the bunch. There are about half a dozen main stars, but your binoculars should reveal a hundred or more. The cluster is about 150 light years away.

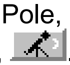
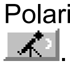
The Bull's Eye is not actually part of the cluster, but sits in front of it, about 62 light years away. To see prove this for yourself, center the "V" and select from the expert menu stars/proper motion. Proper motion being the actual movement of the stars up against the sky. Those which are a part of the same cluster are of course going to be travelling along the same direction, much like a family walking together. The stranger, in this case Aldebaran, will be going along in his own way. The lines you see represent 50,000 years of motion, with the red dot showing the direction. But notice Aldebaran: It looks like the Bull is going to be losing his eye in about 10,000 years!

Viewing the Sky

In First Light, there are two main ways of viewing the sky as seen from the Earth.

"Local Mode" shows you the sky as seen from your own location on Earth. This is useful for locating objects at this very moment, but is pointless for locating something for someone else. That is, the position of Mars in your sky will be different than for someone a thousand miles distant. This is why astronomers use "Equatorial Mode". In Equatorial mode there is neither day nor night, and the stars stay comfortably fixed year after year. This removes the ambiguities introduced by using your own position on the Earth. That is, an object's equatorial coordinates are the same no matter where the observer is on Earth.

Astronomers use right ascension ("RA") and declination ("Decl") to locate an object in the sky. RA is the celestial form of longitude, but is given in hours and minutes instead of degrees. So an object might be at "3 hours 12 minutes" right ascension. The celestial latitude, declination, identical to Earthly latitude which goes from -90 to +90 degrees. So the North Celestial Pole is at a declination of +90 degrees.

In local mode, you will notice that the North Star, Polaris, indicates one's latitude on this fair planet. If you were exactly at the North Pole, Polaris would be overhead. Were you near the equator, it would be whispering to the horizon, . Were you to go to San Francisco at a latitude of about 38 degrees, Polaris would be 38 degrees above the horizon,
.

The Pleiades

*"The Pleiads, rising thro' the mellow shade, Glitter like a swarm of fireflies
Tangled in a silver braid..." Tennyson*

Gracing the chilly winter skies in the constellation of Taurus is the lovely little star cluster known as "The Pleiades". Also called the "Seven Sisters", the Pleiades is perhaps the most well known cluster in the heavens, outshining even the much larger V-shaped Hyades to the immediate left. The subject of countless legends and mentioned in equally countless works of literature the cluster is a striking sight in even the smallest pair of binoculars, and absolutely breath-taking in a telescope.

"Him that maketh the Seven Stars and Orion..." Amos 5:8

Nearly every culture mentions the Pleiades in some respect. Chinese writings appear to mention it from 2357 BC. American Indian folklore of the Kiowa talks of the "Seven Maidens" who where protected from giant bears by their placement in the skies.

Tradition Greek legends speaks of the Seven daughters of Atlas and Pleione, named Alcyone, Asterope, Celaeno, Electra, Maia, Merope, and Taygete. In one story the giant hunter Orion was pursuing them as he did with many maidens, and Zeus transformed them to "celestial doves" to escape his interest. As it ended up, both Orion and the sisters are both immortalized in the heavens and sentenced to an eternal dance through the winter skies.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m45.sbm}Now take your binoculars and if it is clear, go and see this chase for yourself. Is Orion battling off the giant bull, Taurus with his club upraised? Or is he protecting the sisters to gain their trust? Are the able to stay away from his grasp? The Pleiades are about 400 light years away, that is, when the light you see tonight left, Galileo was still about 20 years away from his turning a telescope to the heavens for the first time. You should be able to see dozens, numbering in the hundreds with a small telescope. Current estimates suggest that there are over 500 "sisters" in all. Load in the secondary star catalog (using the menu expert/stars/more stars) that goes down to 16th magnitude (beyond what most amateur telescopes can see), print out the display and compare to what you can see through your instrument, .

The Pleiades is one object that low power is essential for. Some buyers of telescopes are always interested in how much it will magnify, but with anything beyond 20 power only a part of the cluster is seen lessening the effect.

Photos show a faint blue nebulosity surrounding the cluster, possibly the source material for the stars themselves for this is a very young object of only a few million years.

"The ground was as if strewn with colored enamel, and necklaces of Pleiades seemed to hang upon the branches of the trees..."

The Hyades and Proper Motion

The head of Taurus the Bull is formed by the V-shaped collection of stars called "The Hyades". Fiery red Aldebaran forms the Bulls Eye as he charges ever present Orion. Over the ages mythographers have vainly attempted to name the brightest members of this group as has been the case of the Pleiades, however no one could agree on just how many stars should be named nor what exactly they should be. So up to the present day, none of the stars have official names accept for Aldebaran, the brightest one. There are about a half dozen main members but your binoculars should reveal a hundred or more. The cluster is about 150 light years away and contains a total of several hundreds of stars, .

The Bull's Eye is actually not a part of the cluster, but is in front of it, about 62 light years away. To prove this for yourself center the "V" and select from the expert menu *stars/proper motion*. Proper motion is the actual movement of the stars up against the sky. Those which are a part of the same cluster are natrually going to be travelling along the same direction, much like a family walking together. The stranger, in this case, Aldebaran, will be going along in his own way. The lines you see represent 50,000 years of motion, with the red dot showing the direction. But notice Aldebaran? It looks like the Bull is going to be losing his eye in about 10,000 years.

The Crab Nebula

{ewr ewdll.dll,ewBitmap,ew_bmps\dso\m1.sbm}Nestled near the left horn of Taurus the Bull, you will find the Crab Nebula, so called due to its spindly, delicate appearance. The "Crab" also known by the less romantic name of "M1", was discovered in 1731, and is the remnant of the supernova of July 4, 1054 AD. Its hydrogen cloud is expanding at a rate of over 600 miles/second making it well over six light years across.

M1 is one of the strongest x-ray sources known. Its source was traced to a neutron star, the first ever seen. A neutron star is the final remnant of a supernova which collapsed so tightly on itself that it is likely on the order of *6 miles* in diameter, but with a density so great a single teaspoon full would be, well, really really *REALLY* heavy (on the order of a 1000 million tons). This discovery of the Crab Nebula's central star was the first visible evidence of such a peculiar beast and only happened when after first being detected by radio. As the star collapsed it picked up a spin, and as it would get smaller the spin rate would increase, not at all unlike an ice-skater who spins faster when he holds his arms in close to his body. Combine this with several other extreme conditions, radio energy was shot out of the poles much like a shining beacon in the night. The spinning motions would bring the beam around to us as if it was a lighthouse beacon. In this case the lighthouse was flashing us once every 1.33 seconds. At first some astronomers felt that this might a sign of extraterrestrial intelligence, but more rational heads prevailed once the star was visually detected and seen to flash on and off. Since then well over a hundred of these "pulsars" have been discovered, one flashing of the incredible rate of 30 times a second!

At nineth magnitude, the Crab is probably too dim to see with binoculars but is clearly visible in modest telescopes, . You may want to see if you can find it now, and while doing so place yourself back nearly a thousand years when all eyes turned toward that same location in the sky and marveled at this wondrous new star.

supernova :
The destructive explosion of a star, one of the most spectacular and dramatic events in the Universe (aside from the 1994 Republican sweep of Congress). A star is often in delicate balance between its own force of gravity and the pressure caused by the heated material. If this pressure is increased (usually caused as it begins to burn out) it can increase its size from that of our Sun to that of the solar system in only a *day or two*. It will shine brilliantly for a few weeks, often visible in daylight, then collapse back on itself to finally die a slow and invisible death. Oh, but what an exit!

Auriga the Charioteer

Suspended above that mighty hunter Orion you will find the constellation of Auriga, known as the charioteer. Auriga is clearly seen on any crisp winter's eve as a large ring of bright stars of about the same size as Orion.

The myths surrounding Auriga are numerous, as with so many of the other constellations. One of the most popular of the stories states that this is actually the king of Athens, Erichthonius, who became a master charioteer. His skill and innovations earned him the praise and adoration of Zeus, who honored him with a position among the stars.

Another and more entertaining story states that Auriga was Myrtilus, who was employed as charioteer for the king, Oenomaus. As is so often the case, this king had a beautiful daughter with the unweildly name of Hippodamia. Despite her name, she was the subject of much interest among the young men (which the king was opposed to, not wanting to lose her). So he established a chariot race wherein the winner would receive the hand of Hippodamia. The losers? Well. . ., they would have their heads removed from their bodies. Since the king had the speediest chariot in the realm, he could not lose. One day, spying the handsome Pelops readying his chariot, Hippodamia plead with Myrtilus (Auriga) to fix the race so Pelops would win. Myrtilus obliged, never telling her that he was secretly in love with her. He sabotaged the king's vehicle, causing the wheels to fall off and throwing the king to his death. Upon learning of his interest in Hippodamia, Pelops threw Myrtilus into the sea, drowning him. To honor his son, Hermes placed Myrtilus into the skies for all eternity.

Auriga is home of the sixth brightest star in the sky, Capella, the "she-goat", . Capella is a mere 40 light years distant and is actually a multiple star, two large stars rotating in tandem around each other (10 million and 5.6 million miles in diameter and a couple of small ones. They perform their slow dance once every 104 days separated by only 70 million miles, closer than the Earth is to the Sun. Imagine what a view that must be from a nearby planet!

Auriga is also the home of several small star clusters, M36, M37 and M38. You might want to try and see them for yourself, now using your binoculars and using First Light to locate just where they are.

neutron star :
The tiniest and densest stars known, typically the final remnant of a supernova which having collapsed so tightly on itself it in effect becomes a single atomic nucleus measuring only six miles in diameter. Its density is so great a single teaspoon full would be, well, really really REALLY heavy (on the order of a 1000 million tons).

Capella, the sixth brightest star

Tonight locate the constellation Orion. Located above Orion, you will find the bright constellation of Auriga, the charioteer. Auriga is home of the sixth brightest star in the sky, Capella, the "she-goat", . Capella is a mere 40 light years distant and is actually a multiple star, two large stars rotating in tandem around each other (10 million and 5.6 million miles in diameter) along with a couple of small ones. They perform their slow dance once every 104 days, separated by only 70 million miles, closer than the Earth is to the Sun. Imagine what a view that must be from a nearby planet!

See also -
Auriga : the Charioteer

Three star clusters in Auriga

Tonight locate the constellation Orion. Located above Orion, you will find the bright constellation of Auriga, the charioteer. Auriga is home of the sixth brightest star in the sky, Capella, the "she-goat" and a mere 40 light years distant. Also you will find three star clusters:

M36 is a small but bright open cluster of about 60 stars and 14 light years across, low power is recommended for viewing. With low enough power, another cluster M38, may be visible in the same field-of-view.

Considered the finest of the three open clusters in this region (M36 and M38 being the others), M37 is called "superb" even in small instruments. Containing over 500 stars, it ranks as one of the older clusters in the area, being over 200 million years in age. M37 is about 25 light years across.

Visible in the same field-of-view as M36, M38 contains over 100 stars and is about the same size as M37.

Study them using First Light then go outside if it is clear and use your binoculars or telescope to see what you can see for real. M37 is the best for binoculars but all 3 should be splendid even in small telescopes.

See also -
Auriga : the Charioteer

The strangest star in the sky

Some have said that the Universe is indeed an odd place. And the star Epsilon Auriga seems to go out of its way to prove just that. This is a moderately bright binary star near Capella in the constellation of Auriga, the Charioteer. For those in the northern hemisphere, it should be visible on most any clear night, especially during the winter evenings.

This is called an "eclipsing binary", that is, it comprises two stars orbiting around each other. When one passes in front of the other, eclipsing it, the brightness level goes down. In the case of Epsilon Auriga the magnitude changes from 3.0 to 3.85 over a period of 27 years. What makes this star so peculiar is that the visible part of the pair appears to be smaller one, the larger of the two so far has remained hidden.

One theory suggests that the invisible partner is hidden in huge cloud of dust the size of the orbit of Saturn. The other states that the companion is actually two stars orbiting around each other as they in turn circle the visible star. (similar to the Earth-Moon system orbiting around the Sun). The two stars in turn are surrounded by leftover building materials (gas and dust) keeping the material stirred up.

Astronomers will be needing more data in the next eclipse period before they can even attempt to come to a conclusion, but that won't be until 2007. You don't have to wait until then to see this peculiar star. Merely step outside if it is clear and take a peek and wonder along with the scientists about what might be going on.

See also -
Auriga : the Charioteer

Eridanus, the river

Meandering through the brisk winter skies and right beneath the constellation of Taurus the Bull, is a river named Eridanus. Notice how it laps up against the feet of Orion.

An extensive constellation, Eridanus is the sixth largest in the sky whose true identity is not quite known, . Some feel it might have been the Nile, others consider it to be the Po river of Italy or the Euphrates. In Greek mythology Eridanus in involved with the story of Phaethon who against his the better judgment of his father, the Sun god Helios, was permitted to drive his chariot across the sky. The boy lost control of the mighty horses who galloped their way off the path, sweeping by Draco, teasing Scorpio, and bringing catastrophe to the Earth. Angered at this, Zeus struck Phaethon with a bolt of lightning forcing him to dive, hair on fire, into the river Eridanus.

Despite its size, Eridanus is in all respects an average constellation containing few noteworthy deep-sky objects. However, it does have several nice double-stars along with the nineth brightest star in the sky, Achernar.

Epsilon Eridani is one of the closest stars in the sky, being literally right next door at a distance only 11 light years away. This is an easy object for the naked eye at a magnitude of 3.7.

Use First Light to locate the impressive double star *32 Eridani* for you. Use Stars/center/stars and select the "SAO" option. This will search for a star based on its SAO number. The one we want is SAO130806. When centered print out a chart and use that with your binoculars to find it in the real sky. The pair should be green and yellow, but will probably need more power than a pair of binoculars can offer.

deep-sky objects :
The category of objects beyond our own solar system, excluding individual stars. Deep-sky objects would include galaxies, nebula, star clusters and the like.

How to become an astronomer

Astronomy is one of those sciences that is perhaps the most interesting to the public yet at the same time has relatively little demand. If you have ever considered that it might be a cool profession to get into for both fun and profit ,be prepared to spend a lot of time in the classroom or hunched over computers. Unfortunately, the romantic days of a professional astronomer carefully adjusting the eyepiece of a massive telescope, readying to peer into the dim past of the Universe unlocking her mysteries, is all but past. Few of the major telescopes permit direct observing anymore as they are loaded down with various complicated cameras and other equipment. And instead of freezing inside an unheated dome, the astronomer is likely to be sequestered inside a comfortable computer lab possibly in another building or state.

However, if the image of the lone figure adjusting a telescope's eyepiece does appeal to you, even if it pays nothing, feel free to join the band of *amateur astronomers*. If you have already participated in some of the other projects and observations that these activities encourage, you might already be there, even if you don't have a telescope. But if you do, don't ignore the fact that many "amateurs" are making important contributions to the field on a daily basis. For astronomy is perhaps the only science in which hobbyists can truly contribute, and they have done so with so much enthusiasm that sought after observation time on the Hubble Space Telescope has been set aside for these so-called amateurs.

Since time in the major observatories is precious and expensive, the professionals must rely on the cadre of amateurs to do the extensive day by day observations and celestial reconnaissance which don't require a million dollar instrument, such as observing variable stars for instance, or hunting for comets. Recently, important cloud patterns on Saturn were first reported by an amateur. At some times there is very little that separates the pros from the amateurs, except that the amateurs might just have a little bit more fun.

So do you want to be an astronomer? If you have gazed heavenward, studied the meandering river of Eridanus, had a staredown with the fiery Trapezium of the Orion nebula or watched the Sun rise over the crater Copernicus, maybe you already are.

Apparent vs. Absolute magnitudes

Project. . .

A star's brightness or magnitude is based on several factors: What kind of star it is, how much interstellar stuff (dust) is in the way to interfere with its light, its size, age and distance. That is why astronomers call the brightness that we see "apparerent magnitude". However this is a rather meaningless value, what is more useful is the "absolute magnitude" or the brightness it would shine if placed at a known distance of about 32 light years.

Our own Sun, which can burn our retinas with a magnitude of -26, would be an unimpressive fourth magnitude object. Using First Light, locate the star Betelgeuse, . If you have followed previous discussions on Orion, it should be an old friend by now. Betelgeuse is the upper left corner of the body of Orion, and by now, you should be able to easily identify it in the sky as well. Betelgeuse blazes away at about 0.5 magnitude, making it one of the brightest in the sky. Now find Sirius, the brightest star next to the Sun. Sirius, the "Dog Star" shines at -1.46 and is located only 9 light years away while Betelgeuse is nearly 300 light years distant.

So mentally move Sirius about three times its distance while at the same time, move Betelgeuse up to a tenth of the distance away. Now what should you see? The mighty Sirius has now become a less remarkable star of magnitude 1.5 while on the other hand, Betelgeuse, already a giant, blasts away at magnitude -7.0, 15 times brighter than the brightest Venus. Bright enough to cast a clear shadow on the ground and to be seen during the daylight. Now that's bright!

Distances to the stars

Project. . .

Often astronomers are asked how exactly do they know the distances to various objects in space. Aside from the planets, it gets pretty tough to directly measure such a value.

Distance measurements are made several different ways, depending on the kind of object, its relative distance and so on. The planets are easy, but as one looks at objects progressively further out it becomes more and more of a guessing game.

It was an astronomer named Fredrich Bessel who was the first person to ever measure the distance to a star beyond the Sun using a very simple mathematical principles. Bessel specialized in determining the precise position of stars (known now as "astrometry") and did so for over 60,000 individual objects! One star in particular seemed to have a slight motion through the sky as detected by an Italian astronomer in 1792. This suggested that it was very close. If this was the case then the object should appear to change position up against the background stars depending on the location of the Earth. So using this information, in 1838 Bessel measured what is called the "parallax" of the star, 61 Cygni. From here he used standard surveyors methods for figuring out the distance. It seems straightforward enough, but Bessel was working at the limits of his science, having to detect a change in position of *1/10,000th of a degree*! From his calculations he determined that the star was over 10 light years away.

The unfortunate thing about using parallax is that it only works for only about 1000 of the closest stars.

Parallax works like this : hold out one of your fingers at arms length and view it with one eye. Now change eyes and you will notice the finger "jumping" relative to the background. The closer the finger the bigger the jump.

You can now use this phenomenon to roughly determine the distance to an object. Go outside and stand a few yards away from a tree or post, or some other well defined object. This is your starting reference point. Imagine a line drawn between you and the object. Now walk either toward the left or the right, perpendicular to the line. That is the line that you are walking on will form a nice squared angle with the original reference line. Look back at the object and walk until the new line from you to it forms a 45 degree angle to your line of travel. (The reference line is "90 degrees", and the further you walk the smaller the angle will get). When you think you have hit 45 degrees, stop and measure the distance traveled. It should about equal the distance to the object.

What is "astrophysics"

"Astrophysics" is a relatively recent science that applies the laws of particle physics, thermodynamics, relativity, atomic and nuclear physics to explain just what is happening out there.

If you think being a rocket-scientist is impressive, try being an astrophysicist.

An astrophysicist may for example, try to explain what happens to matter when it is heated to a temperature of 30 million degrees inside a star. Or they might tackle the tough question of what gravity really is. Much work is currently being done on the study of the atmospheres of stars aiding in the understanding of a star's internal workings. How do they form? What happens when they die?

Another popular topic is the "interstellar medium" (dust in between the stars) and the "missing mass" problem. According to various theories the Universe should have about 10 times as much stuff in it that we can see. What happened to it? Why can't we see it? Was it lost in the mail?

These and many other key questions are still being hammered out and are still far from being answered. But with better tools, bigger telescopes and more sleepy astronomers, by golly someone's going to find the answers, either that or find more questions.

Voyager 2 and Uranus

On this date in 1986 the planet Uranus was forced to give up her secrets. Having been launched in the summer of 1977, the spindly Voyager 2 and her {ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm} sister, Voyager 1 were to make space history returning images and information about the four largest planets in the solar system that would keep scientists busy for decades, not to mention giving the editors of Astronomy magazine dozens of new cover photos.

The secrets of Jupiter fell to the heavenly twins in 1979, followed by Saturn in 1980 and 81. After Saturn, Voyager 1 completed her planetary investigations and was sent out of the solar system to sail on forever into the inky blackness of space. However Voyager 2 wasn't done, not by a long shot. Using a technique known as "gravitational assist" the spacecraft stole a little bit of energy from Saturn and was shot toward her next stop, Uranus, which wouldn't come into view for another 5 1/2 years. Oh, but it was worth it, !

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\uranus2.sbm}Uranus has the distinction of being the first planet not known to the ancients, the first discovered by telescopic observations. In 1781 noted astronomer William Herschel detected this pale blue disk during an otherwise routine star survey.

The planet is about 31,000 miles in diameter and requires 84 Earth years to make a single one of its years. Unlike the dramatic views of Saturn and Jupiter that Voyager returned, Uranus at first was a disappointment. The Uranian atmosphere was a featureless, opaque blue-green. Under heavy computer processing some very slight cloud bands were revealed. However, its moons were another matter altogether.

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\titania1.sbm}There is Titania, the largest of the Uranian moons at almost 1,000 miles in diameter. Titania was named for the wife of the fairie king, Oberon. (Both Titania and Oberon appear as characters in Shakespeare's "A Midsummer's Night Dream").

Oberon, named for the fairie king, husband of Titania is the outermost moon of Uranus, and at 961 miles in diameter is the second largest by a few miles. Oberon's surface appears to be the oldest, showing relatively little activity. This is probably because of its great distance from Uranus (362,000 miles) so it will be the least affected by tidal effects. Tidal forces are the result of the difference in gravity across an object based on the size and distance of the object. The differences can then literally tear an object apart if it is close enough, or at least bend and flex it around creating canyons, mountains, ice flows, and so on.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\miranda.sbm}Even though it is the smallest and innermost of the five "major" moons, Miranda was a giant of surprises. Similar in makeup to the other moons, ice and rocks, Miranda's surface is crisscrossed with huge fault canyons way out of proportion to its tiny size. This shows that little Miranda has had a violent geologic past.

After Uranus, Voyager stole just a little bit more energy and was shot toward its last stop, Neptune.

You may use First Light to investigate the path the Voyager 2 as it swept by the blue giant. Use the flyby option under planets, select "Voyager 2 at Uranus" and explore to your heart's content, . Notice the arc around the planet as the spacecraft's pathway is distorted by the Uranian gravity field. Next drag the path around and position it so the red part (the part after closest approach) is almost aligned with your eye as it recedes into the distance. You will see a blue spot which is none other than Neptune, a full 3 1/2 years distant.

Volcanos in space

One of the big questions planetary geologists ask about a newly explored body, is: "is it still alive?" That is, does it still have active geologic processes going on or is it a "dead" world. The greatest indicator of activity past or present is the existence of volcanoes. By far the largest and most spectacular of all known volcanoes is that of Olympus Mons (Mount Olympus) on Mars.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\olympus.sbm}This is perhaps the most famous feature on Mars next to the ice caps and the nonexistent canals. Its base is over 370 miles across and is nearly 17 miles high or almost three times the altitude of Mt. Everest. When the seeing is very clear and Earth and Mars are at their closes, Olympus Mons becomes visible in Earth based telescopes, one of the only Martian geologic features to be so.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\io1.sbm}Next stop is the wild landscape of Io one of the original moons discovered by Galileo. Perhaps the greatest singular moment in the missions of the Voyager probes was when photographs were returned of a volcano on Io actually in the very process of erupting! In fact dozens of volcanoes were found, with about 5% of the surface made up of active volcanic vents. There was so much activity, it appears that Io is hellbent on turning itself completely inside out.

The third volcano is wildly different than the other two, and as with Io, it to was caught in the very act of erupting, but unlike Io, it is a *frozen* volcano. The plumes carry darker material from within the planet to the lighter surface. This makes Triton only the third object after the Earth and Jupiter's moon Io, to have active volcanoes. The streaks are about 100 miles long and were enhanced by Triton's thin nitrogen atmosphere.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\tri_clo2.sbm}This image shows the southern region of Triton. The coloring most likely comes from methane based material. The light areas are nitrogen or methane snows.

How high the mountains?
Project. . .

Materials needed : scientific calculator (any calculator with trigonometry functions), a tape measure, the Sun and something really really tall outside (Shaq doesn't count).

It is no great secret the the heights of lunar mountains and the depths of lunar craters are pretty well known. Well, how does one figure out these things anyway without actually going there? Do you remember your high-school trigonometry classes? Sure you do!

Knowing the distance to the Moon, astronomers can visually determine the physical length of shadows cast by various mountains. Using that information along with the angle of the sunlight at the time of the readings it is a very easy matter to find out the heights.

You can do that with your house or a nearby tree, telephone pole or other high object. For this exercise you will need to know the "altitude" in degrees of the Sun at noon. Set up First Light to noon of the day (today or tomorrow for instance if it is already after noon) you intend to do the experiment. Use go into Local mode and center the Sun. Turn on the altitude scale, done through *extras/markers/local altitude*. This will give you good general figure for the angle the Sun at noon. Now, right at noon, go outside and measure the length of the shadow of the object using a tape measure. This distance must be measured from under the highest point of the object. If it is a tree or telephone pole, they are slender enough not to make a difference, but if it is your house, the distance from the outer wall to the end of the shadow will probably be too short. Using your calculator determine the "tan" (tangent) of the Sun's angle. If the angle is say, about 45 degrees, the tangent will be around 1.0, if it is less, the tangent will likewise be less. Multiply this value by the shadow's length and that should be the height of the object! See, that was pretty painless, wasn't it?

Caelum, the Chisel

Besides mythological beasts and heroes of old, the night skies are also populated with bits of man-made machinery. Caelum, the chisel is one such constellation. Another would be Circinus the compasses, Fornax the furnace and Horologium the pendulum clock.

Most of these constellations are rather small and uninteresting and were introduced in the 18th and 19th centuries by various zealous astronomers who wanted to honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient constellations.

Caelum is one such creation, added by the French astronomer Nicolas Louis de Lacaille in the mid-1700s, . Caelum has no myths surrounding it, no major stars or no significant objects. However, as an eye test you might want to try and see it for yourself. Go ahead, I dare you!

And, you too, can now claim to have seen the most pointless of all constellations.

Apollo 1

Space travel is dangerous, and always has been. Man pushes machines to their very limits and in turn machines push man to their limits, and sometimes beyond. And if someone makes a mistake, it might be their last in this most unforgiving business. This truth was never more clearly realized on this date in 1967 when three American astronauts paid the ultimate price for their exploratory quests.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\apollo1.bmp}It was early evening in Florida and the crew of the first manned Apollo mission was on board their spacecraft, rehearsing the countdown. With only about a month to go until the actual flight, such rehearsals were becoming very common in order to get the last kinks out of the system. However the mission would never take place. At a little past 6:30, the astronauts Gus Grissom, Ed White and Roger Chaffee were getting frustrated over a long tiresome day of technical glitches, communication problems and other things that did not bode well for their vehicle. At 6:31 the word "fire" was heard crackling over the communications loop. Views from a closed circuit TV camera clearly showed bright flames dancing in Apollo's windows. Rookie astronaut Roger Chaffee then stated "we have a fire in the cockpit". Less than half a minute after the first transmission a scream was heard and the craft went silent as the complicated cockpit crammed with hundreds switches, dials and lights was tranformed momentarily into a blast furnace. The temperature rose to 2500 degrees and unable to handle that the spacecraft split open due to the intense heat. The crew never have a chance.

No one seemed to have considered a spacecraft fire to be a serious problem. The investigation pointed out dozens of flammable items in the cabin. Even things that were fire resistant under normal use became deadly when the cockpit was filled with its standard pure oxygen atmosphere. Shoddy construction caused the initial spark and thoughtless designs helped it along. Not to mention perhaps the simple fact that the crew hatch was made purposefully difficult to open. Its design was selected to save precious weight which was at a premium, and to minimize the possibility of cabin leaks since the air pressure inside essentially locked the hatch tight up against the hull. When the fire occurred, the high pressure did what it was supposed to do: it made the hatch impossible to open.

January was not a good month for NASA, and on another January day 19 years and one day in the future seven other astronauts would also pay the ultimate price as their spacecraft, the Challenger, lifted off into the cold cruel morning sky.

Oort Cloud

So, where *DO* comets come from? Such a question is asked frequently in the astronomical circles. Dutch astronomer Jan Oort decided to answer it, and the result was the concept of the "Oort Cloud", a "cloud" of comets orbiting between 30,000 and 100,000 astronomical units distant from the Sun. Such a cloud would consist of pristine primeval solar system material left over from the creation of the solar system, frozen in the darkness of deep space. Every so often a passing object, be it a star or unknown planet may disturb the cloud and cause one of its members to swing toward the Sun. When close, the frozen material, water ice mainly, evaporates and forms the now familiar tail, rendering it a spectacular sight for inhabitants of the third planet. Once it sweeps past the Sun it heads back out in the the darkness, not to be seen for perhaps millions of years to come. If its orbit is perturbed in any way by Jupiter for instance, it may end up in a new relatively short term orbit, and become a *periodic* comet such as Halley's (which returns every 75 years or so).

While the Oort cloud has never been seen, it seems to fit all of the current facts. One of the experiments scheduled for the Hubble space Telescope will be a study of neighboring stars to see if they have cometary clouds of their own (this experiment was proposed by an amateur astronomer, not a professional, and shows just how seriously the pros take the hobbyists).

Challenger

Yesterday, January 27, was the anniversary of the nation's first space-related accident, when three Apollo astronauts died as fire roared through their cabin during a launch countdown rehearsal.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\sts51.bmp}However, on this day in 1986 NASA would herald a new era in space exploration, an era that suggested that space travel was now safe enough to be considered routine, and routine enough so an average citizen could fly. In this case the citizen was the distinctly non-average New England school teacher named Christa McAuliffe. From her perch high atop everything, Christa would beam broadcasts back to schools across the country explaining space travel to millions of students.

But such was not to be. It was a cold morning that day, and icycles hung from all over the shuttle. Some in NASA management and others were concerned that perhaps something on board might not like that cold, but everything was supposedly rated at freezing temperatures so the mission was given a go.

The most dangerous part of any shuttle mission is the first two minutes as the mighty solid-rocket boosters are firing. If something were to go wrong there would be no way to shut them down, nor could they be released early. Once burned out and thrown away the rest of the flight would be relatively smooth sailing. Solid rockets are also fairly simple not needing the delicate machinery that liquid-fueled rockets do. The tricky thing with these boosters was that they had to be built in segments and the segments had to be sealed. If a seal gave way during a mission, well, there was nothing the crew could do.

The cold temperatures did not affect the rubber seals favorably. On launch, the seals would normally slam shut when the pressurized gases hit them, but on this day the rubber was too cold and sluggish to react, opening up a small leak along one of the joints. And as it would happen the leak was aimed in the worst possible direction, right onto the mounting supports for the booster. Acting like a flame thrower the leak burned through the supports causing the one booster to pivot along the remaining support and crash into the top of the giant external fuel tank. The tank collapsed causing the shuttle to hit the air at angles it was not designed for, and the stresses ripped it apart instantly. Horrified spectators watched as fragments fluttered down to the ocean for over an hour, falling from an altitude of 65,000 feet. It would be a full 2 1/2 years before the next shuttle would fly.

The deaths of the crew, Dick Scobee, Michael Smith, Ellison Onizuka, Ron McNair, Judy Resnik, Christa McAuliffe and Gregg Jarvis would spawn the creation of the Challenger Centers, a network of space education facilities world-wide that would continue their mission. Through hands-on experiments and mission simulations, thousands of students and teachers alike would get a taste of the promise of space travel and spark an interest in science and the wonders of the Universe. Much in the same way that Apollo did for the author of First Light.

In honor of the seven astronauts the International Astronomical Union named 7 craters on the Moon after them. The craters, ranging in size from 20 to 60 miles across are located in a larger crater named Apollo, on the back side of the Moon.

Gravity in space
Project. . .

Materials needed : a penny, a clear plastic pop bottle, some gravity.

It is a common misconception that in space there is no gravity. We have all heard of "zero-gee" from the astronauts, so maybe gravity ceases to exist outside the atmosphere. Wrong graviton breath! Gravity is everywhere we go. There is no such thing as zero-gravity, if there was the planets would have spun away from the Sun eons ago.

The effect of zero-gee is created simply when you are falling along with your frame of reference. Imagine being in an elevator at the top of the shaft. Now imagine that the cable breaks and the elevator free-falls down the shaft. You and all of your packages would fall right along with it at the same rate and to all appearances at least for a very brief period of time, you would be weightless, experiencing zero-gravity. Yet gravity was there all along.

The same thing essentially happens inside the space shuttle, but the shuttle while "falling" is falling over the horizon of the Earth in a curve that precisely matches that of the Earth. So the fall is continuous, and since everything inside moves at the same speed weightlessness happens.

You can see this for yourself. Create an "elevator" out of a clear plastic pop bottle. Place inside a penny, close the top and drop it. You should see the penny for a brief moment "floating" around the bottle.

Explorer 1

On October 4, 1957, the world was shocked wide awake when the supposedly backwards Soviet Union launched the first ever artificial Earth satellite, Sputnik 1. The United States in turn was readying their own satellite, the Vanguard 1, for a launch later in the year. Compared to Sputnik, the round silvery Vanguard looked a might puny. Sputnik weighed nearly 200 pounds where Vanguard weighed in at less than 10. Pressured by the bad publicity at being the also rans, the Vanguard crew prepared for a launch on December 6, 1957. The launch went OK but the rocket's range was a bit on the "short side" as one of the official put it. For on live TV   the rocket was seen to move up two feet before it fell back to the pad collapsing into a ball of flame.

Vanguard was a civilian project, the rocket having been created from scratch. President Eisenhower wanted it that way to avoid any military overtones whatsoever. (in fact, some 1956 military launches were required to weigh down the nosecones with sand actually to ensure that nothing could accidentally go into orbit). However, the military had the technology to do the deed, so they were given the go ahead to put up something as quickly as possible to get over the embarrassment of Vanguard. A mere five weeks later on this date in 1958 the Explorer 1 was lofted on a four stage Jupiter C rocket into Earth orbit. Like the Vanguard, the Explorer was small when compared to Sputnik, but what the Soviets had to do with might, the Americans could do with advanced electronics and satellite design. And unlike the Sputnik which merely had a radio beacon, the Explorer carried scientific equipment that lead to the discovery of the Van Allen radiation belts.

Vanguard would go on to fly two modest missions later that year, but that first tiny "silver grapefruit" may be seen in its charred glory at the Smithsonian Air and Space Museum to this day.

Horologium - the Pendulum Clock

Besides mythological beasts and heroes of old, the night skies are also populated with bits of man-made machinery and miscellaneous stuff. Horologium is one such constellation. Another would be Circinus the compasses, Fornax the furnace and Sculptor, the artist's studio.

Most of these constellations are rather small and uninteresting and were introduced in the 18th and 19th centuries by various zealous astronomers who wanted to honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient constellations.

Horologium is one such creation, added by the French astronomer Nicolas Louis de Lacaille in the mid-1700s. Lacaille was also responsible for Antlia, Caelum, Circinus, Fornax, and several other machine-based arrangements. Of the two other modern era astrocartographers, Pieter Keyser concentrated on creating animal constellations such as Dorado the goldfish or Pavo the Peacock. While Johannes Hevelius preferred a mixture of animate and inanimate objects and tried to link them in to the existing Greek constellations if possible.

Horologium is one of the faintest constellations, its brightest star shining a feeble fourth magnitude. It has no deep-sky objects of any interest to amateur astronomers.

Since it is in the southern skies, Sculptor will be low on the horizon for northern observers, but see if you can find it tonight, lying right below Eridanus.

Gemini, the Twins

"When wintry tempests o'er the savage sea
Are raging, and the sailors tremblingly call
On the Twins of Jove with prayer and vow...", Percy Bysse Shelly

The twins in Greek mythology were Castor and Pollux, sons of Zeus. Together they shared many exploits...sailing in search of the golden Fleece with Jason and the Argonauts, or fighting over a pair of women with another set of twins. At several times they were instrumental in saving Jason and the crew of the Argo making the twins the patron "saints" of sailors. In the book of Acts of the Apostles in the New Testament, the Apostle Paul while sailing toward his next destination wrote "we departed in a ship of Alexandria which had wintered in the isle, whose sign was Castor and Pollux".

When fighting for the women, Phoebe and Hilaira, Castor was killed. His brother begged Zeus to permit them to "share immortality", and Zeus obliged by placing them both in the Heavens where we see them to this day gazing Earthward in their brotherly embrace.

The two brightest stars in Gemini are rightfully named after the brothers. Pollux, the brighter shines its orange light at magnitude 1.1, while Castor is just slightly dimmer shining at 1.6 and is a complex multiple star with 6 known members.

Also in the constellation is the star cluster M35. Located near the foot of Castor it shows up as a fuzzy patch in binoculars but may be resolved in to myriads of tiny glittering stars with a telescope. Over near the "arm" of Pollux is the planetary nebula NGC2392 also called the Eskimo Nebula due to its resemblance of a person's face surrounded by a fur parka hood (trust me, it really looks like that!). At eighth magnitude it might be visible, just barely, in binoculars but should be a fine object in a scope.

It was also near the star *Delta Geminorum* that Pluto was first discovered.

Click here and First Light will center Gemini for you.

M35

As winter drones on, feel free to step out and take a look at the constellation Gemini, the Twins. Marked by two brilliant stars, Castor and Pollux, Gemini plays host to a fine open star cluster, M35 visible even with the naked eye on the darkest nights. It has several hundred stars and is considered a good object even in the smallest scopes, . Its diameter is estimated to be around 30 light years.

Virgo Galactic Cluster

Hidden within the realm of the undistinguished constellation of Virgo is one of the most remarkable regions of the sky. If you set your gaze toward the upper border you'll be looking at the great Virgo cluster of galaxies. So thick are these it is sometimes referred to as a swarm or even "cloud".

Located some 65 million light years away the Virgo Cluster (also called the Virgo-Coma cluster) has had over 3000 members identified, 300 being visible in a small telescope.

Click here  to have First Light show you this fascinating area.

The cluster is important not only for the variety of members, but as an aide to determining the size and age of the Universe. For it is situated just right to yield the information the astronomers need. Unfortunately, that information was locked up inside individual stars called "Cepheid Variables" but the galaxies were just too far away for Earth based telescopes to show them. The Hubble Space Telescope changed all of that, rendering the Virgo galaxies with a clarity that astronomers could only fantasize about a few years before.

Cepheid Variables are stars that vary their brightness in a predictable fashion. Their brightness would peak at given intervals based on their overall luminosity. If you know their period, you know how bright the star really is and can then easily determine just how far away based on its visual brightness. Using the Space Telescope a number of these "Cepheid" stars were spotted very quickly. The data led to the dramatic conclusion that the Universe was a lot younger than believed, only about 10 billion years than the previously assumed 15 or 20 billion. This has caused many problems forcing armies of cosmologists back to the drawing boards to rework their many theories. Not all are so quickly to accept it and much more study will be needed to prove the new values. However it is expected that within the next three to five years the last questions will be answered and the most vexing question of all will at last be solved.

astronomical unit :
One astronomical unit is the distance from the Earth to the Sun, or about 93 million miles. Jupiter orbits at about five AU for instance and Pluto at about 40 AU.

Halley's Comet

{ewl ewdll.dll,ewBitmap,ew_bmps\ast_etc\halley1.sbm}IPerhaps some of the most visually interesting objects in the solar system are comets, and the most famous of these is Halley's. Composed mainly of frozen water with particles of other materials, comets are referred to as "dirty snowballs", and are believed to represent the most pristine material in the solar system. Some comets are very well known such as Halley's Comet, but most tend to live their lives in relative obscurity far from the Sun in what is called the Oort Cloud. This is believed to be located between 30,000 and 100,000 astronomical units from the Sun. On occasion a passing star or planetary body might disturb the comets driving some toward the Sun in its wake. When near, the solar-heating will cause the outer layers of the body to evaporate creating a fuzzy halo (the coma) which can be thousands of miles across. As it draws closer, the distinctive tail begins to form as the electrically charged solar-wind sends the gases millions of miles behind the main body. These gases are extremely rarefied, making a comet "the closest thing to nothing which can be called something".

Comets are typically discovered only two or three months before their greatest visibility. Most are found by dedicated amateur astronomers and are named after their discoverers.

What makes Halley's so unique among the 700 plus known is that it was the first whose return was predicted. Sir Edmund Halley, the second English Astronomer Royal realized that bright comets seen in 1531, 1607 and 1682 were in fact the same object. From this information he predicted that a bright comet would be visible in 1759. His prediction proved correct and the comet was named after him in his honor. It is now known that Halley's comet has formed a rich thread through history, being recorded since 240 BC in both literature and art. Because of this, its 1986 apparition was eagerly awaited by astronomers and laymen alike. Unfortunately 1986 was a bit of a disappointment due to the fact that even at closest approach the comet was still 36 million miles away. Compare this to the apparition in 837 AD when Halley's was a mere 3.7 million miles distant (only 15 times the distance of the moon).

To see Halley's at its last appearance, click here . Your view should now be set up starting in 1982. Why 1982? This was when the comet was first seen since 1911, recovered by astronomer G. Edward Danielson of Caltech. Halley's was now just outside the orbit of Saturn. Over the next three years the comet gradually brightened up until it was finally visible in medium sized telescopes by the fall of 1985.

Set the date to October 1, 1985 and you will see the comet sweeping toward the orbit of Mars with a small tail just starting to show. Now things begin to get real busy. Use the fast-clock button to advance the date only two months to December 1, at one day increments. The comet has brightened up to where it is just on the edge of visibility for the naked eye for the first time in nearly 76 years. Notice how it moves in the opposite direction of the Earth, as Halley's gets closer to the Sun, the Earth moves further away. Advance the date to January 15, 1986. Now the comet fades from view as it heads into the evening twilight toward its closest approach to the Sun on this date, February 9th..

Jump ahead to March 15, as Halley's emerges from behind the Sun. At this time it is visible in the early morning hours, rising slowly in the sky. Closest approach is on April 10. Notice that the geometry is such that the comet is viewed nearly front-on making the tail appear to be extremely short. This is one reason why this apparition was so poor. By contrast, in 1910 the Earth actually passed through the tail.

May 25 began the last period of time to see the comet with the naked eye as it headed outbound. Switch over to the view from Earth and center the comet. Now turn on the time-rate to one-day increments and watch Halley's say "goodbye".

You might want to go back and observe the it again, but from different viewpoints in the solar system.

Now set the clock to todays date and center Halley's. Look at where it is from the Earth, and then jump out into space using *lookdown* and see where it is in relation to the rest of the planets.

March

March 1 : The Oort Cloud
March 2 : Cancer, the Crab
March 3 : M44, the Beehive Cluster
March 4 : What is a "day"?
March 5 : Voyager 1 visits Jupiter
March 6 : Copernicus
March 7 : Puppis, the Ship's Stern
March 8 : Project - Sidereal motions part 1
March 9 : Monoceros, the Unicorn
March 10 : B Monoceros, triple star
March 11 : The Eskimo Nebula
March 12 : William Herschel, astronomer extrodinare
March 13 : Discovery of Uranus
March 14 : North Galactic Pole
March 15 : Project - watching a sunset
March 16 : Hydra, the water snake
March 17 : Felis, the cat
March 18 : The Ecliptic
March 19 : Back side of the Moon
March 20 : Spring, the Vernal Equinox
March 21 : Spring skies : Leo, Virgo, Hercules, Bootes
March 22 : Project - Sidereal motions part 2
March 23 : Spring Deep sky objects
March 24 : Spring skies : Libra, Scorpius, Corvus
March 25 : The Redshift and stellar distances
March 26 : Charles Messier and his catalog
March 27 : Lunar Libration
March 28 : The Biggest Telescope
March 29 : Missing Mass problem
March 30 : Copernicus, the crater
March 31 : Project - Light Pollution

The color of the stars

Project. . .

supplies : a clear night, binoculars (if available), a red giant and blue supergiant star

Go outside if it is clear tonight, and glance up at the stars. What color are they? Chances are you'll say "white, you dweeb! Don't waste my time, I gotta get back to Star Trek Voyager".

But are they really white? You have probably heard of "red giants" or "blue giants", or double stars described as being green and violet. Stars do have colors, unfortunately our eyes are not quite sensitive enough to tell without a bit of practice.

Star "colors" (more commonly called "spectral type") have proved to be a convenient way to classify them. The color, or "spectra" is used to tell astronomers such things as the temperature of the star and its chemical makeup. To do this they use a "spectrascope" which breaks the stars light up into a rainbow much in the same way a prism does when placed in sunshine. The rainbow will then reveal dark lines, called absorption lines, at certain precise locations that are caused when the different chemical elements within the star absorbing certain colors of light. So helium shows up as one set of lines and hydrogen as another set.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\hr_dgram.bmp}Stars are first subdivided by one of 11 spectral classes : O B A F G K M N R S W. O through M were the first types specified and go from the hottest to the coolest. The others, N R S W, were added later to cover more recent discoveries. The Sun is a type G star.

No doubt you have seen how a hot piece of metal will turn red then orange then up to white the hotter it gets. The same happens with stars. O stars are blue-white due to their intense heat, and on the other hand the cooler ones are red or orange.

Now we're going to take a look at Aldebaran an orange giant, (type K5) and Rigel a blue supergiant, (type B8). Once you find them with First Light go outside and take a look at them for real. Rigel if you recall is the foot of Orion, the hunter, whereas Aldebaran is the eye of Taurus the Bull right next door. Use your binoculars and you will likely detect the rusty hue of Aldebaran when compared to the burning blue-white of Rigel. Note how bright Rigel is then realize that it is *15 times* further away from us than Aldebaran (900 light years vs. 60, a good indicator their actual brightness). Also as a supergiant Rigel is 60,000 times the luminosity of our own Sun, making it one of the most luminous stars known. On the other hand Aldebaran is only 125 times that of the Sun.

Procyon

The constellation of Canis Minor, , the Little Dog is rather insignificant except for the fact that it leads Canis Major, the Great Dog. It also it is home to the eighth brightest star in the sky, Procyon, whose name is Greek for "before the dog". Like Sirius and other of the brightest stars, Procyon has a rich history of references in ancient literature. The Arabs called it "Al Shi'ra al Shamiyyah," the Babylonians called it "Kakkab Paldara."

According to the Greeks, Canis Minor was Maera, belonging to Icarus the inventor of wine. One day he gave some wine to a few clueless shepherd. Mistaking their drunken state for being poisoned they killed Icarius. Maera the dog ran home to and returned with Erigone, the daughter of Icarius who upon seeing her dead father both she and the dog committed suicide. Taking pity on them, Zeus immortalized the three in the heavens for all eternity. Maera became Canis Minor, Erigone is now seen as Virgo, and Icarius is Bootes.

Like Sirius, it has a white dwarf companion, too dim to see. With a mass 65% that of the Sun and a diameter of only 17,000 miles, it has a density of two tons per cubic inch. Now go out and see if you can find Procyon. As the name says, he should be there, leading the Great Dog.

Canis Major, the great dog

Running after Orion in the winter skies you will find Canis Major, the great dog, . Is he merely following the hunter? Or is he possibly chasing after the rabbit, Lepus, beneath Orion?

As with many of the mythological constellations, there are many different conflicting stories surrounding the dog. One has it that he is the guard dog of Orion. Another suggests that he belonged to Procris, the daughter of the king of Athens. He was said to be a gift from Zeus, presented along with a javelin that would always hit its target. This turned out to be a curse as she was killed in a hunting accident.

Her husband took ownership of the dog and brought it with him to Thebes, north of Athens, where the countryside was being destroyed by a terrible fox, a fox that was so fast it was considered uncatchable. The dog, Laelaps, was released to rid the town of this scourge. But the fastest fox stayed ahead of the fastest dog, creating a paradox that seemed without solution until Zeus turned them both into stone. Laelaps he then honored by placing him in the heavens.

Canis Major contains a number of very bright stars, one of them being Sirius, the brightest of all (not counting the Sun of course). The name comes from *seirius,* which means "searing" in Greek. Naturally, Sirius was given many powers and attributes. When it first becomes visible in the late part of summer, rising just before sunrise, it marked the hottest time of the year. Hence the name "Dog Days of Summer", since the ancients thought the brilliance of the star had a heating effect on the Earth.

Sirius is a double-star with a white dwarf companion visible only in telescopes, that orbits once every 50 years.

Canis Major also contains a number of fine deep-sky objects. M41, just south of Sirius, is a large naked eye open cluster of about 100 stars. The cluster is receding from us at around 20 miles/second and is 20 light years across. This is one of the few deep-sky objects to have been recorded by the ancients, being mentioned by Aristotle around 325 BC.

Sirius, the brightest star

Alpha Canis Majoris, "Sirius," has also been known as "The Dog Star," "The Nile Star," and "The Scorching One", . Being the brightest star next to the Sun, Sirius has an impressive collection of myths and legends attached to it. To the Egyptians, it signaled the time for the Nile to rise. Virgil told on how it brought drought and disease.

The name comes from *seirius,* which means "searing" in Greek. The star was given many powers and attributes. When it first becomes visible in the late part of summer, rising just before sunrise, it marked the hottest time of the year. Hence the name "Dog Days of Summer", since the ancients thought the brilliance of the star had a heating effect on the Earth.

Sirius is about 23 times the luminosity of our Sun over twice the mass and at 1 1/2 million miles across, is nearly twice the diameter.

This is an unusual double star in that it has a tiny "white dwarf" companion (mag. 8.65) visible only in larger telescopes. The dwarf is only twice the size of Earth, but has as much mass as the Sun. This makes it so dense that a cubic inch would weigh over *2 tons!*

There are a number of mysteries surrounding the star. Many of the ancients described it as reddish in color. Yet it seems unlikely that it could change it color so drastically over only a few thousand years. More recently in certain popular books over the past couple of decades, much as been made over the apparent fact that the Dogon tribe of Africa speak of Sirius and her invisble companion in their legends. Some say that this can only be due to extraterrestrial visitors passing on their knowledge to the Dogons. How else could such a thing happen? Piffle! More likely their unusual knowledge was handed to them by a passing 19th missionary who would likely know of such things if he was well read. Noting their interest he no doubt simply told them of the most recent discoveries dealing with "their" star.

M41 - Open Cluster

Within the constellation Canis Major, the great dog, is a splendid star cluster called M41, . Located just south of Sirius, it is a large naked eye object of about 100 stars. The cluster is moving away from us at around 20 miles/second and is said to be about 20 light years across. This is one of the few deep-sky objects to have been recorded by the ancients, being mentioned by Aristotle around 325 BC.

Beta Pictoris, a most unusual system

Beta Pictoris is, for the most part, an unremarkable star in the most unremarkable constellation of Pictor. However, what makes this star different is the possibility that it has planets in formation.

One of the so-called holy grails of astronomy is to detect planets around other stars. Unfortunately, when compared to a possible central star, any planet is going to be very very dim, for the most part undetectable. Even from the nearest stars, our own solar system would be invisible.

The solar system fell into place not so much due to wayward planets captured by the Sun. Rather it was formed at the very same time from extra stuff left over from the Sun's own birth. This material would first create a flat disk or ring surrounding the Sun, and over a period of eons the material would begin to clump into what would later become planets. Due to the size of the dust cloud, some scientists felt that it might be possible to detect one around other stars which had their own planetary systems in formation. Such appears to be the case with Beta Pictoris. Pictor is deep into the southern skies, and should only be visible from the lower northern latitudes. Should you be able to find this, track down Beta Pictoris and imagine yourself an ancient astronomer four billion of years ago. You are observing an average yellow star and being witness to the creation of a new planetary system. A system which would later produce a total of nine planets including a lovely, mostly harmless, blue one somewhere near the central star.

Barnard's star, the runaway

To the ancients, the stars were fixed, unmoving symbols of a comfortably consistent Universe. They never knew of Barnard's Star. Discovered by E. E. Barnard in 1916, "his" star is at once one of the least luminous known and one of the swiftest. It is a "red dwarf", a small cool star with only 1/2500th the power output of the Sun. But what it is really known for is its swift motion through the sky. Called "proper motion", this is simply a measure of the movement of a star as viewed from Earth. The proper motions of the stars in the Big Dipper, for instance, will cause the bowl to flatten out in 20 or 30 thousand years. Need I say that First Light can demonstrate proper motion? Center the winter constellation of Taurus the Bull and zoom in to the Hyades star cluster, that "v" shape of stars that forms the bulls head right next to Orion. Select the option, expert/stars/proper-motion. You will notice all sorts of dim gray lines being drawn through the stars. These show the stars' pathways through the sky for a 50,000 year period of time, the red dots indicating the end of the journey 25,000 years from now.

At this rate, Barnard's star would be placed somewhere near Nome, Alaska, for it is moving 1 degree every 400 years! That's one quarter of a degree in 100 years! Pretty amazing when typical motions are in the neighborhood of 1/1000th of a degree per century or less.

Barnard's star is also one of the nearest, at merely six light years distant only 3 other are closer. Located in the constellation Ophiuchus, it shines at a paltry magnitude 9.5.

A Comet's Tail

Project. . .

supplies : Ping-pong ball, several 12 inch pieces of string, some tape, a 12 inch stick and a blow dryer.

The most noticeable part of a comet it its notorious tail, usually a million miles or more of very tenuous gases streaming out into space. Composed of mainly frozen water with particles of other materials, comets are referred to as "dirty snowballs", yet are believed to represent the most pristine material in the solar system. Some comets are very well known, such as Halley's Comet, but most tend to live their lives in relative obscurity far from the Sun in what is called the Oort Cloud. This is believed to be located between 30,000 and 100,000 astronomical units from the Sun. On occasion, a passing star or planetary body might disturb the comets, driving some toward the Sun. When near, the solar-heating will cause the outer layers of the body to evaporate, creating a fuzzy halo (the coma) which can be thousands of miles across. As it draws closer, the distinctive tail begins to form as the electrically charged solar-wind sends the gases millions of miles behind the main body. These gases are extremely rarefied, making a comet "the closest thing to nothing which can be called something".

Contrary to what you may think, a comet's tail does not flow "behind" the comet, relative to its motion (as exhaust trailing from car for instance). Instead, it goes opposite the direction of the Sun. You may demonstrate this by the following: Take a ping-pong ball and tape some short (12 inch) lengths of string to it. Mount the ball on the end of a small stick or pencil. Now take the blow-dryer and aim it at the ball. The dryer is the Sun, and of course the ball is the comet. You can move the "comet" around in any direction : forwards, backwards, left or right and you will notice that no matter which direction it moves, the streamers will always be stretched out away from the dryer.

Click here and you should see Halley's near its closest approach. Advance the time using the button on the toolbar, and you can see that the comet's tail always points away from the Sun, about 90 degrees from the direction of motion.

white dwarf :
A tiny star about the same size of the Earth with a luminosity of less than 1/10,000th of the Sun.

Canopus, the second brightest star

Most people know who the first U.S. president was, but who remembers the second? Most people know who the first person to fly across the Atlantic was (Lindbergh), but who remembers the second? Likewise many will know that Sirius is the brightest star in the sky, next to the Sun. But how many know about the second brightest star, Canopus?

The legends about Canopus are somewhat fewer than other stars since it could not be seen from Greece, limiting exposure to those who could travel south. Canopus is named after the helmsman of King Menelaus of the Greeks. Returning from Troy with Helen, he landed in Egypt after having been driven off course by a mighty storm. In Egypt, he was killed as a result of a snake-bite and buried with honor. It was at this site that the city of Canopus grew at the Nile's mouth.

One reason why Canopus is relatively unknown, at least to the northern hemispherians, is that it lies deep in the southern skies, as part of the constellation Carina, . If your latitude is less than 38 degrees you might just be able to see it tonight. From the southern United States, for instance, it will rise at about 10 PM and be directly south. Use First Light to determine the best time for your viewing and to find out if it is even visible.

Canopus is believed to be about 30 times more luminous than the Sun, and is commonly used by spacecraft for navigational purposes.

Telescopium Herschelii (huh?)

How many constellations are there? Currently there are a total of 88, however this has not always been the case. The classic Greek based constellations number only 48, and these include those of the Zodiac for instance, or Orion, Canis Major, Hercules and so on. . .for the most part mythological beasts and heroes of old. However in the mid-18th and 19th centuries numbers of over zealous astronomers and celestial mapmakers introduced "new" constellations in order honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns. While one astronomer would seek to popularize one of his own, a competitor would ignore him and add *his* own. And for this reason, the skies are littered with odds and ends of constellations that once were. Most of these are rather small and uninteresting.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\telhersh.bmp}Forty of the new ones have been officially recognized and remain to this day on the charts. These bits of celestial flotsam include such noteworthy spectacles as Caelum, the chisel, Circinus the compasses, Fornax the furnace and Horologium the pendulum clock. Few have with any interesting objects, and all are rather dim. However there are many more of these that never made it in to regular use or were absorbed by larger neighbors. One such grouping is *Telescopium Herschelii*, created in 1789 by Maximilian Hell of Vienna to honor William Herschel's 1781 discovery of the planet Uranus. Originally there were two such constellations, Tubus Herschelii Major depicting Herschel's mammoth 20 foot long scope and Tubus Herschelii Minor dealing with his smaller 7 foot scope, the one actually used in the discovery. Later these were condensed to merely the one and set in between Lynx and Auriga. If you look there now you will see a small arrangement of fourth and fifth magnitude stars reminding us of a constellation that never was, .

Asterisms

When asked about favorite constellations, some might respond after a few moments of deep thought, "Oh! The Big Dipper!", . For which you have my full authority to say "wrongo, magnitude breath!". For the Big Dipper is not a constellation, but what is known in the trade as an "asterism", or a portion of a constellation. Asterisms are simply convenient grouping of stars which may lie within a single constellation, or stretch across several, and frequently reflect local culture. What we call the Big Dipper, since it looks somewhat akin to a large spoon or water ladle, the English refer to as the Plow.

Another popular asterism is the Teapot of Sagittarius, perhaps as clear as any pattern you'll ever see, . Then there is the Sickle in Leo formed out of the lions tale, or the Northern Cross embedded inside Cygnus the Swan, . Center Virgo and see if you can spot the Virgo Triangle made up of Spica in Virgo, Arcturus in Bootes and Denebola in Leo, . Then there is the Great Square of Pegasus, , and Summer Triangle (Vega, Deneb and Altair), . In winter there is the lesser known Winter Hexagon comprised of Capella, Pollux, Procyon, Sirius, Rigel and Aldebaran (major stars of six different constellations), .

See if you can make up your own asterisms. Name them after yourself, your pets, your state senator or your favorite character on "The Simpsons".

Project - making craters

Project. . .

supplies : *flour, chocolate powder, a plastic bowl, meteor, er, marble and a clear area that can get messy.*

If you've observed the Moon at all you have no doubt marveled at its pockmarked face. Craters by the millions litter the lunar landscape and provide dramatic views through even the smallest telescope or pair of binoculars.

Craters are produced two main ways : by volcanoes or by the impact of meteors. Most impact craters on the Earth have been washed out due to eons of erosion from the weather, but scientists have identified dozens of impact sites around the world. The most notable one is the Barranger Meteor Crater in Arizona. As far as craters are concerned this is a rather pathetic specimen, but since it is so recent (relatively speaking) it is the only Earth-based impact crater that really looks like one! It measures about 4000 feet wide and is about 400 feet deep. Current estimates place it at around 50,000 years old.

On the Moon you probably have seen the crater Tycho, one of the most visible of all due to its massive network of light colored "rays" spreading out from the impact site. These rays are caused simply by lighter material being thrown out across the darker lunar surface thousands of miles away, much like a splash of water.

In this project you will make your own impact craters with rays. Get a moderately sized plastic bowl and fill it with a couple of cups of flour so you have a region about six inches across or more. Now on top of the flour sprinkle some chocolate mix, not too deep but just enough to completely cover the white. This will symbolize the darker material on top of the lighter. Place the bowl away from things that might get messed up if flour should hit them. Outside always works if the air is still or inside on a hard floor away from the carpets and the family dog. Take a marble, and from a height of about four or five feet drop it down into the middle of the bowl. You should now have your very own crater! The white flour should have sprayed out over the dark surface of the chocolate. Take a bright light and shine it across the crater from one side and notice the shadows it produces and how similar it looks to the Moon (you may have to remove the marble if it didn't completely disappear in the flour).

When you look at the Moon you rarely see just one crater in any area, you see many on top of many on top of many more. You can achieve this effect by dipping your fingers in some water and dripping it from several feet above your moon's surface to add more detail. When done make sure to remove the marble and clean up things completely.

If you desire to do more complicated and authentic simulated lunar surfaces, charcoal ash from the barbecue is a bit more realistic lunar soil. It is fluffy and much lighter than flour and can make some very realistic surfaces if you want to take simulated lunar photos.

The Discovery of Pluto

The ancients knew of five planets in the solar system : Mercury, Venus, Mars, Jupiter and Saturn. It wasn't until 1781 when the sixth planet was added to the great pantheon thanks to the dedicated work of William Herschel who discovered Uranus during a routine star survey. This was a tremendous achievement, leading one celestial map maker to add a new constellation commemorating Herschel's telescope. After this discovery, the hunt was on for still further planets. Close observation of the Uranian orbit showed that it had slight irregularities suggesting that there was still another unknown body gently tugging it out of a pure orbit, like a puppy tugging at its masters pantleg. From this information two different mathematicians independently predicted the location of the unseen planet. Finally on September 23, 1846 French astronomer J. Galle and his assistants located Neptune, near where it was predicted to be (even though it is now known that Galileo himself saw Neptune all the way back in 1613, but mistook it for a star).

Taking a cue from the mathematicians, intensive analysis was made of the Neptunian orbit looking for clues of a possible nineth planet. By the beginning of the 20th century, astronomer Percival Lowell predicted where this new planet, "Planet X" could be located and just what magnitude it would be. Up until his death in 1916 the search for "his" planet consumed Lowell, who took thousands of images of the sky in his fruitless hunt.

In 1929 a young assistant at the Lowell Observatory, Clyde Tombaugh, was tasked with the hunt. Tombaugh was faced with the laborious task of taking highly detailed photos of the sky, and then using a "blink comparator" he would examine every one of the 100,000 or more stars on each plate. The blink comparator was a device which would flip between two different pictures permitting the user to easily spot an object that might be moving such as a planet. It was *extremely* tedious work. But on this day (February 18), in 1930 it paid off handsomely.

{ewl ewdll.dll,ewBitmap,ew_bmps\pluto\plutdisc.sbm}Using two photographs taken 5 days apart in January, at about 6:00 PM Tombaugh noticed one tiny spot which jumped about 1/8 of an inch. Checking a third plate confirmed that this wasn't merely a speck of dust, but a real body in orbit around the Sun. And to add to the body of evidence, Pluto was right were it was determined to be by Lowell nearly 30 years earlier. The official announcement was made on March 13, 149 years to the day of Herschel's discovery of Uranus and Lowell's 75th birthday. Ironically, images of Pluto were found on Lowell's own photographs as early as 1907 but were overlooked since it was far dimmer than expected.

Based on Lowell's prediction Pluto should have been about seven times larger than the Earth and 2 1/2 times brighter than it was. But it is only about 2000 miles across, nearly the size of our own Moon. Why the discrepancy? Some suggested that there was a tenth planet beyond Pluto. But Pluto showed no unpredictable motions. So only recently has it been discovered that the irregularities in Neptune's orbit were in fact, errors in observation! They never existed after all and Lowell's calculations, while correct for Pluto were merely plain dumb luck! Until that conclusion, the search for Planet-X continued, but it is now felt that there are no more major planets to be found, at least around our Sun.

In order to see Pluto on the night of it's discovery, click here . Now move out above Pluto and investigate its odd orbit
. Notice how at times during its year Pluto is not the furthest planet, Neptune is and will remain so until the year 1999.

The origin of Pluto is still unclear. It's density is less than that of water so it could be composed of light frozen gases and water ice. Its 17 degree inclination to the plane of the solar system suggests that it was possibly a captured object, rather than one which formed with the rest of the planets.

{ewl ewdll.dll,ewBitmap,ew_bmps\pluto\pluto_g.sbm}But Pluto was still full of surprises. In 1978 a tiny "bump" was seen on some photographs of the planet could only be one thing : a tiny moon! "Charon" as it was called orbits once every 6.3 days and is felt to be about 1/2 the size of Pluto, in effect making the

Pluto-Charon system a double-planet.

Pluto remains the last planet unexplored by our satellites. There is currently a proposal to launch a "Pluto Fast Flyby" mission later in the decade or early next. It is important to reach the planet by 2010 while it is closest to the Sun. An opportunity not to be missed! Due to the slight heating, parts of the surface would be revealed that might otherwise be covered up by methane snow. It we miss this time, it would be another 220 years before the next heating cycle.

Pluto is just barely within the range of larger amateur telescopes. Hovering around 14th or 15th magnitude it can only be viewed with the clearest seeing and careful star charts, .

Ceres, the first asteroid

Project. . .

supplies : *flour, chocolate powder, a plastic bowl, meteor, er, marble and a clear area that can get messy.*

In the 18th century an interesting mathematical relationship, popularized by German astronomer Johann Bode, appeared to predict the relative distances of the known planets from the Sun. "Bodes Law" as it was known, suggested that there was a large gap in between Mars and Jupiter where a planet should be, at a distance of 2.5 astronomical units. Therefore, astronomers around the world began searching that gap for this missing planet. On the first day of the 18th century, Jan. 1, 1801, Italian astronomer-monk, Guiseppe Piazzi, discovered a small body which would later be named Ceres.

Ceres became the first known asteroid, and since its discovery over 3500 have been cataloged. Besides being the first, it is also the largest with a diameter of about 600 miles (a quarter the size of the Moon). Click here to take a look at Ceres on the night of its discovery, . Once done, set the clock to *now* and find its position for this evening.

Asteroids usually receive their names from their discoverers. In recent years the astronomers have shown a heightened sense of whimsy in their naming decisions. For instance, Elvis really is "alive" and out in space orbiting the Sun. Or Beatles fans will be pleased to know that John, Paul, George and Ringo have been immortalized forever with orbiting rocks named after them. And it would be illogical not to mention asteroid "Spock".

Planetary geologists and space visionaries alike see asteroids as an enormously valuable source of raw materials for man's expansion into the solar system. But there is a darker side. Arthur C. Clarke speaks of it so well in his classic book *Rendezvous with Rama*, when in the opening chapters he describes the potential of a stray asteroid striking the Earth. In *Rama* the Earth of the future establishes an organization called SPACEGUARD so as to predict such an event. Recently a real life SPACEGUARD has been established to track potentially dangerous asteroids, and if possible destroy or deflect them preventing impact.

April

April 1 : Leo, the lion
April 2 : Regulus
April 3 : Leo Minor, the lion cub
April 4 : Project - Photographing the Moon
April 5 : Kinds of Galaxies
April 6 : Project - Diurnal motion
April 7 : Buying a telescope
April 8 : Glass Giant of Palomar
April 9 : Project - Finding Polaris
April 10 : Sextans, the Sextant
April 11 : Antlia, the Pump
April 12 : Vostok 1
April 13 : Apollo 13
April 14 : Venus, greatest elongation
April 15 : Venus, third brightest object in the sky
April 16 : Seeing Venus in the daytime
April 17 : The Big Bang
April 18 : Asteroid Armageddon
April 19 : Project - why is Mars red?
April 20 : Random meteors
April 21 : Brightness of the Moon
April 22 : Lyrids
April 23 : Building a planetarium
April 24 : Conjunctions
April 25 : The Brightest stars
April 26 : Stellar Spectra
April 27 : Exploding stars
April 28 : Satellite Clouds
April 29 : Kepler
April 30 : Project - Dark Adaptation

Asteroid Armageddon

{ewl ewdll.dll,ewBitmap,ew_bmps\ast_etc\ida.bmp}In the 18th century an interesting mathematical relationship, popularized by German astronomer Johann Bode, appeared to predict the relative distances of the known planets from the Sun. "Bode's Law" as it was known suggested that there was a large gap in between Mars and Jupiter where a planet should be, at a distance of 2.5 astronomical units. Therefore astronomers around the world began searching that gap for this missing planet, and on the first day of the 18th century, Jan. 1, 1801, Italian astronomer-monk, Guiseppe Piazzi discovered a small body later named Ceres.

Ceres became the first known asteroid and since its discovery over 3500 have been cataloged. Besides it being the number one, Ceres is also the largest with a diameter of about 600 miles (a quarter the size of the moon). Now, as with Halley's Comet, set your viewpoint looking down on top of the solar system, load in Ceres and change the date to the night of discovery. Move back to the Earth, and you will see the small planet in between the constellations Aquarius and Cetus.

Planetary geologists and space visionaries alike see asteroids as a enormously valuable source of raw materials for man's expansion into the solar system. But there is a darker side. Arthur C. Clarke speaks of it so well in his classic book *Rendezvous with Rama*, when in the opening chapters he describes the potential of a stray asteroid striking the Earth. In *Rama* the Earth of the future establishes an organization called SPACEGUARD so as to predict such an event. Even now, scientists are working on programs similar to SPACEGUARD in order to discover and track potentially dangerous asteroids, and if possible destroy or deflect them preventing impact.

While most asteroids stay in their place, snuggly between the orbits of Mars and Jupiter, a few venture in closer to the Sun giving rise to the fears that someday we may in fact witness a collision. At the time of this writing only about 30 of these "Apollo" type asteroids are known. But the threat became all the more real when in 1989 a small Apollo asteroid, 1989-FC, made what was determined to have been the closest known approach of any known comet or asteroid in history.

You can witness this event by clicking here . The date is now February 15, 1989, and we are looking straight down on top of the solar system from a distance of five astronomical units. You should see the 1000 foot 1989-FC just outside the orbit of Venus heading toward an Earth crossing. Now use the fast clock,   and watch what happens. On March 22, asteroid 1989-FC passed within a mere 400,000 miles of the Earth. A little closer and it would have been inside the orbit of the moon. Notice how it is coming from the sunward side as seen from Earth. This is why it wasn't even discovered until March 31, a full *nine days* after closest approach. Whew! Fortunately, such events are exceedingly rare, and the chance of a head-on collision even more so. But had it happened, it could have likely have created a crater over *four miles* wide.

Note, also, that 1989-FC passed through the point in space that the Earth had been a mere six hours earlier!

Now reset the date back to mid-March, but watch the asteroid from an Earth based position. Set the time-rate to an increment of 6 to 12 hours. Watch how fast it moves at the closest approach, hitting rates of over 70 degrees in a single day! Crossing nearly a quarter of the sky. Now that's moving!

FLASH : It was recently announced that on December 9, 1994 Spacewatch captured on video a new Earth crossing asteroid, called 1994 XM1. It was discovered at a distance of only 330,000 miles from Earth, and only *14 hours* from its closest approach at a razor thin *63,000 miles*! The 43 foot object would have done tremendous damage had it struck the Earth near a major city.

Project - Limits of visibility

Project. . .

supplies : *some dim stars, printouts from First Light, a clear night.*

The brightness of a star or other object in the sky is given by a value called the "magnitude". The lower the value the brighter the object, and vice versa, each magnitude representing an intensity of about 2.5 times less than the next lower value. The dimmest stars visible to the unaided eye are about magnitude 6.5. This means that under the best stargazing conditions, approximately 3000 stars can be seen from horizon to horizon.

By comparison an inexpensive set of binoculars will show you stars as dim as magnitude 8, small home telescopes to 11 or 12. Large home scopes should be able to show 14th magnitude objects such as Pluto, while your local observatory 1 to 2 magnitudes dimmer yet. The largest observatories can see in excess of magnitude 22 and the Hubble Space Telescope will see stars below 28th magnitude.

Originally, the method was designed so the brightest stars would be magnitude zero, but when measurements of stellar brightnesses were refined it became necessary to indicate even greater luminosity. Thus, some of the brightest objects are actually given *negative* magnitudes. For example, the Sun blazes away at -26.3, while the next brightest star, Sirius, shines at a "paltry" -1.46.

Now, let's see how good your eyes are. Click here  and First Light will center Beta Aurigae, a third magnitude star in the constellation of Auriga. Notice the fifth and sixth magnitude stars nearby. Print out this view, go outside if it is clear, and see just how faint of stars you can make out. How does the seeing compare when you are in the city vs. the country? How does the phase of the Moon effect your seeing? (full vs. new). How about the length of time you spend outside letting your eyes adjust to the darkness, after having been in a well-lighted room?

Pluto

The ancients knew of five planets in the solar system : Mercury, Venus, Mars, Jupiter and Saturn. It wasn't until 1781 when the sixth planet was added to the great pantheon thanks to the dedicated work of William Herschel who discovered Uranus during a routine star survey. The was a tremendous achievement, leading one celestial map maker to add a new constellation commemorating Herschel's telescope. After this discovery, the hunt was on for still further planets. Close observation of the Uranian orbit showed that it had slight irregularities suggesting that there was still another unknown body gently tugging it out of a pure orbit. From this information two different mathematicians independently predicted the location of the unseen planet. Finally on September 23, 1846 French astronomer J. Galle and his assistants located Neptune, near where it was predicted to be (even though it is now known that Galileo himself saw Neptune all the way back in 1613, but failed to recognize it for what it was).

Taking a cue from the mathematicians, intensive analysis was made of the Neptunian orbit looking for clues of a possible nineth planet. By the beginning of the 20th century, astronomer Percival Lowell predicted where this new planet, "Planet X" would be visible and just what magnitude it would be. Up until his death in 1916 the search for "his" planet consumed Lowell, who took thousands of images of the sky in his fruitless hunt. {ewl ewdll.dll,ewBitmap,ew_bmps\pluto\plutdisc.sbm}However in February 1930, a young assistant at the Lowell Observatory, Clyde Tombaugh, discovered Planet-X while studying extensive star fields on some recently made photographic plates. In order to see Pluto on the night of it's discovery, click here .

Based on Lowell's prediction Pluto should have been about seven times larger than the Earth and 2 1/2 times brighter than it was. But it is only about 2000 miles across, nearly the size of our own Moon. Why the discrepancy? Some suggested that there was a tenth planet beyond Pluto. But it showed no unpredictable motions. So only recently has it been discovered that the irregularities in Neptune's orbit were errors in observation! They didn't exist after all and Lowell's calculations, while correct for Pluto were merely plain dumb luck! Until that discovery the search for Planet-X continued, but it is now felt that there are no more major planets to be found, at least around our Sun.

The origin of Pluto is still unclear. It's density is less than that of water so it could be composed of light frozen gases and water ice.

{ewl ewdll.dll,ewBitmap,ew_bmps\pluto\pluto_g.sbm}But Pluto was still full of surprises. In 1978 a tiny "bump" was seen on some photographs of the planet could only be one thing : a tiny moon! "Charon" as it was called orbits once every 6.3 days and is felt to be about 1/2 the size of Pluto, in effect making the Pluto-Charon system a double-planet.

Pluto is just barely within the range of larger amateur telescopes. Hovering around 14th or 15th magnitude it can only be viewed with the clearest seeing and careful star charts.

Click here to center Pluto to see where exactly it is for this evening. Now move out into the solar system
to see the planet from above and investigate its peculiar orbit.

Pluto remains the last planet unexplored by our satellites. There is currently a proposal to launch a "Pluto Fast Flyby" mission later in the decade or early next as it is important to reach Pluto by 2010 while it is closest to the Sun. This is an important opportunity not to be missed since due to warmer temperatures, parts of the surface would be revealed that might otherwise be covered up by methane snow. It we miss this time, it would be another 220 years before the next Plutonian "summer".

Friendship 7

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\friend_7.bmp}On this date in 1962 a slender silvery rocket took off from Florida sending America's first astronaut into orbit and John Glenn's name into the history books. To U.S. public it was a long time coming. The Soviet Union "beat" the U.S. into space with the Sputnik 1, beat the U.S. to the moon with the Luna 2 in 1959 and the first man in space in 1961. Compared to their space extravaganzas, the United State's effort seemed puny and second rate at best. After Cosmonaut Yuri Gagarin's triumphant one orbit mission, the best NASA could do is to send Alan Shepard up for only 15 minutes. Not until an American could make it to orbit would it even appear that NASA was on the pace to catch up. And on February 20th that finally happened.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\glenn.bmp}After numerous postponements, Friendship 7 headed toward its successful three orbit mission marked with dramatic descriptions of the Earth, fears that the all important heatshield may have been damaged and the discovery of mysterious "fireflies" (later determined to be a cloud of ice particles knocked off the launch vehicle). Glenn would never fly another mission unlike the other early astronauts. He was the oldest and knew that by the time Apollo would be flying he would be too old to go to the Moon. So America's hero retired from NASA in 1964 and was elected senator from Ohio ten years later.

Tycho Brahe

Every science has its share of brilliant eccentrics. Theoretical physics has the beloved prankster, Richard Feynman and astronomy has Tycho Brahe.

Brahe (1546-1601) is considered the most skilled observer in the pre-telescope era (which started only 9 years after his death). The utmost care and accuracy of his planetary observations provided mathematician Johannes Kepler with the raw data needed to describe his laws of planetary motion. From this, the modern view of the solar system (that the planets orbited the Sun) was established.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\tych.bmp}At first a law student, he witnessed an eclipse in 1560 which turned his interest to astronomy. Upon realizing that the present day planetary tables were in great error he set off to develop his own. In 1572 his observations of a supernova, now called "Tycho's star" proved that it was too far away, residing not among the planets but in the realm of the stars instead. This shattered the contemporary thinking that the stars were unchanging. In 1576 the king of Denmark gave him the island of Ven where he set up what became the astronomical capital of the world. Here he reigned like a king, or more like a tyrant as some would say. And here he made better observations than ever before, precisely determining the positions of thousands of stars and measuring the length of the year to within a *single second*.

A very arrogant and stubborn fellow he got caught in a student duel in 1565 in which he lost the bridge of his nose, which he replaced with a golden substitute.

In 1588 the king died and the new king, unwilling to tolerate him, caused Tycho to leave. Until his death, he analyzed the data he had collected, passing it on to a young student named Johannes Kepler in 1600. Tycho, while disproving the traditional Earth centered Universe developed his own model which stated that the Earth was still the center, but all other planets orbited around the Sun which in turn circled Earth. He had hoped that young Kepler would prove his theories correct. How wrong he was! Kepler later teamed up with a gentleman named Galileo, and established the modern day view of a Sun-centered solar system.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\tycho.sbm}While the ancients would honor their great heroes with constellations, great astronomers are honored with craters on the Moon. So it is only fitting that he most prominent crater on the moon is named "Tycho". Look for it at the next full Moon. It's the big one near the bottom with the massive system of rays spreading out over the entire face of the Moon. You can't miss it!

Celestial Coordinates

It is at this point that we ought to take a brief moment to explore some of the basic concepts of visual astronomy, which will help you in working with First Light.

For starters, it is helpful to think of the sky in the same way the early astronomers did -- by imagining the stars and planets as being attached to the inside of a hollow sphere with the Earth at the center. This sphere, in turn, revolves around the Earth, creating the stellar motions.

Variations on this theme had each planet on a separate crystalline sphere revolving on its own, which explained their independent movements. But for now, the single sphere model will do.

Another concept which is essential for understanding how astronomers describe the various locations of celestial objects is that of coordinate systems.

We are all familiar, in one way or another, with coordinate systems. This is a method of specifying the location of a particular place, be it on a piece of paper or the Earth. Our home addresses, for example, represent one coordinate system; the Earth's latitude and longitude lines are another.

In order to pinpoint the location of a star, astronomers have developed their own system for the sky analogous to the Earth's. The sky's latitude is termed declination, (or "dec") and its longitude right ascension, (or "RA").

In this "equatorial coordinate system", declination is measured in degrees, as is latitude, and like latitude, ranges from -90 degrees to +90 degrees. Zero degrees declination is called the "celestial equator".

Right ascension, on the other hand, is measured not in degrees, but in hours, minutes and seconds, with each hour being the equivalent of 15 degrees.

A second coordinate system that is important is the horizon system, used in specifying the location of an object in your own sky at a specific time. The two coordinates used are azimuth, or compass heading with north being 0 degrees, and altitude, or the angular elevation above the horizon. Both are measured in degrees. And while right ascension increases by motion toward the left, azimuth increases to the right. Because of the Earth's rotation, horizon coordinates of a particular object are constantly changing, while its equatorial coordinates are constant. You will very rarely hear the coordinates of any object given in horizon coordinates since they are specific to a location and time.

A third system is called "Galactic coordinates" which use the galactic poles as the northern and southern limits and the galactic center in Scorpio as the 0 point of galactic longitude.

Bode's Law

In the 18th century, an interesting mathematical relationship, popularized by German astronomer Johann Bode, appeared to predict the relative distances of the known planets from the Sun. Bode noticed that if he took the number sequence 0, 3, 6, 12, 24, 48, etc. (doubling each value) and then added four he had a series which gave a pretty close approximation of the distances each planet was from the Sun. The final series ; 4, 7, 10,16, 28, 52 and 196, matched the known planets at that time. With Earth placed at "10", Mercury would then be at 4 and Venus at 7. Since Earth is about 93 million miles from the Sun, multiply that value by 4/10ths and you should arrive at the distance for Mercury. The results are 37.2 million miles. In fact Mercury is about 35.8 million miles, very close indeed. Similar results can be found for the other planets out to Saturn.

Bode's Law remained more of a curiosity until William Herschel discovered Uranus to be located at "52" on the scale, seemingly proving the law correct. Many wondered about the fact that there was no planet at "28", so the Uranian proof prompted many to hunt for the missing object, no doubt, all with visions of glory dancing through their heads as they adjusted eyepieces and wiped dew from their scopes night after night.

Finally, on the first day of the 18th century, Jan. 1, 1801, Italian astronomer-monk, Guiseppe Piazzi, discovered a small body later named Ceres. Shortly after, several more were discovered near section "28", leading to the speculation   that a planet had been there but perhaps had been destroyed. Or maybe it never quite formed to begin with, leaving chunks of scattered debris floating around.

At any rate, over 3500 of these small bodies, later called "asteroids", have since been discovered ranging from only a few meters across (large meteors) up to 600 miles in the case of Ceres.

In 1823, Neptune was discovered at a point well off of the Bode sequence, proving it to be merely a curiosity and little more.

You may want to now use First Light in off-Earth mode and load in some asteroids yourself to see just where their orbits fall.

H-R Diagram

Not all stars are alike. Some are 100 times the size of the Sun blazing forth with a brilliant blue-white intensity. Others may be five miles across, and so dense that a single teaspoonful would weigh *100 tons*. One thing for sure is that a star's luminosity is generally related to its temperature. The hotter, the brighter. Duh.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\hr_dgram.bmp}

In order to demonstrate this relationship, the H-R diagram was created which plotted the distribution of stars based on luminostiy vs. the spectral type (or color, based on temperature). The strong central band is called the main sequence whcih describes about 90% of the stars with the Sun right in the middle. In the upper right are "red giants", large cool stars similar to Aldebaran, several hundreds of times the diameter of the Sun. Over on the other side are blue supergiants such as Rigel in Orion. These may be up to 50,000 times the luminosity of our own Sun. Down in the lower left corner are the "white dwarfs" tiny, but intensely bright stars not much larger than the Earth.

The letters O,B,A,F,G,K and M are used to identify the main classes. Finer distinctions are marked by the numbers 0 to 9 following the letter. For instance, our Sun is spectral class G2, or Rigel is B8. Still finer classifications are required due to differences in luminosities within a particular spectral type. These are given by the "MK" identifiers. Therefore the complete class of the Sun is G2 V, while Rigel is B8 Ia.

Constellations and their origin

How many constellations are there? Currently there are a total of 88. However this has not always been the case. The classic Greek based constellations number only 48, which come from a list first published in 150 AD. These include the nightly pageant of the Zodiac, or Orion the hunter and his dog, Canis Major and so on. For the most part these were mythological beasts and heroes of old parading their exploits into eternity for all to see and seek inspiration from. However in the mid-18th and 19th centuries numbers of over zealous astronomers and celestial mapmakers introduced "new" constellations in order to honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns. While one astronomer would recognize or try and popularize one of his own, a competitor would ignore him and add *his* own. And as such the skies are littered with odds and ends of constellations that once were. Most of these are frankly, rather small and uninteresting.

Forty of the new ones have been officially recognized and remain to this day on the charts. These bits of celestial flotsam include such noteworthy spectacles as Caelum, the chisel, Circinus the compasses, Fornax the furnace and Horologium the pendulum clock. Few have any interesting objects, and all are rather dim. However there are many more of these that never made it in to regular use or were absorbed by larger neighbors.

Some of these forlorn "obsolete" figures include Argo Navis, the 50 oared ship that carried Jason and the Argonauts on their fantastic voyages. Argo was far too big of a constellation so it was "subdivided". What remains of it are located in Carina the keel, Puppis the Poop deck, and Vela the sails. Then there was Antinous the boy lover of Hadrian the Roman Emperor, and one of the few authentic characters to be honored in the sky. Don't overlook the three headed monster of Cerebus, or Felis the Cat or Gallus the Cockerel.

Many of the newer figures clearly show the influence of the age. Hence there were numerous man made tools and machines placed upon the heavenly dome. Globus Aerostaticus was a hot air balloon. Machina Electrica was an electrostatic generator, an "electric machine". Officina Typographica honored Gutenberg and his press, while Telescopium Herschelii celebrated the telescope of William Herschel which discovered the planet Uranus.

Why don't you make some printouts from First Light without the traditional constellation outlines and make up some of your own? How about the constellation "Beavis", "Newt" or "Ed". Or perhaps the constellations of "Nike","M&M" or "Frisbee". Let your imagination soar, even unto the heavens.

Cosmology

Cosmology is the study of the origin and evolution of the Universe. It started back before the times of the Greeks with the simple study of the Earth, expanded toward the heavens (touching on planetary motions) and exploded with the invention of the telescope as cosmologists sought to determine the shape of the galaxy.

Cosmology is the branch of science that developed the "Big Bang" theory using the concept of the expanding Universe. "If" as they say, "the Universe is expanding as it seems to be, it probably started from one point. If it started at one point, the expansion was likely caused by a massive explosion of some sort . . .". This is at odds with the "steady state" theory which states that the Universe has always been around and will always be around. The Big Bang is pretty much, ahem, "universally" accepted nowadays, thanks to a number of recent discoveries.

Current theories place the age of the Universe at between 10 and 20 billion years old. Recent discoveries suggest it is on the shorter end of that scale, however, stars have been observed that are clearly older than that. So how can this be? I am content to let the cosmologists figure that one out. But that is likely to be one of the major questions tackled over the next decade.

Since Cosmology covers the beginning of it all, it must, by symmetry, cover the end of it all. The Universe could either expand forever, or at some point stop expanding and collapse back onto itself in what is called the "Big Crunch", only to explode again and start it all over, the "Big Bounce". However knowing if this will ever happen also falls into the lap of the cosmologist. For they must calculate the total number of galaxies and from that determine the total mass of the Universe to see if there will even be enough gravity to pull everything back together.

So the cosmologist has a lot to think about, but he also has a lot of time to think about it.

Geocentric Universe

Before the era of "modern" astronomy with the invention of the telescope, mankind's concept of the Universe had a comfortable simplicity about it. The Earth was the center of everything with the Sun and planets orbiting in neat little circles all attached to crystalline spheres. {ewl ewdll.dll,ewBitmap,ew_bmps\misc\geo_uni.bmp}However, a few inconsistencies crept in to upset this idyllic viewpoint. For example, the planets would on occasion, slow up and of all things, *move backwards!* In an effort to explain this, the astronomers of the day invented "epicycles" which forced the hapless orbs into making small orbits on top of their main orbits causing them to back up every so often. This still did not explain all of the motions so more epicycles were added on top of the earlier ones. Eventually some planets collected up to 14 levels, but still refused to behave. What was once a simple and elegant theory was getting to be hopelessly complex. But according to the theologians of the day, God created the Universe and since He was perfect, the Universe was perfect and since perfection demanded that the Earth be the center of things, it was the only way things could or would ever be.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\zloty.bmp}This view was maintained until a young upstart polish physician named Nicholas Copernicus dared to "stop the Sun" buy suggesting that it was the center of all and the Earth orbited it along with the other planets. With this one simple suggestion all of the observed motions fell into place and the complicated system of epicycles vanished overnight. Copernicus had no mathematical proof to his theory, only "gut instinct" which so often has played in a role in the worlds great discoveries. Copernicus' finally published his findings and received his own personal copy on the day he died in 1543. The illustration is from the back side of a current Polish 1000 "Zloty" bill.

The Copernican theory was slow to catch on until 70 years had passed and Galileo began his famous observations which quickly eroded away the last vestiges of the old theory. Johannes Kepler at the same time provided the mathematical support for Galileo's conclusions. By the mid-1650s geocentricism was all but a quaint memory.

February 28 : Author's birthday

Celebrate in moderation and send cash.

February 29 :

Hey computerboy, turn this thing off tonight and visit with the family. OK pal?

M44, the Beehive Cluster

Standing out in the crisp late winter's sky is one of the largest and loveliest open star clusters in the sky, . "Open clusters" are loose associations of stars, usually numbering from less than a dozen up to several hundred. Both the Hyades and the Pleiades in Taurus are the finest examples of these.

Cancer, the dimmest of the 12 Zodiacal constellations, is the home of the Beehive Cluster, also called the "Praesepe". It is a wonderful object for binoculars or a small telescope as it contains nearly 200 stars. At a magnitude of 3.7, the cluster should be visible to the naked eye as a fuzzy patch of light, and as such was known to the ancients and actually included in some of their myths. Hipparchus in 130 BC called it "the little cloud". Its true nature was never revealed until 1610 when Galileo became the first person to ever see it through a telescope.

If it is a clear night, go outside and try to locate this vivid grouping. Using your binoculars, count the stars you can see. You should find about 80 (or more if you're using a telescope). Since the Beehive is about 450 light years away the light you are seeing tonight left before Galileo first lifted his telescope toward the sky.

Cancer

Cancer is the dimmest of the 12 Zodiacal constellations and has a relatively minor role in Greek mythology. The crab is known only for biting Hercules on the foot while he was struggling with the monster Hydra.

Even though Cancer is dim, it contains one of the loveliest and closest star clusters of the sky. Called the Beehive Cluster, it is a wonderful object for binoculars or a small telescope containing 200 stars. At a magnitude of 3.7, the cluster should be visible to the naked eye as a fuzzy patch of light, and as such was known to the ancients and included in some of their myths.

If it is a clear night, go outside and try to located this faint constellation and its vivid cluster, . Using your binoculars, count the stars in the cluster. You should see about 80 (more are revealed in telescopes). Since the Beehive is about 450 light years, away the light you are seeing tonight left before Galileo first lifted his telescope toward the sky.

Meaning of a "day"

No doubt when someone mentions the word "*day"* around you, you imagine a 24 hour period full of work, fun, sleep, meals and playing around with really, really cool astronomy software. But to an astronomer, the concept of day can take on several meanings.

First there is there is the "Mean Solar Day", which is what clocks are based on. Since the Earth's distance varies between about 91 and 94 million miles its speed will likewise change, as the Earth moves around the Sun, the Sun in turn "moves" making its position at noon vary slightly depending on the date. Were the day's length measured by the time the Sun reaches its highest point in the sky, for example it would vary up to 16 minutes. The Mean Solar Day averages out these changes.

Then there is the "Ephemeris Day". This is very similar to the previous, but doesn't take into account the fact that the Earth's rotation is slowing down at the rate of .000015 seconds a year.

A third kind is "Sidereal day". This is the period of revolution of the Earth but based on the fixed stars. Since the Earth is moving around its orbit, the positions of the stars will change slightly from night to night, by about four minutes earlier each evening. Thus the siderial day is 23 hours 56 minutes in length.

You may want to measure the length of time it takes for the Sun to cross a specific reference point such as a point on the house on the day the Earth is closest in its orbit (early January), vs. when it is furthest (in July), to prove these things for yourself.

Voyager 1 at Jupiter

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\jupiter1.sbm}Beyond Mars, lie the "outer planets." Before the age of space travel, they remained enigmatic telescopic blurs only grudgingly giving up their secrets to the most dedicated of observers. It wasn't until the Pioneer spacecraft and later the phenomenally successful Voyagers 1 and 2 that the real nature of these distant worlds became known.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm}In 1979 both Voyagers would sweep by Jupiter returning thousands of high quality images. Later they would visit Saturn, the mysterious ringed planet unlocking many of its mysteries but raising many more. As Voyager 1 sailed out of the solar system, Voyager 2 was retargetted to visit Uranus in 1987 and Neptune in 1989 after over 13 years in space.

What had up until than been merely pinpoints of light first seen by Galileo in 1610, Jupiter's four largest moons became real worlds, each strikingly different, each with a different story to tell.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\io1.sbm}On this date in 1979 the first of the two vehicles crossed into Jupiter space. It revealed the unimaginably hellish world of Io, the sulfurous orange moon literally turning itself inside out through dozens of active sulfur volcanoes.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\callist1.sbm}Then there is Callisto, the third largest moon in the solar system, the second largest around Jupiter. Unlike many of the other moons, Callisto seems to be completely "dead" with no noticeable geologic activity whatsoever.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\ganymed1.sbm}Ganymede is named for the cup-bearer of the Greek gods and is the largest known moon in the solar system. It is similar to Callisto in materials, but has a much thinner ice crust (60 miles vs. 150) which floats on top of 400 mile thick layer of slushy water. Numerous white craters are visible, the bright material being "fresh" snow or ice splashed up and across the dark dusty surface.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\europa.sbm}Unlike Callisto, Europa has had a violent, active history. With a surface covered by water ice, only three craters have been identified. The more intriguing marks are the dark "linea" crisscrossing the entire surface.

After stripping the moons of their secrets, Voyager 1 peered down into the massive "Red Spot" an intricate network of cloud patterns locked forever in a gigantic storm. It measures about 15000 miles long by 7000 miles wide and makes a complete rotation in six days. The red coloring is believed to come from "phosphine" which rises to the top of the clouds and is then broken down into"red phosphorus-4", .

This film shows the final approach to the massive gas giant, . The small dot speeding across the view is one of Jupiter's 16 known moons.

To further investigate the Voyager 1 encounter you may use the First Light flyby option. Click here to demonstrate.

Copernicus

He was said to have "stopped the Sun and thrown the Earth into motion". His name was Nicholas Copernicus, a Polish renaissance astronomer whose work revolutionized both astronomy and dramatically changed Man's concept of the world and his place in the Universe.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\geo_uni.bmp}As a well read student, Copernicus had known that some Greek philosophers suggested that the Earth moved around the Sun rather than the widely held belief that the Sun, Moon, planets and stars all rotated around the Earth, the so-called Geocentric view. But there were numerous discrepancies that the Geocentric view did not answer satisfactorily. What was once a simple and elegant theory was getting to be hopelessly complex in order to explain some of the subtle motions of the various planets. But according to the theologians of the day, God created the Universe and since He was perfect, the Universe was perfect and since perfection demanded that the Earth be the center of things, it was the only way things could or would ever be.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\zloty.bmp}Copernicus believed that the Earth should be made equal to the other planets with the Sun in the center of things.With this one simple suggestion all of the observed motions fell into place and the complexities vanished overnight. Copernicus had no mathematical proof to his theory, only "gut instinct", which so often has played in a role in the world's great discoveries. Afraid of ridicule, he refused to publish his findings for many years. Finally in 1543, a friend persuaded him to do so, and the book "On the Revolution of the Celestial Spheres" was let loose upon the world. Copernicus would received his own personal copy on the day he died.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\coperpor.bmp}The Copernican theory was slow to catch on until 70 years had passed and Galileo began his famous observations which quickly eroded away the last vestiges of the old theory. Johannes Kepler at the same time provided the mathematical support for Galileo's conclusions. By the mid-1650s geocentricism was all but a quaint memory and Man was clearly dethroned as the center of all creation. Copernicus is now honored by having his image used on the Polish 1000 Zloty bill.

Puppis, the Ship's Stern

Currently there are a total of 88 "official" constellations on the charts, however this has not always been the case. The classic Greek based constellations number only 48 which come from a list first published in 150 AD. These include the nightly pageant of the Zodiac, or Orion the hunter and his dog, Canis Major and so on. For the most part these were mythological beasts and heroes of old parading their exploits into eternity for all to see and seek inspiration from. However in the mid-18th and 19th centuries numbers of over zealous astronomers and celestial mapmakers introduced "new" constellations in order honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns While one astronomer would recognize or popularize one of his own, a competitor would ignore him and add *his* own. And as such the skies are littered with odds and ends of constellations that once were. Most of these are rather small and uninteresting.

One of these retired constellations was Argo Navis, the 50 oared ship that carried Jason and the Argonauts on their fantastic voyages through the Crashing Rocks to recover the golden fleece. Argo was far too big of a constellation so it was "subdivided". What remains of it are located in Carina the keel, Puppis the Poop deck, and Vela the sails.

While relatively faint as far as constellations go, Puppis stretches across a rich portion of the Milky Way star fields, . Also located in Puppis is a nice binocular star cluster, M47. It contains over 50 stars and is about 15 light years across. Also look for the red star known as *L2 Puppis*. This is a double star system known as an eclipsing binary in which one member will eclipse the other on a regular basis. Due to this it changes its brightness from a relatively bright third magnitude down to a barely visible sixth magnitude in only 70 days.

If the night is clear, you might want to try and locate Puppis and M47 with a pair of binoculars. Several other smaller star clusters may also be found here, see if you can spot them as well.

Sidereal motions : The stars nightly dance, part 1

Project. . .

supplies : *a bright star, watch, two weeks.*

Due to the Earth's rotation around the Sun, the stars change their apparent location nightly. The stars visible in the winter vanish in the summer. In other words, the night side of the Earth is facing one direction in January and the opposite direction six months later. This slow change of our perspective may be seen by the following experiment :

If it is a clear night, go outside and locate a bright star such as Arcturus and align it with some object in the foreground such as a tree or fence. Note your exact location and the time. Come back two weeks later and once again note the time the star crossed that object. Divide the difference in time by the number of days what are your results?

Sidereal motions : The stars nightly dance, part 2

Project. . .

supplies : *a bright star, watch.*

This is part two of the experiment that started two weeks ago on March 8 (and is meant to merely remind you to complete it). If you've missed the original I've repeated the text here. . .

Due to the Earth's rotation around the Sun the stars change their apparent location nightly. The stars visible in the winter vanish in the summer. In other words, the night side of the Earth is facing one direction in January and the opposite direction 6 months later. This slow change of our perspective may be seen by the following experiment :

If it is a clear night, go outside and locate a bright star such as Arcturus and align it with some object in the foreground such as a tree or fence. Note your exact location and the time. Come back two weeks later and once again note the time the star crossed that object. Divide the difference in time by the number of days what are your results?

You may want to use first light to examine the direction the Earth is facing from month to month using Hover mode.

Monoceros, the Unicorn

Few creatures can excite the imagination more that the stately unicorn. In a sky full of dragons, serpents, flying horses and great heroes, the unicorn is right at home. Monoceros first appeared in star charts around the time of Galileo in the early 17th century. Unfortunately due to its "recent" birth there are no myths of any kind. Orion never rode a unicorn off to battle, Jason never found a unicorn on is journeys, Zeus never gave a unicorn to Helen.

Monoceros is a faint constellation, no stars are brighter than fourth magnitude but it is home to a number of fine deep-sky objects, . Beta Monoceros is a fine triple-star, three stars locked in an eternal gravitational grip. This should be a fine object for even the smallest telescopes. The star cluster, M50 is a compressed open cluster of about 200 stars and should be clearly visible in binoculars. One of the brightest is a red giant, and should stand out from its background of cooler blue-white stars. M50 is estimated to be around 10 light years across.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\ngc2237.sbm}Perhaps the most spectacular object in Monoceros is the famous Rosette Nebula. It is a very large, but rather faint expanding circle of gas surround a bright cluster of about 20 stars. Using First Light you should be able to at least locate the cluster, NGC2244 then use your binoculars to find it for real. With long exposure photography the nebula is revealed like a strikingly delicate intergalactic flower, its petals spreading across many light years, radiating a deep reddish hue. Unfortunately, only the largest instruments can show this. Oh well....

Beta Monoceros, a fine triple star

The fourth magnitude Beta Monoceros is one of the finest triple stars visible in small telescopes. A triple star is simply three stars all orbiting around each other, not unlike the Sun with its planets. In fact, had the planet Jupiter been slightly larger, it might have formed into a small star in its own right giving *us* a multiple star system (but definitely ruining our nighttime seeing).

The three stars have nearly identical magnitudes and colors, and form a "narrow triangle". Discoverer of Uranus, William Herschel, called it "one of the most beautiful sights in the heavens". It is believed to be about 200 light years away with a diameter no more than five times that of the solar system. If you have a telescope and can find it, mentally imagine the solar system as being superimposed on top to get a good sense of the scale of both the stars and the solar system at these distances.

Eskimo Nebula, NGC2392

Planetary nebulae are expanding shells of gas released after a star has exploded, and provide some of the most stunning deep-sky objects. One such object is called the Eskimo Nebula (or officially, NGC2392)   in Gemini. It earned its name due to   its resemblance of a person's face surrounded by a fur parka hood (trust me, it really looks like that!). This object is considered the most beautiful planetary to bless the winter's sky.

With larger instruments it is bright enough to show actual color (a bluish-green) and the tenth magnitude central star that illuminates the surrounding cloud. The Eskimo is felt to reside about 3000 light years away and about half a light year across. The gases are expanding at a rate of 68 miles per second.

Use First Light to find NGC2392, , then see if you can find it in your own evening sky.

William Herschel

Sir William Herschel...musician, astronomer. Born in 1738, Herschel would become one of the greatest amateur astronomers ever, and discoverer of the planet Uranus.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\hershtel.bmp}At first an organist he was a consummate amateur astronomer, never quiet satisfied with the commercial telescopes at the time. Eventually he learned how to make his own instruments of exquisite quality. In 1781 during a routine sky survey Herschel stumbled across a bluish disk which could only be one thing, a new planet. Named Uranus, this planet would lead him to become the official court astronomer of King George III at which time he left music for astronomy full time. Using his new found fame and financial backing, he constructed the largest telescope of the world: a 40 foot long monster with mirror four feet in diameter.

With these he became one of the most skilled and accomplished observers of his or any other time. Joining him were his sister Caroline and son, John. During his lifetime he cataloged over 2500 "fuzzy stars", which proved to be either very distant star clusters or clouds of gas. His observations lead him to the conclusion that stars in fact were forming out of these gases (precisely what was happening), giving us the first clear understanding of stellar formation. Not bad for the 18th century.

One of his greatest achievements was analyzing the Milky Way star clouds, which led him to conclude that the galaxy was a round, "lens shaped slab", which in fact is the fundamental form of most types of galaxies.

Herschel's sister was a fine scientist in her own right, discovering eight comets and the recipient of many awards. John Herschel his son, took one of the telescopes to South Africa in the 1830's and made extensive surveys of the southern skies. William's grandson made a few basic contributions to the science but after him the Herschel's astronomical dynasty came to a quiet end.

Discovery of Uranus

Throughout the history of man the skies have always provide a seeming constant. We can look up at the same moon that Columbus gazed at as he crossed the ocean, we can read about the constellation Orion in the Bible, writings that are over two thousand years old. From ancient times the concept of there being 5 planets : Mercury, Venus, Mars, Jupiter and Saturn, was likewise one of those comforting constants, until. . . until that William Herschel fellow and his homemade telescope came on the scene in the 1780s.

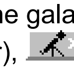
{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\uranus2.sbm}William Herschel was a musician by training and an astronomer by hobby, spending every clear evening at the eyepiece of his handmade telescope in search of nebula and comets, charting the positions of the stars, etc. On this date in 1781 while cataloging double stars he came across an unusual bluish object. At first thinking it might have been a comet he logged it, and checked it a few days later noticing that it had moved slightly, hence it must have been a member of the solar system. A little more study proved that it wasn't a comet after all but in fact a planet, the first one not known to the ancients. Named Uranus this planet would lead him to become the official court astronomer of King George III at which time he left music for astronomy full time. Using his new found fame and financial backing, he constructed the largest telescope of the world: a 40 foot long monster with a mirror four feet across. With this he earned the reputation of being one of the foremost observers of all times.

Click here to see the planet on that fateful night when the lights were first turned on her.

This film is a computer generated view of the Voyager 2 flyby of Uranus in 1986, .

Sagittarius, the Archer

Unlike many of the constellations which are of Greek origin, Sagittarius comes to us from the Sumerians, but was later adopted by the Greeks. Sagittarius is known as the Archer and is usually portrayed as a "centaur" (one of the two in the heavens). This is very little story behind the Sagittarius, but in Greece he is considered to be Crotus, the inventor of archery himself. He frequently kept company with the "Muses", the daughters of Zeus, who asked him to place archer in the heavens to be enjoyed all times.

Look for the distinctive "Teapot" pattern of stars which form the bulk of Sagittarius and mark the galactic center (due to all of the stars and dust, we cannot actually see the core of the galaxy however), . This is what is referred to as an asterism, a convenient grouping of stars which may lie within a single constellation or stretch across several, and frequently reflect local culture. The Big Dipper is another fine example. Doesn't it appear that the Teapot is pouring its contents onto the stinger of the Scorpion?

As with the neighboring Scorpius, the region contains a wealth of objects for observational enjoyment since it is up against some of the most luxurious regions of the Milky Way.

The brightest star in the constellation is called Rukbat, from the Arab for "knee of the archer".

Beta Sagittarii is a double-star visible to the naked eye. Unlike most double-stars this is merely a "visual double" in which the two members just happen to be close to each other but are not related in any other way. Both stars are about fourth magnitude

With your binoculars you should be able to see a triumvirate of the fine stellar clusters, M23, M24 and M25. The first one contains over 150 stars. M24 is not a true cluster, but is in fact one of the densest parts of the Milky Way plainly obvious to the naked eye. And open cluster M25 contains over 100 stars, of which 50 or so are brighter than 12th magnitude.

Besides these "open clusters" you'll find one of the most splendid globular clusters in the sky, M22, about half the size of the full Moon. Shining fourth at sixth magnitude it becomes visible to the naked eye on the darkest of nights. Binoculars reveal a ghostly condensation of in orbit around the galactic core.

Right above the lid of the Teapot is M20, the Trifid Nebula. Sporting two patches of nebulosity, one red the other blue, the Trifid is one of the finest objects in the sky and very easy to find in binoculars. The same goes for M8, the much larger Lagoon Nebula which challenges the full Moon for size.

Sagittarius is one of the most prominent constellations. For northern observers it is seen skirting the horizon most any summer's eve, chasing the wayward scorpion. Perhaps the archer is on the hunt once again.

See if you can find it tonight, and if it is dark, scan across the galactic dust lanes and you may be delighted with what you see.

North Galactic Pole

Rising in the eastern skies about mid-evening is the faint constellation, Coma Berenices, Berenice's Hair. Undistinguished as it seems, this constellation has one significant feather in its cap : This is where the North Galactic Pole (NGP) is located in between stars Beta and Gamma. The galaxy, like everything else in the Universe, rotates around on an axis. Where the Earth spins every 24 hours, our galaxy takes about 20 million years for each rotation. The NGP is where the North Pole of the galaxy is aimed. The southern Galactic Pole is located in Sculptor. Since you are looking away from the galaxy you will see fewer bright stars than toward the body the Milky Way. But now you have a clear shot into extragalactic space revealing many more galaxies which would otherwise be hidden by our own.

Now imagine if you were able to instantly move 100,000 light years in the direction of the NGP. Looking back you would see a breathtaking view of of our galaxy spreading out beneath you, millions of scintillating suns shimmering alone in the dark. You'd be witness to a great expanse misty clouds forming broad sweeping curves, among delicate interlaced webs of gas. Upon closer inspection you'd see these aren't clouds of gas, but of individual stars so dense, so numerous you are unable to make out the individual members. And this is a relatively average galaxy, one of literally *millions.*

Watching a sunset

Project. . .

supplies : *a free hour right around sundown.*

This is not exactly a tough assignment. Use First Light to find the time of sunset for your area, locate a comfortable chair and viewing location, bring out a good or radio and simply observe. Note the speed of the changing length of the shadows, the chill in the air. You can almost feel the Earth's rotation, spinning around like a top through space. Notice the color change in the sky from a light blue to a dark and finally black. Does it show any red or pinkish hues? The stronger the red/orange coloring the more dust in the upper atmosphere which reflects the longer wavelengths (red) better than the shorter ones (blue). Has there has a major volcanic eruption anywhere in the world? If so for the next few days you might see some unbelievably red sunsets.

Watch for the first objects to come out and jot down the time. Do they show after only 10 minutes? 30 minutes? Count them and compare the number of objects verse the time from sundown. You can use First Light to show you what the brightest objects are this evening and where they will be.

Look toward the western horizon right after sunset, then look behind you and notice the color change across the entire sky. Remember, the darkness toward the east is actually the Earth's shadow being lifted up above you and projected out into space. If your region of the country is cloud free you might briefly see a pinkish band of light immediately above the Earth's shadow. This is the "Belt of Venus" caused by the reddish sunlight reflecting back to us. If there are low clouds in the east, they would block the light. When the sky is finally dark, and the crickets strike up their nightly symphony, head on in and make some hot chocolate.

You may now want to do the same exercise for a sunrise, getting up about 40 minutes ahead of time and note the similarities and differences between the two.

Hydra, the water snake

Hydra is another of the 48 ancient constellations and is the largest in the sky. It, er, "snakes" across nearly a quarter of the heavens, lying beneath Virgo, Leo and Cancer, . Aside of its great size, this is an otherwise unremarkable constellation.

Hydra is remembered in the Greek myths for its battle against Hercules. Hydra laid waste to the surrounding countryside poisoning everything it came in contact with, devouring cattle, destroying the land. Hercules came to the rescue in his chariot forcing Hydra out into the open with flaming arrows. The snake would wrap itself around the strongman, only to have its head rudely wacked with Hercules mighty club. But where as a single head was destroyed, two more grew in its place. Finally with the help of his driver, Hercules as able to subdue the monster by burning the stump of each new head. The land was saved and Hercules was a hero yet another time.

Use First Light to locate the star cluster, M48 in Hydra, and then use your binoculars to find it in the real sky. It contains about 50 stars and is around 20 light years across.

If you have a telescope you might try for the planetary nebula NGC3242. This is also known as the "Ghost of Jupiter" due to its modest resemblance to the planet. As a nineth magnitude object it will be out of range for binoculars but should be clearly visible in telescopes.

Felis, the cat

How many constellations are there? Currently there are a total of 88, however this has not always been the case. The classic Greek based constellations number only 48, and these include those of the Zodiac for instance, or Orion, Canis Major, Hercules and so on. . .for the most part mythological beasts and heroes of old. However in the mid-18th and 19th centuries numbers of over zealous astronomers and celestial mapmakers introduced "new" constellations in order honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns. While one astronomer would recognize or try and popularize one of his own, a competitor would ignore him and add *his* own. And as such the skies are littered with odds and ends of constellations that once were. Most of these are rather small and uninteresting.

Forty of the new ones have been officially recognized and remain to this day on the charts. These bits of celestial flotsam include such noteworthy spectacles as Caelum, the chisel, Circinus the compasses, Fornax the furnace and Horologium the pendulum clock. Few have with any interesting objects, and all are rather dim.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\felis.bmp}One which is no longer in use is Felis, which depicts a kitty between Antlia and Hydra, . The "inventor", Frenchman Joseph Lalande, created it out of his fondness of cats. User First Light to center that region and see if you can recognize anything that even loosely resembles a cat.

Ecliptic

The ecliptic is the plane of the solar system defined by the Earth's orbit. Visually, it is the path of the Sun through its year long journey in the sky. Click here to center the Sun. You will notice that it is placed exactly on the line. Drag the sky around and look for the various planets. They are all on or near the ecliptic, well, all except for that trouble maker Pluto.

Move your eyepoint off of the Earth, slightly above the solar system and snoop around. Using object-droplines in the preferences/animation menu you can see the relative heights above or below the ecliptic for each planet. Center Pluto and you'll see a very long line. While most planets are tilted no more than a few degrees, Pluto is inclined at a full 17 degrees lending some credence to the theory that it is not a part of the original solar system but a wayward planet caught in the clutches of the Sun at some distant time in the past. This suggests that there are other Pluto-like planets highly tilted from the ecliptic plane, therefore escaping most planetary or asteroid searches which focus along the ecliptic.

The name comes from the fact that all lunar and solar eclipses happen when the Moon is near this plane.

Spring : the Vernal Equinox

The beginning of spring is marked by the passage of the Sun from the southern sky to the northern.

Click here  to center the Sun. The yellow line is the ecliptic, the pathway the Sun travels on its year long journey through the sky. Notice how the Sun is on the zero declination point, the celestial equator, a heavenly projection of the Earth's own equator. Everything above is said to be in the northern skies, those below, in the south. This point is also the zero point for right ascension.

As the Sun crosses this point it is directly overhead at the equator making the days and nights the same length of time. As it progresses north the days get longer for the northern hemisphere and shorter for the southern. Use the Hover mode to look at the Earth from space and you will notice that the line separating the day and night sides is exactly vertical, as to be expected. If you jump ahead in time even a few days the line tilts toward the north bringing the arctic into sunlight for the first time in 6 months, but leaving the south polar regions in the dark.

As the Sun continues northward, its rays get more and more direct, more concentrated than they were when it was low on the horizon, hence the days get warmer even though the Earth is actually further from the Sun then in the winter. The opposite of the Vernal Equinox is the Autumnal Equinox as the Sun dips into the southern skies, signaling that the cooler weather is soon to be upon us.

declination :
Along with right ascension, forms the celestial coordinate system. Declination is equivalent to the latitude on the Earth measured in degrees, and right ascension ("RA"), the Earth's longitude. Unlike declination, the RA is given in "time", hours, minutes and seconds, where each hour is equal to 15 degrees.

Spring Skies

With the snows on the verge of melting and the chill in the air just starting to fade, we know that spring has arrived. Storms have lessened and the air is filled with the fragrance of new growth all around us.

In the sky, spring is marked by the appearance of a whole new slate of constellations. By mid-evening, the winter constellations are saying farewell as Taurus the Bull slips silently below the horizon, chased by Orion, his club still raised in perpetual attack. Sirius, the brightest star in the sky is still clearly visible, but not for much longer.

Rising now in the east you'll see Leo, the lion, one of the few constellations that actually resembles its heritage, . In Leo you'll find Regulus, the 21st brightest star in the sky. Leo also contains many fine bright galaxies, well suited for small to medium telescopes. Leo is believed to be the lion that Hercules fought as one of his 12 labors.

Trailing after Leo is Virgo, the maiden, . This is the second largest constellation in the sky, next to Hydra the water snake. Virgo is where you will find famous Virgo-Coma cluster of galaxies, lying over 65 million light years away and containing over *1000* bright galaxies.

Above Virgo you will see Bootes, the herdsman, . Bootes is the home of the reddish Arcturus, the fourth brightest star in the sky, lying some 36 light years away. In the Greek myths, Bootes is identified as Arcas who chased a great bear, not knowing it was his mother in another form. Another legend says the Bootes is the inventor of wine.

In later part of spring, the mighty Hercules takes a bow, . The son of Zeus and the strongest of the Greek heroes, Hercules plays host to one of the brightest star clusters in the sky, M13.

These constellations along with Hydra, Corvus, Crater, Ursa Major and Minor, Puppis, Vela and Carina form the "Harvesting and Harnessing" group.

Now go outside if it is clear and see which of these constellations you can make out.

Galileo Encounters Jupiter

Few NASA projects have had the twisted history that Galileo has been cursed with. First started in 1976, entire careers have been built upon this one probe. Original project scientists retired, new ones joined on who were in high school at project conception. Galileo is regarded as one of NASA's last big probes, ending the golden age of planetary exploration. Future spacecraft fall under the "faster, better, cheaper" framework instituted to avoid 20 year long projects, and designed to support larger numbers of small probes for the price of a single costly one.

Launched in 1989, the Galileo probe encounts its target on this very evening. Galileo is the largest, most complicated interplanetary spacecraft ever flown. Originally it was meant to be launched in 1982, but delays with the Air Force supplied booster moved that to 1984. At the time the Air Force canceled their project, leaving the spacecraft with no where to turn but the space shuttle. It was finally targeted for launch four years late onboard the space shuttle Discovery in the spring of 1986. Using a powerful new booster rocket it would have sped on its way to Jupiter taking only about three years where it would then spend 18 months in orbit, making close up observations and taking hundreds of thousands of pictures. However due to the Challenger accident, the new booster was deemed too dangerous to launch onboard the shuttle so a lower powered substitute was used instead. And now instead of taking a direct route to the planet, Galileo was required to spend twice as much time in its journey. Over a period of six years it would have to "steal" a little bit of extra energy from other planets to sling it on out to Jupiter using the well proven "gravitational assist" technique. So now instead of three years in space, it would require six years taking a torturous path that would spin it by Venus once and Earth twice.

The scientists made the best of the new, longer route, taking photos of Venus, sweeping past two different asteroids, making major discoveries of one. And observing the Comet Shoemaker-Levi collision in July of 1994.

Even after all of this, the probe would still suffer other indignities. The biggest problem was traced back to the long storage the orbiter was to suffer during the many agonizing delays. One rib of the flexible umbrella-like antenna appears to have stuck onto a vertical support rendering it useless. The antenna was to permit the spacecraft to return it's mountains of data instantaneously. But after years of trying to hammer it loose with its deploy mechanism, or baking the rib in the sunlight, the freezing it in the dark of space, it remains stubbornly stuck. Tonight is the last possible chance for the pesky antenna to be released as some engineers think that the jolt of the breaking rocket might knock it free at last. All is not lost, as in the intervening years the spacecraft's software has been modified along with Earth based receiving antennas that can the signal received by several times. Even then it can still take several hours to return a single image, in the same way it takes a lot longer to download an image from Compuserve when you are running at only 300 baud, vs. 14.4K baud.

And now after 19 years, on this evening, Galileo's rocket engine will fire away one last time, nudging it gently into a sweeping orbit of the mighty gas giant. Five months earlier, Galileo dropped off its atomspheric entry probe, which if all goes well, will slam into the Jovian cloudtops at thousands of miles an hour. The probe is expected to return data for up to an hour after deploying parachutes to slow it down, permitting it to drift in the yellow methane winds.

Click here  and use First Light to observe the path of Galileo over the past several years. This first view shows where it is right now (if you are reading this after orbital insertion on December 7, 1995, it will not appear until you change the date back to before December 7). Move back to the launch date of October 18, 1989 and use the fast-forward button on the toolbar to advance the spacecraft. Notice how it swings around Earth and Venus and gains a little bit of speed each time. As Galileo approaches Jupiter, see how it is actually "in front" of the planet, but goes slower so Jupiter can catch up with it.

Back side of the Moon

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\farside.sbm}Wrongly called the "Dark side" of the Moon, the back, or far side remained a mystery to man for as long as he had turned his gaze toward the heavens. No doubt you have noticed that the Moon always keeps the same side to us. It does rotate, slowly, but at exactly the same rate as its orbit around us. The two motions synchronize exactly together, giving us the same face. It wasn't until the Soviet's Luna 3 spacecraft sailed over the mysterious side in October 1959 and returned some fuzzy pictures that our nearest neighbor began to reluctantly give up her secrets. For these pictures showed an almost entirely different planet. While the near side is full of dark flat planes, ("seas" to the ancients, lava filled basins to the moderns), the far side is virtually devoid of such things. It was a vast wasteland of craters upon craters upon craters, a very ancient surface.

Using First Light you can see the Moon in a way that only 21 humans have ever experienced. Clicking here will place you in hover mode situated about 6000 miles behind the Moon. Notice the Earth in the background. From the Earth the Moon is nearly new, practically invisible due to the Sun's glare. Were you in darkness on the near side, the Earth would be full, as seen here. Now notice the rough cratered surface. This is a definitely not your father's Moon.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\tsiolkov.sbm}You will notice that this side does have one outstanding feature : a small black lava basin called Tsiolkovskii. This was about the only detail visible in the relatively crude Luna 3 photos, hence it was named after the greatest Soviet space pioneer. Ten years later the Apollo missions returned many fine images of the hidden terrain including Tsiolkovskii. Click here to see a video clip transmitted by Apollo 17 as they were leaving the Moon back in 1972, the last humans to visit our "twin" planet.

The "seas" on the near side were caused by massive impacts of asteroids 80 to 100 miles across or more. They would carve out deep basins through the lunar crust which were later filled with lava as the lunar interior heated due to radioactive decay. Many of the asteroids were denser than the native lunar material, causing a slightly higher gravity forcing the Moon to lock its aim toward the Earth over the period of billions of years. There is still a latent effect called "libration", which causes a slight swing back and forth of the Moon, permitting us to see almost 60% of the total surface.

Spring deep sky objects

With the coming of spring comes an explosion of wonderful deep-sky objects. Glistening in the dark is the spectacular globular cluster M13, a tightly condensed sphere of 100,000 stars. M13 is located in the constellation Hercules and rises in mid-spring.

A little to the west in the Virgo is the famous Virgo-Coma galactic cluster. Since you are looking away from the interference of our own galaxy the rest of the Universe is laid out in all its splendor. Relatively speaking this is quite close, only 60 million light years away. 20 members are clearly visible in small telescopes, and larger ones will reveal hundreds more. Remember, each galaxy is likely quite a lot like our own.

In fact the whole sky is flooded with galaxies. There is M104 the famous Sombrero Galaxy, resembling the hat. NGC2903, a bright spiral galaxy in Leo and NGC4449 in Canes Venatici a bright irregular. Granted, through all but the largest telescopes, these great "cities of stars" will never look like their pictures, the human eye is not nearly sensitive enough. And imagine the possibility that an astronomer in say, NGC4449, 50 million light years away, might be peering through his telescope at a faint fuzzy patch that we call home. A patch no doubt logged among thousands of others as a slightly larger than average, but otherwise unremarkable spiral.

Spring shows us also the fiery red Arcturus the forth brightest star in the sky, Spica in Virgo, the 15th brightest and Regulus, in Leo, the 21st brightest.

Spring skies : Libra, Scorpius, Corvus

As you begin to settle into spring I'll cover three other spring constellations you may want to check out (see the March 21 activity for more constellations).

Rising late in the evening in March is Libra, the only constellation in the Zodiac the does not represent an animal or person, . Libra means "the scales" and is one of the most ancient constellations having been known by the Sumerians 4000 years ago. The concept of balance has to do with the fact that in Libra was once located the Vernal Equinox, the point where the Sun passed from the northern skies to the southern, hence a sense of "balance" in nature. Since then, the equinox has shifted to Virgo due subtle motions of the Earth called precession.

Scorpius is one of those constellations that really looks like the object it represents, . Its deadly tail is clearly visible and mighty claws spread, ready for any hapless victim who might stroll by. In legend the Scorpion was the downfall of Orion. The stories of his death vary greatly. According to one Orion was boasting how he was the greatest of all hunters. However, he made the mistake of stating this to Artemis the goddess of hunting and Leto her mother, claiming that he could kill any creature on Earth. Unwilling to tolerate such presumption, the Earth itself split open revealing a giant scorpion which stung Orion to death. Now he is placed opposite in the sky from Scorpius, so as the great scorpion begins to rise in the east, Orion makes his escape by ducking below the western horizon. Located in Scorpius is Antares the brilliantly red star often mistaken for Mars and the 16th brightest in the sky. Scorpio also suffers an embarrassment of riches in the star cluster department, having numerous naked eye and binocular objects.

Corvus is more of a novelty constellation, tossed in with these other two for entertainment value only, . Corvus represents a crow that according to legend was sent by Apollo with a cup to fetch some water from a spring. Not being too bright, the crow was distracted by a fruit tree and waited several days for it to ripen so he may eat. By then the water was no longer needed and the crow needing an alibi, returned with the water snake Hydra saying that it blocked his way. Angry, Apollo condemned him, Hydra, and the Cup to their current heavenly domain. Corvus is traditionally shown on the back of Hydra along with the cup, now known as the constellation of Crater. Corvus is home to a number of dim galaxies and a nice telescopic binary star, *Del Corvi*.

precession :
A slow "wobble" of the Earth much like that of a child's top. Each "wob" takes about 25,800 years and has the effect of changing the direction the poles are pointing at (currently Polaris, the northern star for instance) and also causes the equinoxes to slowly drift.

Charles Messier and his catalog

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\cmessier.bmp}Charles Messier was an 18th century French astronomer known primarily for compiling his famous catalog of deep-sky objects. Messier had a fondness for comet hunting and all told discovered 15 new comets during his lifetime. Comet hunting is a tedious and exacting work. From time to time, Messier would stumble across fuzzy objects that could easily be mistaken for comets. He would note them for future reference and for the benefit of other hunters like himself so as not to be deceived. This list eventually grew to 110 of the finest objects in the heavens. And those objects that proved to be a irritant to Messier turned out to be wonders such as the great Galaxy in Andromeda (M31), the Orion Nebula (M42), the Ring Nebula in Lyra (M57) and other fantastic sights. While Messier's comets are not remembered this day, his catalog is still in use. Messier objects begin with an "M" and are followed by a number from 1 to 110.

First Light distinguishes between the Messier catalog and the other main listing called the "New General Catalog", or NGC for short. Several objects have been dropped from the original Messier list due to they're either turning out to be something as mundane as a double star, or being merely his imagination.

Redshift and stellar distances

There are many ways astronomers measure the distances to the stars and galaxies. Some better than others, depending on the distance and kind of object. The most common method in practice and the only one available for the furthest objects is through the use of the "redshift".

We have all noticed what happens to sound on a moving object. If an ambulance is moving toward us, the pitch of the sound goes up. This is called the "Doppler" effect. With light the same thing happens. If an object is moving away from us the color changes (the "pitch" for light waves) and shifts toward the red part of the spectrum. If it is coming toward us the light moves toward the blue end. This color shift can be directly converted into velocity.

One aspect of the Universe is that the objects nearest the edge are moving faster than those near the center. Therefore measuring their velocity can give us a rough estimate of their distances. Astronomer Edwin Hubble (whom the Hubble Space Telescope is named after) proved that the redshift is directly proportional to an object's distance from the Earth. From him we get the equation :

distance to object=H/velocity

Velocity is the "recessional velocity" as measured by the redshift and **H** is called the "Hubble Constant". This value is the amount of velocity added to an object for every million parsecs of distance. The exact value of is not known and remains one of the more elusive targets in the field of Cosmology.

Redshift is given in terms of the percentage of shift. If an object's colors shift 10% its redshift is ".1". The furthest galaxies show a value of about one, the furthest visible objects, quasars, are pushing four. Beyond this lie the "background radiation", echoes of the creation of the Universe. Radiation detected from this has a redshift value approaching *1000*! Between the Quasars and this radiation boundary is the great unknown void. The Hubble Space Telescope may help solve some of these mysteries bringing us closer than ever the Big Bang, and the beginning of everything.

Cosmology :
The study of the Universe on its largest scale from the beginning to the end.

parsec :
Sometimes used in place of a light-year. One parsec=3.26 light years. In other words, it takes light 3.26 years to travel a single parsec.

Libration

Wrongly called the "Dark side" of the Moon the back or far side remained a mystery to man for as long as he had turned his gaze toward the heavens. No doubt you have noticed that the Moon always keeps the same side to us. It does rotate, slowly, but in exactly the same rate as its orbit around us. The two motions synchronize exactly together so the giving us the same face. It wasn't until the Soviet's Luna 3 spacecraft passed sailed over the mysterious side in October 1959 and returned some fuzzy pictures did our nearest neighbor begin to reluctantly give up her secrets. For these pictures showed an almost entirely different planet. While the near side is full of dark flat planes, "seas" to the ancients, lava filled basins to the moderns, the far side is virtually devoid of such things. It was a vast wasteland of craters upon craters upon craters, a very ancient surface.

The seas were caused by asteroids bombarding the surface, carving out deep pockets which would eventually be filled by lava. Many of the asteroids were denser than the native lunar material causing a slightly higher gravity forcing the Moon to lock its aim toward the Earth over the period of billions of years. There is still a latent effect called "libration" which causes a slight swing back and fourth of the Moon permitting us to peek behind and see almost 60% of the total surface.

Missing mass problem

One of the most perplexing problems in all of astronomy is "where is 90% of the Universe?". For only about 10% of the Universe seems to be visible. Over the past few decades it has been established that the observed gravitational effects from both our galaxy and those of nearby clusters of galaxies are much stronger than what is possible by what is visible. This would suggest that most of the matter, the stuff that makes up the Universe, is simply not visible. Many theories abound as to where it might be hiding. Possibly large dark clouds of matter might surround the the galaxies. Or, up until recently, one of the most popular theories suggested that it was tied up in massive numbers of very dim, low mass stars that are so unobtrusive that they have managed to escaped attention. The Hubble Space Telescope shot this one down in flames. Yet another theory states that the matter is hidden in the form of tiny particles called neutrinos, left over from the Big Bang.

Whatever the case, astronomers have determined that the Universe's average density is about three hydrogen atoms per cubic meter of space. However they have observed only about one tenth this amount.

I have a theory that most of this missing mass is tied up in the closets and the storage rooms of America. I alone can probably account for about 5% with another 3% in the garage.

Just imagine what the skies would look like were all of this matter condensed only to blaze forth into untold billions of tiny stars and millions of brand new galaxies.

So, why don't you check your closets for missing mass and if you find any, alert your local astronomer.

Copernicus, a most impressive crater

He was said to have "stopped the Sun and threw the Earth into motion". His name was Nicholas Copernicus a Polish renaissance astronomer whose work revolutionized both astronomy and dramatically changed Man's concept of the world and his place in the Universe. For it was Copernicus who dared to suggest that it was the Sun was the center of the solar system and not the Earth.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\lo_coper.sbm}While the Greeks would honor their heroes by making constellations out of them, more modern astronomical heroes are recognized with lunar craters. And fittingly, Copernicus had perhaps the most prominent of all craters named after him. Clearly visible slightly above and to the left of the Moon's center, Copernicus is noted for his bright dramatic rays, rugged deep sides and stark central peak. The crater yawns 57 miles wide and is over 2 1/2 miles deep.

The crater becomes visible when the Moon is at gibbous phase, slightly past first quarter. If the Moon is visible tonight, see if you can make out this most magnificent sight.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\coprna17.sbm}At one time NASA considered landing the last of the Apollo missions actually *inside* the crater right next to the central peak. Unfortunately the final three missions were canceled, along with the Copernicus mission. But perhaps one day man will return and tread the floors of this 57 mile wonder.

Light pollution

Project. . .

supplies : *a clear sky, First Light star charts of Leo and Gemini, a moonless night and a nearby town.*

There are many kinds of pollution : air, water, sound, and now, *light.* What is "light pollution" you ask? If you live in or near a city or town, go outside and gaze upward. Chances are the skies above will not be black, but will instead be gray or yellowish. This is caused by the light glow from street lamps, high rise buildings and so forth. Some effort has taken place to limit light pollution over the years, such as replacing the white mercury-vapor street lamps with the yellow sodium lamps. Also placing larger hoods over the street lamps, preventing as much light from going up as possible has had some effect. However, the mere growth of the urban areas across the country is now threatening many observatories.

The Lick Observatory above San Jose has seen its western skies all but destroyed by the phenomenal growth of the city. Mt. Palomar in Southern California has seen its sky brightened up from both the Los Angeles basin and San Diego. From space the shuttle astronauts described the Las Vegas Strip as "obscenely bright".

In order to see light pollution in action go to the heart of the local town or city and study the constellations Gemini and Leo. Using star charts from First Light, note the faintest stars you can see with your naked eyes. Now drive out into the country and do the same. How faint of stars can you see now? Compare the differences. If you are sufficiently close to the city you should probably still see the glow along the horizon.

You should perform these observations on a moonless night. Otherwise the Moon itself will generate its own form of light pollution. The glow from a full Moon in particular can crowd out all but the brightest stars and destroy your own ability see dim objects.

It is a dramatic experience for city dwellers when they see the pure, unfiltered night sky for the first time. Many have never witnessed the soft gentle caress of the Milky Way and often mistake it for some high clouds. Those who first learn the constellations from the city may get lost in the country skies due to there being just TOO MANY STARS!

While light pollution is the natural result of human expansion you can do your part by ensuring that sodium street lamps selected over the mercury kind for new developments in your town. Or to sponsor public star parties out away from town to reacquaint your neighbors with what the night sky must have looked like a thousand years ago.

Keck Observatory : The Biggest Telescope Around

When the Mt. Palomar Observatory opened for business in 1946, it gained the title of "The Glass Giant", for it was the largest optical telescope ever.

Optical scopes are divided into two main categories : Reflector and refractor. The reflector has a slightly curved mirror at the bottom of a tube. The mirror captures a lot of starlight and focuses it down to increase its brightness. This light is then fed into camera, spectrascope or human eye. The refractor on the other hand is what Galileo used, and consists of a set of lenses that essentially do the same thing as a mirror. Reflectors are considerably cheaper to build as it has always been easier to construct large mirrors rather than large lenses. A telescope's "size" is measured by the diameter of the mirror or lens. Palomar's is a whopping 200 inches across, considered the largest possible at that time (whereas most home scopes are typically 8 to 10 inches). Any larger mirror would likely sag under its own weight corrupting the image. Such was the case when the Soviet Union unveiled their own glass giant in the 1970s. Measured at 236 inches across it never worked quite right thanks to the mirror flexing under its own massive girth.

A radically new design would have to be developed to get around this problem. Thanks to a combination of clever engineering and sophisticated computer technology, much larger telescopes became a possibility during the 1980s. Such designs would eventually lead to the construction of the $94 million Keck telescope high atop Mauna Kea, Hawaii. The Keck 1 instrument truly dwarfs anything before it. While the Palomar telescope was an astonishing 200 inches in diameter, the Keck measures a staggering *400* inches across, twice the diameter and able to collect four times the light. What made this possible was moving away from the concept of a single gigantic mirror to using a number of small mirrors. This required new untried mirror making technology along with complicated computer driven approaches to aligning the mirrors together in the telescope assembly. Also, thanks to a $70 million grant from he W. M. Keck foundation the project was almost fully funded from the start. During the late 1980s and early 1990s the Keck became a reality. Keck 1 saw "first light" in 1992 and is destined to revolutionize astronomy in the same way Palomar has nearly 50 years earlier.

The first telescope was so successful, and so completely fulfilled its design goals coming in on time and on budget the Keck Foundation voted to fund a second telescope, a virtual clone of the first. Keck 2 will be located 250 feet from the first and when combined together using a technique called "interferometry" can work in tandem to simulate a much larger telescope yet. The detail that these two telescopes will be able to see is truly staggering, they will have the ability to separate a car's headlights 16,000 miles away (not that they plan to do that). This will lead to being able to peer further inside the distant galaxies or perhaps to one day gaze upon the surface of another star. With the combination of the Keck telescopes, the Hubble Space Telescope, a half dozen other monster telescope projects scattered around the world, and a really neat piece of Windows software, we are truly in the golden age of astronomy. So sit back grab a cup of cocoa and watch the Universe come into focus.

Leo, the Lion

Rising now in the east you'll see Leo, the lion, one of the few constellations that actually resembles its heritage, . Leo is believed to be the lion that Hercules fought as one of his 12 labors. The lion was the scourge of the region, freely devouring its inhabitants. Hercules chased after the animal when he discovered its pelt was impervious to all weapons. Cornering him in his cave, the son of Zeus justified the many stories about his legendary strength by choking Leo to death and skinning him. He would later wear the pelt with the lion's head propped up on his own enhancing his already fearful profile.

In Leo you'll find Regulus, the 21st brightest star in the sky which is said to mark the lion's heart. Another star, although one that you are likely not to see, is the faint "Wolf 359", the third nearest star. At a distance of only 7.75 light years it is a surprisingly dim 14th magnitude, making it one of the least luminous stars known, shining with only 1/63,000th the energy of the our own Sun.

Leo also contains many fine bright galaxies, well suited for small to medium telescopes. Now step outside and see if you can make out the king of beasts.

Regulus, the Lion's Heart

Rising now in the east you'll see Leo, the lion, one of the few constellations that actually resembles its heritage. Leo is believed to be the lion that Hercules fought as one of his 12 labors.

Alpha Leonis, "Regulus," is the 21st brightest star in the sky, . For thousands of years Regulus has been associated with royalty and kings. Called "the Kingly One" by the Arabs, "The King" by the Babylonians in writings all the way back to 2100 BC. Regulus is a double star with an orange 7.9 magnitude companion 177" away and an easy object for small telescopes. If you are able to "split the double" note that the distance between the two stars is about 4700 AU or 5 times wider than our own solar system. Now visualize the solar system superimposed on top of the pair, but only 1/5th the width and you'll get an idea of what *we* would look like from an observer at the other end of the telescope 85 light years away.

The companion star is itself a double-star, much fainter then the parent and visible only in the largest telescopes. So that means that Regulus is in fact a triple star. Imagine what the view would be like from a planet orbiting any one of the three!

Leo Minor, the Lion Cub

Leo Minor is a faint and obscure constellation that will challenge your seeing abilities, not to mention your imagination, . Even though this is named after the ancient Leo, it is one of the "newer" constellations created in 1687 by Johannes Hevelius and therefore has no stories behind it. The brightest star shines at a meager fourth magnitude.

Star "names" in constellations are given in several different forms. There are proper names such as Rigel, Naos and Altair. Next below that are Greek identifiers where the brightest stars are named after letters in the Greek alphabet. The brightest star is called "Alpha", the next brightest is "Beta" and so on. After that comes various catalog numbers for the numerous stellar catalogs that abound. Leo Minor bucks this trend slightly in that it has no "brightest" star, that is, no star named Alpha while there is a Beta. Apparently this was a mistake when English astronomer Francis Baily was labeling the new constellations in the 19th century.

Leo Minor has no major deep-sky objects worth the bother of an amateur. But see if you can find it, and amaze your friends at the same time!

Photographing the Moon

Project. . .

supplies : a clear night, SLR camera, telephoto lens (135 mm or greater), telescope if you have one, the Moon.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\moon_pix.bmp}Perhaps the easiest celestial object to photograph and first target for budding "astrophotographers" is the Moon (next to the Sun that is). It has a clear advantage over any other object, it has good lighting (that is, it's bright!). That means that exposures can be short, standard films can be used, and it can yield beautiful pictures with relatively little effort.

You should have access to a standard "SLR" camera. The pocket cameras and those cardboard things will not work very well as they don't give you the control over the exposures and lenses that you will need. Your camera should have interchangeable lenses and permit you to go into a manual mode so you can set the exposure yourself. A good tripod is also helpful for basic photography, and a telescope if you have one.

There are several different ways to photograph the Moon . The easiest is using the camera alone, that is, without a telescope. If you have a telescope then you can mount the camera where the eyepiece should go, this is called "prime focus" photography. The "best" and hardest is eyepiece projection where you project an image from the eyepiece back onto the film directly.

Using the camera alone is not much different than taking standard pictures, but will likely require somewhat longer exposures. This is good for taking pictures of the Moon rising or setting, with something in the foreground such as a mountain or city skyline, but will not reveal any of the fine detail. Even with the largest consumer lenses, 400 to 500 mm, the image will be only about 1/5th the size of the film's frame. The exposure will depend on the film speed and lighting, but you should be able to use the camera on automatic for brighter scenes. For dimmer twilight shots, doubling or quadrupling the exposure should get you into the ballpark. It is recommended that you "bracket" the shots, that is, take several pictures at different f-stops or shutter speeds.

The other two methods are beyond the scope of this project as they require equipment beyond the basics. However, there is a hybrid form of lunar photography that is relatively easy and should produce results that you can show off to your friends, and that is to simply aim your telescope at the Moon and hold the camera with a standard lens, up to the eyepiece. This will simulate just what you see through your eyes. You should use faster films of ASA200 or ASA400 since this is a handheld approach, and remember to bracket the exposures as the proper exposure will require a lot of experimentation. As a challenge you might want to try this using a pocket camera just to see if you can coax decent space shots out of them.

Another way to photograph the moon is to use video. Simply take your video camcorder if you have one and hold it up to the eyepiece and see what happens. Then study the tapes afterwards and see what craters you can identify.

The best time to shoot is when the Moon is around first quarter as the most dramatic scenery just starts to become visible at that time. And remember : take accurate records of each exposure so you know what works and what doesn't. Start the roll with an identifier shot of a building or your pet gerbil, just so you know which Moon shot is the first.

Kinds of Galaxies

It wasn't until the early part of this century that the concept of galaxies outside the Milky Way was developed. Edwin Hubble, using the newly christened 100 inch telescope at Mt. Wilson California (the largest in the world at that time) determined that the "Great Nebula in Andromeda" was in fact far beyond the edge of the Milky Way and not a nebula after all. For the cloudy bands and swirls where in fact clouds not of gas, but of individual *stars*! Millions of them!

Hubble determined that the Milky Way is merely a galaxy similar to the Andromeda object, and similar to thousands or millions of others.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\gal_type.bmp}There are three kinds of galaxies : Spiral (A), elliptical (B) and irregular (C).

The spiral galaxies are those carrying the classical vortex or whirlpool shape. The have a bright central region of older stars and a disk of gas a newer stars orbiting around. Spirals are typically 100,000 light years in diameter and 2000 light years thick. Spirals are subclassed as to the shape of the bulge, number of arms and so on.

Elliptical galaxies have no strong disk but still maintain a rounded form made up mainly of older stars with no dust clouds at all. Their sizes can go all the way from a whopping 300,000 light years (three times the Milky Way) in diameter down to a relatively puny 100 light years, not much different than a globular cluster.

The third class, irregular galaxies, are usually smaller than spirals and have no discernible form at all. They contain both young and old stars. The Small Magellanic cloud in the southern skies is an example of this kind. Irregular galaxies may form that way, or may be other kinds disturbed by either an explosive core or disruption by nearby galaxies.

globular cluster:
A round, concentrated cluster of old stars which usually form into halos around galaxies. They contain between 100,000 to 10 million stars and are typically 100 light years across. Globulars are wonderful objects in small telescopes due to their perfectly rounded shape and the delicate glistening of the nucleus.

nebula :
Interstellar cloud of gas or dust from which stars are likely to form. Some nebulae are illuminated by embedded stars such as the Orion Nebula, while others are "dark nebula" which have no nearby stars.

Voyager 2 at Jupiter

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\jupiter1.sbm}Beyond Mars, lay the "outer planets."   Before the age of space travel, they remained enigmatic telescopic blurs only grudgingly giving up their secrets. It wasn't until the Pioneer spacecraft and later the phenomenally successful Voyagers 1 and 2 that the real nature of these distant worlds became known.

What had up until than been merely pinpoints of light first seen by Galileo in 1610, Jupiter's four largest moons became real worlds, each strikingly different, each with a different story to tell.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\io1.sbm}On this date in 1979 the second of the two sister vehicles crossed into "Jovian"   space following Voyager 1 by four months time, . It went on to further survey unimaginably hellish world of Io, the sulfurous orange moon literally turning itself inside out through dozens of active sulfur volcanoes.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\callist1.sbm}Then there is Callisto, the third largest moon in the solar system, the second largest around Jupiter. Unlike many of the other moons, Callisto seems to be completely "dead" with no noticeable geologic activity whatsoever.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\ganymed1.sbm}Ganymede is named for the cup-bearer of the Greek gods and is the largest known moon in the solar system. It is similar to Callisto in materials, but has a much thinner ice crust (60 miles vs. 150) which floats on top of 400 mile thick layer of slushy water. Numerous white craters are visible, the bright material being "fresh" snow or ice splashed up and across the dark dusty surface.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\europa.sbm}Unlike Callisto, Europa has had a violent, active history. With a surface covered by water ice, only three craters have been identified. The more intriguing marks are the dark "linea" crisscrossing the entire surface.

After stripping the moons of their secrets, Voyager 2 peered down into the massive "Red Spot" from an altitude of 444,000 miles and silently observed an intricate network of cloud patterns locked forever in a gigantic cyclone. It measures about 15000 miles long by 7000 miles wide and makes a complete rotation in 6 days. The red coloring is believed to come from "phosphine" which rises to the top of the clouds and is then broken down into"red phosphorus-4", .

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm}Voyager 2 sailed above the turbulent clouds twice as far is the first visitor but as with Voyager 2, spacecraft 2 would likewise visit the ringed giant Saturn. Nevertheless as Voyager 1 sailed out of the solar system her task completed, Voyager 2 was only half done. Being retargetted to visit Uranus in 1987 and Neptune in 1989, the delicate machine was called upon to survive over 13 years in the freezing depths of space.

To further investigate the Voyager 2 encounter you may use the First Light *flyby* option. Click here to demonstrate. Now move your eyepoint around and advance the time using the flyby control panel.

Diurnal motion

Project. . .

supplies : a clear night, SLR camera (something more sophisticated than the pocket cameras), standard lens (55 mm or so), a clear dark night and some fast film.

Diurnal motion is simply the daily motion of the heavens, from the way the Sun moves across the sky to the rising and setting of the stars. This is caused of course by the rotation of the Earth on its axis once every 24 hours.

Here you will use your camera to demonstrate this motion by photographing the stars.

You will need to do this on a moonless night when the skies are relatively dark. (However if you live in downtown New York, skylight might be a problem.) The camera must permit you to take time exposures. The smaller, pocket cameras probably won't do that. Using First Light, locate Polaris the North Star. Now set up the camera on the tripod with a standard lens and focus to infinity. Using fairly fast film ,ASA200 or ASA400, set the f-stop wide open (making sure to turn off any of the automatic exposure features). Open the shutter, and leave it open for an hour or more. Now you can go and watch Babylon 5 or a good Star Trek rerun. When the final credits are rolling go back out, cover the lens with your hand or the lens cap and carefully close the shutter.

Aim the camera 90 degrees away from the north and do the same to get the equatorial stars.

Process the film and figure out why you see what you see. The "streaks" are called star-trails and are frequently the first ever astro-photographs anyone ever takes.

Tables

Constellations
Eclipses
Meteor Showers
Planets
Stars

Buying a Telescope

If First Light has done its job, by now you may be saying to yourself "Self, I wonder if I should get a small telescope?". Well, what's stopping you?

When you first consider buying a telescope, figure out exactly what you want to do. If you are merely interested in casual peeks at the planets, there is no need to get a $6700 Compustar 11. Or if you want something really portable for backpacking don't get a 17-inch Dobsonian when a good pair of binoculars might do the job.

No doubt your first is thought is, "but I want to see everything!". Unfortunately, there are always going to be drawbacks to accept and choices to be made. Telescopes are measured in the size of their "objective" (either lenses or mirrors). So a "17 inch" Dobsonian will contain a mirror, 17 inches in diameter (in other words, lots of glass). Of course the larger the diameter, the more you will see, but the drawback is that a 17" is large and heavy. Such an instrument may quickly throw water on the enthusiasm of a novice observer if it takes three people to move it out to the backyard. On the other end is a "typical" beginner telescope, such as a 2.4 inch refractor or 6 inch reflector from your local Sears. While easy to transport, the galaxies and such will not be nearly as spectacular, (although the planets and the Moon most certainly will be). Other things to consider would be the accessories available. The more serious instruments are naturally going to have more goodies to spend your money on, while the simpler models might not.

As mentioned above, the aperture is the chief method of measuring the general performance of a telescope. Scopes are simply "light buckets", so the larger the objective, the more light it can capture and the sharper the image. Don't be misled by advertisements for instruments costing only $200 but having 500 power. The "power", or enlarging capability of the telescope, is likewise connected to the aperture size. The higher the power, the more spread out, or dimmer, the image will be. It will also be less distinct. A general rule of thumb is that the maximum usable power of a telescope is going to be 50 times its objective size in inches. Therefore a 2.4 inch refractor will be fine up to 120 power, but after that you'd be fighting a losing battle. Theoretically, the scope could be pushed to 500 power, but the image would be too dim and fuzzy to be usable. (By the way, 50 to 75 power is just right for most solar system observations, so magnification isn't everything).

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\refract.bmp}Perhaps the most familiar kind of scope is the good old "refractor", not much different than Galileo's original instrument. In its most simple form, a refractor combines a set of lenses at the front of a long tube, with an eyepiece at the other. The standard scope of this type has a lens 60 millimeters in diameter (2.4 inches) and a tube about three feet long. Refractors are the most common small telescopes made, mass produced by several large volume vendors and usually sold in the toy sections of major stores. I wouldn't recommend these mass market instruments for anything but the most casual of observing. While inexpensive, the optical quality is usually so poor as to make them nearly useless for anything but the largest and brightest objects. Quality manufacturers such as Meade, Unitron and Pentax all make similar small refractors, but of much higher quality. These are perfect for casual viewing of the solar system and some of the brighter deep-sky objects, but they just don't have the light-gathering power to support astrophotography or serious deep-sky observations. Larger refractors are available, but once you get above 3" models, the prices become "astronomical" (sorry), not to mention the weight.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\newtnian.bmp}Besides the refractors there is the "reflector", which, as its name would suggest, uses mirrors instead of lenses. The most common of these, the Newtonian, was developed by Sir Isaac himself. The light enters in through the front, reflects off of the primary mirror, into the secondary back at the front, and out of the eyepiece. A variation of this kind is the increasingly popular "Dobsonian-Newtonian", which sacrifices some general convenience for very low-cost instruments. Most telescopes are mounted on an "equatorial mount", which permits it to be tilted parallel to the Earth's equator. This allows the scope to track the motion of the stars in only one movement around the central axis of the mount (the diurnal motion is very significant, even at low powers, the object can drift out of the view in only a minute). The Dobsonian opts for the much simpler fork "alt-azimuth" mount which sits parallel to the ground. This means that tracking the objects would require two motions instead of one. Not much effort in and of itself, but it makes automatic motor drives required for astrophotography next to impossible. If you don't think you'll try photography, a Dobsonian might just be the scope for you. The no frills Odyssey-8 and 10 inch scopes by Coulter Optical have been highly regarded by some, and cost less than 300 bucks. Fancier Newtonian scopes by Meade or Celestron in the same sizes are nearly three times as much.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\sct.bmp}The most popular serious telescopes made today are the "Catadioptrics", and are respected for their utter compactness. Known as a "Schmidt-Cassegrain" (SCT), an 8 inch instrument might be only 16 inches long, 1/3 the length of a standard Newtonian of the same diameter. The key is the folded optics as shown in the illustration. The light enters in through a corrector lens, reflects off of the primary to a secondary on the plate and back through a hole in the primary. This places the eyepiece in the back of the scope making for easy viewing. SCTs come with a wide variety of lenses, camera mounts, tracking devices and computer controls. The "typical" SCT is an 8" model, and will go for around $1000 to $1300, although sizes range from 3 1/2" on up the 14". The most common manufacturers are the Celestron, Meade and Bushnell.

While you're looking at all of these high-powered instruments, don't overlook the "richest-field" telescopes. These are deliberately lower power devices meant to give wider sweeping views of the sky. Normal scopes will be much too powerful to view the star clouds of Sagittarius or the larger details of the Hyades cluster (something like investigating the Mona Lisa with an electron microscope). Richest field telescopes are very compact (the Edmund Astroscan slips over the shoulder) and generally quite inexpensive. Along the same line of thought would be a good pair of binoculars. While they don't come close to the light gathering power of an Astroscan, they can provide hours of enjoyment as you sweep across the sky lying on your back munching popcorn.

You may want to think about getting a used telescope. If it is a name brand, it has already depreciated about as much as it will and so could easily be sold at virtually no loss once you outgrow it or loose interest in the hobby. Prices will likely be 15% to 20% off new instruments.

Before buying, try visiting your local astronomy club. You should probably be able to find out how to get in touch with them through your local college observatory or astronomy department. Astronomy clubs periodically have "star parties" in which the members and any interested visitors spend all night observing at some remote site. From here you should be able to get hands-on experience with every conceivable type and brand of scope, as well as getting names of members who might have one for sale.

Other then clubs, *Sky and Telescope* or *Astronomy* magazine will provide excellent information. *Astronomy* generally runs telescope buyer's guides in the October issues which should be available at your local library.

If you are adventurous, you may want to try to make your own telescope. The astronomy department of your local community college may offer telescope-making classes during the summer. The typical homemade instrument is either a 6 or 8 inch reflector, and can offer a real sense of accomplishment that buying a scope never can.

So, get out there and enjoy the sky. And if you get a telescope, let me know. It's nice to have another convert.

Glass Giant of Palomar

The name Mount Palomar is synonymous with astronomical achievement and history unlike any others in the modern era. At an altitude of nearly 6000 feet, located 20 miles northeast of San Diego, California, the Mount Palomar observatory stands as one of the greatest scientific tools of the century.

Optical scopes are divided into two main categories : Reflector and refractor. The reflector has a slightly curved mirror at the bottom of a tube. The mirror captures a lot of starlight and focuses it down to increase its brightness. This light is then fed into camera, spectrascope or human eye. The refractor on the other hand is what Galileo used, and consists of a set of lenses that essentially do the same thing as a mirror. Reflectors are considerably cheaper to build as it has always been easier to construct large mirrors rather than large lenses.

When the watershed 100 inch telescope at Mount Wilson was inaugurated as the largest in the world, talk already had started of building still a larger one. A telescope is measured by the diameter of its "objective", lenses or mirrors as it is this dimension that tells us just how powerful it will be. Amateur instruments are usually six to ten inches, large amateur scopes can reach up to 30 inches. It took the 100 inch Mount Wilson scope to discover the fact that the Milky Way is not the only galaxy, that thousands of other fuzzy patches in the sky were independent "cities of stars" much as our own.

Mount Wilson was completed in 1917, and by 1923 the first funding came through for the follow up instrument. The Rockefeller Foundation gifted $6 million to construct a telescope twice the size of the previous one.

The main problem to overcome was the weight of the mirror, it is a delicate part and must be shaped to a very exact form. If the mirror should flex at all, even the slightest bit, the image will be destroyed. However, the heavier the mirror the more likely it is to bend under its own weight. It was felt the a 200 inch mirror would likely to exceed the theoretical flex limit so telescopes much larger than the 100 inch were impossible. But thanks to a unique design Palomar became a reality. Instead of making a solid 200 inch slab of glass the mirror was cast with a hollow framework underneath cutting its weight in half, down to a "mere" 20 tons. Still, it was so large, it took a full 8 months to cool after having been cast (despite being threatened with floods twice).

Now the massive size of the instrument was becoming known. The "tube" would weigh in at 125 tons and the mount another 300 tons, but the balance was so good that it could be moved by the gentle push of a hand. In all it took six years to build and was completed in 1946.

The story is told that at "first light", when first turned toward the heavens that first clear night, the image was *blurry* (sound familiar?). Had years and intricate and costly work been wasted? Was the mirror really too big after all? It was decided that perhaps it just needed to cool down and adjust to the ambient temperature, that the thick piece of glass was changing shape due to the different temperatures surrounding it. A few tense hours went by and again the lens was focussed, but this time the stars popped in as clear as could be. It was a success!

(Much more so than the next "largest" telescope which would be built in Soviet Union in the 1970s. Measured at 236 inches across it never worked quite right thanks to the mirror's own massive size and the fact that it literally took all night to adjust to the temperature. By the time it was ready for use the Sun was beginning to rise!)

The Hale Telescope as it is now called, named after the observatories first director, was a "prime focus" design. Instead of a lens off to the side it actually had the lens or the focus point in a little cage *inside* the tube. It is said that one time shortly before his death, Albert Einstein was taken way up to the tiny cage. As they started to move the telescope around he was heard to shout "get me out of here! get me out of here!!" At any rate, such large instruments are rarely if ever used for direct viewing nowadays. Instead of an eyepiece you will more likely find cameras of all sorts, spectroscopes and any other sort of odd and obscure light gathering instrument. Most astronomers do their observing not from a folding chair under the dome, but from a cramped computer room nearby or in some cases around on the other side of the world using remote networks. The largest telescope available now for public observing is the 36 inch Crossly Refractor located above the city of San Jose at the Lick Observatory. (During the summer, Lick hosts a series of concerts followed by public viewing and is an event not to be missed. There is something about live harpsichord music in an antique observatory's dome that can't be duplicated anywhere else.)

The Mount Palomar observatory is open for tours, so if you find yourself in the San Diego area you may want to check it out.

Finding Polaris, the North Star

Project. . .

supplies : a clear night, location in the northern hemisphere, a bag of M&Ms and Polaris

Perhaps the most familiar single star in the sky is Polaris, the North star, . What makes Polaris unique is the fact that the Earth's axis points almost directly toward it. So when our planet spins in its daily motion, only Polaris appears to stay fixed while all other objects spin around it.

Polaris has not always been the "North Star". Due to the effects of "precession",   the Earth wobbles much like that of a child's top. Each "wob" takes about 25,800 years and has the effect of changing the direction of the poles. The celestial pole will pass closest to Polaris in 2012 and then slowly drift away.

During each 25,800 years, or *cycle of precession* the Earth's poles draw out a circle in the sky. So in a mere 12,000 years from now the axis will circle around to Vega and it will become the pole star. In 2500 BC it was Thuban and in 4000 AD it will be Alrai in Cepheus.

While Polaris is far from the brightest star in the sky at about second magnitude, it is very easy to find. First locate the Big Dipper, perhaps most familiar celestial form in the northern skies. Find the end of the Dipper's "bowl" and draw an imaginary line up and above it. The next bright star you come to should be Polaris. Use First Light to see if this is so, then go outside and look for the real article.

The height of Polaris above the horizon, its altitude, is directly related to your latitude. The further south you go the lower on the horizon Polaris will be found. From the North Pole, it is directly overhead, from the equator, it is right on the horizon. So in order to find your latitude simply measure the angle of Polaris is above the horizon.

Oh, while you're looking for the star open up your M&Ms and munch on a few. The peanut butter ones are the best. They along with popcorn are the perfect astronomy food.

Sextans, the Sextant

The classic Greek based constellations number only 48 which come from a list first published in 150 AD. These include the nightly pageant of the Zodiac, or Orion the hunter and his dog, Canis Major and so on. For the most part these were mythological beasts and heroes of old parading their exploits into eternity for all to see and seek inspiration from. However in the mid-18th and 19th centuries numbers of over zealous astronomers and celestial mapmakers introduced "new" constellations in order honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns.

Forty of the new ones have been officially recognized and remain to this day on the charts. These bits of celestial flotsam include such noteworthy spectacles as Caelum, the chisel, Circinus the compasses, Fornax the furnace and Horologium the pendulum clock. Few have with any interesting objects, and all are rather dim.

One of these is the faint constellation called Sextans, or the sextant, . A sextant is an instrument used to find out the positions of celestial objects and Sextans was named in honor the one that astronomer Johannes Hevelius used for his stellar observations in the late 17th century. Hevelius was known for creating many of the modern constellations including Canes Venatici, Leo Minor, Lacerta, Lynx, Scutum and Vulpecula.

Sextans is known for only one significant deep-sky object : galaxy NGC 3315. This stands out due to its relative brightness (9.8 magnitude) and large size. Other than that it is rather unmemorable, except perhaps for its abbreviation.

Use First Light to find Sextans, then if it is clear and dark out tonight (that is, no Moon to light up the sky), see if you can locate it on your own.

Antlia, the air pump

The classic Greek-based constellations number only 48, which come from a list first published in 150 AD. These include the nightly pageant of the Zodiac, or Orion the hunter and his dog, Canis Major and so on. For the most part, these were mythological beasts and heroes of old parading their exploits into eternity for all to see and seek inspiration from. However, in the mid-18th and 19th centuries, numbers of over-zealous astronomers and celestial mapmakers introduced "new" constellations in order to honor their kings or favorite pets, or merely to fill in perceived gaps between the ancient patterns.

Forty of the new constellations have been officially recognized and remain to this day on the charts. These bits of celestial flotsam include such noteworthy spectacles as Caelum, the chisel, Circinus the compasses, Fornax the furnace and Horologium the pendulum clock. Few have with any interesting objects, and all are rather dim.

Antlia the air pump is yet another of the "Oreo" constellations, a filler between the big ones, . Many of the modern constellations are in the southern skies, due to the simple fact that they were not visible to the ancients. Antlia was created by Nicolas Lacaille in 1756. To the best of my knowledge and extensive research, there are no legends dealing with pumps. Hercules never had to use an air-pump, Orion never fought off an avenging air-pump, Zeus never lusted after an air-pump. . . well, you get the idea.

Antlia should be visible as far north as 50 degrees latitude, but its brightest star shines at a pitiful 4 1/4 magnitude. Zeta Antlia is a nice wide double star for binoculars. On the southern border of Antlia is NGC3132, the "Eight Burst" nebula. It is fine planetary about the size but somewhat brighter than the Ring Nebula in Lyra, M57.

Random meteors
Project. . .
supplies : a comfortable chair, clear skies, moonless night, popcorn, Snapple, notebook with a pen or pencil and a couple of hours of free time.

Meteors are small solid particles in orbit around the Sun and, in many cases, believed to be debris left by passing comets. For this reason meteors tend to be grouped together in comet-like orbits and often have been linked to known comets. It is when the Earth passes through one of these streams that a meteor shower occurs as the particles burn up in our atmosphere. On any night, the average observer should be able to see about five stray meteors per hour. The typical shower will generally triple that rate while the best ones (such as the Persieds of August and Geminids in December) may have 50 or more.

Tonight is just a couple of days before the spring meteor shower called the Lyrids. This means that the meteors will be coming form the direction of Lyra, which will be east at this time of year. So the project is to observe for stray meteors and then compare them to the peak of the shower. (The date of the peak will fluctuate a day or so, so you may want to call up the astronomy department of your local college and find out the best time for observing). Any streaks not coming from the east are likely random bits of interplanetary dust that just happened to encounter the third planet, and *just happened* to meet its fiery demise after billions of years of peaceful existence somewhere over your neighborhood.

Meteor observing works best on Moonless nights as the dimmer ones can easily be washed out by the Moon's glare. Find a comfortable place to lie down, a backyard with a lounge chair works fine for me. Turn on some music,munch the popcorn and watch as the stars slowly wheel above you.

Meteors can appear as faint brief streaks of light, barely perceptible even if you are looking right at them, all the way up to massive fireballs that burn bright red or purple and leave a trail for several minutes. As you see one, note on a pad of paper a general description. How bright was it? How long was the trail in, say, the width of your fist held at arms length? What direction did it come from? If it was from the east, it was probably an early Lyrid. You will need a fair amount of patience, so give yourself about two hours. During tonight you should see about five or ten strays. During the Lyrids, you might see as many as many 30 an hour.

When done set your notes aside and repeat the same experiment for the Lyrids or another of the yearly meteor showers.

Vostok 1

On this date in 1961, a 27 year old Soviet Air Force pilot became the first ever human to hear the roar of a rocket's engines beneath him, to see the sky turn from blue to purple to black in the matter of minutes, to witness the Sun setting over the Earth's curving limb. . . *to be the first in space.*

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\yuri_g.bmp}Born in 1934, Yuri Gagarin roared into the history books on top of a Soviet A1 rocket, riding the "Vostok 1" spacecraft. Unlike the conical shapes the American spacecraft assumed, the Vostok was a 7 1/2 foot in diameter silver sphere on top of a cone shaped equipment module. The interior was a simple tube that was just large enough for a single man, an ejection seat and a crude instrument panel.

Gagarin's flight lasted a mere one orbit, slightly over 1 1/2 hours and sent him to a record breaking altitude of 203 miles. At the end of his time in space, ground control radioed for his capsule to fire its reentry rockets and he began his decent to Earth. At about 8,000 feet the cosmonaut popped open the hatch and ejected from the cabin landing on his own a little ways away in a farmers field, silently observed by a cow and a couple of curious workers.

Before the mission the doctors on the ground argued that weightlessness might render a man insane, so he was not be be given any control over his on spacecraft lest he fire the retro-rockets in the wrong direction or refused to do so altogether. The cosmonauts didn't want to rely on ground control or for the radios having to work, so the designers struck a compromise giving the crewman a three digit number to unlock the rockets if they had to. Gagarin's was "145".

With the intensive documentation American flights have had since the first one, it is surprising to note that Gagarin had no cameras on board. A single crude TV camera recorded his movements but there exists no photographs taken from his mission.

Gagarin immediately became a world-wide hero and the Soviets used him as such. He made extensive goodwill trips around the world for several years, only to rejoin the cosmonaut program in the late 60s finally getting assigned a second mission. Unfortunately he was to die in an airplane accident on March 27, 1968.

Gagarin is so revered by the cosmonauts that even to this day much ceremony surrounds his memory. For example, on the eve of a new mission, the cosmonauts will sleep in the same small cottage he slept in right before his flight. Likewise, honor must be paid to him at his office which is still preserved exactly as he kept it the day he died. Many other of his common activities are still duplicated by each and every new Russian crew no matter how mundane (or even tasteless).

Compared to the mighty Vostok, our Mercury efforts seemed frightfully timid at the time. Three weeks after Gagarin swept around the world, Alan B. Shepard became America's first man in space. But while Gagarin's flight lasted 108 minutes, Shepard's lasted a mere 15, while Gagarin sailed over 200 miles in altitude, Shepard managed to travel only 116. Gagarin sped along at nearly 18,000 miles/hour, but Al hit only 5,180. But it was victory to the Americans and all those who disliked the Soviets, sending the space race into full throttle. And with only 15 minutes of space experience, three weeks later, President Kennedy announced that we were going to the Moon.

In all, six Vostok missions were flown. The second would last an entire day. The third and forth would be flown together as a "formation flight". The final two were likewise a dual mission, but included the first woman to fly in space, Valentina Tereshkova. Her partner, Valeri Bykovsky made the longest spaceflight to date at nearly five days and still holds the record for the longest solo mission.

It is interesting to note that the rockets used to this day for Russian manned missions are descendants of Gagarin's, and that variations on the Vostok are still being flown for unmanned scientific and military missions, over *30 years* later.

It is also interesting to note that on this date in 1981 exactly 20 years to the day Gagarin made his flight, another new era in space exploration began when the very first Space Shuttle mission headed for orbit.

Apollo 13 : the one that didn't make it

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\a13_ptch.bmp}Imagine being in a spacecraft over 100,000 miles from Earth and finding out that your oxygen tanks have been destroyed and you are losing all of your electrical power. Such was the case with Apollo 13 on this date in 1970. What started out as America's third manned mission to the Moon turned into a dramatic life and death struggle.

The mission started off well enough with a beautiful launch on April 11 at 2:13 PM, despite the naysayers who warned NASA to skip the number "13". Since the United States proved that a manned landing was in fact possible, the novelty had begun to wane. This mission would be little different than Apollo 12, except for the fact that the landing site would be in the lunar highlands, the oldest part of the lunar surface. Network coverage would be minimal. Veteran astronaut Jim Lovell was the commander and the first person to go the Moon a second time. With him came Fred Haise and Jack Swigert (a last minute replacement when Tom Mattingly was exposed to the measles only 4 days before the flight).

On the 13th, shortly after an evening TV broadcast home to the families, a large explosion rocked the spacecraft. Over the next hour the news became worse and worse as the meters onboard Apollo rapidly sank down to zero. Apollo was losing all electrical power and had apparently lost its oxygen. While the "service module" (that holds all of the oxygen, power supplies and main rocket engine) was apparently a goner, the Lunar Module was still in good health. Its meager supplies would have to be stretched to take care of three men for three days when it had been designed to handle only two men for two days. The spacecraft would have to limp back home using less power than it was ever designed for. The Command Module that must return the astronauts to the Earth was in good health, but had never been completely powered down in space before. Would the cooling system freeze up? Would other systems be destroyed, systems required for reentry?

Over the next three days the temperature would drop down to freezing as the spacecraft swept around behind the Moon, . Water would be in short supply, causing the crew to get dangerously dehydrated. Sleeplessness would have Jim Lovell mistype a critical command to the computer system. And one of the mission controllers confessed that he doubted the men would return home alive but instead miss the Earth and go into an eternal orbit around the Sun.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\a13_sm.bmp}But somehow they managed, and as Apollo 13 fell toward the Earth with only four hours to go, the crew released the dead service module finally getting a first hard look at the carnage. Jim Lovell shouted "and there's one whole side of that thing missing!" stunned and shook mission control. A couple of hours later, the Lunar module was released and the Command Module revived from its cold slumber. It all worked well and the crew returned to the warm waters of Earth.

The next Apollo mission was to wait nine months to fly as the problem was determined and fixed. Apollo 14 flew the mission that Apollo 13 was supposed to fly, successfully landing in the Fra Mauro region. Interestingly enough, after scientists got their looks at the lunar material that took two missions to collect the conclusion was "we need to select our landing sites more carefully" as the hoped for ancient material never quite appeared.

Venus, greatest elongation

"Greatest elongation" is the point in a planet's orbit when it is visually furthest from the Sun. For the inner planets, Venus and Mercury, this is important because it places them furthest away from the Sun's glare and at their best viewing. For Venus, greatest elongation happens about two times a year. Using First Light find where Venus is and advance the time via the fast-clock to see its next greatest elongation.

Now do the same for Mercury.

If either planet is going to be visible tonight or tomorrow morning take out your binoculars and see if you can make out the phase of Venus. Since at greatest elongation, Venus is directly to one side or the other of the Sun, half will be dark and half will be illuminated, looking much like the first quarter Moon.

Greatest elongation has no real meaning for the planets further than the Earth, since we can go in between them and the Sun, they can be as far away as 180 degrees. This point is called "opposition".

Venus, third brightest thing in the sky

The second planet from the Sun, Venus, is frequently the third brightest object in the sky. Only the Sun ('natch) and the Moon are brighter. Because Venus changes phases much like the Moon its brightness will vary substantially depending on whether it is "new" or "gibbous" phase. It also depends on its distance form the Earth, not to mention the brilliant white clouds that eternally shroud the surface.

Note, that as Venus and the Earth get closer, its phase gets thinner. As it sweeps around the Sun away from us, we see more of its face but it gets further away and is eventually blocked by the solar glare.

So Venus at maximum brilliancy depends on a balance of phase, distance from the Earth and angular separation from the Sun. When all of these things fall into place, the sight you will see is remarkable. The sight of a white fire Venus suspended low over the horizon with thin lunar crescent dangling nearby is nothing short of breathtaking. A times as this the planet is so bright it can cast a shadow. It is so bright that some people have reported it as a UFO. And it is *so* bright that it is even visible during the *daytime.* At its best, the white planet will outshine everything with a searing -4.5 magnitude.

One reason for this brightness are those mysterious clouds. Composed mainly of carbon dioxide with trace amounts of water vapor, Nitrogen and Carbon Monoxide the 100 mile layer reflects almost 65% of the sunlight that hits it. Compared this to the Moon's paltry 12% or the Earth's 37% albedo. Those delicate clouds belie the true surface of the planet, a nightmarish hell of eternal twilight with average daily temperatures of 850 degrees F or more (but it's a dry heat).

Use First Light to see just where Venus is right now. Zoom in to a very small field-of-view and check out the current phase. If it is visible in the evening or morning, break out the binoculars and see if you can make out the actual phase for yourself.

albedo :
The amount of light an object reflects. For example, the Moon has a 12% (very low) albedo, so it reflects only 12% of the sunlight that hits it.

Big Bang

How did the beginning begin? Such is the question that has perplexed cosmologists since day one. This is the question that serves as a bridge between philosophy and science. Over the years, two main theories were developed to explain how the Universe became. The "Steady State" theory suggested that things have always been and will always be, that there was neither a beginning as such, nor an end. The alternate theory became known as "The Big Bang" and is the most widely held belief as new data comes in daily to support it.

In 1929, astronomer Edwin Hubble discovered that the galaxies were all flying away from each other implying that if you were to go back in time there would be a point at which they would have all been crowded together. Go back even further and you get a seething homogeneous mass of material containing the entire Universe! That material would have been released in a sudden terrifying explosion. Such nonsense!

But "such nonsense" predicted that as a result of the explosion, there would be an "echo" of sorts. This "background radiation" would be left over since there was no place for it to go. In 1965, two scientists from the Bell Telephone Laboratories, while researching satellite communications, noticed an unaccountabale dull low level "noise" coming from all directions. It just so happened that this low level of noise was exactly the amount the Big Bang theorists predicted and sounded the death knell for the Steady State crowd.

When we think of the Universe and time, one usually must think on scales of millions or even billions of years before significant things can happen (such as the end of the OJ trial). But in the study of the Big Bang one must abandon that mentality and start thinking in terms of merely seconds or fractions of a second.

The "thermal soup", or celestial swamp that started it all is said to have had temperatures beyond 10,000 million degrees and conditions that go beyond known physics. The initial phase of the cosmic fireball took place in less than a second. By the time the Universe was an infant of only three minutes of age, it was down to a relatively balmy 1000 million degrees. Helium started to form at 20 minutes. By a few million years the first stars stated to condense, and from the powerful nuclear reactions at their their fiery centers the heavier elements began to form. Now jump two billion years later and quasars started to form, followed by the first observable galaxies a couple of billion years after that.

Today, we can see objects believed to be nearly 20 billion years old near the very edge of the Universe. The new Hubble Space Telescope is expected to expand that even further, permitting scientists to get even closer to the beginning.

However, there are still many unanswered questions. One major problem that continues to vex the researchers is the question of how will it all end? It is believed that that at some point the Universe will stop expanding and begin an orderly collapse resulting in "The Big Crunch". But in order to do so, there must be enough gravity to yank everything back. Unfortunately, only about 10% of the Universe seems to be visible, not nearly enough! Over the past few decades, it has been established that the observed gravitational effects from both our galaxy and those of nearby clusters of galaxies are much stronger than that possible by what is seen. This would suggest that most of the matter, the stuff that makes up the Universe, is simply invisible. Many theories abound as to where it might be hiding. Possibly, large dark clouds of matter might surround the the galaxies. Or, up until recently, one of the most popular theories suggested that it was tied up in massive numbers of very dim, low mass stars that are so unobtrusive that they have managed to escaped attention. The Hubble Space Telescope shot this one down in flames. Yet another theory states that the matter is in the form of tiny particles called neutrinos, left over from the Big Bang. This "missing mass" problem will no doubt provide a lot of employment opportunities for young astronomers in the years to come.

Venus in daytime

The second planet from the Sun, Venus, is frequently the third brightest object in the Sky. Only the Sun ('natch) and the Moon are brighter. When Venus reaches maximum brilliancy it actually becomes visible in the *daytime*!

Venus' brightness depends on a balance of phase, distance from the Earth and angular separation from the Sun. When all of these things fall into place, the sight you will see is remarkable. The sight of a white fire Venus suspended in space, low over the horizon with thin lunar crescent dangling nearby is nothing short of breathtaking. At times as this the planet is so bright it can cast a shadow. It is so bright that some people have reported it as a UFO. At its best, the white planet will outshine everything with a searing -4.5 magnitude.

In order to see Venus in the daytime you can either catch it in the morning before sunrise and carefully follow it as the Sun comes into view. Or, you can take the more challenging test and try to find it while it is in the afternoon before sundown if it is an evening object. Even though it is bright, chances are you'll not find it merely by cupping your hands over your eyes and scanning the heavens. You will need to know exactly where it is. For that you can use First Light. Once you know the area of the sky pull out your binoculars and and start slowly sweeping back and forth. With a little luck it will pop right into view and you will see the slender white crescent up against the bright blue of the lazy afternoon sky. Now carefully remove the binoculars and see if you can see it with your naked eyes. If not, locate again in the binoculars with something in the foreground that can be used as a pointer such as a tree branch, flag pole or Regis Philbin.

Jupiter and Saturn are also said to be visible in the daytime if you know exactly where to look. Since they considerably dimmer than Venus, finding them merely by scanning the sky will likely be fruitless. Following the planets before sunrise will be the best way in this case.

July

July 1 : Hercules
July 2 : M13 and Globular Clusters
July 3 : Alpha Herculis
July 4 : Earth, furthest from the Sun
July 5 : Project - Ellipses and Orbits
July 6 : Aquilla, the Eagle
July 7 : Delphinus, the Dolphin
July 8 : North Celestial Pole, 13,000 AD
July 9 : Voyager 2 at Jupiter
July 10 : Jupiter
July 11 : The Great 1991 Eclipse
July 12 : Project - following Jupiter's moons part 1
July 13 : Galactic Halos
July 14 : Moons of Jupiter
July 15 : Project - following Jupiter's moons part 2
July 16 : Apollo 11, the Launch
July 17 : Phases of the Moon
July 18 : Comet Strikes Jupiter
July 19 : Apollo 11 Enters Lunar Orbit
July 20 : Apollo 11 Lands on the Moon
July 21 : Viking 1 lands on Mars
July 22 : Copernicus, Tycho
July 23 : Lunar "Seas"
July 24 : Results of the Moon Landings
July 25 : Scorpius, the Scorpion
July 26 : Antares
July 27 : Scorpius, Deep-sky Objects
July 28 : Delta Aquarids
July 29 : Project - Observing Sunspots
July 30 : Scutum, the Shield
July 31 : Project - Gravity on the Moon

Mars - why is it red?

Project. . .

supplies : an old baking dish, plastic wrap, thick gloves, two cups of sand, steel wool

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\marsglo2.sbm}Mars has always been known as the "red" planet due to its unmistakable ruddy hue, . Through binoculars or a telescope, in a Universe devoid of brilliant colors, Mars stands out. So, why exactly is it so red? Well, Mars, the "god of war" is rusty. Yup, that's it. Mars' surface contains high levels of iron which apparently rusted when the planet once had surface water. You can create your own Martian surface. Take the sand and dump it in the dish. While you are wearing gloves, cut up the steel wool into fine slivers of no more than 1/2 to 1 inches in length. Mix into the sand and pour it water just enough to cover things. Wait for about 3 days and see what happens. Watch it over the next few days, adding a little more water to keep it moist and observe how the color deepens.

The Brightness of the Moon

When you gaze at the brilliance of the full Moon you probably marvel at its great snowy white countenance. But in fact the Moon isn't as white as it appears. It may surprise you to know that it is one of the darkest objects in the solar system and only appears bright since there is nothing to compare it with.

The amount of sunlight on object reflects back is known as the "albedo". For the Moon, the albedo is a paltry 7% to 12%. For the Earth it is more along the line of 37%, that is, the Earth reflects back 37% of the sunlight that hits it. Thanks to its thick layers of clouds, Venus' albedo is a full 65%! While Mercury is similar to the Moon at about 15%.

The soil samples returned from the Moon turned out to be a very dark gray-brown: they were so dark that they almost resembled charcoal in some cases. So when you look upon the Moon the next time, just remember that that white shining orb is in reality a really really dark-gray shining orb.

The Lyrid meteor shower

Meteors are small solid particles in orbit around the Sun and, in many cases, are believed to be debris left by passing comets. For this reason, meteors tend to be grouped together in comet-like orbits and often have been linked to known comets. It is when the Earth passes through one of these streams that a meteor shower occurs as the particles burn up in our atmosphere. On any night, the average observer should be able to see about five stray meteors per hour. The typical shower will generally triple that rate while the best ones (such as the Persieds of August and Geminids in December) may have 50 or more.

The distribution of meteors along their orbits is not uniform. Therefore, what may have been a bland shower one year might be a memorable event the next. The most notable one of this sort is the Leonids of November. Usually they produce about 15 or 20 streak an hour. But early one morning in November 1966, along the western coast of the United States, rates approaching *one-hundred fifty-thousand* per hour were reported. This was a repeat of the famous 1833 shower which prompted one 19th century writer to exclaim : "Never did rain fall much thicker than the meteors fell to the Earth. . .".

Occasionally, meteors the size of small rocks will join the fray, producing what is called a fireball. The bigger ones may be seen to break apart forming two or more fiery trails. The biggest of these might survive their entry and strike the Earth. These meteors are then called meteorites. The 4000 foot wide Barranger Crater in Arizona is a dramatic example of this.

The names of the showers are derived from the area of the sky from which the meteors appear to radiate (hence the name *radiant*), like spokes in a wheel. Therefore todays shower, the Lyrids would appear to be coming from the summer constellation of Lyra which is currently low in the east during the evening.

The best time to observe a shower is after about 2:00 AM local time until dawn. Since the meteors can appear in any part of the sky, a telescope or pair of binoculars would only hinder the viewing.

The date of the peak will fluctuate a day or so, meaning you may want to call up the astronomy department of your local college and find out the best time for observing. A moonless night is also recommended for a bright Moon will both destroy your night vision and wash out the dimmer meteors.

So if you care to watch the Lyrids, find yourself a comfortable place to lie down, a backyard with a lounge chair perhaps, or better yet, a jaccuzi. Turn on some music, munch some popcorn and watch as the stars slowly wheel above your head. And with a little luck you just might see some bits of interplanetary dust that just happened to encounter the third planet, and *just happened* to meet its fiery demise after billions of years of peaceful existence somewhere over your neighborhood.

Build your own Planetarium

Project. . .

supplies : poster board, scissors, flashlight, compass (the kind used for drawing circles), masking tape, Quaker Oats can, glue or spray adhesive

If you live anywhere near a college they may have a planetarium that you probably have gone to at one time. Planetariums in various forms have been around for thousands of years and were designed to demonstrate the workings of the solar system and the night sky to the public, not to mention legions of grade school kids. In the mid-1600s Adam Olearius built something called the "Gottorp Globe", a rotating 10 foot diameter hollow copper sphere. Inside a small audience would sit on a platform and watch as painted constellations marched above them powered by a water wheel.

It wasn't until 1919 when the modern planetarium came into existence at the Carl Zeiss optical works in Germany. They decided that the audience would be placed inside a white dome in which the stars and planets would be projected from the center of the room. The star projector was not much different then dozens of tiny slide projectors, each covering a small portion of the sky. Small metallic star slides hid behind lenses and a single brilliant sharp light source from the center served to power this artificial Universe. This first projector was completed in 1923 and opened to the public on October 21 at the Deutches Museum in Munich, where it was finally retired from service in 1960.

Using First Light you can make your own simple planetarium. Print out a chart of a single constellation. Orion works the best for now. Make it such that Orion is no greater than 3 inches across. Glue the chart to the piece of black poster paper and carefully punch out the individual stars using a sharp pencil or better yet, the compass point. The dimmest stars should be smallest holes you can make, the brighter the stars, the larger the holes.

Take the Quaker Oats can and open up both ends. Over one end mount the paper. You may want to trace the end of the can on the paper first and cut the chart down to size so it just fits over the end. Attach the paper so the printout faces inside the can, this will ensure that the constellation is oriented the right direction. Carefully tape the paper on the front with masking tape and seal up the edges so no light can leak through. Now take your planetarium into a darkened room, place the flashlight in the other opened end, turn it on and aim toward the ceiling.

You may want to experiment a little with different flashlights or smaller holes on the chart. Also once you become adept at doing a single constellation try to make a *star cube*.

For that you will make an entire box with star charts on each side illustrating the equatorial and the polar regions of the sky. Cut out 5 posterboard squares, about 8 inches on a side. Use a thick board so the cube can stand by itself. Print out 4 charts that can join together at the seams to form the equator of the sky with declinations of plus or minus 45 degrees, and then one for the northern regions above those. The four sides of the cube will be the equator and the top the polar skies. Mount them in the same way as before and carefully poke out the holes. If the Sun is shining, you might want to take each square out in the Sun to test it first, to make sure the constellations look correct and that your stars are the right relative intensities.

For light you need a bare bulb. Perhaps a flashlight with no reflector aimed up would work, but something that will spread light all around. (Use only flashlight bulbs, don't attempt this with the larger room lamps as they can tend to get pretty warm). Now tape the squares together and return to your dark room. See how many constellations you can recognize. Why not prepare a planetarium show for your family.

Planetary Conjunctions

A "planetary conjunction" occurs when two or more planets appear very close together in the sky. Conjunctions are not very important scientifically speaking, but can provide wonderful scenes not to be missed. One of the most spectacular in recent years happened in June of 1991, when not two, but *three* planets appeared all within two degrees of each other.

Click here to see the triple conjunction of 1991. Notice how close Jupiter, Mars and Venus came to one another. Now feel free to investigate this further by using the fast clock option to animate the planets back and forth looking for their closest approach. Go into lookdown to see the Earth's position as compared to the others and notice how they are not physically close, but are in the same line of sight of each other. Now you should be able to travel to the opposite end of the planetary lineup, Jupiter and look back toward the Earth. Notice now that we still have a triple conjunction but this time it is of the *Earth*, Venus and Mars.

The 10 Brightest Stars

Of course the Sun is the brightest star in the sky. It shines forth at a magnitude of about -27 and provides the light, heat and energy that make life on the planet possible. When the Sun sets, the other stars begin to check in one at a time. The second brightest is magnificant Sirius in Canis Major, .

The name comes from *seirius,* which means "searing" in Greek. The star was given many powers and attributes. When it first becomes visible in the late part of summer, rising just before sunrise, it marked the hottest time of the year. Hence the name "Dog Days of Summer", since the ancients thought the brilliance of the star had a heating effect on the Earth. Sirius is an unusual double star in that it has a tiny "white dwarf" companion (mag. 8.65) visible only in larger telescopes. The dwarf is only twice the size of Earth, but has as much mass as the Sun. This makes it so dense that a cubic inch would weigh over two tons.

The second brightest star is Canopus, . The legends about Canopus are somewhat fewer than other stars since it could not be seen from Greece, limiting exposure to those who could travel south. Canopus is named after the helmsman of King Menelaus of the Greeks. One reason why Canopus is relatively unknown at least to the northern hemispherians, is that it lies deep in the southern skies, as part of the constellation Carina. If your latitude is less than 38 degrees you might just be able to see it in mid-winter directly south. Canopus is believed to be about 30 times more luminous than the Sun, and is commonly used by spacecraft for navigational purpose.

Next comes Alpha Centauri which also happens to be the closest star next to the Sun located at a neighborly 4.3 light years distant, . It is one of the finest visual binaries in the sky with an orbital period of 80.089 years. The brighter star is very close to our Sun in size, etc. As seen from Alpha Centauri, the Sun would be a first magnitude star, with the Earth too dim to be visible. Also, this was the destination of the spacecraft Jupiter II in that "legendary" TV series, "Lost in Space."

The fourth brightest star is Arcturus, . "The Guardian of the Bear", shines at a magnitude of -0.06. It is about 115 times as luminous as the Sun, 25 times its diameter but only four times its mass. This means that it is around .0003 times as dense as the Sun, essentially a very hot vacuum. The heat received on the Earth from Arcturus is equal to that delivered from a candle five miles away. It also has one of the largest proper motions of the bright stars. It will come closest to us in a few thousand years, then recede toward Virgo, where it will vanish in the darkness in 500,000 years.

At .04 magnitude, Vega is the fifth brightest star, . As with all bright stars, has its share of myth and lore bound to it. The Greeks called it "Cithara," the Babylonians named it "Dilgan" and it was "Allore" to the Arabs. It is toward this part of the sky that our solar system is rushing (the "Solar Apex"), at 12 miles-per-second. At this rate, it will take us 450,000 years to reach the vicinity of Vega. But what a view we will have then!

Right above Orion is the constellation Auriga, the home of the sixth brightest star in the sky, Capella, the "she-goat", . Capella is a mere 40 light years distant and is actually a multiple star, two large stars rotating in tandem around each other (10 million and 5.6 million miles in diameter) and a couple of small ones. They perform their slow dance once every 104 days separated by only 70 million miles, closer than the Earth is to the Sun. Imagine what a view that must be from a nearby planet!

Rigel is a supergiant, the seventh brightest star in the sky and the brightest in all of Orion at a magnitude of 0.14, . It has luminosity of about of 57,000 times the Sun, making it one of the most luminous known stars in the galaxy. Were the star the same distance as Sirius (eight light years, vs. 900 light years), it would blaze away at a magnitude of -10! Rigel is a double star with a 6.7 magnitude companion easily visible in a small telescope. The name comes from the Arabic "rijl", meaning foot.

Procyon whose name is Greek for "before the dog", is the eighth brightest star, . The Arabs called it

"Al Shi'ra al Shamiyyah". The Babylonians called it "Kakkab Paldara." According to the Greeks, Canis Minor was Maera, belonging to Icarus, the inventor of wine. One day he gave some wine to a few clueless shepherds. Mistaking their drunken state for being poisoned they killed Icarius. Maera the dog ran home to and returned with Erigone, the daughter of Icarius who upon seeing her dead father committed suicide together with the dog. Taking pity, Zeus immortalized them in the heavens for all eternity. Maera became Canis Minor, Erigone is now seen as Virgo, and Icarius is Bootes. Like Sirius, it has a white dwarf companion, too dim to see. With a mass 65% that of the Sun and a diameter of only 17,000 miles, it has a density of 2 tons per cubic inch. Now go out and see if you can find Procyon. As the name says, he should be there, leading the Great Dog.

Eridanus is home of the nineth star in stellar hit parade, Achernar at magnitude 0.48, . It has a luminosity of about 650 suns, and a surface temperature hovering around a toasty warm 14,000 degrees K.

Beta Centauri, "Hadar," is the tenth brightest star in the sky, . This is one of the "Orion" type stars, those with both high temperature and luminosity. Hadar is 10,000 times more luminous than the Sun, with an absolute magnitude of -5.2.

Spectrum

The light as we see it from the Sun is not white, but is made up of all colors called the "spectrum". This can clearly be seen by placing a prism in the sunlight and observing how it breaks up the white solar rays into their component colors. Scientists use the spectrum to determine the composition of the stars.

Using special equipment such as a spectrascope, a star's light is split up in a way so as to exhibit dark lines across the color bands. These bands were first seen by Joseph Fraunhofer and are called Fraunhofer Lines. What is being observed is in effect, the "fingerprint" of the star. The lines are caused when particular colors of light are absorbed by the elements that make up the star. So Hydrogen will have one set of lines, and Helium another.

A star or galaxy's spectra, can also be used to determine the distance. It was noticed that the Fraunhofer Lines would vary back and forth, apparently due to the motion of the object. Most of the time the lines shifted toward the red end of the spectrum which is called "redshift." The further the shift was the faster the object was moving, and the faster the object, the farther away it is.

Spectral lines have also been used to determine the pressure of the star's atmosphere, the temperature of the surface and any subtle motions it may have. In fact, the shifting of spectral lines as described above has been used to study the possibility of planets around nearby stars. If there is a major planet, both the star and planet would rotate around a common center of gravity making the star "jiggle" back and forth slightly with respect to us. But even at those small rates, astronomers are able to observe the stellar motion so as to detect "unseen" bodies in orbit.

Nova : when a star goes nuts!

The word nova, simply means "new star". From time to time, out of nowhere astronomers will spot a star where one had not been before. Two or three novas are discovered each year, typically by amateur astronomers. A nova will brighten up very rapidly increasing its luminosity by a factor of hundreds or thousands, frequently in less than a day, before fading over a period of up to a year or more. Nova are typically binary stars, two stars orbiting around each other. One will draw material from the other only to lose its structural stability with all of the extra stuff piled on top of it. This leads it to a sudden flare up or eruption, to cast off the extra material into space. While dramatic, the total material lost is typically .00001 % of the entire mass, in other words, not a whole lot.

There is a much more spectacular form of nova, called a "supernova". Supernovae are extremely rare, happening only once every 100 years or so in the average galaxy. While a regular garden variety nova tosses off a little extra weight with no real consequence, a supernova quite literally destroys itself. Normal stars maintain their form due to a careful equilibrium between their inner pressures pushing out and their gravity trying to hold things together. In a supernova, this balance collapses and over the period of perhaps a day or less an average Sun sized star will expand to the *size of the entire solar system*! The outer layers of the star will form a shockwave traveling outward at 6000 miles per second, increasing the star's surface area by millions of times. This explains the sudden increase in brightness and why a supernova might outshine its entire parent galaxy for a few brief days. As the shell continues to expand it will eventually cool off and turn into a "common" nebula. Several such supernova remnants are visible, the most well known is the Crab Nebula in Taurus, created from the supernova of 1054 AD.

So far this millennium only 5 supernova inside our galaxy have been seen. The brightest was in the constellation of Lupus and was reported to have been visible during the daylight. Others include the one in 1054, two in Cassiopeia in 1181 and 1572 and the most recent in 1604 in Ophiuchus. It looks like we're well overdue!

The most recent supernova of note happened in 1987. While this didn't occur in our galaxy, it was mighty close, taking place in one of our satellite galaxies: the Large Magellanic Cloud. It became the first supernova to be visible to the naked eye since 1885 and the closest since the 1604 explosion. Unfortunately due to its still considerable distance it didn't quite make it to fourth magnitude, hardly spectacular visually, but to the astronomers it was ample cause for celebration. If placed only 30 light years away it would have been considerably more visible, blazing forth almost as bright as the Sun.

Satellite Clouds of Earth

In 1772, French mathematician Joseph Lagrange discovered that there were five points in an object's orbit that would present a region of gravitational equilibrium between the object and its parent. For instance, in the Moon's orbit around the Earth, there are five locations where both the Earth's and Moon's gravity would create a "pocket" of stability for very small objects. And sure enough this was proven when Jupiter's Lagrange Points showed that there were numbers of small trapped asteroids destined to either lead the gas giant or trail it forever.

Does the Earth/Moon system have similar pockets of material? It wasn't until the 1950s that faint "satellite clouds" were first actually observed by a Polish astronomer exactly where predicted. While the Moon's Lagrangian Points were too weak to contain asteroids, they were plenty strong enough to sweep up clouds of dust into their clutches.

Few people have actually seen these clouds due to their feeble glow. The seeing conditions must be just right and the skies as dark as possible. So if you have a clear night and live in North Dakota, you might just want to give it a shot. The two locations where the clouds collect are called "L4" and "L5". L4 leads the Moon by 60 degrees in its orbit, and L5 trails the Moon. Unfortunately the clouds are going to be their brightest when directly behind the Earth, meaning that the Moon will be nearly full and capable of washing out the entire sky. Look for the L5 cloud a couple hours after sunset and 3 to 5 days after the full Moon. The L4 cloud should be favorable a couple of hours before sunrise 3 to 5 days before the Moon is full. The clouds should be about two degrees across, four times the width of your thumb held at arm's length. Also make sure that the clouds are not going to be up against the gentle glow of the Milky Way.

When scheduling your observing session, you may use First Light to find out where the clouds will be located in your skies. Since they are exactly 1/6th of an orbit to either side of the Moon you can use the Moon to indicate their positions once you have decided on a date and time. For example, you want to observe the L5 cloud on a given date. Reset the display date of First Light five days earlier (four days 22 hours if you want to be exact, but it shouldn't make much of a difference). The Moon is now 1/6th of its orbit behind the position for you observation date, right where L5 would currently be. Print out the chart and take it out to the field with you. Do the same for L4, but instead add 5 days to the date.

Kepler and his Laws

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\kepler.bmp}Situated well among the pantheon of great astronomers is Johannes Kepler (1571-1630). Originally intending to become a Lutheran minister, he was sidetracked by his interest in mathematics and how to apply it to astronomy. In 1600 Kepler became assistant to Tycho Brahe, the great Danish astronomer who specialized in making the world's most accurate position measurements of the stars and planets.

A believer in the heretical theories of Nicolas Copernicus which stated that the Sun was the center of the Universe and the Earth was no different than any of the other planets, Kepler used Tycho's observations of Mars to develop what are now called "Kepler's Three Laws of Planetary Motion". These showed that the planets moved in predictable fashion based on mathematical principles. When combined with the Copernican theories it became possible to predict with a high degree of precision the behavior of the planets and where they were going to be in the future.

His discoveries showed that Mars moved in an elliptical orbit and varied its speed based on its distance from the Sun. This was completely against the Church's doctrine that stated that planets moved in circles because the circle is the most perfect geometric shape.

The three laws are as follows :

I

Every planet orbits the Sun in an ellipse with the Sun at one focus of the ellipse.

II

The radius vector (the line from the planet to the Sun) sweeps out equal areas within the ellipse in equal times. That is, when the planet is close the the Sun it moves faster along its orbit, but the net area swept out over a fixed period of time, say one day, will be equal no matter how close or how far it is. The area is defined as the small wedge or triangle bound by the slice of orbit the object travels, and the radius vector at the start and end of the period.

III

A fixed ratio exists between the time taken to complete an orbit (a planet's year) and the size of the orbit.

Now use First Light to demonstrate these. Load up a comet and use the fast-animation feature to speed it through its orbit. Turn on the orbital traces and the shape you see is an ellipse. As the comet gets close to the Sun it will speed up, as it moves further away it slows down dramatically.

Project - Viewing the "Ring"

Project. . .

supplies : *a dark night, a telescope*

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m57.sbm}Located in the radiant little constellation of Lyra high overhead during mid-summer you will find one of the most enchanting of all deep-sky objects, the Ring Nebula. The Ring is what is called a "planetary nebula" formed largely from an expanding shell of material cast off by a star as it ages. M57 is one of the brightest and best of these. Unlike many deep-sky objects that often require just a bit of imagination to make out, this comes close to actually looking like the photographs. A stark, slightly elongated loop of material standing out against the darkness of the sky, the nineth magnitude ring is very easy to find, located right in between the two end stars of the constellation.

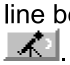
Located about 1400 light years distant the Ring is estimated to be about 1/2 light year in diameter, expanding at 12 miles per second.

Planetary nebulas are the results of a star casting off its outer layers during periods of transformation. Not at all unlike "shedding its skin". The word nova, simply means "new star". From time to time out of nowhere astronomers will spot a star where one had not existed before. Two or three novas are discovered each year, typically by amateur astronomers. A nova will brighten up very rapidly increasing its luminosity by a factor of hundreds or thousands, frequently in less than a day before fading over a period of up to a year or more. Nova are typically binary stars, two stars orbiting around each other. One will draw material from the other only to lose it's structural stability with all of the extra stuff piled on top of it. This leads it to a sudden flare up or eruption, casting off the extra material into space. While dramatic, the total material lost in cases like these is typically .00001 % of the entire mass, in other words, not a whole lot.

The central star that illuminates the material is a real challenge for amateur telescopes. Shining at a feeble 15th magnitude, it is well beyond the range of smaller instruments.

This project will challenge you to find the ring for yourself, and is the only one that requires an actual telescope. If you have a large pair of binoculars you may be able to just make it out under very dark skies. But even in smaller telescopes it is unmistakable.

There are three main ways to locate objects in the sky. The cheaters use a computer-driven telescope. They would simply say "find me M57", and the scope is automatically slews to the proper position. Those with a bit of astronomical honor to their names will use "setting circles", simple indicators that will let them locate by hand an object based on its coordinates. But if you like the thrill of the pursuit, there is the "star hopping" method. Using star hopping one locates objects by finding a series of stars as "landmarks". And hopping from a bright one to a dimmer one to a dimmer one yet until the desired object comes into view.

The Ring Nebula is one of the easiest to find. Using First Light you will notice that it is nearly exactly on a line between *Beta Lyrae* and *Gamma Lyrae,* the two bright stars along the bottom of the constellation, . Simply locate Beta Lyrae in the telescopes viewfinder and move it about 1/3rd the distance to the other star and M57 should be right in view looking like a ghost planet.

Color photos show the outer edges to be red, while the inner portions are green and yellow. Not exactly a lovely color combination. In very large instruments a bluish-green color is revealed.

Many other objects can be found by simple star hopping. M13 in Hercules, the great globular cluster, is also a fairly easy target.

Dark Adaptation

Project. . .

supplies : a brightly lit room, a dark night, flashlight with red cellophane over the end

When you step outside at night from a brightly lit room you have no doubt noticed that you probably can't see a thing, and that it takes some time for your eyes to adjust. This process is called "dark adaptation." Bright lights will temporarily destroy your eye's sensitivity to faint lighting conditions ruining your "night vision", your ability to see faint objects such as stars.

The rule of thumb is that it takes about 20 to 30 minutes for your eyes to regain their night vision.

In this project you will see how long it takes your own eyes to adjust to the darkness. First, decide on an easy constellation that will be visible tonight, and print out a chart from First Light with the magnitudes along side each star. Place yourself in a bright room for several minutes, you might even want to push the "envelope" and stare into a light to really screw up your seeing. Now take the flashlight and chart and step outside away from any porch or street lights if possible and try to locate Leo (if the Moon is out and interfering with the sky, you may want to wait a few days for a Moonless night). Note the time it takes before you can see it. Once you have found the great lion use the flashlight to identify the dimmest stars you can see. Wait a few more minutes and check again. How much time does it take before you no longer see any more stars? The red flashlight is a common tool for astronomers as red light has almost no effect on night vision.

spectra :
The color breakdown of a star's light, the output of a spectrograph. When seen it appears as a strip of the rainbow with tiny dark lines. The lines are specific colors absorbed by various elements and can tell an astronomer exactly what a particular star is made of. The spectra is also used to detect motion of the star due to "doppler shift". If the star is moving away the lines shift toward the red end, if it comes toward us, they move toward the blue.

May

May 1 : Virgo - the Maiden
May 2 : The Virgo Galactic Cluster
May 3 : M87 and Black Holes
May 4 : Meteor shower - nu Aquarids
May 5 : Freedom 7
May 6 : Quasars
May 7 : Coma Berenices
May 8 : Planet X
May 9 : Planetary eclipses
May 10 : Ursa Major, the Great Bear
May 11 : Mizar and Alcor
May 12 : X-ray Astronomy
May 13 : Crux, the Southern Cross
May 14 : Jewel Box
May 15 : Project - Drawing a Star Chart
May 16 : Eta Carina, the heavy weight
May 17 : Spica
May 18 : Retrograde motion
May 19 : Galactic Superclusters
May 20 : How far away are things?
May 21 : Project - Making craters
May 22 : Three Leaps of the Gazelle
May 23 : Celestial Mechanics
May 24 : North American Nebula
May 25 : Bootes, the Herdsman
May 26 : Arcturus
May 27 : Project - Surveying the Planet Earth
May 28 : Interferometers
May 29 : Interlopers from Deep Space
May 30 : Project Gemini
May 31 : Project - distances to the Stars

Stellar Distances

Project. . .

supplies : handful of marbles (small and large), a BB, a large flat clear area outside such as a driveway or parking lot, a plate and a lunar spacecraft.

This one of those basic projects to help you visualize the distances between things in our Universe.

Take one of the small marbles and call it the "Sun" and place it down on the ground. Take another marble which will be *alpha Centauri*, the next nearest star and place it 4 1/4 inches away. Each inch represents a light year. Put another small marble at about six inches, that is Barnard's Star, the fastest moving star in the sky. At 7 1/2 inches put down the BB, and it shall be Wolf 359, the least luminous star known. At 8 3/4 inches put a large marble. This is Sirius, the brightest star in the sky next to the Sun.

Grab yet another marble and call it Polaris, the pole star. Step away from the "Sun" about 25 *feet* and put it on the ground whcih equals a distance of 300 light years. Take another large marble, this will be Rigel the seventh brightest star in the sky, and place it 75 feet from the Sun. Now look back at tiny Wolf 359 only 7 inches from the Sun. This little star is sends out only 1/63000th the energy of the our own Sun and shines at a feeble 14th magnitude. But notice Rigel at your feet, how far away it is, yet it blazes away at magnitude zero. With a luminosity 57,000 times the Sun, Rigel is one of the most luminous known stars in the galaxy, and *3 1/2 billion* times brighter than Wolf 359!

Now take the plate. This will represent the closest major galaxy in the sky located in the constellation of Andromeda. Step back 31 *miles* and place it on the ground. You are now "2 million" light years away from your little Sun. At about 900 miles away you would be smack dab in the middle of the Virgo cluster of galaxies. And if you want to travel to the "end" of the visible Universe, grab a space suit. For at our scale of 1 inch=1 light year, the furthest known objects would be right about where the Moon is, 236,000 miles, or about *15 billion* light years. Boggles the mind, doesn't it?

Virgo, the Maiden

When it comes to learning the evening's sky, astronomers use many memory games based on the various patterns within the constellations. Remember to "follow the arc to Arcturus" in order to find the fourth brightest star in the sky at the base of Bootes. The arc in this case is the handle of the Big Dipper. Simply draw an imaginary curve away from the Dipper's bowl, and by continuing that arc you will bump into ruddy hued Arcturus. Next "drive a spike to Spica" by extending the arc further and there you will find Spica, the beautiful blue-white first magnitude star in the constellation Virgo, .

As with most of the ancient constellations, Virgo has a rich history of legend behind it. Several stories are told, but one of the most common suggests the Virgo was actually the beautiful Persephone, the daughter of the the Greek goddess of agriculture, Demeter. One day while picking flowers in a field her uncle Hades, god of the underworld, kidnapped her. Sweeping her away in his black chariot the Earth split in two as Hades sped back home to make her his unwilling wife and queen. Demeter was so devastated by this she turned her back on her duties causing widespread crop failure and famine. At last the Sun, who sees all, told her what happened. Demeter confronted Zeus and insisted he speak with his wayward brother. Finally they came to a compromise where Persephone would spend half the year with her dubious husband in the underworld and the other half above ground with her mother. When with her mother, Demeter is alive and happy and spring came upon the Earth. When she returns to her home, winter settles in.

Virgo is a rather dim constellation with Spica being the only noteworthy exception. This is a most interesting star, having been the first "spectroscopic binary" discovered. A binary star is actually two (or more) stars in orbit around each other. In Spica's case, the two members are so close that they cannot be visually seen but were only detected in the slight variations of the star's spectra. It was determined that the two stars are only 11 million miles apart (one third the distance from the Sun to Mercury) and spin around each other in only *4 days*.

While Virgo is visually timid, it contains one of the most fertile regions in the sky. For splashed across the upper corner like so many diamonds in the dust lies the great Virgo cluster of galaxies. So numerous are they that it is sometimes called a "galaxy cloud". Lying at about 65 million light years away, the Virgo cluster is said to contain over 3000 members, each like our own, each with a billion stars and each with countless solar systems, planets, star clusters and wonders yet to be discovered.

If it is clear, step outside and see if you can make out the fair maiden of Virgo.

M87 and black holes

M87 is one of the most massive galaxies in the Virgo galactic cluster, and of all known galaxies, . It is calculated to be about *800 billion times* more massive than the Sun, and is moving away from us at 755 miles/second. In detailed pictures literally hundreds of globular clusters may be seen swarming around the main body like bees in a hive. It is estimated that there are over 1000 globulars and possibly as many as 4000, amazing when you consider that in our own Milky Way only 110 are known.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m87.sbm}M87 is a very strong source of radio emmisions, the fifth most intense such source in the sky. The actual emmisions are coming from a peculiar 4100 light year long jet of material shooting out from the very nucleus of the galaxy. Also extremely strong x-rays have been detected from this region far greater in energy than either the radio or light emissions. One explanation is that there is a super-massive black hole in the center, tearing matter apart at a ferocious rate.

Black holes were first theorized based on the predictions from Einstein's theory of relativity. The theory states that gravity can bend light and distort "space". Therefore, if you have enough gravity, any light generated by an object would get sucked back and the space and physics in the area would be distorted out of recognition. With that kind of power, any passing stars, for instance, would be ripped apart, torn atom by atom and imprisoned forever. An event such as this would let out an enormous amount of energy which would be in all likelyhood be witnessed as x-ray emissions.

The density of a black hole is so great that the Sun would have to be squeezed down a ball of only 1.8 miles in diameter to match it. If the Earth were to become a black hole, it would be the size of a marble! A mere 1/3 of an inch!

Many black holes are believed to be created as a result of supernova explosions. Once the supernova sheds its outer layers and cools down, the center collapses in on itself with no outward pressure to continue holding it up. What happens afterwards strains the human mind. Theoretically speaking, within a few thousandths of a second the matter, the star, collides together at a single point called the "singularity" and its density rises to infinity. With such high gravity, time essentially comes to a halt. While inside, the collapse happens in the wink of an eye. To the outside world it may take a billion years. The black hole has now ceased to exist in our Universe and time frame, suspended forever in some interstellar purgatory where only mathematics can survive.

Meteor shower - nu Aquarids

The nu Aquarids meteors last from May 1 to May 7 with there peak rates visible about the third or fourth of the month. The peak duration is about three days and up to 20 meteors per hour can typically be seen.

Producing very swift meteors (40 miles/sec), the Aquarids are believed to be derived from none other than Halley's comet. They generate long, glowing trails, many bright meteors, often yellow. The rates may exceed 40/hour. The Aquarids are best seen in the southern hemisphere. The Orionids in October are believed to be from the same meteor stream, crossing our orbit a second time.

Meteors are small solid particles in orbit around the Sun and, in many cases, believed to be debris left by passing comets. For this reason meteors tend to be grouped together in comet-like orbits and often have been linked to known comets. It is when the Earth passes through one of these streams that a meteor shower occurs as the particles burn up in our atmosphere. On any night, the average observer should be able to see about five stray meteors per hour. The typical shower will generally triple that rate while the best ones (such as the Persieds of August and Geminids in December) may have 50 or more.

The distribution of meteors along their orbits is not uniform. Therefore, what may have been a bland shower one year might be a memorable event the next. The most notable one of this sort is the Leonids of November. Usually they produce about 15 or 20 streak an hour. But early one morning in November 1966, along the western coast of the United States, rates approaching *one-hundred fifty-thousand* per hour were reported. This was a repeat of the famous 1833 shower which prompted one 19th century writer to exclaim : "Never did rain fall much thicker than the meteors fell to the Earth. . .".

Occasionally, meteors the size of small rocks will join the fray, producing what is called a fireball. The bigger ones may be seen to break apart forming two or more fiery trails. The biggest of these might survive their entry and strike the Earth. These meteors are then called meteorites. The 4000 foot wide Barranger Crater in Arizona is a dramatic example of this.

The names of the showers are derived from the area of the sky from which the meteors appear to radiate (hence the name radiant), like spokes in a wheel. Therefore todays shower, the Lyrids would appear to be coming from the summer constellation of Lyra which is currently low in the east during the evening.

The best time to observe a shower is after about 2:00 AM local time until dawn. Since the meteors can appear in any part of the sky, a telescope or pair of binoculars would only hinder the viewing.

The date of the peak will fluctuate a day or so, meaning you may want to call up the astronomy department of your local college and find out the best time for observing. A moonless night is also recommended for a bright Moon will both destroy your night vision and wash out the dimmer meteors.

Freedom 7

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\shepard.bmp}On this date in 1961, the United States was where it was pretty used to being : way behind the Soviets in the "space race". Only 3 weeks had elapsed since a young Soviet air force officer, Major Yuri Gagarin rode his Vostok 1 spacecraft into the history books becoming the first human to ever travel in space. The U.S. had been here before, as the Soviets had bested them with the first satellite in orbit (Sputnik), the first man-made object to strike the Moon (Luna 2), the first spacecraft to photograph the Moon, (Luna 3), and so on. By comparison, the United State's efforts seemed timid at best.

On the morning of May 5, 1961, astronaut Alan B. Shepard climbed into his cramped Mercury spacecraft, Freedom 7. At 9:34 am, the single rocket engine of his Redstone launch vehicle ignited sending him on a simple ballistic trajectory to an altitude of 116 miles. 15 1/2 minutes later his spacecraft settled into the Atlantic ocean having traveled a total of 297 miles away from the launch, and having hit a maximum speed of 5,180 miles per hour.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\freedom7.bmp}Not very impressive when compared to the audacious flight of Gagarin who went an entire orbit of the Earth for over 90 minutes in space. But it was a start, and unlike Gagarin's mission, Shepard's was broadcast for the entire world to see as it happened. By 1965, the U.S.'s space efforts were finally pulling ahead of the Soviet's which would lead to a successful lunar landing in 1969, while the Soviets were still struggling to get a working moon-rocket which wouldn't explode on liftoff.

Following this brief flight, the newest American hero would be forced to inactive status due to a minor heart problem. Years later, after a long stretch which involved selecting crews for other NASA flights, his own flight status was restored after going through a new operation. Having missed the two-man Gemini program entirely only Apollo missions were available, Alan Shepard, America's least experienced, experienced astronaut assigned *himself* the role of commander of Apollo 14. It was on this mission that the first American in space also became the fifth man to walk on the Moon and the first (and so far only) person to hit a golf ball on the lunar surface.

Coma Berenices

Rising in the eastern skies about mid-evening is the faint constellation, Coma Berenices, "Berenice's Hair", . Undistinguished as it seems, this constellation has one significant feather in its cap : this is where the North Galactic Pole (NGP) is located in between stars Beta and Gamma. The galaxy like everything else in the Universe rotates around on an axis. Where the Earth spins every 24 hours, our galaxy takes about *20 million years* for each rotation and the NGP is where the North Pole of the galaxy is aimed. The southern Galactic Pole is located in Sculptor. Since you are looking away from the galaxy you will see fewer bright stars than toward the body the Milky Way. But now you have a clear shot into extragalactic space revealing all many more galaxies which would otherwise be hidden by our own.

While Coma Berenices is one of the more modern constellations (being created in 1551), the grouping was mentioned on occasion by the ancients. Frequently referred to both as the "hair" of either Ariadne or Queen Berenice of Egypt. Unlike most constellations this is one of the few that refers to a real person.

Berenice married her brother, Ptolemy III (as was Egyptian royal tradition) in the third century BC. A few days after her marriage Ptolemy went off to war. She promised him that if he were to return safely she would cut off her hair. He did, and so she did, placing it in the temple as a gift to the gods. The next day her hair mysteriously was gone, gone to the stars according to the court mathematician.

While dim in stars, Coma Berenices is a very fertile playground for astronomers, containing about half of the famous Coma-Virgo galactic cluster. So it has many fine galaxies well within the grasp of amateur telescopes.

See also the Virgo galactic cluster.

Quasars

First discovered in 1963, quasars are among the most enigmatic objects in the Universe and the most distant. They are enormously powerful energy sources poised on the very limits of the known Universe. The name stands for "quasi-stellar objects", or objects that are "kinda-sorta-maybe-if-we-used-our-imaginations-like-stars". However, unlike stars, astronomers measured their distance to be billions of light years away. At this distance an average galaxy would shine at about 18th magnitude, well beyond the range of all but the largest telescopes. But the first quasar discovered was a comparatively brilliant 12th magnitude. This would suggest that it was no normal object. Could this be some sort of super-galaxy? Another problem arose when it was determined that by certain behavior, the quasars could be no larger than a few light years at best, far too small for this kind of energy output. So, what are these things??

Many explanations abound. Some say the perhaps they are bright galaxies a lot closer than we think. Others say that it may be two galaxies in collision while a third tells us that a quasar is the collapsing core of an dying galaxy. Perhaps the best definition is that of a galactic core collapsing onto itself being swallowed up into a massive black hole. The powerful forces inside a black hole are quite capable of generating the kinds of energies observed, and at the rates seen it would require the consumption of an entire star once a year to sustain its monstrous output. Perhaps it started as a relatively small black hole after the collapse of a massive star, but over the period of a billion years or more it grew and grew devouring anything in its pathway. Like an unstoppable monster or a great cosmic drain it will likely gobble up its entire galaxy.

Since we've been studying the constellation Virgo for the past few evenings, you should note that the brightest quasar is located here. Called 3C-237, this is still hardly a naked eye object even though its energy output is equal to about *30 trillion* Suns (that's 30,000,000,000,000 folks). Shining at a feeble magnitude 12.8 it is available in moderately sized amateur telescopes, about 4.7 degrees NW from Gamma Virginis. When you look at this object you are looking *3 billion* years into the past, when the Earth was still in diapers.

black hole :
An object that is so dense with a gravity field so strong that nothing can escape, not even light. If the Sun were to become a black hole, it would have to be compressed to only 1.8 miles in diameter, or the Earth down to 1/3 of an inch.

Planet-X

The ancients knew of five planets in the solar system : Mercury, Venus, Mars, Jupiter and Saturn. It wasn't until 1781 when the sixth planet was added to the great pantheon thanks to the dedicated work of William Herschel, who discovered Uranus during a routine star survey. This was a tremendous achievement, leading one celestial map maker to add a new constellation commemorating Herschel's telescope. After this discovery, the hunt continued for still further planets. Close observation of the Uranian orbit showed that it had slight irregularities suggesting that there was still another unknown body gently tugging it out of a pure orbit. From this information two different mathematicians independently predicted the location of the unseen planet. Finally on September 23, 1846 French astronomer J. Galle and his assistants located Neptune, near where it was predicted to be (even though it is now known that Galileo himself saw Neptune all the way back in 1613, but failed to recognize it for what it was).

Taking a cue from the mathematicians, intensive analysis was made of the Neptunian orbit looking for clues of a possible nineth planet. By the beginning of the 20th century, astronomer Percival Lowell predicted where this new planet, "Planet X" would be visible and just what magnitude it would be. Up until his death in 1916 the search for "his" planet consumed Lowell, who took thousands of images of the sky in his fruitless hunt.

{ewl ewdll.dll,ewBitmap,ew_bmps\pluto\plutdisc.sbm}In 1929 a young assistant at the Lowell Observatory, Clyde Tombaugh, was tasked with the hunt. Tombaugh was faced with the laborious task of taking highly detailed photos of the sky, and then using a "blink comparator" he would examine every one of the 100,000 or more stars on each plate. The blink comparator was a device which would flip between two different pictures permitting the user to easily spot an object that might be moving such as a planet. Needless to say, it was *extremely* tedious work, perfect for grad students. But on this day (February 18), in 1930, it paid off handsomely. Using two photographs taken five days apart in January, at about 6:00 PM Tombaugh noticed one tiny spot which jumped about 1/8 of an inch. Checking a third plate confirmed that this wasn't merely a speck of dust, but a real body in orbit around the Sun. And to add to the body of evidence, Pluto was right were it was determined to be by Lowell nearly 30 years earlier. The announcement was made on March 13, 149 years to the day of Herschel's discovery of Uranus and Lowell's 75th birthday. Ironically, images of Pluto were found on Lowell's own photographs as early as 1907 but were overlooked since it was a lot dimmer than expected.

Based on Lowell's prediction Pluto should have been about seven times larger than the Earth and 2 1/2 times brighter than it actually was. But it is only about 2000 miles across, nearly the size of our own Moon. Why the discrepancy? Some suggested that there was a tenth planet beyond Pluto. But Pluto showed no unpredictable motions that would indicate an additional body. So only recently has it been discovered that the irregularities in Neptune's orbit were errors in observation! They didn't exist after all and Lowell's calculations, while correct for Pluto were merely plain dumb luck! Until that discovery, the search for Planet-X continued, but it is now felt that there are no more major planets to be found, at least around our Sun.

Planetary eclipses

We are all familiar with eclipses. A few years ago was the great solar eclipse of July, 1991, one of the finest in the century. And you may have seen a lunar eclipse in your lifetime, when our Moon passes into the Earth's shadow. But did you know that there are also eclipses on other planets as well? When the positions of the Earth and Jupiter are just right it is possible to view one of Jupiter's moons ducking for cover in its great shadow, being eclipsed by the gas giant itself.

Click here to set First Light to show you the Ganymede eclipse on the morning of March 30, 1995. This first view is from the San Francisco Bay Area. Using the clock advance button, , start moving the time ahead until you see Ganymede turn blue. It is now in the shadow of Jupiter. Advance it until it turns white again exiting the darkness. Notice that Io is also now in the shadow.

These events are clearly visible in small telescopes. The moon will slowly dim over a period of 10 minutes and vanish altogether only to reappear an hour or two later on. Now click here to see this event from *behind* Jupiter. Since you are now in hover mode, feel free to drag the view around and investigate it from all angles.

While First Light is extremely powerful, it cannot predict these eclipses with a tremendous amount of accuracy as there are all sorts of minor factors that it currently doesn't take into account. The best it can do is come within an hour or so of the real times. Down to the minute predictions are available in *Astronomy Magazine*.

Ursa Major, the Great Bear

Rising high up in the spring skies is one of the most easily found constellations, Ursa Major, the Great Bear, . Within the boundaries of Ursa Major lie the most recognizable grouping of stars in the entire heavens known as the Big Dipper to the Yanks, or the Plough to the British. This is only a portion of the constellation and is prime example of an asterism.

There are many, many stories about the bear in Greek mythology. The most common one associates it with Callisto, the daughter of King Lycaon of Arcadia. Callisto was the favorite hunting partner of the goddess of hunting, Artemis. The god Zeus wanted Callisto and succeeded by assuming the appearance of Artemis one day. When it became clear to the real Artemis what had happened she banished her friend from her company.

After Callisto gave birth to her son, Arcas, the wife of Zeus became angry at her husband's indiscretions. Cursing her, Arcas changed her rival into a bear and condemned her to wander the forest for years to come. Years later Arcas himself became an accomplished hunter and stumbled across this bear in the woods. At that point Zeus stepped in and sent the both of them into the heavens where Callisto was turned into Ursa Major and her son Arcas became Bootes.

Ursa Major is contains a wealth of fine objects for the amateur astronomer. Perhaps the finest double star in the sky is in the bend in the Dipper's handle. Named Mizar and Alcor, these two stars were known as a test of one's eyesight to the American indians, . They are clearly visible to the naked eye and a spectacular sight in a pair of binoculars.

Considered one of the most beautiful galaxies in the sky is M81. At a bright magnitude 8, it is one of the easiest for small telescopes. Only spaced 1/2 degree away from another galaxy, M82, they form a pair which is one of the most dramatic such duos in the sky. Being rather bright, both objects are easily visible in small telescopes. M81 is only about one-third the size of the Milky Way, 36,000 light years across, and has a luminosity of 80 billion of our suns.

Now go outside and see if you can find the Great Bear. Look for Mizar and Alcor. Would you have passed the Indian eye test?

asterism :
Asterisms are convenient groupings of stars which may lie within a single constellation or stretch across several, and frequently reflect local culture. The Big Dipper is one fine example, the Teapot of Sagittarius is another.

Mizar and Alcor

Located in the bend of the Big Dipper is the most famous double star in the sky : Mizar and Alcor, . These two stars were known as a test of one's eyesight to the American indians. They are clearly visible to the naked eye and a spectacular sight in a pair of binoculars.

Mizar comes from the Arabic, meaning "waistband". It is a moderately bright star at second magnitude. Alcor on the other hand is several times dimmer at fourth magnitude, but should be an easy sight in darker skies. Mizar is about 70 times the luminosity of the Sun and is separated by about 380 astronomical units from its dimmer partner. Note that this represents 10 times the distance of between Pluto and the Sun. So when you see them for yourself, imagine Mizar as the Sun and visualize our solar system at those distances, overlayed on top of Mizar. It should give you a good feel for the scale of the system.

The two stars rotate around each other with a very long period of estimated at several thousands of years. And both stars themselves are binaries, so the system actually is a double binary complex.

X-ray astronomy

X-ray astronomy began in 1949 with the discovery that the Sun emitted x-rays. It wasn't until the beginning of the space-age before this phenomenon could fully be explored. The emission of x-rays requires extraordinarily energetic activity. The first extra-solar x-ray source discovered was Scorpius X-1 and is the brightest source known which also has both radio and optical counterparts.

There are several different kinds of x-ray sources, the first being x-ray binaries. These represent most of the 50 or so known x-ray objects. An x-ray binary is the result of a double star in which one of the members has gone "supernova" leaving behind an extremely dense object called a "neutron star". This draws matter out of the other with such ferocity that x-rays are generated.

Black holes are other heavy x-ray emitters. Operating similar to the binaries above, the radiation is generated as matter is drawn into the black hole and rather thoughtlessly shredded apart.

A number of galaxies also emit x-rays due to high velocity ionized gases swirling around a massive nucleus which might in turn contain a black hole to add to the effect.

Crux - The Southern Cross

Crux is the smallest of the constellations and for being deep in the southern skies, a surprising number of northerners seem to be familiar with it, .

The stars of Crux were know to the ancients, but were never formed into their own constellation until the 16th century. As are result there are no myths or legends associated with it.

The brightest star in Crux is "Acrux", the 14th brightest in the sky with a magnitude of 0.87. It is located at the base of the "cross" and is a considered one of the finest double stars in the sky with both members virtually identical in type and luminosity. At a distance of 370 light years the two stars are separated by about 500 astronomical units, or about 6 times the diameter of the solar system.

Mimosa, the left arm of the cross, is the 20th brightest star in the sky at a magnitude of 1.28. Mimosa is about 490 light years away, so the light you would see tonight left there shortly after Columbus landed in the New World. It is about 5800 times the luminosity of the Sun and is moving away from us at about 12 miles per second.

Also in Crux is one of the most beautiful star clusters in the sky, delightfully named "The Jewel Box", officially called by the less delightful name of "NGC4755", . It is one of the youngest clusters known, and believed to be about 7700 light years away. It contains about 50 members tightly compressed into a small area, many are among the most luminous stars known.

If you happen to live south of 25 degrees north latitude you should be able to see this wonderful constellation directly south in the mid to early evening. If so take your binoculars and get up close and personal with this wonderful little constellation.

Jewel Box

Crux is the smallest of the constellations, but has one of the most spectacular star clusters in the entire heavens. The delightfully named "Jewel Box", officially called NGC4755, is one of the youngest clusters known, and believed to be about 7700 light years away. It contains about 50 members tightly compressed into a small area, many are among the most luminous stars known.

If you live south of 25 degrees north latitude you should be able to see it yourself in the mid to early evening hours. If not click here  and First Light will show it to you.

The Jewel Box is estimated to be about 25 to 50 light years across and chock full of red supergiant stars tens of thousands of times more luminous than the Sun.

Interesting, the Jewel Box is located right next to the "Coal Sack" one of the heaven's dark nebulae. Looking like a hole in the sky, the Coal Sack is no different than any other nebula except it simply has no light source. At a distance of only about 500 light years, this is one of the closest of the dark nebulae.

Drawing a star chart
Project. . .
supplies : a clear night, pad of paper, pencil, flashlight with red cellophane over the front

This project put you in the place of the Medieval astronomers, who would spend their evenings endlessly charting out the heavens using no more serious tools than a drawing pad and their eyes. Tonight you will chart out Ursa Major, the location of the Big Dipper. Take the pad of paper and the pencil outside and find a comfortable location. Using the red flashlight will ensure that you can see the paper without ruining your night vision.

Now start sketching out the constellation, drawing the brightest stars as larger dots, the dimmest stars as the smallest dots. Label the stars, calling the brightest "a", the next brightest "b" and so on. (This is similar to the way the stars are officially named using Greek characters instead). When you think you've completed your chart, go back inside and print out a chart of the same region using First Light with the star labels turned on (using Expert/stars/data/greek-name option). Compare the two and see if your brightness levels agreed with the way the astronomers of old saw things.

Eta Carinae, Heaviest Star Known???

In 1845 the star Eta Carinae blazed forth as the second brightest star in the sky, having increased from fourth magnitude star in the early 1800s to a searing -0.9. Its pathway was a irregular one, bouncing up and down one or two magnitudes at a time, defying explanation. From its maximum in 1845 it faded out to a feeble seventh magnitude, right below naked eye visibility, where it currently is today, .

With a distance believed to be an astounding 8000 light years away, at its most brilliant it had to have been shining 4,000,000 times brighter than our own Sun and over 100 times its mass making it one of the heaviest stars known. Shortly after the peak, a cloud of gas was seen expanding around it moving out at about 300 miles per second. It is believed that the star is still as luminous as it ever was but most of its light is now being blocked but the nebulosity. The Eta Carinae nebula is a beautiful and delicate red flower in the heavens called the "Key Hole Nebula".

Eta Carinae is thought to be a dying star, having burned up most of its hydrogen it is in effect, "sputtering out", going unstable. And if so, it might go supernova in only a few hundred years. And this time it truly will outshine even Sirius, and possibly even rival the Sun.

Retrograde Motion

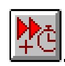
To the ancient astronomers the planets were called "the wanderers" since they were observed wandering about from evening to evening. Unless one were to observe the planets on a daily basis, their movements might not be noticed. However, if we were to plot their motions over a period of several weeks, we can get an idea of just what the ancients saw.

Up until the time of the astronomer Copernicus, common belief maintained that the Earth was the center of the Universe with the Sun, Moon, planets and stars all orbiting around it. Unfortunately, a few inconsistencies crept in to upset this idyllic viewpoint. For example, the planets would, on occasion, slow up and of all things, *move backwards*! (the nerve!)

In an effort to explain this phenomenon, the astronomers of the day invented *epicycles* which forced the hapless orbs into making a small orbit on top of their main orbits, causing them to back up every so often. This still did not explain all of the movements, so more epicycles were stacked on top of the earlier ones. Eventually, some planets collected up to 14 levels of epicycles, but still refused to behave.

We can see this mysterious behavior (now called "retrograde motion") by observing Venus and Mercury.

Click here  to center Mercury on the screen. The date is June 30, 1992.

Now start advancing the clock using the fast forward button, .You should notice a very unusual plot. Hey, what's going on here?

Now select *lookdown/inner* and reset the date back to June 30 and advance the time again. This should help explain things. Essentially what is happening is that Mercury, being closer to the Sun than the Earth is whipping around to the other side of its orbit and therefore appears to be going the other direction (which in fact, it really is doing). This would not be possible from an Earth centered Universe!

Another example may be seen in the plot of Halley's comet. Click here  to load in the comet. The date is June 1, 1986, a couple of months after closest approach. As before start advancing the time. Notice the funny zig-zag trail it leaves. In this case the comet is not moving back and forth, but the Earth is, changing Halley's apparent position in the sky. Notice as the comet gets further away the loops get smaller.

No wonder the ancient astronomers were confused!

Spica

When it comes to learning the evening's sky, astronomers use many memory games based on the various patterns within the constellations. Remember to "follow the arc to Arcturus" in order to find the fourth brightest star in the sky at the base of Bootes. The arc in this case is the handle of the Big Dipper. Simply draw an imaginary curve away from the Dipper's bowl, and by continuing that arc you will bump into ruddy hued Arcturus. Next "drive a spike to Spica" by extending the arc further and there you will find Spica, the beautiful blue-white first magnitude star in the constellation Virgo.

Virgo is a rather dim constellation with Spica (Latin for "ear of grain") being the only noteworthy exception, . This is a most interesting star, having been the first "spectroscopic binary" discovered. A binary star is actually two (or more) stars in orbit around each other. In Spica's case, the two members are so close that they cannot be visually seen but were only detected in the slight variations of the star's spectra. It was determined that the two stars are only 11 million miles apart (one third the distance from the Sun to Mercury) and spin around each other in only *four days*.

At a distance of about 275 years the light you see tonight left when the colonists in America were just starting the chafe under British rule, the "French Enlightenment" began to sweep across Europe, Easter Island was discovered by the Dutch, Daniel Defoe had just finished *Robinson Crusoe* and the first smallpox inoculations were given.

Galactic Superclusters

Before the turn of the century, it was believed that the Milky Way *was* the Universe, and therefore was the *only* galaxy. The fuzzy disks visible in the largest telescopes of the time were merely members of the Milky Way, flattened spinning nebula, clouds of mere gas. It wasn't until the 100 inch Mt. Wilson telescope opened for business right after World War I (becoming the largest in the world) did astronomers realize the these fuzzy disks were in effect, other Milky Ways. Huge cities of stars scattered from here to infinity. And that our own galaxy wasn't so unique after all.

As stars can cluster together, so can entire galaxies. And as galaxies can cluster together, so can clusters of galaxies! These are called "superclusters", and even now it appears that superclusters have formed larger associations still called "super-super clusters".

A relatively recent (1970s) discovery   the "shape" of the Universe is slowly coming into view. When originally theorized, superclusters were felt to form "bubbles" of galaxies. The galaxies would be at the center of these bubbles with empty space where the seams would be, where one bubble or cell would join another. Up through the 1970s and 1980s as more and more measurements were made on thousands of objects, it was seen that this was actually opposite! The cores of the bubbles where virtually empty of galaxies, but the boundaries from one to another were littered with the things. This gives rise to a very almost web like Universe with delicate filaments of galaxies stretching from end to end. But still these exhibited a clustering nature suggesting yet a higher order form of structure.

Our "local group" of galaxies measures about five million light years across and contains some 20 members including the great Andromeda Galaxy and its companions. This in turn belongs to the Canes Venatici/Ursa Major galactic cloud which stretches about 30 million light years in length. Joining with six other clouds it forms local supercluster with the Virgo cluster as the center. At about 100 million light years on a side it contains literally millions of galaxies, each not to much unlike our own. Kind of humbling isn't it?

So tonight grab a friend to haul outside. Locate the constellation Virgo and say "see that, there's the center of our Supercluster!....." They will either be amazed, humbled or incredibly annoyed.

How Far Away are Things??

Often astronomers are asked exactly how they know the distances to various objects in space. Aside from the planets, it gets pretty tough to directly measure such a value.

Distance measurements are made several different ways, depending on the kind of object, its relative distance and so on. The planets are easy, but as one looks at things progressively further out it becomes more and more of a guessing game.

It was an astronomer named Fredrich Bessel who was the first person to ever measure the distance to a star beyond the Sun using a very simple mathematical principles. Bessel specialized in determining the precise position of stars (known now as "astrometry") and did so for over 60,000 individual object! One in particular seemed to have a slight motion through the sky, as detected by an Italian astronomer a in 1792. This suggested that it was very close. If this was the case then the object should appear to change position up against the background stars depending on the location of the Earth. So using this information, in 1838 Bessel measured what is called the "parallax" of the star, 61 Cygni. From here he used standard surveyor's methods for figuring out the distance. It seems straightforward enough, but Bessel was working at the limits of his science, having to detect a change in position of 1/10,000th of a degree! From his calculations he determined that the star was over 10 light years away.

The unfortunate thing about using parallax is that it only works for only about 1000 of the closest stars.

Beyond parallax measurements, astronomers have adopted "standard candles" or reference objects of known brightnesses. No single object can do the job, so a number of methods have been derived.

One of the most traditional and reliable candles are "Cepheid" variable stars. Cepheid variables are stars that vary their brightness in a predictable fashion. Their brightness would peak at given intervals based on their overall luminosity. If you know their period, you know how bright the star really is and can then easily determine just how far away based on its visual magnitude. These work for distances out to about 30 million light years so are used to determine the distances to some of the nearer galaxies.

The other workhorse of distance measurements are the dimmer "RR Lyrae" stars. These are aged yellow variables with very fast periods of less than a day. As with Cepheids their periods are an indicator of their true brightnesses. However since they are dimmer, RR Lyrae stars are useful only to about 10 million light years.

A relatively new approach uses planetary nebulae, expanding clouds of gas thrown off from a stellar explosion. Using extensive statistical evidence, it has been discovered that the distribution of planetaries in other galaxies is roughly the same as in our own. So by merely counting the old and new, the large and small planetary nebulae, and comparing them to nearby galaxies it is possible to derive a distance. The method works out to about 75 million light years.

For distances out to several hundred million light years, one can use entire galaxies. In the mid-1970s it was discovered that there was a direct relationship between the rate of a spiral galaxy's rotation and its total luminosity. The faster the rotation the more massive, hence bigger and brighter it would be.

Beyond the galaxies it is anybody's guess. Most distance measurements become rough approximations using a number called the "Hubble Constant". Unfortunately, the exact value of the Hubble Constant is still unknown and since its conception in the 1920s it is still remains at the very center of a major astronomical firestorm. Stay tuned!

Zodiacal Light

There are a number of sky phenomenon that fall under the heading of "elusive glows". None are more well known than the Zodiacal light, a ghostly cone, a reclusive glow best seen after sunset or before sunrise.

The Zodiacal light is caused by sunlight reflected off of the interplanetary dust in the solar system. The best time of the year to witness this is either near the beginning of spring or fall when the plane of the solar system ("ecliptic") is high in the sky. Also, the closer to the equator, the brighter the glow.

If it is a moonless night and you are far from major city, you might try and catch this elusive glow. Wait until about 1 1/2 hours after sundown and find the darkest observing spot you can. Give your eyes a good 20 minutes to adjust to the light. Looking west where the Sun had set you should see a faint "pyramid" or conical shaped tower of light stretching up from the horizon to at least 30 degrees in altitude. This is not at all unlike the light seen cascading off of dust particles in a beam of warm afternoon sunlight.

Since the dust marks the plane of the solar system (the "ecliptic") you may want to follow it month after month to see it's angle change. Using First Light in local mode, you will notice that in the spring and fall the ecliptic stretches high up in the sky, but dips very low to the horizon in the Summer and winter.

Also, compare the brightness of the Zodiacal light to that of the Milky Way. On a good night they should just about be equal.

Three Leaps of the Gazelle

There are many charmingly named stellar groupings in the sky, perhaps none more so than the "Three Leaps of the Gazelle".

This is what is called an "asterism", a convenient grouping of stars which may lie within a single constellation or stretch across several, and frequently reflect local culture. The Big Dipper is one fine example, the Teapot of Sagittarius is another.

The story is told that the Gazelle is trying to escape from Leo the Lion. The empty region between Leo and Ursa Major, the Great Bear is called The Pond. So we can imagine the fleet footed animal skillfully splashing through the shallow water away from Leo's grasp. The three leaps are made of three pairs of stars, the first one being nu and chi Ursa Majoris. Click here  to center the first leap. (The names "nu Ursa Majoris" etc. are the Greek names given by early stellar cartographers. "Nu" is a Greek letter which denotes its relative brightness as compared to the others in the constellation. The brightest star will then be "alpha", the next is "beta" and so on. In the center dialog, select the Greek names option and type in "nu UMa", the UMa being the official abbreviation of Ursa Major.) The first leap will now be centered and is clearly seen right next to Leo Minor. With a field of view of 60 degrees all three pairs should be visible cascading up and to the right,
.

Now go outside this evening if it is clear and see if you can find the pond, as the leaps should be high up in the sky.

The fate of the gazelle is unknown, but the ripples it stirred up in the pond remain to this day for us to see and enjoy.

Celestial Mechanics : finding things in orbit

Celestial mechanics is the branch of science started by Sir Isaac Newton in an effort to explain the motions of the planets by using the laws of physics and mathematics. About 80 years before the brilliant mathematician Johannes Kepler derived the three laws of planetary motion by direct observation but could never explain just why things worked the way they did. This required Newton, and a new branch of mathematics called "calculus" he invented to aid him in his work.

Kepler's laws worked for simple systems with only two bodies, apart from any other possible influences, but the solar system is not nearly so simple. The orbit of Halley's Comet is constantly changing due to the gravitational effects of Jupiter and Saturn. The planet Uranus was observed varying its orbit slightly, being gently tugged by an unseen planet which would later be seen as Neptune.

Kepler showed that all objects traveled in an ellipse, a flattened circle, and that most orbits and the location of the object in space can be specified by six pieces of information.. The "eccentricity" is a value that indicates the amount of flattening. An eccentricity of zero is a perfect circle, Venus comes very close to this. An eccentricity of 1.0 makes the orbit a "parabola", essentially an open ended ellipse. Halley's Comet has an eccentricity of .96 giving it the highly elongated orbit. Next, it is possible for an orbit to be inclined to its parent body. For instance, Pluto's "inclination" to the Sun is about 17 degrees. Use First Light and you can see this for yourself.

Now we need to know some starting point in the orbit. The closest approach to the Sun is usually used, called the "perihelion". But his is useless unless its location is known relative to some other spot. Thus we have the "perihelion longitude" based on the same absolute point in space for all objects in orbit around the Sun. The value in effect specifies how the entire orbit is rotated. If it is 90 degrees it means that the beginning of the orbit is 90 degrees away from the common point.

With these we still need to know the size of the orbit, usually expressed in "semi-major axis", which is simply a term from geometry to specify the size of an ellipse.

So now we know the pathway the object travels, but where is it on a given date? There needs to be an absolute date used as a staring point, usually called the "epoch date", and an orbital period, the length of time it takes to complete a single orbit. With all of these bits of information it is possible to tell exactly where an object will be along its orbit.

But that is not the real world, as Newton showed us. while Kepler's work is fine for approximations, it fails when one wants highly accurate information. But a discussion of Newtonian mathematics is well beyond the scope of this little write up. Trust me. When you start summing up the gravitational effects of all of the solar systems major objects along with some spatial distortions caused by the Einsteinian relativity this can get very messy. Now consider that the Voyager 2 spacecraft came within only a few dozen miles of its desired target near Neptune after travelling over three billion miles and this stuff can seem downright magical!

You may want to load up one of the comets in the *create new orbit* dialog and play with the individual parameters to see exactly what they all do.

perihelion :
The closest approach to the Sun by an object in orbit around the Sun.

North American Nebula

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\ngc7000.sbm}Nope, this isn't a nebula in North America, it is an enormous and vivid cloud of gas and dust which has striking resemblance to North America, . Due to its large size (four degrees across, eight times the angular size of the Moon), the nebula must be viewed with low power instruments such as richest field telescopes or binoculars. Located in Cygnus the Swan, it rises in the east in the early evening on this date and becomes an easy object by 11:00 PM. Using First Light, locate the object for your own location this evening and see if you can make it out (it will be called "NGC7000" in the database). For a relatively faint patch such as this a dark moonless sky is going to be necessary. First look for it with the naked eye. If you can't find it that way, try sweeping across the area with your binoculars.

Behind the nebula lies the part of the Milky Way. Photographs will show a million dancing fiery lights all splashed wildly across the ebony sky.

Deneb is thought to be the illuminating star, at about 70 light years away. The cloud is itself about 45 light years across.

Bootes, the Herdsman

As May heads into June, the precession of Greek character continues across the evening skies. This evening you will likely see Bootes, the Herdsman, rising high in the heavens , .

Bootes is believed to have been Arcas the illicit son of Zeus and Callisto, the daughter of Arcadia. Callisto was the favorite hunting partner of the goddess of hunting, Artemis. Zeus wanted Callisto and succeeded by assuming the appearance of Artemis one day. When it became clear to the real Artemis what had happened, she banished her friend from her company.

After Callisto gave birth to her son, Arcas, the wife of Zeus became angry at her husband's indiscretions. Cursing her, she changed her rival into a bear and condemned her to wander the forest for years to come. Years later Arcas himself became an accomplished hunter and stumbled across this bear in the woods. At that point, Zeus stepped in and sent the both of them into the heavens where Callisto was turned into Ursa Major and her son Arcas, Bootes.

In another legend Bootes was identified as Icarus, the inventor of wine. One day he gave some wine to a few clueless shepherds. Mistaking their drunken state for being poisoned they, killed him. Maera, his dog ran home and returned with Erigone, the daughter of Icarius who upon seeing her dead father committed suicide along with the dog. Taking pity on them, Zeus immortalized them in the heavens for all eternity. Maera became Canis Minor, Erigone is now seen as Virgo, and Icarius of course is Bootes.

The constellation is best known for housing Arcturus, the fourth brightest star in the sky, .

Arcturus

Arcturus means "the Bear Watcher", and is an apt name for the brightest star in the constellation Bootes the Herdsman, .

In the Greek myths, Bootes is identified as Arcas, who chased a great bear, not knowing it was his mother in another form. Arcturus is the fourth brightest star in the sky and is about 115 times as luminous as the Sun, 25 times its diameter but only four times its mass. This means that it would have to be about .0003 times as dense as the Sun. The heat received on the Earth from Arcturus is equal to that delivered from a candle burning five miles away. It also has one of the largest proper motions of the bright stars. It will come closest to us in a few thousand years, then recede toward Virgo, where it will vanish in 500,000 years.

Arcturus is a bit of an oddity among the heavens. Most stars are satisfied to flow with gentle galactic motions, like leaves drifting along in the breeze, all going about the same general direction lazily swirling around the galactic core into eternity. All except Arcturus. While it, too, moves around the nucleus of the galaxy, it does so perpendicular to plane to the Milky Way, blazing a trail up and over the center only to come down the other side millions of years later. It belongs to a thin "halo" of stars, a spherical shell of material that surrounds the galaxy.

The star is also relatively new to the sky, having become a visible member only a half million years ago. A few million years into the future, its time will come as it slowly burns itself out leaving only an empty spot in the sky.

Cosmic Rays

Cosmic rays are nuclei of atoms stripped of all of their electrons. They zip through space at speeds close to light and represent the highest energy particles in the Universe. Most cosmic rays are either Hydrogen or Helium nuclei which have had to suffer incredible catastrophic conditions in order to reach their states.

A ray's energy is measured in electron volts ("eV"). The energy of an air molecule at room temperature is about 0.1 eV and those from an x-ray machine hover about 10,000 eV. However some cosmic rays have energies approaching *10,000,000,000,000,000,000 eV!*

The lower energy cosmic rays are thought to come from the Sun and are commonly associated with bursts of solar-flares. The high powered ones come from the centers of supernovae or pulsars.

Cosmic rays rarely reach the Earth's surface as they are usually trapped by the magnetic field or are destroyed by smashing into molecules in the atmosphere which in turn break apart and smash into other particles, causing a chain reaction. The resultant "air shower" of particles can spread over several thousands of square yards of the ground.

Cosmic rays have interesting effects on life forms. Astronauts can loose brain cells if hit while in space. On the ground DNA can be altered by an air-shower. Some think that evolutionary mutations may have been spurred on by this effect.

pulsars :
Tiny stars the represent the collapsed core of a supernova. They are typically on the order of 5 or 10 miles across and spin an a rapid rate sending out a tightly focused beacon of energy from their poles. When that beam spins past the Earth we see a brief flash. Pulsar rates vary from 1/30th of a second on up one flash every few seconds.

Interferometers

What the heck is an interferometer? Well. . .it is simply a form of telescope. Two main attributes of telescopes astronomers are constantly attempting to increase are the resolution (the amount of detail visible) and light gathering ability (how dim of objects it can see). Increasing the light gathering is simply a matter of increasing the size of the telescope. The resolution is likewise affected by the size, but is really determined by the maximum width of separation between the edges of the mirror. The stuff in between the edges is actually not that important as long as the object is bright. So, what if you could actually bind two telescopes together that might be separated by a mile? Then you would get a resolution (but not light gathering) equivalent of a telescope one mile in diameter.

Theoretically telescopes stretched across the face of the Earth could be linked together forming an instrument literally thousands of miles in size.

Currently the two largest telescopes in the world, Keck 1 and Keck 2 in Hawaii when completed will be 250 feet apart and themselves will be joined as an interferometer. The detail they will deliver is truly staggering, such as being able to separate a car's headlights 16,000 miles away (not that they are planning to do that). This will let them peer further inside the distant galaxies or perhaps one day gaze upon the surface of another star. With the combination of the Keck telescopes, the Hubble Space Telescope, a half dozen other monster telescope projects scattered around the world, and a really neat piece of Windows software, we are truly in the golden age of astronomy. So sit back grab a cup of cocoa and watch the Universe come into focus.

Interlopers from Deep-space

At first it looked like any other new asteroid, a simple streak across a picture of the constellation Aries. In time it was named Chiron. However, if it was an asteroid, what was it doing in a monstrously large comet-like orbit of 51 years in duration, going from the distance of Uranus to the to inside the orbit of Saturn? Most asteroids reside comfortably in between Jupiter and Mars.

With a diameter of about 180 miles it was much too big to be a comet, but located incorrectly for an asteroid. Could it be an entirely new class of object? After an extensive search only this one item was discovered. To make matters more interesting, Chiron started to fluctuate in brightness at distances too far away from the Sun for heating effects. Further studies of the orbit showed that the complex interactions of the gravity form Jupiter, Saturn, Uranus and Neptune would normally clear out any object in that region implying that its presence was rather new to this area of space.

In the 40s, one of the world's foremost planetary astronomers, Gerald Kuiper, suggested that the solar system didn't end at Pluto, that there was ample matter well beyond in a disk of pristine primordial material. This was forgotten until the 1980s when other astronomers noticed that comets would be impossible without the existence of such a disk. If there was a "Kuiper disk" with objects similar to Chiron they just might be at the limits of Earth based visibility. In 1992 as new more powerful telescopes were built the hunt was on looking for objects in the 23rd magnitude region, 10,000 times dimmer than Pluto. Finally within the space of two years eight similar Chiron type objects were found in a very small area of the sky and all within 35 to 45 astronomical units distant. At least another 1,000 to 10,000 are predicted to be in this fairly narrow band. Extrapolate that out to 200 astronomical units (5 times the distance of Pluto) and potentially millions of Chiron objects exist, all orbiting in the lonely silence of interstellar space.

Beyond the Kuiper disk is the Oort Cloud, similar but it extends to about 20,000 astronomical units, well on its way to the next star.

So what exactly is Chiron? Could it have been a fragment of a planet that might have been? Is it similar to objects that are busily producing planets around other stars? And how did it get sidetracked so far away from its home? Whatever the answers Chiron might at last give us a look at what the solar system was like billions of years ago. Proposals are on the table now for a Chiron flyby. Such a journey would take up to seven years after launch but could start filling some of the final major gaps in our knowledge of planetary formation.

Gemini Project

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\gtlaunch.bmp}The United States' first manned space program was called "Project Mercury". It was simply to conduct the most basic of tests needed to see if man could perform tasks in the space environment, survive re-entry, and verify the technology. Originally Mercury was meant to be a "stand alone" project, but ended up kicking off the whole Moon landing program. When completed six missions had been flown, the longest over a day and a half. But there was still much to be learned before Apollo could fly, so a "two man Mercury" was proposed. Later called "Gemini" in reference to the constellation of the twins, it would fly 10 missions in a space of only two years and pioneer such needed procedures such as space walks, dockings and long duration flight, without which Apollo would've been impossible.

While Gemini was being prepared, the Soviets would not be content with launching merely a two man spacecraft, but a *three man* mission as the first mulitman spaceflight so as to beat Apollo by four years. Next came a two man flight with the first ever spacewalk. However after these two spectaculars the Soviet manned space program would lay dormant for nearly two years, giving the Americans more than enough time to leap ahead in the "Space Race" for good.

The first manned Gemini, Gemini 3, sped upward into the heavens in March of 1965. Since it was merely a shakedown cruise it lasted an all too brief three orbits. And compared to the recent Soviet efforts this still looked like catch up time. The Gemini 4 mission answered the spacewalk challenge as Edward White stepped into the void of space for 20 minutes   doubling the time Cosmonaut Leonov was outside his spacecraft. Gemini 5 took astronauts Pete Conrad and Gordon Cooper on the first ever spaceflight to last longer than a week. Flying for over eight days they proved that man would have no medical problems on a "lunar duration" mission.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\gemini.bmp}In the fall of 1965 the Gemini 6 was to perfect rendezvous techniques with a "target" launched separately. Unfortunately the Agena target exploded shortly before it entered orbit and the mission was scrubbed. Then someone got the brilliant idea that Gemini 6 use the Gemini 7 spacecraft as its target and the spectacular twin mission was born. Flight number 7 actually left the ground first, taking astronauts Jim Lovell and Frank Borman to a record smashing 14 days in space. Afterwards Gemini 6 was loaded on the pad and a few days later however in a frightening turn of events the launch had to be aborted after the engines ignited then shutdown on the pad. Mission rules told the astronauts that they were supposed to have ejected from the spacecraft, essentially ending any hopes of the flight. But they sensed that things were safe and stayed put only to successfully launch three days later after the problems were fixed.

The eighth mission of Gemini was piloted by the man who would later become the first on the moon : Neil Armstrong. Joining him was another would be moonwalker, David Scott. Theirs would have the distinction of being the first manned United States mission to abort in mid-flight. What was supposed to have been a three day space spectacular putting together everything learned up to that time, turned into a near-death experience. Five hours into the mission, Gemini 8 completed the first ever docking between two vehicles when its nose gently nudged into the docking ring on the Agena spacecraft simulating the joining of an Apollo lunar module with its mother ship. Only 20 minutes later the joined spacecraft started spinning wildly out of control. Thinking that the Agena was going nuts they separated only to find the Gemini spinning faster than ever. Apparently one of the small maneuvering thrusters was stuck on due to a short circuit sending the men whirling up to *60 times a minute*! Much faster and their spacecraft might   have been torn apart. It took Armstrong another orbit to get things under control while using most of his fuel and activating a system used only for re-entry. Now they were committed to returning and shortly after made a perfect splashdown only 10 hours after launch.

The Gemini 9 flight was to repeat much of the previous one's goals : Docking and a spacewalk. The docking target malfunctioned this time making that part impossible, and the spacewalk was plagued with many problems when what should have been simple tasks became supremely difficult in zero-gravity.

Gemini 10 lasted a brief three days, but at last managed a full up mission. No major malfunctions inhibited the flight which included two spacewalks, a docking, a "reboost" to a new altitude record (474 miles) and two rendezvous. The next mission would accomplish as much and even more as they demolished the short lived altitude record and flew up to over 850 miles high. Also added to Gemini 11 was an interesting artificial gravity experiment.

The final flight, Gemini 12 at one time was proposed to coincide with the first manned Apollo Mission, but delays in Apollo would prevent that. Mission 12 was the capstone to an incredible program. Taking everything that had been learned and summing them up into a single four day flight. Buzz Aldrin who would become the second man on the Moon would make three highly successful spacewalks, getting out the gremlins that plagued all previous ones, a docking would be made along with another gravity experiment. The Gemini program ended on November 14, 1966 and had cleared the path to the Moon. Next stop would be Apollo.

Summer triangle

The Summer Triangle is what is known in the trade as an "asterism", or a portion of a constellation. Asterisms are simply convenient grouping of stars which may lie within a single constellation or stretch across several, and frequently reflect local culture. For instance, what we call the Big Dipper since it looks somewhat akin to a large spoon or water ladle, the English refer to as *The Plow*.

The Summer Triangle is made up of the three stars Vega in Lyra, Altair located in Aquila, and Deneb which is found in Cygnus the Swan. Vega is the brightest of the three and at .04 magnitude, the fifth brightest star in the sky. As with all bright stars it has its share of myth and lore tightly bound to it. The Greeks called it "Cithara," the Babylonians named it "Dilgan" and it was "Allore" to the Arabs. And it is toward this part of the sky that our solar system is rushing (the "Solar Apex"), at 12 miles-per-second. At this rate it will take us 450,000 years to reach the vicinity of Vega. But what a view we will have then! Vega, about 27 light years away, is 58 times the luminosity of the Sun and 3 1/2 times the diameter.

Over toward the east is Deneb, the tail of the swan. Deneb is one of the furthest of the bright stars, and one of the most luminous. Deneb is a "supergiant," and represents one of the greatest known. With a luminosity equal to 60,000 suns, it has an absolute magnitude of -7.1 and lies 1600 light years away.

Below Cygnus is Aquila the Eagle, home of Altair the 11th brightest star in the sky at magnitude 0.76. It is also one of the closest, nine times more luminous than the Sun and 1 1/2 times the size. Altair has one of the fastest rotations known, making a complete spin in only 6 1/2 days, compared to over 25 days for the Sun. Because of this it must be rather flattened, with an equatorial diameter nearly *twice* the polar diameter.

Use First Light to see where this lovely object is right now, . And see if you can find it for yourself this evening.

October

October 1 : Aquarius, the Water Bearer
October 2 : Project - Why do Stars Twinkle?
October 3 : NGC7293, the Largest Planetary
October 4 : Sputnik 1
October 5 : The Nearest Stars
October 6 : Faster than Light Travel
October 7 : Fomalhaut
October 8 : Occultations
October 9 : How Stars Form
October 10 : Project - Building a telescope
October 11 : NGC457 in Cassiopeia
October 12 : Sculptor
October 13 : SETI
October 14 : Project - Rings of Uranus
October 15 : Space movies : 2001 vs. Star Trek
October 16 : The "Reddest" Star in the Sky
October 17 : Triangulum, the Triangle
October 18 : Galaxies of the South
October 19 : M52
October 20 : 6000000000 AD
October 21 : Meteor Shower - Orionids
October 22 : Magellanic Clouds
October 23 : NGC1528
October 24 : Naming the Stars
October 25 : Project - Looking for Satellites
October 26 : Astrology
October 27 : What Makes a Year?
October 28 : Calendars of the Ages
October 29 : Cetus, the Sea Monster
October 30 : Grus, the Crane
October 31 : Halloween objects

Aquarius, the Water Bearer

When it comes to the rich lore of Greek mythology, Aquarius is perhaps one of the most insignificant characters, identified alternately as Ganymede the son of King Tros to Cecrops, king of Athens.

In the Greek stories, Aquarius, after being kidnapped by Zeus (for reasons left unsaid as this is a family program), ends up becoming waiter to the gods, serving up a mixture of water, wine and a special nectar. In another version, he is identified with King Cecrops of Athens, who is said to have made sacrifices of water to the gods since he lived before wine had been invented.

Aquarius contains a number of decent deep-sky objects. M2 is a "fine" globular cluster, its sixth magnitude intensity making it an easy object for binoculars and small telescopes. Containing over 100,000 stars, M2 consists of primarily 14th and 15th magnitude objects. (By comparison, were the Sun at that distance it would only be 20th magnitude).

NGC7293 is called "The Helix Nebula", and is considered to be one of the nearest and largest planetaries. Even though its angular diameter is nearly half that of the Moon, its low surface brightness makes it rather faint. It is an easily sighted object in both binoculars and small telescopes using low power. It is illuminated by a very hot 13th magnitude star, said to be roughly 180,000 degrees F and only four times the Earth's diameter. NGC7293 is estimated to be 1.75 light years across.

Aquarius is one of the fainter constellations, with no stars brighter than about 3 1/2 magnitude, . If the sky is fairly dark tonight, step outside and see if you can find it. Remember to give your eyes a few minutes to adjust to the dim light.

NGC7293 the Largest and Nearest Planetary nebula

NGC7293 is called "The Helix Nebula", and is considered to be one of the nearest and largest planetaries. Even though its angular diameter is nearly half that of the Moon, its low surface brightness makes it a rather faint. With a total magnitude of 6.5 it is a relatively easy object for both binoculars and small telescopes using low power and will look like a ghostly circular patch. It is illuminated by very hot 13th magnitude star, said to be roughly 180,000 degrees F and only four times the Earth's diameter. NGC7293 is estimated to be 1.75 light years across. Its distance is still not clearly known, with estimates ranging from 85 all the way out to 590 light years.

In long exposure photographs, a wealth of detail appears. Long sinewy spokes of gas radiate out from the central star and a symmetrical double helix becomes visible.

About 500 planetary nebulae are known, but it is expected that the galaxy might play host to over 10,000.

If the skies are dark and clear tonight, why don't you try and find it for yourself. Use First Light to locate the Helix Nebula in the constellation Aquarius, . Then go outside, remembering to give your eyes a few minutes to adapt to the darkness.

Project : Building a Telescope

Project. . .

supplies : a large sheet of black flexible cardboard, a loupe, a 70 mm convex lens of "2 diopters" power, glue, tape, scissors

In the early 1600s it was discovered that if you were to place two lenses in line with each other and look through them they would magnify things in the distance. This discovery soon reached the ears of one Galileo Galilei who built his own small instrument and aimed it toward the heavens, becoming the first human to witness the moons of Jupiter or the ruddy surface of Mars.

You can become like Galileo and build your own telescope. In principle it is quite simple, but in practice it is a bit complicated because of having to use a Windows based instructional system. All you have to do is to place the loupe about 18 inches from the lens and look through it. You can do that now and if you hold it steady you should be able to see a distant image. What you need to do now is to mount the two lenses together in a tube assembly.

The loupe may be found at any descent camera shop, the lens will be a bit trickier. A local optician may have one, or a science catalog such as Edmund Scientific. In fact you may just want to use a simple magnifying glass. Depending of the glass the dimensions of the tubes will change but it should be easy to find one. Or better yet, Edmund Scientific (1-609-547-8880) has its own simple telescope making kit for kids.

The telescope you will make is called a "refractor", since the light it gathers, it refracts through lenses. The other main kind of telescope is a "reflector" which reflects the light from a large mirror. All of the largest telescopes are various kinds of reflectors since the largest possible lenses that can be made, max out at about 40 inches. Beyond that they sag under their own weight and distort the image. Refractors are considered slightly better quality, but are much more expensive in general than reflectors.

Create two tubes with the thin poster board. One is to hold the loupe and the other the lens. The lens tube should be made the same diameter as the lens which will fit at one end. Now make the second just large enough to slide into the first one snugly. Both should be about 14 inches long.

Mount the lens at the end of the larger tube by simply taping the edges there. Stretch some tape across the edges, touching just enough to hold it, but not enough to obscure much. If you want to be more elaborate you can create out of paper some sophisticated mounting rings that will let you glue the lens inside. Feel free to figure this one out.

The loupe fits in the end of the other tube. You will need to make several cuts an inch long up the length of one end to permit it to be collapsed around the loupe. Wrap tape around it to secure it firmly.

Now take another strip of black paper about 4 inches wide and 8 inches long and wrap around the end of the lens tube to act as a "glare shield". This will recess the lens out of the light by a couple of inches to cuts down the glare.

Place the smaller tube inside the larger one and take a peek. you may have to slide the tubes in or out a bit to get the image into focus. Tonight if it is clear, take it out for a spin and see if you can make out the craters on the Moon of the little "stars" around Jupiter. Galileo's telecope was about 30 power, how much power does yours have?

Project - Why do Stars Twinkle??

Project. . .

supplies : a clear night, some stars, Saturn

"Twinkle twinkle little star. . .", a song we are all familiar with. But why does a star twinkle? Why does it flicker and dance in the dusky twilight skies? It is said that you can tell a star from a planet in the planets don't twinkle. Why?

When seen above the atmosphere the stars are as rock solid as could be, but down at the bottom of the great seething ocean of air the starlight must struggle to get through. The ever present eddies and currents, heat waves and ripples in the atmosphere serve to refract and distort the image causing the glimmering effect. While lovely for the romanticists it is most unwelcome by astronomers, one reason why observatories are placed high on top of mountains where the air is thin and steady. Most of the air turbulence happens below 30,000 feet.

Planets scintillate less because they present a disk rather than a pinpoint of light so chances are the entire disk will not be distorted at the same time. However this will still make the planetary images blurry in telescopes, what is generally called "bad seeing".

Good seeing is aided by calm, still air (no wind storms please), perhaps a hint of moisture, and some say, a slight bit of haze in the atmosphere. Also heat waves generated by nearby objects can have a catastrophic affect on seeing. In other words, don't expect quality images when peering through your telescope over the neighbor's roof.

Tonight Saturn should be out. If it is clear, step outside and drag yourself away from the computer for a few minutes. Study the stars and note their twinkling. How bad is it over your house? How does this compare when they are in the clear? Compare the "seeing" now with warmer days, vs. colder days. Now find Saturn. What does it look like compared to the stars?

Sputnik 1

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\sputnik1.bmp}It was on the date in 1957 that the space age was born. Not with a cry, but with a steady beep-beep-beep of a single solitary radio beacon raining down upon the heads of the world's population from hundreds of miles out in space.

In the early 1950s with the aid of captured German rocket engineers, the Soviet Union was well on their way toward constructing an intercontinental ballistic missile ("ICBM"). The Soviet scientists, always willing to help the march of socialism responded to the call, or so it would seem. . . when the rocket was delivered, it was massive! It was nasty looking, it had an enormous payload capacity, was hideously expensive and was exceptionally difficult to fuel and launch. In other words, it was a poor missile, which you want to be cheap, easy to launch and service, lightweight and small. But it just so happened that it was a great satellite launcher, which is exactly what the Soviet engineers wanted all along. At first, Soviet premier Nikita Kruschev had little of no interest in space flight. But after some persuasion he approved the launching of a small satellite. With only a few months lead time the shiny sphere with four antennas that so symbolized the coming of the future quickly took form. "Sputnik" as it was called, means "fellow traveler". And in early October it was launched into the history books.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\sputnik.bmp}The scientists appealed to Kruschev's ego to get the thing built. "If you launch it" they said, "think of what the world's reaction would be!" But whatever the chubby premier thought was likely very conservative, as no one could ever predict the waves of admiration mixed with sheer terror that swept around the world in the little sphere's wake. "For if the Soviets could put a radio beacon into orbit above our heads, could they not also place a nuclear warhead up there as well?" Kruschev was overjoyed with his new found fame and power. Overnight he became the defacto world puppet master, able to threaten and posture safely out of anybody's range. This first space spectacular was quickly followed by one of even greater glory, the flight of a living creature. Sputnik 2 carried the dog, Laika, and weighed nearly 10 times as much as the first.

In response the United States finally entered the race in January, 1958 with the Explorer 1 spacecraft. It was their second try in only six weeks after having the first satellite suffer a humiliating on pad explosion in front of the world's media.

The early success of Sputnik spelled trouble for the entire Soviet space program as it becaome a house of cards, built upon the concept of space spectaculars. Few missions were repeated, a process needed to refine equipment and techniques. Instead each successive launch had to break a record, never permitting the engineers to get proficient at one skill level before they were expected to go to the next. Due to this the failure rate was very high by the early 1960s. The successes were costly missions that bought great headlines but seldom made no scientific or engineering sense. By the end of the decade, the United States had landed four men on the Moon, sent five successful unmanned lunar landers to the dusty surface, five successful lunar orbiting mapping satellites, spacecraft to Venus and Mars and were in the cusp of starting the Space Shuttle. At the same time the Soviet program was for the most part, in a shambles, directionless, not willing to settle for being the second to the Americans. They pretended that they had never intended to go to the Moon, but finally settled on low Earth orbit space stations. Stations that would eventually earn a good reputation by the late 70s and early 80s as the program gained focus. But it all began with the little beep-beep-beep and an ego-driven bald-headed, communist tyrant.

June

June 1 : Libra, the Scales
June 2 : Project - observing variable stars
June 3 : Canes Venatici, the Hunting Dogs
June 4 : M51, the Whirlpool Galaxy
June 5 : Project - Tracing the Analemma
June 6 : Other Planets?
June 7 : Equuleus, the Little Horse
June 8 : Aristarchus, a Greek ahead of his time
June 9 : Corona Borealis, the Crown
June 10 : Project - sketching the Moon
June 11 : Tropic of Cancer
June 12 : Draco, the Dragon
June 13 : Draco and the Celestial Pole
June 14 : Draco and Binary Stars
June 15 : Eratosthenes, and the Size of the Earth
June 16 : Midnight Sun
June 17 : Project - Shortness of shadows
June 18 : Cosmic Rays
June 19 : Project - Finding the Distance to Alpha Centauri
June 20 : Omega Centauri
June 21 : Summer Begins
June 22 : The Summer Skies
June 23 : Summer Constellations : Cygnus, Hercules, Scorpius
June 24 : Summer Deep-sky objects
June 25 : Cygnus, the Swan
June 26 : Albireo
June 27 : Cygnus X-1
June 28 : Cygnus A and Radio Objects
June 29 : Project - the Expanding Universe
June 30 : The Tunguska Event

Libra, the Scales

Sailing high in the skies in early evening is Libra, the only constellation in the Zodiac the does not represent an animal or person, . Libra means "the scales" and is one of the most ancient constellations having been known by the Sumerians 4000 years ago. Once a part of Scorpius, Libra is now associated with Virgo, the goddess of Justice who holds the scales of justice.

The concept of balance has to do with the fact that in Libra was once located the Vernal Equinox, the point where the Sun passed from the northern skies to the southern, hence a sense of "balance" in nature. Since then the equinox has shifted to Virgo due to subtle motions of the Earth called precession.

Libra is a relatively dim constellation, the brightest star being the third magnitude Zubenelgenubi. This is a widely separated binary star, easily visible in binoculars. The dimmer companion is 5.6 magnitude and orbits about 4600 astronomical units away from the parent.

Delta Librae is an eclipsing variable star. That is, it is a close double star wherein one member is much dimmer than the other,and periodically eclipses the brighter. This creates a "brightness curve" that is readily visible even to the naked eye. The brightest the pair will reach is magnitude 4.8, only to dip down to sixth magnitude once every 2.4 days. This "dip" is only about 6 hours wide, and should it occur during the evening you should be able to clearly observe the star getting dimmer, almost winking out of view only to brighten up once again a few hours later.

Now since you know about Libra, go outside and find it for yourself.

Variable Star Observing

Project. . .

supplies : *binoculars, a couple of late nights.*

Sailing high in the skies in early evening is Libra, the only constellation in the Zodiac which does not represent an animal or person. Libra is also among the most ancient constellations.

Libra is the home of a fast eclipsing binary star, Delta Librae. That means it is a close double star wherein one member is much dimmer than the other, and periodically eclipses the brighter in a fairly rapid orbit. This creates a "brightness curve" that is readily apparent even to the naked eye. The magnitude will vary from 4.8 dipping down to 6 within only 2.4 days, with the minimum period lasting a mere 6 hours. The two stars are separated by only 4.5 million miles and are about 200 light years distant.

Use First Light to center Delta Librae (select Stars etc.../center/stars... and type in "del Lib"). Now go outside and locate with it with your own eyes. Since even at its brightest it is fairly unspectacular you may need binoculars unless you live away from significant skylight and the Moon isn't out. But if it already at "minimum" you will surely need your binoculars. The idea now is to find the time of greatest eclipse and the time of the next, to determine the orbital period of the star. You may have to observe it fairly regularly to catch the curve at its dimmest. Once done you will need to determine the time to the next. You can cheat since above I have already alerted you to the fact that it is 2.4 days from dip to dip, which means that the next one will probably occur during daylight so you will have to skip that and catch the following one. When you collect the times figure out the difference between the first and the third dips and divide by two. Congratulations! You have just joined thousands of amateur astronomers around the world who are members of the "AAVSO", the American Association of Variable Star Observers.

Variable star observing is one of those specialties in amateur astronomy in which hobbyists prove a boon to the professionals. Since time on the large telescopes around the world is precious and costly, it is foolhardy to use them for the more time consuming but necessary tasks of sustained observations; observations which may be done with small telescopes, ideal for amateurs. There is no other hobby in the world in which the participants and the professionals work so closely together.

Canes Venatici, the Hunting Dogs

Currently, there are a total of 88 constellations, however, this has not always been the case. The classic Greek-based constellations number only 48, and these include those of the Zodiac for instance, or Orion, Canis Major, Hercules and so on. . .for the most part mythological beasts and heroes of old. However, in the mid-18th and 19th centuries numbers of over-zealous astronomers and celestial mapmakers introduced "new" constellations in order honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns. While one astronomer would recognize or try and popularize one of his own, a competitor would ignore him and add *his* own. And as such the skies are littered with odds and ends of constellations that once were. Most of these are rather small and uninteresting.

Forty of the new ones have been officially recognized and remain to this day on the charts. Canes Venatici is one of these, created in 1687 by Johannes Hevelius. He also credited with inventing Lacerta, Leo Minor, Lynx, Scutum, Sextans and Vulpecula.

Pictured as a pair of hunting dogs being led by Bootes, this is an exceedingly dim constellation, . The brightest star, Cor Coroli, is only third magnitude, the next brightest at fourth and the rest are fifth magnitude. Cor Coroli literally means "Charles' Heart" and was named to honor King Charles I of England about 1660. A number of stellar mapmakers at the time pictured the star drawn surrounded by a heart, capped with a crown turning it in effect, into a one star constellation.

Canes Venatici is home to a fairly bright globular cluster, M3, visible as a fuzzy ball in binoculars, and M51, one of the most spectacular spiral galaxies in the heavens.

So, if you have really good eyesight and dark skies, go outside and see if you can make out the Hunting Dogs, and check for M3 while you're at it.

Whirlpool Galaxy, M51

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m51.sbm}M51 is better known as the "Whirlpool Galaxy" due to its pronounced spiral form, . This was the first ever to be seen as a spiral in the mid-19th century. While visible in the smallest instruments, its twisted nature will not show in anything less than an eight inch telescope, while a 12 inch is recommended. Its galactic arms loop around the central core three times. With a luminosity of 10 billion suns and a diameter of 100,000 light years, M51 is roughly equivalent to M31, the great Andromeda galaxy and in turn, our own Milky Way.

The Whirlpool is about 35 million light years away and glows at a genial eighth magnitude. In the sky it is seen face on and is about 1/3rd of the visual width of the Moon. It should be visible as a dim fuzzy patch in a pair of binoculars in a very dark sky. If you are lucky in that regard, step outside and see what you can see tonight.

Project - Analemma

Project. . .

supplies : *white drawing surface about 18 inches on a side (plastic or white masonite, or something else that can stand a year in the Sun), nail, string with small weight at the end such as a washer or bolt, crayon or laundry marker.*

Analemma is Greek for "sundial". But nowadays it has little to do with a sundial. Several years ago, an amateur astronomer shot a multiple exposure picture of the Sun. He made an image every 10 days for the entire year of the Sun right at noon, carefully keeping the camera securely locked in the same position each and every day. When developed the film had captured 36 different images of the Sun, which interestingly enough traced out a large figure-8 in the sky. This shape is called the "analemma" and is caused by two main factors. The most prominent is the changing of the seasons. In the winter, the Sun is lower in the sky; in the summer it is higher, giving us longer, warmer days. This gives the vertical movement in the analemma. The back and forth motion has to do with the irregularities in the Earth's orbit around the Sun. Since our orbit is not perfectly round, but varies between 91 and 94 million miles, the Earth's speed will likewise vary. The closer an orbiting object is to the parent the faster it must travel to stay in orbit. So when we are closer to the Sun, its apparent position in the sky will move slightly faster than when it is furthest.

If clocks were set to an exact solar position, they would have be changed constantly, (not a very good idea). As a result the concept of the "mean solar day" was adopted, which averages out the subtle motions of the Sun. This has the effect of shifting its position at noon back and forth slightly, up to 16 1/2 minutes worth of motion in November, for instance. And so, this is what "unfolds" the analemma into the figure-8.

First Light can simulate this for you. Click here and the time is set for the morning on January 1. Now advance the time clicking on the button on the toolbar, each update is 5 day increments. Notice the figure??

You can create your own analemma diagram. No, you don't have to dedicate a camera year round to do it (unless you want to). Practice first for a few days or weeks to get the exposures right and make sure it is protected from the weather and meandering children.

Find a spot that is struck by sunlight every day of the year. If it is protected from the elements, so much the better. Mount the plastic so it will be undisturbed. Above and in the middle, drive the nail partially into the wall and from this hang the string with the weight until the shadow is near the center of the plastic at noon. Using the crayon or grease pencil, mark the spot where the shadow is and date it. Now, on the same day of the week continuing throughout the year, repeat the readings as done above. In about two months you should begin the see the pattern starting to appear. If it's cloudy, simply wait until the first clear day.

If you are in a very dry location, you might want to use paper, but the harsh daily sunlight would likely have a negative effect on the surface. Another substitute for the plastic might be a "white board", a piece of masonite painted white, or a piece of white cloth from an old sheet perhaps, and a laundry marker.

Above all, make sure to adjust for any time changes! If you don't, the shadow will take a sudden jog to the side. So if you started out during the winter, when the clocks are set forward, you will need to take your readings at 11:00 AM instead of noon, until the fall.

Are There any Other Planets Out There?

One of the Holy Grails of astronomy is the discovery of planets orbiting around other stars. Since planets shine only from reflected light and are located so close to their parent stars, visually seeing them is unlikely. Even a monster like Jupiter, if placed around the closest star Alpha Centauri would be invisible. But there are other ways to detect the presence of planets.

In 1991 a group of astronomers announced to the world the discovery of an apparent planet orbiting around a peculiar form of star called a "pulsar". Pulsars are tiny, extremely dense stars on the order of only a few miles in diameter. Believed to be the core of a star gone supernova, pulsars are identified by their beacon like nature. Due to the strong gravitational effects, much of their energy is focussed along the magnetic poles and radiates out much like beam from a search light. And like a search light, the star spins very rapidly (in one known case, 30 times a second!). If the Earth happens to be in the way of the beam's sweep, we see very precise flashes that can be timed to within a trillionth of a second.

The 1991 discovery was quite accidental as there was no intent to look for planets. In fact, pulsars were among the least likely objects to have planets due to their catastrophic beginnings. But this one star unromantically named PSR 1929-10, was varying its rate very slightly. This could only mean one thing, a planet was likely orbiting around it and its gravitational tug was moving the star back and forth in relation to the Earth. Moving away would increase the distance to Earth, increasing the time each pulse would appear to take. Much of the astronomy world scoffed at the concept. Planets around pulsars? Hurrummph!

But another team set out to study some recent pulsars they discovered. And sure enough, one of them likewise showed minute variations in its time. It showed that there were apparently two planets, one about 3 1/2 times the mass of Earth orbiting about at the distance of Mercury with a year of 66 days in length, the other about 2.8 times the Earth's mass, 10 million miles further with year of 98 days. They announced their discovery in January of 1992. As with the previous team, they had not intended to look for planets, but merely stumbled on their discovery quite by accident.

Then a most unusual thing happened. The original team in refining their data discovered that they had in fact made a mistake and their pulsar was not varying its rate! They then publicly announced this to the whole world in front of all of their peers. One of the greatest discoveries in decades was suddenly not to be. But their mistake inspired others to consider the possibility, remote as it was, of pulsar planets. The second team hurridly rechecked their data, but found it to be *correct* after all, and by the most incredible of circumstances really did uncover the Holy Grail of astronomy!

Equuleus, the Little Horse

Equuleus has the distinction of being the second smallest constellation in the sky, . One of the original 48 ancient formations, the Little Horse is formed of primarily of fourth magnitude stars or dimmer.

The only possible legend behind Equuleus is not really fit for a family program (you know those lusty Greek gods and all), so I'll just skip it.

There are no significant deep-sky objects in Equuleus, but the star *delta Equulei* is interesting in that is one of the shortest period double stars which may be visually "split". In order for a double star to be seen its members usually have to be very far apart which means that they orbital periods are very long, on order of hundreds or thousands of years. However this star is the exception as its companion makes an entire circuit in a mere 5.7 years. It is still hard to resolve and requires fairly large telescopes to do the job. As to be expected, it is a fairly close star, only 55 light years away, and the distance between the two is less than that of Jupiter and the Sun.

Aristarchus, a Greek ahead of his time

Aristarchus of Samos (~310 to 230 BC) was the first known astronomer to suggest that the Sun was the center of the solar system, but he is primarily known for his attempts to measure the distance from the Earth to the Moon.

His method was a simple one using basic trigonometry. When the Moon is at first quarter phase it forms a right angle with the Earth and the Sun. So all he needed to do was measure the angle between the Moon and the Sun, which according to him was 87 degrees. This gave him the relative distances between all 3 bodies. Combining this with their assumed sizes (coming from eclipse observations) he concluded that the Moon was about 1/19th the distance between the Sun and the Earth (it is actually 1/400th).

While his approach was correct, his data was incorrect in a science that requires accurate values. His angle of 87 degrees should actually have been 89.83 degrees, well beyond naked eye precision, having the effect of shrinking the Universe substantially.

And regarding his views of the Sun-centered Universe? Well, they just went against the common wisdom of the day and never quite caught on.

Corona Borealis, the Northern Crown

The Northern Crown is a lovely half-circle of stars adjacent to Hercules, .

In seems that one time the daughter of King Minos of Crete, Ariadne, was being vexed by a minotaur. Along comes the prince of Athens, the handsome and powerful Theseus, who is able to kill the minotaur with his bare hands. Ariadne was hooked, and falling madly in love with him, they took to the sea and sailed off to the island of Naxos. It is here that Theseus dumped her. Dionysus, who happened by, took pity on the weeping woman and married her immediately.

The crown is said to have been a wedding gift from Aphrodite. And, after their joyous wedding, Dionysus tossed it into the sky, its jewels changing into stars.

The star T Coronae Borealis is known as the "Blaze Star" for its erratic behavior. It is normally about a tenth magnitude object, but on occasion will flare up to second or third magnitude with no real pattern. Called a "recurrent nova", the star last flared in 1946.

While a tiny constellation, Corona Borealis contains one of the most remarkable clusters of galaxies known. Sometimes called a "super galaxy" over 400 members have been identified all in an area that could be covered by the Moon. At an estimated distance of over one billion light years, the cluster is not visible in amateur telescopes as the members average 16th magnitude.

minotaur :
A dreadful mythological creature that was half man and half bull.

Project - Sketching the Moon

Project. . .

supplies : *your eyes, the Moon, a sketch pad and a pencil.*

Even with the fast film and electronic cameras these days, few things can see more clearly and in more detail than the human eye. That is why visual observations will always be important in astronomy.

This is also why many amateurs still hand draw what they see. If the atmosphere is turbulent distorting the view, the eye can trace out fine detail in between the dancing of the images.

In this project you are to hand draw the Moon. If you have a telescope, so much the better, but it isn't necessary.

First, the Moon must be visible (natch!), the times between first quarter and full will be the best. If it is not available tonight, use First Light to determine the next time and plan for that.

Next, find a comfortable area that will let you sit down and firmly balance your sketch paper. Since the Moon is bright you can get away with having a porch or garden light on to illuminate your masterpiece in progress. Now sketch away. First you might want to use a white piece of paper with a black pencil, but for a switch, go to an art store and get some black paper and use a white pencil.

A finer way of drawing eliminates the pencil altogether and uses powdered graphite and a smudge pencil (a large round paper "dowel" used to draw subtle shadings or smudge existing drawings). An eraser is then used to remove the image at certain points sharpening it up.

If you have a telescope, zoom in on one of the features such as the crater Copernicus and draw that out. If the seeing is good you should be able to make out the small double crater Fauth just to the south.

Tropic of Cancer

The Tropic of Cancer is the line around the Earth that marks the furthest northern latitude in which the Sun appears overhead. This is equal to the Earth's tilt, or about 23 1/2 degrees. This happens usually on or around June 21, and marks the first day of summer, hence the name "summer solstice." The opposite of the Tropic of Cancer is the Tropic of Capricorn and denotes the beginning of winter.

The name comes from the fact that about 2000 years ago, the Sun would be located in the constellation of Cancer for the summer solstice. But thanks to the slow wobbling effect of the Earth's axis called "precession", this point has migrated to Gemini next door and will sneak into Taurus in only a few years.

Draco, the Dragon

According to the Greeks, the dragon was in the employ of Hera, the wife of Zeus. As a wedding gift she had been given a tree which grew golden apples. In order to thwart pilferers, the dragon Ladon was placed around the tree to scare them away.

Then along comes Hercules, who was required to steal some apples from the famous tree so as to atone for his murdering his sons in a fit of madness. He killed the dragon with his arrows poisoned by the blood of Hydra the water snake.

Even though it is one of the largest constellations in the sky, Draco is not very prominent, but it does have a few fine objects for amateurs, . Most notably are the many "binocular" double stars. Using your own binoculars, see if you can locate *nu Draconis*. This is a very wide double star easily visible in small telescopes and binoculars. You can even see it with the program by clicking here : . Now zoom in to a field of view less than three degrees. Both stars seem to be nearly identical in all regards and are separated by about 2300 AU.

Another good double is *39 Draconis* (use "39 Dra" when you're searching for it). It is said to be actually a triple star system, but only two are visible through small instruments. The fifth magnitude member has been called yellow in color, the dimmer seventh magnitude star carries a bluish tint.

Also located in Draco is NGC6543 one of the most prominent planetary nebula in the sky. At low power it looks like a bright star, turning into a "luminous disc" at higher powers. Large telescopes will reveal an strong aqua cast. Its diameter is said to be about 1/3 light year. The central star is a 9.6 magnitude bluish object.

Draco and the Celestial Pole

The brightest star in Draco is "Thuban", a variation on the Arabic word for "The Serpent's Head." In most regards, Thuban is a rather average star, except for one exception: That 4800 years ago it used to be the pole star in the place of Polaris.

Due to a slow drifting or wobble (called "precession") of the Earth traces out a large circle with its axis. No at all unlike a top slowing down, one "wob", takes about 25,600 years to complete. Thus the north star will change over the course of history. Right now Polaris has that high honor, but thousands of years ago it was Thuban. Click here and First Light will transport you back 4800 years and show you this spectacle.

One popular myth surrounding Thuban has to do with the construction of the great pyramid at Gizeh, one of the most puzzling and remarkable architectural works of mankind. Leading up from the burial chamber is a small straight passage aimed heavenwards toward the pole. Much conjecture has been made of this, trying to tie in the ancient position of Thuban to the direction of the shaft. However one runs into trouble in the fact that the star was no where near the needed direction when it was built in about 2600 BC as it would have been pointed toward a blank area of the sky at that time about three degrees to low. Since the Egyptians were avid sky watchers, this could not have been a mistake. One possible theory is that they knew the star would be in the right direction in about 500 years, which might possibly be significant for some as of yet undetermined religious reasons.

At any rate, if it is clear tonight you might want to go out and find Thuban for yourself. And then imagine it being 4500 years in the past, and join the ancients in their wonder of the heavens.

Draco and Binary Stars

Even though it is one of the largest constellations in the sky, Draco the Dragon is not very prominent, but it does have a few fine objects for amateurs. Most notably are the many "binocular" double stars. Using your own binoculars, see if you can locate the following stars. First on the list is *nu Dra*. This is a very wide double star easily visible in small telescopes and binoculars. You can even see it with the program by clicking here, . Both stars seem to be nearly identical in all regards and are separated by about 2300 AU.

Another good double is *39 Draconis* (use "39 Dra" when you're searching for it). It is said to be actually a triple star system, but only two are visible through small instruments. The fifth magnitude member has been called yellow in color, the dimmer seventh magnitude star is a blue.

Mu Draconis is about 100 light years away with a period estimated in the neighborhood of 1000 years. The current separation may be too close for binoculars, but give it a shot. Both members are about fifth magnitude and are the same colors.

Too dim for binoculars but visible in telescopes is *Sigma 2398*, one of the closest double stars to our system. Located a mere 11 light years away it is made up of two dim red dwarf stars. The orbital period is still unknown since more observations must be made, but it has been estimated at anywhere between 346 and 2500 years.

red dwarf :
Small cool stars somewhat smaller than our own Sun.

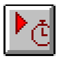
Eratosthenes, and the Size of the Earth

240 years before Christ was born, the Greek mathematician Eratosthenes sought to determine the size of the Earth. Observant guy that he was, he noticed that right at noon, at the beginning of summer, the Sun was exactly overhead when viewed from the town of Syrene, casting no shadows of any sort. However, at a point about 600 miles north at exactly the same time, short shadows were in fact being cast. Using this basic piece of information he was able to calculate the Earth's diameter. The Sun, he measured, was seven degrees off the vertical. Seven degrees was about 1/50th of a circle. Therefore the the distance between the two cities miles must represent about 1/50th of the circumference of the Earth. He determined that the Earth was 29,000 miles in circumference or 9,300 miles in diameter. Sound familiar? The real value is of course 25,000 miles around, or 8,000 miles across. Hmmmm, not bad. Not bad at all.

Eratosthenes was also responsible for establishing many of the basics of geometry. He is likewise credited with creating his "sieve", a method of determining prime numbers and for figuring out the the tilt of the Earth's axis.

Midnight Sun

The Midnight Sun is a phenomenon created due to the Earth's 23 degree tilt. (The same tilt that is also responsible for the seasons). As we head toward summer in the northern hemisphere, the Earth's axis is aimed more and more toward the Sun. We notice this in the way the Sun rises higher in the sky and by the lengthening of the days and the shortening of the nights. As you more north, the nights will eventually shorten to zero, and you'll be in the region of the *Midnight Sun (oooooooohh!)*. This is caused when the northern polar regions are tilted such no matter what time of day it is they are always in sunlight. Think of it this way : were you on the night side of the Earth and headed north, well before you would even hit the pole you would "peek" over the darkened edge and see the Sun.

Click here  to see the Earth right at the start of summer. Note the entire polar area is in sunlight. Advance the clock one hour at a time using
 and see how the planet rotates always keeping that one area in the light. Now, click here
 and you will be tranported to the Earth at about 80 degrees north latitude. It is now *midnight*. Advance the time using
 on the toolbar and notice how the Sun dips close to the horizon, but doesn't quite reach it.

Now set the date to December 21, the start of winter. Notice that since the Earth has traveled one half an orbit around the Sun, the axis is now facing away from the Sun, plummeting the North Pole into 24 hour long nights and the South Pole into eternal daylight.

Project - Shadow Length

Project. . .

supplies : *tape measure, scientific calculator*

As we slide toward the summer months you have probably noticed the days getting longer and the Sun rising higher in the skies. This is all due to the Earth's 23 1/2 degree tilt, the "obliquity", of its axis. During the summer the Earth's North Pole is facing toward the Sun favoring the northern hemisphere, while in the southern hemisphere the nights are short and days grow cold.

In this project, you will demonstrate the tilt by measuring the length of shadows at noon. Find an object such as a flag pole, street lamp or telephone pole nearby. At noon in the next couple of days, take the tape measure and determine the length of the shadow. Now record that and repeat on the beginning of the other three seasons : September 21, December 21 and March 21. Make a note on your calendar as a reminder, you might even want to add your data to the note to avoid having to keep track of the extra pieces of paper.

You will notice that the shadow's length will be the same for spring and fall, but will be very short on in December (unless you are in the southern hemisphere in which it will be opposite).

For extra credit you can also use the shadow information to determine the altitude of the Sun above the horizon. If you know the height of the pole you used, take the shadow length and divide it by the pole's height. This is the "tangent" of the Sun's altitude. Take the "arctan", or sometimes called "atan" on your calculator of this for the angle in degrees. Compare the value with that from the other three readings.

Project - Surveying the Planet Earth

Project. . .

supplies : a small survey team, Kodak disposable cameras, baggies for sample collection, notepad and pens.

This is a fun project for several people to participate in, perhaps a even school class. Imagine that you are travelers from another planet, the planet Elbow for instance. You have been dropped off on the third planet from the Sun to make a short survey. Assume that the Elbownians are looking to expand their markets and want to buy the place out. Or you can set up your own goals. If you want to invade the Earth, look for weaknesses. If you want to simply perform a scientific expedition, look for general data that the Elbownian public might find interesting.

You have half an hour to collect information and samples that will describe the nature of the planet, the kinds of people who live here and cultural habits (such as the strange compulsion to congregate at McDonalds at noon-time). Be prepared to explain the things you see. Collect samples of your surroundings. Would a few rocks be important? Some samples of their food, plants or flowers (don't destroy any public property while doing this). Remember that you are Elbownians and have no knowledge of any Earther habits whatsoever. So be creative in your assessments.

If you want to spend some extra time, take pictures of your survey sites using inexpensive Kodak disposable cameras. Have them processed overnight and make your presentation the next day. Note that if you survey a store, get permission ahead of time to take pictures.

Choose your sites carefully. One person might go to a shopping mall. One might go to a park, another to a nearby school. Or use your own home. But remember, you only have 30 minutes to complete the task. If you want to make things slightly more challenging realize that Elbownians won't be able to speak or understand English, so sample collection might be harder in some cases. Also, it would be unlikely that you would understand how to use Earther's money so it might be tough to collect samples of say, M&Ms. How would you do this without resorting to shoplifting?

Beforehand you might also want to create a "uniform" and your own mission patch (all real space missions must have a patch). So do one for the "Elbownian Survey Expedition".

Other questions to consider : Why do only some Earthers wear their hair really long? Why do they stop their cars at those funny lights? Why do they come in different sizes and colors? Why do some actually *like* eggplant? Why do some like to stick things through their earlobes? What is in those little boxes some like to carry around with them?

Remember, you are looking for things that are important. Since you don't have much time, choose your targets carefully.

(This method was used to train Apollo astronauts for lunar surveys. At first the astronauts cared very little for the science aspects of travelling to the Moon. Since they were primarily pilots, they wanted to fly, and that was it. Finally NASA hired a professional geologist, Jack Schmitt, as an astronaut who helped set up a well defined geology program. So the question was how to get tough fighter pilot types interested in geology in the first place? Schmitt brought on board one of his professors, who on his own time took the men to various interesting sites across the country. In order to appeal to the competitive nature of the astronauts he told them to collect 5 samples in 10 minutes at a particular location, that would best describe that location. Afterwards he would lead them about showing them things that they missed. They would go through these drills time and time again for months, combined with extensive classroom work, but it paid off. With their limited time on the Moon, in many cases only 10 or 20 minutes at each sample location, this training proved to be absolutely invaluable.)

Note to any teachers who might use this project for a class : Please send me a sample the results, I would be delighted to see that the students come up with.

Project - finding the distance to Alpha Centauri

Project. . .

supplies : *scientific calculator*

Alpha Centauri, "Rigel Kentaurus," is the closest star to us next to the Sun, . Being a mere 4.34 light years away, the star is one of the finest visual binaries in the sky, with an orbital period of 80.089 years. The brighter star is very close to our Sun in size, etc. As seen from Alpha Centauri, ours would be a first magnitude star and the Earth far to dim too be visible. This is also the third brightest star in the sky, blazing fourth at magnitude -0.27. Only Sirius and Canopus are more intense. Also, note that Alpha Centauri was the destination of the spacecraft Jupiter II in that "legendary" TV series, "Lost in Space."

Alpha Centauri is deep in the southern skies, and therefore a tough object for northern observers to spot. If your latitude is less than 30 degrees north, you should be able to catch it skirting along the horizon at around 8:30 in the evening.

The distance to Alpha Centauri was first determined in 1839 by using the parallax method. That is, any objects close enough should show a bit of "movement" up against more distance objects, in the same way that telephone poles appear to shift against their background from a moving car, when in reality they are fixed. Since the Earth is the "car" in this case and the star can stand for the telephone pole, it becomes an easy matter to find the distance through the amount of movement.

The astronomer Thomas Henderson discovered that Alpha Centauri's parallax was 0.0002086 degrees by measuring its position at different locations on the Earth's orbit. Using simple trigonometry, *you* can determine just how far away this thing is in miles if all you know are two angles and the length of one side. Letting the Sun, Earth and star form a right triangle, the "baseline" will be from the Sun to the Earth, which is 93 million miles. The angle measured exists between the lines from Alpha Centauri to the Earth and Sun. What you need is the length from the Sun to the star. The formula is :

distance=93,000,000/tangent(0.0002086)

(That is, the distance equals 93,000,000 divided by the tangent of 0.0002086 degrees.)

What is your answer? If it was 25 followed by lots and lots of zeros congratulations!

Omega Centauri

One of the prettiest of all deep-sky objects is the "globular cluster". This is a round, concentrated cluster of old stars which usually collect to form a halo around galaxies. They contain between 100,000 to 10 million stars and are typically 100 light years across. Globulars are wonderful objects in small telescopes due to their near perfect spherical shape and the delicate "diamond dust" nucleus scintillating up against the velvety blackness of space.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\ngc5139.sbm}The greatest of these is Omega Centauri, one of the only deep-sky objects visible to the ancients due to its relatively bright fourth magnitude glow. This is even indicated by its name, "Omega Centauri", which is a type only given to visible stars.

The cluster density at the center is about 25,000 times that of our area of space. Imagine the view! (Although were you on a planet in the core, chances are you would never see beyond the borders, and your universe would be compressed to only a few dozen light years across).The average distance between stars would be only about 1/10 of a light year! Compare that to the closest star, Alpha Centauri at over 4 lights years away.

While it is the brightest, it is not the closest, being about 17,000 light years away. With a real diameter of about 350 light years, it shows a visual diameter about equal to that of the full Moon! Thus this is an excellent binocular object, and is spectacular in small telescopes. Unfortunately it is also in the southern skies, so can only be seen if your latitude is less than 42 degrees. From northern locations right at this time of the year it will be visible around 9:00 at night directly south skirting along the horizon. You must have a complete clear southern horizon, any low hills or buildings will probably get in the way.

Summer

The balmy days of summer are at last upon us. The days are now as long as they will ever be, warm evenings invite the whole family out for barbeques and games of catch. With the flowers in full bloom now you can quite literally smell the seasons changing, and now is the time for shirtsleeve skywatching. No more scraping frost off the binoculars, or fumbling for the focus through a pair of mittens!

June 21 (or 22) marks the time in the year when the Sun is at its highest point along its pathway in the sky. Click here  and you will see it just riding the top of the "ecliptic", the pathway the Sun traces through the sky during the year. Once past this period you will notice the it slowly getting lower in the sky each day until it hits the lowest point around December 22, known as the *Winter Solstice*.

The ecliptic marks the plane of the solar system. It is tilted due to the Earths own 23 1/2 degree tilt, called the "obliquity". And at the start of summer, the Earth's North Pole is "aimed" as far toward the Sun as it will be all year. Using First Light, go into Hover mode around the Earth to see this. Advance the time by 6 months to December, and notice how the North Pole is now tilted away from the Sun and the South Pole is getting all of the extra light (bringing summer to the Aussies for instance).

One might think that this would be the hottest time of the year, since the Sun's rays are at their most direct. But actually there is about a 4 to 6 week delay due to the complex heating and cooling patterns of the Earth. So the hottest time of the year in the north will usually be in August, and the coldest lands in February.

Summer Skies

Like children marching around the block in a parade, we at last say goodbye to our old friends from the winter skies in order to make way for some new ones. Gone is the stately Orion, having finally been lost in the evening twilight by late April, with Sirius and Canis Major following. And gone are Taurus and the Seven Sisters, the Hyades and Rigel. But they will return in a few months, but now take the time to acquaint yourself with Hercules, Cygnus, Lyra and Scorpius.

As the balmy days of summer sweep upon us, it is time for late night games of catch, family barbecues and good times outside. It is also time for shirtsleeve observations. Now you may gaze upon the Milky way in all its glory, with the very center coming into view in by late July. Make way for the Persied meteor shower in August. Take your friends outside and show them the great globular cluster in Hercules, or the intergalactic smoke ring know as the "Ring Nebula" in Lyra as it stares down upon us from its sky-high vantage point.

All through summer you will find, meandering like a river above our heads, the Milky Way, our home galaxy. Nestled in the middle is Cygnus the Swan, sweeping above us, sometimes called the Northern Cross, . Cygnus is said to be Zeus in disguise sneaking home from one of his many affairs.

By mid-July your find Scorpius the mighty scorpion and arch-foe of Orion sweeping along the southern horizon, . Its shape is instantly recognizable, marked with the fiery red star Antares, frequently mistaken for Mars. Notice the deadly stinger. It encircles many of the Milky Way's star clouds with the very heart of the galaxy lying just slightly to the north.

Following right behind in August is Sagittarius the Archer, . Hard to mistake because of its distinctive teapot pattern, always ready to pour a little out. Could this be the headwaters for the Milky Way? Sagittarius llikewise know for its many fine star clusters, looking much like someone had taken a handful of diamond dust and flung it up against the blackest of velvet.

August also brings us the Persieds, at times capable of being the finest meteor shower of the year. Over the past couple of years the hourly rates have been increasing, so it should not be missed this time around. Now the spring constellations are finally disappearing from view, and the first from the fall make a sneak preview in the early morning hours.

At this time the four "gas giants" are all clearly visible. Jupiter will set around midnight, but Saturn, Uranus and Neptune keep watch all night long.

By September, Pegasus the Winged Horse is clearly seen in the early evening, leading the start of the fall parade, . Delphinus the tiny Dolphin reaches its highest point in the sky as well as Microscopium the Microscope and Equuleus the small Horse. The rich star clusters of mid-summer are still available but now may be found in the western skies soon to be lost in the Sun's glare in a matter of weeks.

Summer constellations : Cygnus, Hercules and Scorpius

By mid-summer, as the long lazy days drag on you will notice sailing high in his heavenly perch, Cygnus the Swan, . Also called the northern Cross, Cygnus is considerably more pronounced that its southern counterpart. In mythology, Cygnus is said to actually be Zeus in disguise sneaking home from one of his many affairs. The tail of the swan is marked by Deneb, Arabic for "tail". Deneb is one of the furthest of the bright stars, and one of the most luminous. It forms one corner of the summer Triangle, Vega and and Altair being the other two. Forming the swan's beak is one of the loveliest double stars in the sky, the beautifully named Albireo. Its members glow a green and amber and should be an easy sight for a pair of binoculars. This stellar swan sails nightly right along the Milky Way, where time exposure photographs reveal star clouds of unimaginable beauty.

A somewhat smaller and less conspicuous constellation is Hercules, which is interesting considering how important a character he his to the Greek legends, . Suffering from a fit of madness, this most powerful of men killed his wife and children. In order to atone for his sins he is required to perform 12 deeds or "labors". Among which included stealing a golden apple from a special tree belonging to Hera the wife of Zeus, destroy the multi-headed Hydra, killing a great lion which was tormenting a number of towns, and so on. Usual hero type stuff. As great as he was, the constellation of Hercules has few significant objects. The most notable one is M13, the brightest globular cluster of the northern skies. Containing about 300,000 stars, M13 is one of the finest deep-sky objects known and should be easily visible in a pair of binoculars.

Tracing the southern horizon about the same time Hercules is reaching his highest point is the constellations of Scorpius, the mighty scorpion and nemesis of Orion, . It is said the Scorpius stung Orion the Hunter to death after his boasting that he could destroy any creature sent his way. And even to this day, as Scorpius rises in the east, Orion is seen fleeing, ducking down below in the western horizon in eternal cowardice. Its shape is instantly recognizable, and home of the fiery red star Antares, frequently mistaken for Mars. The stinger of the scorpion is immediately below the very center of our galaxy, and since we are looking straight into the heart of the Milky Way expect a high concentration of star clusters and nebula. With only a pair of binoculars, a dozen different objects easily pop into view.

So if the sky is clear, step outside and become acquainted with these three constellations. Use your binoculars and get to know them well, you'll be glad you did.

Summer deep sky objects

With the coming of summer you will find embarrassment of riches when it comes to deep-sky objects. As we are now peering straight into the very heart of the Milky Way multitudes of star clusters and nebula come to make their presence known while the galaxies of the spring and winter are lost in the twilight.

Perhaps one of the finest objects is M13, the great globular cluster in the constellation of Hercules, . Globulars are round, concentrated collection of old stars, which then collect to form into a halo around galaxies. They contain between 100,000 to 10 million stars and are typically 100 light years across. Globulars are wonderful objects in small telescopes due to their near perfect spherical shape and the delicate "diamond dust" nucleus scintillating up against the velvety blackness of space. Edmond Halley (of "Halley's Comet" fame) discovered M13 in 1714. The cluster is visible to the naked eye as a "fuzzy star", but requires a four inch scope to resolve individual members. With more than 30,000 stars having been photographed, M13 has a total luminosity of more than 300,000 suns and is about 160 light years across.

Immediately to the east of Hercules is the small but bright constellation of Lyra the Harp. Noted for containing the fifth brightest star in the sky named Vega, Lyra also plays host to the ghostly smoke ring on the gods, M57, otherwise called "The Ring Nebula", . The Ring is a planetary nebula formed largely from an expanding shell of material cast off by a star as it ages, M57 being one of the brightest and best of these. Unlike many deep-sky objects that often require just a bit of imagination to make out, this comes close to actually looking like the photographs. A stark, slightly elongated loop of material standing out against the darkness of the sky, the nineth magnitude ring is very easy to find, located right in between the two end stars of the constellation. Use First Light to find show you exactly where it is, then if there is no Moon (or Sun for that matter) in the sky see if you can find it in your binoculars. It should appear as a ghostly gray disk, like a dim planet.

The real treasure trove of objects is in Sagittarius and Scorpius, both well above the horizon by late July, . Look for the distinctive "Teapot" pattern of stars which form the bulk of Sagittarius and mark the location galactic center (due to all of the stars and dust, we cannot actually see the core of the galaxy however). Immediately to the west is the scorpion whose stinger likewise marks a very rich region of the galaxy. Look for M6 and M7 to the north of the stinger, both open clusters, with the latter being a naked eye object. Right along the base of the teapot you'll find M54, M70 and M69, three relatively bright globular clusters. Above and to the right of the Teapot's lid is M20, the Trifid Nebula. Sporting two patches of nebulosity, one red the other blue, the Trifid is one of the finest objects in the sky and very easy to find in binoculars. The same goes for M8, the much larger Lagoon Nebula which challenges the full Moon for size. Next see if you can find M24, which is not a real individual object, but is in fact one of the densest star clouds in the Milky Way. Time exposures show stars so thick that they cease to be individually visible, choosing instead to form a glowing golden swarm, 20,000 light years away.

In Cygnus you will find the delicate Veil Nebula, one of the "largest" deep sky objects in the sky with a width of over 2 1/2 degrees, five times that of the full Moon.

So head on out, grab your binocs, set back and scan the heavens. You will be richly rewarded!

Cygnus, the Swan

By mid-summer, as the long lazy days drag on, you will notice Cygnus the Swan sailing high in his heavenly perch, . Also called the Northern Cross, Cygnus is considerably more pronounced that its southern counterpart. In mythology, Cygnus is said to actually be Zeus in disguise, sneaking home from one of his many affairs. The result of this one producing Helen of Troy.

The tail of the swan is marked by Deneb, Arabic for "tail." Deneb is one of the furthest of the bright stars, and one of the most luminous. It forms one corner of the Summer Triangle, Vega and and Altair being the other two. One of the loveliest double stars in the sky is Albireo, which forms the swan's beak. Its members glowing a green and amber and should be an easy sight for a pair of binoculars. Cygnus sails right along the Milky Way, where time-exposure photographs reveal star clouds of unimaginable beauty.

Near the southern end of the crossbar you will find the delicate Veil Nebula, one of the "largest" deep-sky objects with a width of over 2 1/2 degrees, five times that of the full Moon.

You may also want to look for the North American Nebula, an enormous and vivid cloud of gas and dust, which has striking resemblance to North America and illuminated by Deneb, . Due to its large size (four degrees across, eight times the angular size of the Moon), the nebula must be viewed with low power instruments such as richest field telescopes or binoculars. Using First Light, find the object from your home this evening and see if you can make it out (it will be called "NGC7000" in the database). For a relatively faint patch such as this a dark, moonless sky is going to be necessary. First look for it with the naked eye. If you can't find it that way, try sweeping across the area with your binoculars.

One of the most unusual objects in Cygnus is called Cygnus X-1, and is not even visible in small telescope. This was the first known source of x-ray emmisions from space. X-rays are extremely powerful, and therefore suggest the existence of an extraordinary level of activity. The only real theory that seems to work is that Cygnus X-1 is a black hole, the first ever discovered after decades of speculation.

Coursing up through the center of Cygnus is a blank spot in the sky. Called the Cygnus Rift, this is a dark vein of unilluminated gases blocking out the star clouds behind.

Albireo

Beta Cygni, "Albireo," is regarded as one of the most beautiful double stars in the entire sky, . The primary shines at a mag. 3.09 and its companion is 5.11. The colors have been described as "topaz and sapphire," or "golden and azure." This pair is best observed with a medium size telescope set to only about 30 power. Albireo is estimated to be about 410 light years away. That means that the light you see tonight began its journey during the time that William Shakespeare was penning many of his works, that Galileo first publicly agreed with the Copernican theory that the Earth moves about the Sun, and that the power of Spain started to decline due to a stagnant economy and lack of a middle class.

Double stars are two stars orbiting around each other. In many cases, they may actually contain several stars swirling around in one complex system.

Use tonight to get familiar with Albireo, see if you can make out the distinctive colors. Compare this to one of the other noteworthy doubles in the sky : Mizar and Alcor at the bend of the Big Dipper's handle.

Radio Objects and Cygnus A

Back in the 1930s, astronomy was pretty much content with what could be seen through a telescope. However, the light that the human eye can see is only a tiny part of of the full "electromagnetic" spectrum. Think of the spectrum as a continuous band specified by the wavelength of the radiation. Visible light is a tiny part of this band and the only part our eyes are sensitive to. If you go beyond the red, to lower, longer wavelengths you quickly come to the infrared region, which we can crudely detect as heat. Continuing further you would quickly come to microwaves, extremely short radio waves. Here is where you'll find the start of radio communications including cel-phone transmission or satellite TV. Further yet and there are more traditional radio waves that carry, well, radio signals, television. If you go the other direction you will bump into the ultraviolet. Going out further one comes to x-rays and eventually gamma-rays.

So, think of it this way: Visible light is simply radio waves we can see. That must mean that perhaps astronomical objects might emit radiation at invisible wavelengths, and possibly even at radio frequencies.

The first radio transmissions from space were discovered in 1931, but not really explored until after World War II. One very strong source of radio waves was located somewhere in the constellation of Cygnus, and was detected well before it was visually seen. The second strongest source in the sky, it was finally discovered to be coming from a very faint galaxy about 1/2 billion light years distant. Cygnus A was revealed to be an 18th magnitude object that first appeared to be two galaxies in collision, but was later seen to be merely a single oddly shaped system. The radio emmisions do not come directly from the visible object itself, but instead emanate from two invisble and very large lobes on either side. The originating sources of the energy is from a highly turbulent nucleus within the galaxy which produce highly energized electrons moving at nearly the speed of light. These it would appear are then getting trapped in the galaxies magnetic fields. This in turn, produces "synchrotron radiation", created when charged particles travel through a magnetic field at nearly the speed of light.

Cygnus X-1

Tonight we are going to look at Cygnus the Swan one last time. But the object in question is not even remotely visible in amateur sized telescopes. For we're looking at one of the greatest enigmas of the entire Universe: ***a black hole***.

Black holes were first theorized based on the predictions from Einstein's theory of relativity. He stated that gravity can bend light and distort "space." Therefore, if you have enough gravity, any light generated by an object would get sucked back and the space and physics in the area would be distorted out of recognition. With that kind of power, any passing stars for instance would be ripped apart, torn atom by atom and imprisoned forever. An event such as this would let out an enormous amount of energy, which would be witnessed as x-rays emissions.

The density of a black hole is so great that the Sun would have to be squeezed down a ball of only 1.8 miles in diameter to match it. If the Earth were to become one, it would be the size of a marble! A mere 1/3 of an inch! Imagine that!

Many black holes are believed to be created by the result of supernova explosions. Once the supernova sheds its outer layers and cools down, the center collapses in on itself with no outward pressure to hold it up. What happens afterwards strains the human mind. Theoretically speaking, within a few thousandths of a second, the matter, the star, collides together at a single point called the "singularity" and its density rises to infinity. With such high gravity, time essentially comes to a halt. While inside, the collapse happens in the wink of an eye. To the outside world it may take a billion years. The black hole has now ceased to exist in our Universe and time frame, suspended forever in some interstellar purgatory where only mathematics can survive.

Understandably, black holes cannot be "seen" as such, but neither can the wind. However we can see the effects of the wind. Scientists theorized that it might be possible to spot a black hole if it had a companion star orbiting around it. The companion would in effect act as food source, as its material was torn form its upper layers and literally sucked down into the hole, the great cosmic drain. And in 1962 that came to pass with the discovery of the first known source of X-ray emmisions from space coming from the constellation Cygnus. X-rays are extremely powerful, and therefore suggest the existence of an extraordinary level of activity.

When the source of the Cygnus x-ray emissions were discovered a rather unassuming nineth magnitude star was found. Further study showed it to be a very hot supergiant, about 30 times more massive than the Sun and about 7000 light years away. Its motions suggested that it had a companion and was therefore a double star system. By all accounts the companion should have been huge and clearly detectable but it was not. Other data indicated that whatever it was could not have been more than a minuscule 100 miles in diameter but at the same time containing a mass over *15 times* that of the Sun! A black hole was the only possible answer.

Since then a number of other possible black hole candidates have been studied. Not to mention countless books and grade-B movies generated (most notably the dreadful Disney film "The Black Hole", which nearly sank the company before Michael Eisner came to the rescue).

Project - The Expanding Universe

Project. . .

supplies : a balloon, a felt pen, a vivid imagination

How did the beginning begin? Such is the question that has perplexed cosmologists since day one. This is the question that serves as a bridge between philosophy and science. Over the years two main theories were developed to explain how the Universe became. The "Steady State" theory suggested that things have always been and will always be, that there was no beginning as such, nor no end. The alternate theory became known as "The Big Bang" and is the most widely held belief as new data comes in daily to support it.

In 1929, astronomer Edwin Hubble discovered that the galaxies were all flying away from each other, implying that if you were to go back in time, there would be a point at which they would have all been crowded together. Go back even further and you get a seething single homogeneous mass of material containing the entire Universe! That material would have had to been released in a sudden terrifying explosion. Such nonsense! Yes, but apparently true.

One of the classic illustrations of the expanding Universe is by use of a balloon. Take a deflated balloon and make about 20 dots all around it with the felt pen representing galaxies. Some really tiny dark latex galaxies. Now slowly blow up the balloon and observe what happens to the dots. They are moving apart aren't they? The same thing is happening to the real Universe, the galaxies are all moving apart from each other. The further out the galaxies are the faster they seem to be moving. Now release the Universe and watch it fly around the room. This part simulates absolutely nothing, I hope.

The Tunguska Event

One this date in 1908 the Earth was hit by, well. . ., *something*.

In July of 1994, the collective world watched with amazement as comet Shoemaker-Levi plunged to a fiery death in the atmosphere of Jupiter. This caused much speculation as to what might happen should the Earth itself be struck by an intruder from space.

In 1989 a small asteroid 1000 feet across whizzed by our planet, silently, undetected, passing a mere 400,000 miles away. It was only discovered *after* its closest approach.

And over the recent years a number of other small "Earth crossing" asteroids have been detected, any of which would wreak widespread mass destruction were they to strike anywhere on the planet. Obviously such events have happened in the dim and distant past, and the solar system space is now quite clean, comparatively speaking, than it was millions of years ago. But still there are rocks out there, big ones, and many that remain undetected that could pose a terrible threat if they were to hit.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\tunguska.bmp}So, what does this have to do with 1908? 38 years before there were nuclear weapons, something exploded high up in the air and took nearly 800 square miles of Siberia along with it (an area larger than the area of New York City). The energy released would have about equaled 1000 times that of the Nagasaki atomic bomb. Tens of thousands of trees were flatted to the ground like so many toothpicks and a devastating wildfire ensued. So what happened? Much wild speculation has surrounded the Tunguska incident. Some have suggested that it was a UFO blowing up. Others theorized that it was a minute black hole that hit the Earth or a tiny fragment of antimatter. Still others feel that it may have been a comet due to the lack of any noticeable debris.

What happened depends on exactly what the object is. Consider the possibility that it is an asteroid, one of about a football field in size or smaller. The unfortunate fellow has been gracefully circling the Sun for perhaps a billion years, bothering no one, just minding its own asteroid business. Then one day a large blue planet looms ahead. The object, moving at speeds well in excess of 30,000 miles per hour, slams unmercifully into the atmosphere, and travelling so fast that the atmosphere literally has no time to get out of the way. Instead it compresses up in the front, and in the back, leaves a vacuum. Soon the pressure difference builds up to such force that as the asteroid heads deeper into the thickest parts of the atmosphere it can no longer stay together. At this point it essentially hits a solid "wall" of air, and explodes. This is not unlike performing a belly flop in a swimming pool. Normally water tends to be rather pliable, but if you impact it too fast for it to move out of the way, it can feel like solid concrete (and be as dangerous)!

Meanwhile our asteroid has also built up tremendous kinetic energy. Once it disintegrates that energy has to go somewhere. So it turns into heat, vaporizing the rock and creating a powerful shockwave that strikes the ground.

Were the Tunguska object a comet it would have exploded far too high to create the kind of damage that was recorded. Were it an iron meteorite, it would have been too strong to fall apart and therefore hit the ground, making a crater about the size of the Barranger Meteor Crater in Arizona. But if it was made merely of stone (called a "rocky meteorite"), it would have been weak enough to blow up right at about 7 miles in altitude. Bingo!

Compared to the grand scheme of things, Tunguska was a pretty trivial event. Just compare it to the face of the Moon. In fact, football field sized objects are now proving to be 10 to 15 times more common than previously thought.

In 1965 something exploded over Revelstoke in Canada releasing energy equivalent to the Nagasaki bomb. No debris was found until a couple of fur trappers discovered some sooty patches on the snow two weeks later.

Events such as Revelstoke and to a lessor degree, Tunguska are therefore probably quite common. The uncommon thing is that there were witnesses to both of these. Possibly several Revelstoke class objects strike the Earth each year, but few are ever seen. At other times some may hit the Earth at a very shallow angle and skip back out into space much like a stone on top of water. But whatever the case, the possibility of being hit unexpectedly by an asteroid is a real one. A remote one, but real nonetheless. The mass destruction variety are said to happen nowadays only once every 20,000 years, so I wouldn't sweat it. (Too much, that is.)

Tutorials

These tutorials are meant to give you a generalized understanding of basic astronomy. It is recommended that you explore them in order, as they will take you from the familiar (the Earth and Moon) to the unfamiliar and beyond.

From time to time you will see some icons scattered throughout the text. Clicking on  will command First Light to demonstrate the event for you. While
 will show a short film about the topic.

Earth/Moon

Solar System

Deep-space

Hercules

A somewhat small and rather inconspicuous constellation is Hercules, which is interesting considering how important a character he his to both the Greek legends and those of many of the other constellations, . Suffering from a fit of madness, this most powerful of men killed his wife and children. In order to atone for his sins he was required to perform 12 deeds or "labors". His first task was to destroy a lion which had been rampaging through the countryside for only Hercules' notorious strength could do the deed. Since the lion had be immune to all weapons, the strongman strangled him to death. The lion was placed in the sky and is now known as Leo. A many headed monster was his second target, and as the battle raged a small crab tortured the feet of Hercules. The crab we now know as Cancer, and Hydra is that monster.

Hercules was required to catch two elusive animals for his third and fourth deeds, and the fifth required him to clean out the stables of king Augeias. Following that he had to get rid of a flock of annoying birds, capture a wicked bull which was wreaking havoc in the land (the bull is now called Taurus) and steal cattle from a three-bodied creature that ruled the island, Erytheia. But wait! There's more. Hercules was required to complete 10 deeds originally, and so he did. But for using deceitful tactics in a couple of the labors he had two more added to the sentence. The eleventh required that he steal a golden apple from a special tree belonging to Hera the wife of Zeus, having to kill the dragon, Draco, in the process. And the twelfth saw the Greek venturing down into the depths of the Underworld where he had to capture the three-headed dog Cerberus, one of the most fearful and odious creatures of all.

Hercules died by the deceit of another, when his true love was given a "love potion" that turned out to be poisonous. He died on a funeral pyre, built by his own hands and was turned into the constellation by a grieving father Zeus.

The most notable object in Hercules is M13, the brightest globular cluster of the northern skies, . Containing about 300,000 stars, M13 is one of the most noble deep-sky objects known, and should be easily visible in a pair of binoculars.

M13 and Globular Clusters

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m13.sbm}Perhaps one of the most noble objects in the sky is M13, the great globular cluster in the constellation of Hercules, . Globulars are round, concentrated collection of old stars contain between 100,000 to 10 million stars and are typically 100 light years across. They clusters in turn collect to form into a halo around galaxies. These are wonderful objects in small telescopes due to their near perfect spherical shape and the delicate "diamond dust" nucleus scintillating up against the velvety blackness of space.   Edmond Halley (of "Halley's Comet" fame) discovered M13 in 1714. The cluster is visible to the naked eye as a "fuzzy star", but requires a four inch scope to resolve individual members. With more than 30,000 stars having been photographed, M13 has a total luminosity of more than 300,000 times our Sun and is about 160 light years in diameter.

This is not the best globular however. The greatest of these is Omega Centauri, one of the only deep-sky objects visible to the ancients due to its relatively bright fourth magnitude glow. This is even indicated by its name, "Omega Centauri" which is a type only given to visible stars.

Most clusters are surprisingly uniform in brightness and size, as opposed to galaxies which range all over the map. The main difference is generally the amount of condensation of stars as one gets closer to the core. M13 is about in the middle of the pack

Alpha Herculis

Alpha Herculis is one of the brightest irregular variable stars, with an average period of 90 days and a magnitude range from about fourth on up to 3.1, . This star is also called one of the finest colored double stars visible in small telescopes. The primary has been described as bright orange, and its dimmer fifth magnitude member an "emerald green", or aqua.

The name, "Ras Algethi" comes from Arabic, meaning "the head of the kneeler". In China it was called "The Throne of the Emperor" (a rather pretentious name for a fairly dim star).

Alpha Herculis is one of the largest stars known. In fact its angular diameter has actually been measured (quite a feat, by the way). At 1/12000th of a degree it is 6000 times smaller than the full Moon (the equivalent of seeing a crater less than 4 tenths of a mile across), whereas most stars are too small and remain merely "pinpoints" of light. The real diameter is felt to be about a whopping *400 times* that of our Sun. With a distance of 430 light years, the light you see tonight left about the time that James Watt patented the steam engine, American colonies started their westward expansion and the musical "fad" of string quartets was gaining in popularity.

Double-stars (also called multiple stars, or "binaries") like this one are extremely common in the heavens. They consist of two or more stars in orbit around each other. In some cases as many as six stars have been seen for some systems. It is said that Jupiter is the star that never quite made it. Had it had a little more mass, it might have started a nuclear reaction, turning our solar system into a binary star with planets.

Some multiples are clearly visible from the Earth, while others are so close together that they cannot be split by the largest telescopes. Those are called "spectroscopic binaries" since their light spectrum betrays their true nature. In some cases, they are so close as to be nearly touching while exchanging materials back and forth. When this happens, a supernova may result as one member gains so much stuff from another it becomes unstable and explodes. Then there are "visual doubles", which are not true binary stars but merely stars that share the same line of sight so they look close to each other.

Still another type of binary is the "eclipsing" version, in which the dimmer member eclipses the brighter one, varying the overall brightness as seen from Earth. These are also called eclipsing variables, which usually only have periods of a few days. Algol in Perseus is the most famous of these, dipping down to magnitude 3.4 from 2.1 in only about 10 hours. This means a change of brightness of nearly *3 times*! The main star is over 2 1/2 million miles in diameter and the dimmer companion, over 3 million and are separated by only 6 1/2 million miles. They're so close that their shapes are probably not true globes, but more like egg shape or giant nuclear tear drops.

Most visual binaries have periods over a dozen years or more. Periods of several hundreds of years are fairly typical, making it possible to actually chart their motion from generation to generation.

Use First Light to center Alpha Herculis by using the "stars. etc/center/stars" menu. Select the "HD" button and we'll use the Henry Draper catalog number for this one. Type in "156014" and select OK. Now click on the star to retrieve the basic information about it. Then go outside if it is clear, and see if you can find the "The Throne of the Emperor" by yourself.

Earth, furthest from the Sun

Right around this date, the Earth reaches its furthest point from the Sun. The day varies from July 2 to 6 due to irregularities in the way the year is determined.

This point is called "aphelion", "apo" meaning furthest and "helios" which is Greek for the Sun. (Similarly, the the closest point is "perihelion", for objects in orbit around the Earth you would use, "apogee" and "perigee", and around Jupiter, it would be "apojove" and "perijove", etc.).

It is commonly thought that the seasons change due to the Earth's distance from the Sun. After all, if it gets colder, shouldn't we be getting further from the Sun? Makes sense. But it is also very wrong. On this date well into summer with the Sun blasting away and the days at their longest the Earth is actually at its furthest point in its orbit. Since the Earth's orbit is not perfectly round but an ellipse, its distance varies from 91,396,000 miles (145,103,000 km) at the closest out to 94,511,000 miles (152,102,000 km), or about 3%. True, the distance change no doubt affects the climate slightly but is not nearly as significant as more nearby factors such as the Earth's tilt, cloud cover, etc.

However, note that while the northern hemisphere is basking in the warm glow if the summer Sun, the southern hemispherians are cranking up the furnaces as they truly do enter into their winter. So I guess the old legends are actually true for half of the planet.

Click here  and First Light will show you the solar system while looking down from above. If you look closely you will notice that Earth's orbit really isn't round after all. Where are we on the orbit? How far are we from the Sun?

Project - Ellipses and Orbits

Project. . .

supplies : a piece of wood at least 10 inches on a side, two push pins, a piece of string about 12 inches long, a pencil, sheet of paper and scientific calculator.

An ellipse is one of a set of curves called "conic sections", roughly a flattened circle and the natural mathematical shape an orbit assumes. In this project you will draw an ellipse and compare it to some real orbits.

First take the sheet of paper and draw a line with the ruler, dividing the sheet exactly in two. Now do the same again but make that line go the other direction, so you have two lines which cross each other in the very center.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\ellipse.bmp}Place it on top of the wood and attach with the two push-pins. Place the pins about four inches apart and along the one of the lines, equal distances from the place where the lines cross, about two inches would work.   Make a loop out of the string about 10 inches around and place over the two pins. Take the pencil and place it on the paper inside the boundary that the loop sets up. Trace out the form always holding the string so it is slightly tight. When your pencil makes the entire loop you will see an ellipse.

The line the pins are on is the "major axis", the other is called the "minor axis", and the pins are at the "focus" of the orbit. In real life you would substitute one of the pins for a planet with nothing at the other focus. A circle is actually an ellipse in which the two pins are at the same spot. The shape of an ellipse is summarized in a value called "eccentricity" and may go from zero for a circle out to but not including 1.0. The Earth's orbit has an eccentricity of only .017, while Pluto is the worse, with a value of 0.250. Comets typically have highly eccentric orbits, Halley's is 0.967, which explains why it goes out beyond the orbit of Neptune and then whips back in closer than Venus.

Let's find the eccentricity of your orbit. Measure the width of your ellipse and divide by 2, call this "b". Do the same for the length which should be aligned along the pins, call this "a". Square the two values, that is multiply **a** by itself, and **b** by itself. Take the square of **a** and subtract the square of **b** from it (it should be positive, just as a check). Take the square root of that value and divide by **a**. That is your eccentricity. The formula is :

eccentricity=square_root(a*a-b*b)/a;

Do you have a planet or a comet?

Aquila, the Eagle

According to the Greeks, Aquila, the Eagle, was essentially the pet of Zeus. The bird would bear his thunderbolts during the lengthy battle with the Titans for control of the Universe.

Aquila also served Zeus in other ways, such as locating a new cup bearer for the gods. The bird found young Ganymede, the son of King Tros and regarded as the most beautiful boy in all the world. Bringing him to Mt. Olympus brought such unmeasurable delight to Zeus that Aquila was rewarded with a permanent place in the heavens. And the cup bearer? He later became Aquarius.

Aquila is also associated with another story in which Zeus, taking the form of swan (now the constellation Cygnus) pursued a young goddess. Aiding him in this deception, Aphrodite assumed the shape of an eagle and chased the swan into the arms of his quarry.

The brightest star of Aquila is Altair and is one corner of the Summer Triangle. Vega in Lyra and Deneb in Cygnus are the other two. Using First Light, center Aquila and see if you can find the Triangle without the aid of the constellation names. At magnitude 0.76 it is the 11th brightest in the sky.and also one of the closest, 9 times more luminous than the Sun, and 1 1/2 times the size. Altair has one of the fastest rotations known, making a complete rotation in 6 1/2 days, compared to over 25 days for the Sun. Because of this, it must be rather flattened, with an equatorial diameter about twice the polar diameter.

Click here and First Light will take to you to the Eagle.

Aquila is also smack-dab in the middle of the Milky Way. If it is clear tonight, look high in the eastern skies and you might find the heavenly eagle soaring above the river of stars.

Delphinus, the Dolphin

When it came to sea travel, the Greeks were no strangers, and so they were no doubt very familiar with the playful dolphin.

In Greek mythology the dolphin was a messenger from Poseidon, the god of the sea. After working together to overthrow their father Cronus, the brothers Poseidon and Hades sought to divide the underworld between them. Hades received the land and his brother, the ocean. Poseidon built a beautiful undersea palace which he felt sorely lacking only one thing. So he sent a dolphin in search of a wife. The creature found Amphitrite one of the sea-nymphs, befriended her and brought her back to his master. In a gesture of thanks, Poseidon placed the dolphin in the heavens where he could swim and play for eternity among the stars.

Another story is told that a Greek poet, Arion (who really lived), was saved by a dolphin after jumping off a ship. He sought to get away from some sailors who had decided they wanted his fortune more than his art, and therefore plotted to kill him. After begging for one last chance to sing, he leapt into the sea where a school of dolphins had gathered, and rode one back to Greece.

Delphinus is a fairly dim constellation with the major stars hovering about fourth magnitude, . The two brightest are known by the peculiar names of "Sualocin" and "Rotanev". Most unusual since the majority of the stars have either Greek or Arabic labels. These are clearly neither, but are rather recent arrivals comparatively speaking, having first appeared in the *Palermo Catalogue* of 1814. It would appear that the youthful assistant of astronomer Guiseppe Piazzi became the first person to ever get away with naming some stars after himself. What was his name? Well take "Sualocin" and "Rotanev" and reverse the spelling.

North Celestial Pole in 13000 AD

Perhaps the most familiar single star in the sky is Polaris, the North star. What makes Polaris unique is the fact that the Earth's axis points almost directly toward it. When our planet spins in its daily motion, it only appears to stay fixed while all other objects spin around it.

Polaris has not always been the "North Star". Due to the effects of precession, the Earth wobbles much like a child's top. Each "wob" takes about 25,800 years and has the effect of changing the direction of the poles. The celestial pole will pass closest to Polaris in 2012 and then slowly move away.

During each 25,800 years, or *cycle of precession* the Earth's poles draw out a circle in the sky at a the rate of 0.014 degrees per year. So in a mere 11,000 years from now, the axis will circle around close to Vega in the small but brilliant constellation of Lyra. Locate Lyra high in the sky and look at the blank area just a few degrees north. That is where the new pole will be at 13,000 AD. Likewise, that is where it was at 13,000 BC. Now imagine you are in the future, watching the slow evening's stellar parade. But this time, instead of the stars patiently circling around the end of the little Dipper, they do so with Lyra.

Jupiter, the Giant

Jupiter, the "greatest of all planets", well deserves the title. Known to most ancient man, Jupiter is named after the Roman supreme god and is the largest planet in the solar system. It wheels around the Sun at a distance near a half-billion miles, its domineering presence accentuated by a diameter of nearly 90,000 miles.

Summer is the time for Jupiter in recent years. In the balmy nights of June and July the golden orb rises by mid-afternoon and is visible until well after midnight.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\jupiter1.sbm}Jupiter's trademark features, the cloud bands and giant Red Spot, are easily visible in the smallest telescopes and even in binoculars. In fact Galileo's observations with his tiny telescope of Jupiter and her 4 largest moons would lead to his eventual downfall. For here he had evidence that the Universe was not the neat and tidy system espoused by the Catholic church wherein we were not the center of all. Here he could show that in fact there were things orbiting something other than Earth!

Jupiter can be called "the star that never was." Had it been slightly larger some speculate that it could have become a star of its own turning, the solar system into a "double star" and making streetlights all but unnecessary. At the time of its formation it was likely 10 times its current diameter, equaling that of the Sun. But slowly it cooled and collapsed upon itself. And where originally it radiated about 1/100,000th the energy of the Sun, it now sends out a much more impotent one ten billionth. However that is still more energy it receives, energy which is the driving force behind its spectacular and complicated cloud system. By contrast, the cold planet Uranus is completely dormant having no visible cloud pattern at all.

The Jovian clouds are made up almost exclusively of helium and hydrogen, not unlike the Sun. Unlike the more "traditional" planets, Jupiter has no surface to speak of. If there is a solid core it is probably no larger than the Earth and covered with thousands of miles of "pressure ice", material frozen not by freezing temperatures, but by extreme pressure! On top of that you will likely find a sea of metallic hydrogen supporting a layer of liquid hydrogen. Despite this great mass, Jupiter is no sluggard for it whirls around on its axis at a frightful rate of a mere 10 hours. So fast that it is not a true sphere, but noticeably flattened along the poles. And certainly fast enough to visually see its rotation during a single evening.

The famous Red Spot has been observed for more than 300 years. It comes and goes, changes colors and sizes and has been one of the great enduring mysteries until the Voyager and Pioneer probes pulled back the curtain to reveal its secrets: it is simply a giant storm, similar to a hurricane or cyclone on Earth. Giant it is, for it alone could swallow an entire Earth if it had a chance!

Click here to see a movie of the spot taken from the Voyager probes.

Jupiter has a busy collection of 16 known moons. The largest, Ganymede is 1100 miles {ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\io1.sbm}bigger than our own, and is in fact larger than the planets Mercury and Pluto. The four "Galilean Moons", Io, Callisto, Ganymede and Europa were discovered by Galileo in 1610. They are large and bright enough to be seen with the smallest telescopes and even binoculars, as a jeweled necklace stretched out in a single line.

Click here and First Light will show you Jupiter as it appears at this very moment.

The Great 1991 Solar Eclipse

One of the marvelous coincidences of the Universe is the fact that the Sun is 400 times the distance of the Moon, while the Moon is 1/400 the size of the Sun. As a result the Moon and Sun appear to be *exactly* the same diameter in the sky. Should the Moon ever slide in front of the Sun it will block out just the burning disk, rendering only the very delicate solar atmosphere visible for all to see. Thus we have a total solar-eclipse which is certainly one of the most beautiful and dramatic of all celestial events.

An eclipse is simply when one object passes in front of the other. Some double stars will eclipse each other, planets will eclipse stars behind them. And the Moon can eclipse the Sun.

Total solar eclipses are relatively uncommon. First the strip of "totality", the shadow of the Moon in other words, is quite narrow, measuring at most 170 miles across and traveling up to 2000 miles/hour. Observers in the strip will be graced with totality, while those near the region will see only a partial eclipse with the Moon blocking only a small portion of the Sun.

Secondly, eclipses can only happen during an "eclipse season". The Moon's orbit is tilted about five degrees to that of the Earth. If there was no tilt, we'd see eclipses every month, but instead they occur only when the Moon cuts across the Earth's orbit around the time when it is new (in between the Earth and the Sun). Combine this with the fact that the Moon's own orbit is slowly rotating so the crossover point happens at different times of the month you can see that eclipses are fairly infrequent and come in cycles as the Moon, Sun and Earth must exactly synchronize themselves.

Up to a total of five eclipses (both solar and lunar) can occur in any calendar year (the maximum only happens once every 270 years or so). Most will be partial if the Moon just skirts above or below the orbital intersection. When the Moon is in front of the Earth we have a solar eclipse, when behind it is called a lunar eclipse and you'll see the Moon darken to a ruddy red as it sails into the our shadow.

Since the balance of distance and size is so exact, if the Moon is at its furthest point on the orbit during an eclipse, it will not even completely cover the Sun. Instead, observers will see a "ring of fire", a brilliant thin loop surrounding a blackened void. This is called an annular eclipse. Click here to have First Light show you the great annular eclipse of 1992. On that date, southern Californians were treated to the unbelievable sight of the ring of fire as it slowly drifted down into the ocean exactly at sunset. Advance the time by clicking on the fast-forward button in the toolbar,
.

"Totality" is the time when the Moon entirely covers the solar disk and is based on many factors. The distance of the Moon, the distance of the Sun, time of day, how close the Moon is the to the ecliptic, and what part of the Earth the shadow strikes. When all of these factors are just right an observer can witnessed up to 7 1/2 minutes of totality. At that time the sky suddenly turns black as if someone turned out the lights, dogs begin to wail and roosters crow. A slight chill settles in adding to the spooky effect. Stars and planets will mysteriously pop out, and up high in the sky, is what used to be the Sun, with the delicate pearl white corona creating a ghostly halo around the darkened lunar sphere.

Totality typically lasts two or three minutes. But on this date in the summer of 1991, one of the greatest eclipses of the century took place. All of the various factors fell into place, and those lucky enough not to be clouded out were witnessed up to 6 minutes 58 seconds of totality. The next total solar eclipse that even goes above 6 minutes won't be until 2009. Click here to see the eclipse about 60 minutes before blackout. Now start advancing the time by clicking on the fast-forward button,
. Each update is one minute. I apologize for the fact that the current version of First Light doesn't support the solar-corona, so your computerized eclipses are not nearly as spectacular as the real article.

Eclipses were always regarded with great fear in the ancient world. In some traditions it was felt that a giant monster or insect was devouring the Sun, their giver of life. Only by concerted efforts at chanting, beating drums or performing other noise making activities (turning up their stereos really high?), were they able to frighten this enemy away.

If you have any interest in actually going to see an eclipse, many companies have so-called "eclipse tours" and advertise for the big ones a year in advance in *Astronomy* or *Sky and Telescope* magazines. You might want to combine a family vacation with one of these tours. So, check the eclipse table and start planning now.

eclipse table

date	duration or start	type	location
July 11, 1991	6m 58s	total solar	Pacific, Mexico
June 30, 1992	5m21s	total solar	South Atlantic
May 10, 1994	6m13s	annular solar	Central/East USA
November 3, 1994	4m23s	total solar	South America
April 15, 1995	12:09 UT	partial lunar	Western Pacific
April 29, 1995	6m37s	annular solar	South America
October 24, 1995	2m09s	total solar	India, Iran, Malaysia
April 3/4, 1996	22:21UT	total lunar	Europe, Africa, S. America
April 17,1996	--	partial solar	New Zealand
September 26/27,1996	1:12	total lunar	USA,Europe,Africa, S. America
October 12, 1996	--	partial solar	Europe, Northern Africa
March 9, 1997	2m50s	total solar	Mongolia, Russia
March 23/24, 1997	2:58 UT	partial lunar	North and South America
February 26, 1998	4m09s	total solar	Columbia
July 28, 1999	10:22 UT	partial lunar	Western USA, Pacific
August 11, 1999	2m23s	total solar	Central Europe
January 21, 2000	3:01 UT	total lunar	North, South America, Europe
July 1, 2000	--	partial solar	Southern Chile
July 16, 2000	11:57 UT	total lunar	Pacific, Australia
December 25, 2000	--	partial solar	USA, Canada
January 9, 2001	20:25 UT	total lunar	Asia, Africa, Europe
June 21, 2001	4m56s	total solar	Southern Africa
July 5, 2001	15:05 UT	partial lunar	Australia, East Asia
December 14, 2001	3m53s	annular solar	Pacific, Costa Rica
June 10, 2002	0m23s	annular solar	North Pacific
December 4, 2002	2m04s	total solar	South Africa
November 11, 2003	1m57s	total solar	Antarctica
April 8, 2005	0m42s	total solar	Columbia
March 29, 2006	4m07s	total solar	West Africa, Turkey
August 1, 2008	2m27s	total solar	Siberia
July 22, 2009	6m29s	total solar	India, China
July 11, 2010	5m20	total solar	South Pacific
March 20, 2012	5m46s	annular	Western USA
November 13, 2012	4m20s	total solar	South Pacific
November 3, 2013	1m39s	total solar	Central Africa
March 9, 2016	4m09s	total solar	Indonesia
August 21, 2017	2m40s	total solar	USA (at last!!)
July 2, 2019	4m32s	total solar	Argentina

Project : Observing Jupiter's Moons, part 1

Project. . .

supplies : sketchpad, pencil, binoculars or telescope

In this project you will simply observe the motions of the four largest moons of Jupiter.

On a cool January's eve in 1610, Italian mathematician and physicist, Galileo Galilei took a small slender tube of his and aimed it toward the sky. This "telescope" invented by Hans Lippershey a year earlier in the Netherlands, improved by Galileo, could magnify distant objects by over 30 times. This opened the window wide on the heavens revealing the beauty and mysteries that lay just beyond the reach of the normal human eye. For at this moment all those years ago Galileo made some observations of the planet Jupiter. Nearby he noticed small stars stretching out on either side like jewels on a necklace. Over a period of several nights these "stars" would move back and forth apparently around the massive planet. Observations which convinced him of the correctness of the radical views of Copernicus, the Polish mathematician who stated that the Earth and other planets all revolved around the Sun (the Heliocentric theory) instead of the Earth being the center of the Universe as was commonly thought (the Geocentric theory).

In honor of him, these four moons are now called the "Galilean Moons", and comprise of Ganymede, Io, Callisto and Europa.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\io1.sbm}Thanks to the two Voyager spacecraft we know much more about these pinpoints of light than Galileo could ever have imagined. Voyager returned thousands of pictures and revealed the unimaginably hellish world of Io, the sulfurous orange moon literally turning itself inside out through dozens of active sulfur volcanoes.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\callist1.sbm}Then it swept by Callisto, the third largest moon in the solar system, the second largest around Jupiter. Unlike many of the others, Callisto seems to be completely "dead", with no noticeable geologic activity whatsoever.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\ganymed1.sbm}Ganymede is named for the cup-bearer of the Greek gods and is the largest known moon in the solar system. At a diameter of 3300 miles it is far larger than our own, and is in fact larger than the planets Mercury and Pluto. It is similar to Callisto in materials, but has a much thinner ice crust (60 miles vs. 150) which floats on top of 400 mile thick layer of slushy water. Numerous white craters are visible, the bright material being "fresh" snow or ice splashed up and across the dark dusty surface.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\europa.sbm}Unlike Callisto, Europa has had a violent, active history. With a surface covered by water ice, only three craters have been identified. The more intriguing marks are the dark "linea" crisscrossing the entire surface.

You may be surprised to know that these moons are very easy to see in binoculars. They are bright enough to be naked eye objects if it were not for the blinding glare of the mother planet.

The moons orbit swiftly around Jupiter, and their motion is quite easily seen. Io the closest for instance takes a mere 42 hours to make one loop around the planet. The furthest, Callisto, requires almost 17 days.

If it is clear tonight, use First Light to locate Jupiter and observe it with your binoculars. Make some sketches of the moons and compare to what First Light shows when zoomed in really close to the planet.

Which is Io? Which is Callisto? Come back a couple of hours later and see if you can notice any movement in either of them. Depending on your location on the Earth, and whether you use binoculars or a telescope the image on First Light may be upsidedown from what you really see, so if your drawing doesn't match up try flipping it. And remember, you are doing exactly what Galileo did nearly 400 years ago (except he never had First Light).

<u>This experiment concludes three days from now with part 2.</u>

Click here and First Light will show you Jupiter as it appears at this very moment.

Project : Observing Jupiter's Moons, part 2

Project. . .

supplies : sketchpad, pencil, binoculars or telescope

This project concludes one started several nights ago. If you missed that go back to part one first.

Repeat the observations you made a few nights ago of Jupiter's moons, and make another drawing. How have they moved? Compare to First Light. You may want to observe the moons every night for a week or two to more precisely map out their motions.

The Mighty Moons of Jupiter

On a cool January's eve in 1610, Italian mathematician and physicist, Galileo Galilei took a small slender tube of his and aimed it toward the sky. This "telescope" invented by Hans Lippershey a year earlier in the Netherlands, improved by Galileo, could magnify distant objects by over 30 times. This opened the window wide on the heavens revealing the beauty and mysteries that lay just beyond the reach of the normal human eye, but not the imagination.   For at this moment all those years ago Galileo made some observations of the planet Jupiter. Nearby he noticed small stars stretching out on either side like beans of water on a cobweb in the morning light. Over a period of several nights these "stars" would move back and forth apparently around the massive planet. These observations convinced him of the correctness of the radical views of Copernicus, the Polish mathematician who stated that the Earth and other planets all revolved around the Sun (the Heliocentric theory) instead of the Earth being the center of the Universe as was commonly thought (the Geocentric theory).

In honor of him, these four moons are now called the "Galilean Moons", and comprise of Ganymede, Io, Callisto and Europa.

Thanks to the two Voyager spacecraft we know much more about these pinpoints of light than Galileo could ever have imagined. And since that date in 1610 a total of 16 moons have been discovered turning Jupiter into a mini-solar system. In fact, one of these busy little moons is seen in this film sailing across the face of the Gas Giant, .

Io

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\io1.sbm}If hell were a planet, it would probably be like Io, the moldy orange of the solar system. One of the most visually interesting of any object in the solar system, Io is also the most intriguing and active. No one ever expected a body like Io existed, as it is an object hellbent on redefining planetary textbooks.

Looking like a giant pizza, the bright orange and reddish coloring comes from a 12 mile thick crust of sulfur that floats on a sea of molten sulfur.

Io is named after the lover of Zeus who was turned into a cow by his wife Hera. It is slightly larger than our own Moon, and vastly more interesting.

Io is the closest of the four large moons of Jupiter. Being so close causes the moon to flex back and forth, due to the difference in Jupiter's gravity from front of the moon to the rear. The "tidal" effects, the flexing, in turn generates tremendous amounts of internal heat.

Callisto

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\callist1.sbm}Callisto is the third largest moon in the solar system, the second largest around Jupiter. Unlike many of the others, Callisto seems to be completely "dead" with no noticeable geologic activity whatsoever. This is believed to be due to it having a 150 mile thick crust which tends to make for a very stable and inert body.

Its surface has few distinct features, and instead seems to be covered by hundreds of tiny uniform craters. A single massive crater named "Valhalla" exists and was measured at nearly 1900 miles across.

Europa

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\europa.sbm}Unlike Callisto, Europa has had a violent, active history. With a surface covered by water ice, only three craters have been identified. The more intriguing marks are the dark "linea" crisscrossing the entire surface. The 40 mile wide objects seem to be cracks in the ice but have no noticeable depth. Narrower white ridges are also visible and have no firm explanation.

Europa plays a key role the third book of Arthur Clarke's 2001 trilogy, *2061.*

Ganymede

Named for the cup-bearer of the Greek gods, Ganymede is the largest known moon in the solar system.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\ganymed1.sbm}It is similar to Callisto in materials, but has a much thinner ice crust (60 miles vs. 150) which floats on top of a 400 mile thick layer of slushy water. Numerous white craters are visible, the bright material being "fresh" snow or ice splashed up and across the dark dusty surface.

Click here and First Light will show you Jupiter as it appears at this very moment.

Galactic Halos

After the highly publicized repair of the Hubble Space Telescope, tremendous discoveries were made on nearly a monthly basis. In the spring of 1995, NASA announced that the telescope had helped solve a two-decade old cosmic mystery by showing that mysterious clouds of hydrogen in space may actually be vast halos of gas surrounding galaxies.

"This conclusion runs contrary to the long-standing belief that these clouds occur in intergalactic space," says Ken Lanzetta of the State University of New York at Stony Brook.

The existence of such vast halos, which extend 20 times farther than the diameter of a galaxy, might provide new insights into the evolution of galaxies and the nature of dark matter -- an apparently invisible form of matter that surrounds galaxies.

The possibility of galaxy halos was first proposed in 1969 by John Bahcall and Lyman Spitzer of the Institute for Advanced Study, Princeton, NJ. Previous observations with ground-based telescopes, the International Ultraviolet Explorer satellite, and Hubble have suggested that these clouds might be galaxy halos. However, the latest results are the most definitive finding yet, says Lanzetta, because they come from a large sample of 46 galaxies.

For the past two decades, observations with ground-based telescopes have shown that the light from distant quasars (the bright cores of active galaxies) is affected by intervening gas clouds. These clouds are invisible, but betray their presence by absorbing certain frequencies, or colors, of a quasar's light. When a quasar's light is spread out into a spectrum, the missing wavelengths appear as a complex "thicket" of absorption features. Ground-based observations also showed that the number of these clouds rapidly rises out to greater distances. However, in 1991, independent observations made with Hubble's Faint Object Spectrograph and Goddard High Resolution Spectrograph instruments detected more than a dozen hydrogen clouds within less than a billion light-years of our galaxy. These clouds could not be detected previously because they are only visible in the ultraviolet part of the spectrum, which is inaccessible with ground-based telescopes. This gave astronomers a powerful opportunity to further test the halo theory by imaging nearby galaxies and attempting to match them with nearby clouds.

Several researchers attempted to match galaxies and clouds by first collecting Hubble archival data on six quasars. Next, using telescopes at The National Optical Astronomy Observatory, the Anglo Australian Observatory, the Lick Observatory and the Isaac Newton Telescope, they identified galaxies near the clouds and measured distances. In the majority of cases they found galaxies within about 500,000 light-years of the clouds. The results explain why so many clouds are seen at greater distances: the light from distant quasars was more likely to pass through a galaxy's halo because the halo is so large.

Apollo 11, the Launch

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\a11_crew.bmp}On this day in 1969, three men would begin a journey to be forever remembered as the most audacious and spectacular ever undertaken. For at 9:32 AM from a cape in Florida, Neil Armstrong, Michael Collins and Buzz Aldrin soared into the skies, the history books, and the imaginations of millions as they started their journey as the first men to land on the Moon.

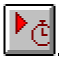
It was the beginning of the end of what started in 1961. President John Kennedy, for reasons that are still debated, committed the entire country to landing a man on the Moon before the end of the decade. A preposterous idea it was, especially considering the fact that the United States had a sum total of 15 minutes of space experience. Some say that he used the Moon program to distract people from the disastrous Bay of Pigs debacle; others claim that it was merely a political stunt, while there are those who credit Kennedy for promoting scientific challenges. Chances are it was a mixture of all three. (Some historians also believe that his unfortunate assassination   only 2 1/2 years later forced his predecessors into continuing the program in honor of his memory). No matter what the reasons, it is hard to doubt the tremendous benefits that resulted : the great technological fallout, the push toward science education and the inspiration of millions of dreamy eyed youth who excelled in the hopes of travelling to the Moon one day themselves.

Right on time the five engines of the mighty Saturn-5 rocket roared to life, , and right on time the world changed forever. In a short 12 minutes the three astronauts making man's third trip to the Moon, the fourth manned Saturn-5 launch and the fifth manned Apollo flight, arrived in orbit around the Earth. A scant two hours later they fired up their engines and headed toward a rendezvous with the Moon.

Phases of the Moon

"What causes the Moon's phases?" is perhaps one of the first astronomical questions a person ever asks. For the Moon is a part of our lives day in a day out. One evening we notice a slender crescent hovering low over the hills at twilight. Two weeks later a full silvery disk, hanging from the sky, rises the moment the Sun slides behind the horizon. Just what is going on here?

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\moonfaze.bmp}Unlike many other space questions this one is among the easiest. For the Moon is simply orbiting around the Earth. One day it is in between us and the Sun, in effect, we are behind it so what we is is the dark side, the side away from the Sun. A week later it is to the side of us, consequently we see half of the illuminated side and a week after that it is behind us so the full sunlit side is revealed.

Click here  and First Light will illustrate this. It starts out with the Moon in New position. Now advance the time one day each click, using the single-step button,
. This view is from the Earth. Let's take a look back at the Earth/Moon system as an extraterrestrial explorer might see it,
. This starts with the Moon at about first-quarter. From Earth, half of the face would be illuminated. Watch it change it's phases depending on your eyepoint. As before, advance the time until it is behind the Earth, hence "full". From the Moon, the Earth would now be "new".

For children, an easy way to show this is to let one child be the Earth, place a bright lamp off in the distance as the Sun. Someone else takes a ball which is now the Moon and circles around the "Earth" imitating its orbit. What happens? You should see the phases of the ball change exactly in the same way the Moon's does.

Jupiter Gets Walloped, Film at 11!

July was a banner month for space and astronomy buffs. Men first stepped on another planet on July 20, the Voyager 2 spacecraft flew by Jupiter on July 9, the first ever soft-landing on Mars happened on another July 20, the first international space mission launched on July 15, and a comet slammed into Jupiter.

When planetary scientists Gene and Carolyn Shoemaker, and David Levy first discovered a fuzzy string of celestial "pearls" it seemed little more than yet another cosmic oddity. But in only a few months as more data was collected it became abundantly clear that this was far from an ordinary comet. For where there would normally be a single nucleus, a single clumping of ice and rock, photos revealed up to 20 fragments of different sizes stretched across nearly 3 million miles of space! While predicated, such an object had never been seen before. Shomaker-Levi 9 as it had become known, had in all likelihood been a fairly average comet up until 1991 when it passed too close to Jupiter. The strong gravity of the gas giant was too much for the weak "cosmic snowball" and easily ripped it apart into pieces no larger than 3 miles across. Later calculations showed that unlike other comets, SL-9 was not in orbit around the Sun, but was actually in orbit *around Jupiter*! But wait, there's more! Not only was it in some bizarre, twisted and sick orbit around the biggest planet, but it was going to collide with Jupiter in July of 1994!! Such events are well told in the histories of various planets and moons by their tortured and scarred faces, but none had ever been seen first hand.

On July 16, 1994, the 25th anniversary of the launch of man's first voyage to land on the Moon, the first comet fragment slammed into Jupiter with an energy release equivalent of *300 MILLION* Hiroshima bombs. Much greater than anyone every dared to predict (some had gone so far to predict that nothing would be seen as the comet quietly sank from view in the massive Jovian clouds). As to be expected the champagne flowed in the observatories and at the Space Telescope Science Institute that night (oh those wild astronomers!). But that was only the first and one of the smaller fragments. Now they knew what to expect and how to calibrate their instruments and observed over the next 6 days as piece after piece met its dramatic demise. Even though the comet struck just slightly around the limb of the planet the explosions were so powerful that their heat welled up through the atmosphere and above Jupiter's edge to be witnessed by hundreds of observatories around the world, not to mention the Hubble Space Telescope and the Galileo Jupiter probe.

Shortly after the first impact as the crash site rotated into view a huge black scar was clearly visible. It was so big and so dark that even amateur astronomer's could make it out in the smallest telescopes. Over the next week Jupiter's southern hemisphere received many more of these scars thought to be cometary material which would be absorbed by the planet and vanish in a few weeks.

The eventful week gave scientists enough data to study for a decade. From this they hope to discover more of the hidden deeper layers of Jupiter's atmosphere from material that was kicked up into view. From the way some of the fragments exploded high above the planet, scientists expect to learn about the "gas dynamics" of the upper Jovian atmosphere. The burning fireball will tell researchers more of the makeup of comets as they study its spectrum.

Thank goodness it was Jupiter that was hit. Had the Earth been the target instead, I would have completely lost my market for this software.

Click here  to see a film of one of the early impacts.

You may also use the flyby feature in First Light to actual place your eyepoint onto one of the SL-9 fragments during the final day of its life. Why don't you create a movie of this?

Apollo 11 enters lunar orbit

On this day in 1969, astronauts Neil Armstrong and Buzz Aldrin stood on the cusp of two eras. This was the last day the Moon would remain a stranger to humanity. The moon had been silvery orb gliding across the skies of a cloudless night. The subject of myths, legends, rumors and sentiment, folk songs and love songs, the mysteries of the Moon would fall in only a few hours. The next day, July 20, the new era would start. It was one that spawned the phrase "if we can put a man on the Moon, why can't we....". Cynics and skeptics alike would drone on for ages to come about "throwing away all that money when we have so many problems here on Earth". But whatever the feelings were, that night Neil and Buzz fell asleep, knowing that the dusty surface of the Moon would be changed forever as the tread of their boots whispered to over four billion years of geologic history.

During their journey they sent back many television broadcasts, in effect bringing the population of the world along for the ride. In this one, , we were given a self-portrait from tens of thousands of miles away. Here Buzz Aldrin gives viewers of tour of the lunar module, Eagle, .

Click here to see what the Moon looked like on that day. And if it is visible tonight, why don't you go out and take a look with your own eyes, and imagine what it must have been like in lunar orbit, wheeling over those ancient plains and rugged scarps back in 1969 AD.

Apollo 11 lands on the Moon

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\footpad.sbm}Every generation has its "where were you when..." question. Most deal with sudden dramatic disasters such as presidential assassinations, earthquakes, war. But on this date in July 1969, anyone who had a radio or TV would be listening not to some breathless reporter describing a scene of devastation, but to the likes of Walter Cronkite, Frank McGee or James Burke being struck speechless, at trying to describe their thoughts as mankind took a small step from one era to the next.

It is estimated that a billion people around the world heard the dramatic lunar descent as Eagle headed toward a rather uninteresting plain in the eastern half of the Moon, . From muddy trenches in Viet Nam to the halls of the Vatican, the world was truly one: one in its ability to be awed and to sit back in breathless wonder at the miracle that had just taken place. At 4:17:32 PM eastern time, after several scares during descent and with fuel so low they were nearly "driving on fumes", Buzz Aldrin coolly stated "contact light". A large blue light had just switched on, indicating the long "probes" dangling from the landing gear were now dragging across the lunar plain. Eagle now dropped the last couple of feet to the Sea of Tranquility and the engine was switched off with only *20 seconds* of fuel left.

Still tingling with excitement, Aldrin prepared for an emergency liftoff if needed (something which came close to happening due to a pressure build up caused by a clogged fuel line), and Armstrong described the unearthly scene before him. The first landing was essentially the final of the test missions. While science would be done, it was still a cautious flight. Two moonwalks from the original plan were cut to one. A geologically interesting sight was bypassed for one of the dullest possible to avoid any unnecessary "challenges". Science in earnest would have to wait until Apollo 12.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\aldrin.sbm}The flight plan stated that the astronauts were supposed to eat and then sleep for four hours before the moonwalk. But do you think you could sleep after landing on the Moon? So the exploration was moved up, and after only four hours on the surface, Armstrong popped open the front door and descended the ladder with a crude black and white TV camera returning the pictures. To this day, his first words are forever immortalized as "That's one small step for man, one giant leap for mankind". A phrase that doesn't seem to make sense when you think about it. Armstrong claims to have said "that's one small step for *a* man..." but the records show otherwise. He finally admitted that maybe he made a mistake and screwed up the most important words uttered by a human in this millennium. Click here and see if you can make out an "a".

Shortly afterwards, Buzz Aldrin descended the ladder as Armstrong took pictures. One seldom mentioned note is that Neil was tasked to pick up "contingency samples" as his first job and to immediately send them up to the cabin before Aldrin came down. This was in the case they needed an emergency liftoff (they would at least have something to show for their troubles). So during the actual moonwalk, Armstrong was instructed many times to get the samples up to Aldrin. But he kept on putting it off. Finally Aldrin stepped down to the surface, and the point was moot. The story is told that Armstrong had learned that there could be a case in which Aldrin might have to leave the Moon without him. This was something he was not supposed to know. Had Aldrin left, he would at least have the samples even if he had to leave Armstrong on the Moon. The day the astronauts were leaving lunar quarantine, Armstrong was approached by General Sam Phillips, the Apollo program director who chastised him for not following direct orders. Armstrong smiled, patted the part of his leg where the samples had been carried in his space suit and said "this was my ticket home".

It is also interesting to note that there exists no high quality photographs of Armstrong on the Moon, only the fuzzy black and white television pictures and some 16mm movie footage. This is because he had the one and only camera on the lunar surface. Aldrin briefly took possession of it, and Armstrong is seen in the shadow of Eagle on a single frame. This was remedied on all later missions when both crewmembers were issued cameras.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\buzzflag.sbm}Man's first moonwalk lasted not much more than two hours. During that time the crew set up an experiments package, took many pictures, collected about 20 pounds of rocks, set up a flag and spoke with President Nixon, . Also a plaque was unveiled on the front leg of the lander, and Armstrong read it off for all of the world to hear, . And as quickly as it had begun, it ended. The next day Eagle lifted itself up above the lunar surface, and the flag that newcasters boasted would "fly" for a million years, quickly toppled over by the blast of the ascent engine.

Three days later, Apollo 11 landed softly in the Pacific Ocean with her precious cargo of the Moon. The very next day geologists huddled around the rock boxes as they were popped open under the tightest of security as the teflon bags were sliced open. Rocks that were worth far more than their weight in diamonds, spilled out looking little more than dusty coal. The blackness of the samples proved that the Moon really is one of the darkest objects in the solar system, reflecting only about 12% of the sunlight it receives.

The rocks would be subjected to hundreds of tests, from searches for organic compounds (none were found), to tests of how plants might grow in lunar soil (quite well thank you) for farming at a future manned lunar base.

Nine more lunar landings were planned for a total of 10. Apollos 19 and 20 were canceled shortly afterwards. A few months later, Apollo 18 was dropped from the list. There was even talk of ending things after Apollo 15, but cooler heads prevailed since most of the hardware had been built for the later flights, so it was better that it be used instead of winding up in a museum. Apollo 12 would land at site where a previous unmanned spacecraft touched down 2 1/2 years earlier. Apollo 13 would never make it to the Moon, having to abort after losing all power and oxygen to the spacecraft while over 100,000 miles from home. Apollo 14 would land where '13 was supposed to at the Fra Mauro region of the Moon, a landing site that ended up being far less interesting than expected. Apollos 15, 16 and 17 would add the delightful lunar rover to their arsenal, permitting them to travel several miles from the spacecraft. Each of the final missions gave the crew 3 moonwalks, each typically lasting 7 hours or more. All told, 12 men walked on the Moon and over 700 pounds of samples were returned. The final Apollo lifted off from the Moon in December of 1972 with astronauts Gene Cernan and Harrison Schmitt on board, ending man's first great phase of exploration which had started with Columbus nearly 500 years before.

Soviet unmanned lunar rovers would study the Moon for another couple of years (equipment that had originally been built to support their manned lunar effort). This effort was abandoned when it became clear that they would not be first. It would be nearly 20 years before the next spacecraft ventured into lunar space, a small Japanese satellite merely testing out some basic technology. No real lunar studies would ever take place until early 1994 when the budget-minded probe Clementine was nudged into lunar orbit on a two month program to map the surface in preparation for possible future lunar studies. When those studies will take place is anybody's guess. But for now, interplanetary travel will have to remain an historical event.

Click here and First Light will show you the Moon as it looked on that wondrous evening so long ago.

First words from the Moon :

Many people assume that besides being the first man to walk on the Moon, Neil Armstrong was the first to actually speak from the lunar surface with his legendary line "the Eagle has landed". However, it was actually Buzz Aldrin, who had the task of relaying the instrument readings back to Houston while Armstrong piloted the spacecraft. After saying "contact light", the Eagle dropped to the lunar surface and Aldrin continued to read off of the instruments and give instructions on what needed to be done. The first words spoken from the surface of another planet were Buzz Aldrin saying "OK, engine stop". And now you know the rest of the story.

Viking 1 Lands on Mars

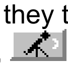
Most historians will tag July 20 as the date man first landed on the Moon. On that Sunday afternoon in 1969 Neil Armstrong and Buzz Aldrin kicked up a bit of ancient dust in the Sea of Tranquility while busily collecting samples, talking to the President and snapping pictures. However July 20 was also the date in 1976 that mankind got his first ever look from the surface of Mars. For that was when the Viking 1 lander settled down on an ancient undulating rust colored plain in Chryse Planitia.

This was not the first time photos have been sent from another planetary surface. One year earlier the Soviet's Venera 9 and 10 Venus landers each transmitted a single image of its hellish surface before they succumbed to its tremendous heat. An astonishing achievement! Whereas the far tamer Mars has proven a tougher target, as they have lost nearly a dozen orbiters and landers over the years due to engines misfierings, windstorms and ground controller errors. Viking was much luckier.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\vik_1st.sbm}Twenty-five seconds after landing and after 10 months in space the oddly shaped lander transmitted its first picture showing a landing pad surrounded by rocks up to several inches across. As further images came in scientists were astonished that the lander survived at all considering the substantial numbers of rocks and boulders surrounding the craft. The first color pictures taken later in the day showed a salmon pink sky hanging above a very red landscape.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\trenches.sbm}Eight days after landing a mechanical arm dug a series of trenches to both study the soil mechanics and to deliver samples of the soil to instruments that would look for possible life (none was detected).

On September 3 the Viking 2 landed in a more northern area of Utopia Planitia. The area looked much like the first landing site, but was considerably rockier. In fact the lander had touched down on a rock and was tilted 8 degrees as a result. Now the 13 Viking experiment teams had their hands full with four spacecraft : Two orbiters and two landers.

{ewr ewdll.dll,ewBitmap,ew_bmps\mars\ars_mons.sbm}While the landers were on the surface, the two orbiters would return 50,000 thousand photographs for nearly four years. From these, Mars was seen going through its seasons. Clouds were observered forming inside craters and the ice-caps grew and shrank as the temperature would change. The first orbiter was deactivated in 1978 due to mechanical problems, but the second churned away until August of 1980 when it finally ran out of fuel. In this film, computers took the Viking orbiter images and made a dramatic sequence showing what future Mars travelers might see were they to fly down through the Valles Marineris and up to Olympus Mons, the solar system's largest volcano, .

Back on the surface the landers likewise witnessed the seasonal changes. Viking 2 even saw frost form on the ground deep into the Martian winter. In 1980 it died possibly due to a battery failure. The first lander continued her mission until its transmitter finally fell silent on November 13, 1982 after over 6 years of tireless labor.

With thanks to Viking, the tremendous variety of the Martian landscape was at last revealed. Channels resulting from water flooding billions of years ago were seen along with complicated networks of runoff channels. Other features revealed meteor impacts apparently in areas that had been muddy, still others showed erosion due to ice flows. Large volcanoes loomed high up, slicing through the thin Martian atmosphere. Valles Marineris, a 2800 mile long canyon up to five miles deep was formed early on when the Martian crust was very active.

The landers discovered that the atmosphere was most carbon dioxide, and detected no life. The soil was made in large part an iron-rich clay (hence the red color, Mars has literally rusted), with 20% silicon, 5% magnesium, 13% iron and some sulfur, chlorine and other stuff. The weather on Mars was studied and showed an average temperatures ranging from -88 degrees C to -12 degrees with mild breezes of only a few miles per hour.

Viking was an astonishing success story, giving scientists literally decades of material to study.

To see the Viking 1's landing site at the time of touchdown, click here . Note how it is right on the terminator, at Martian sunrise.

Copernicus and Tycho

Named after two of the towering figures of astronomy, the lunar craters Copernicus and Tycho are as conspicuous on the Moon as their namesakes are in the history books.

Nikolai Copernicus was the Polish Astronomer who proposed that the Sun was the center of the solar system, and not the Earth. While Tycho Brahe was the Dane who built and managed the greatest pre-telescope observatory.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\lo_coper.sbm}Look at the Moon just slightly after the "first quarter" phase,when a bit more than half of it is illuminated, and right in the center you will see it. The magnificent 57 mile in diameter crater Copernicus. At a depth of nearly 2 1/2 miles the crater is one of the most clearly visible on the near side of the Moon. Its layered edges and mile high central peak make a dramatic sight. Copernicus is believed to be about 800 million years old, relatively young by lunar geology standards. As it on top of a lunar "mare" or "sea" which in turn is younger than the heavily cratered plains, {ewl ewdll.dll,ewBitmap,ew_bmps\moon\copermap.sbm}Copernicus would have to be younger. The big crater was at one time thought to make a perfect Apollo landing sight. A hole two miles deep into the lunar crust would provide for an unparalleled opportunity to get beneath the bedrock. But Copernicus, one of the favorites of all the geologists constantly got knocked back for a "later" mission, probably Apollo 18 or 19. A mission that is now little more than a number of expensive museum exhibits scattered across the country when the last three missions were canceled.

It is felt that come Copernicus material was probably sampled at the Apollo 12 landing site some 300 miles south of the massive crater, so not all was lost.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\tycho.sbm}Tycho on the other hand while desired for a landing was technically out of range due to its far southern position. An Apollo could have reached it, but it would have been a fairly rugged and dangerous mission. Tycho is best known for its enormous "rays", bands of ejected material thrown out across nearly the entire front face of the Moon. Tycho is slightly smaller than Copernicus, 54 miles, and somewhat deeper at three miles. The sharp central peaks rise to well over two miles. The unmanned Surveyor 6 soft-landed a few miles north of the crater in a very rugged hilly region. It is a wonder that it landed safe at all, since the entire crater and the surrounding areas are extremely rough. Even though a landing at Tycho was out, it might be possible to land on one of the rays and sample it that way. And so Apollo 17, the last lunar landing, did just that. On man's second to the last moonwalk, astronauts Gene Cernan and Harrison Schmitt sampled some material that came from the crater and permitted a precise dating of about 110 million years, making. {ewl ewdll.dll,ewBitmap,ew_bmps\moon\tychomap.sbm}Tycho one of the youngest of the major craters. Its creation was so ferocious that in al likelihood some Tycho material probably ended up on Earth as meteorites. And in fact, several meteorites have been discovered in Australia and on the south polar cap, which appear to have come from the Moon (and a couple possibly of Martian origin).

If the moon is nearly full, step outside and see if you can find these two amazing features, and imagine what it must have been like to witness their creation.

Lunar Seas

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\moon_a8.sbm}Originally called "Mare", latin for "sea", the lunar seas are clearly visible as the dark smooth portions of the Moon. The Apollo 11 landed in the Sea of Tranquility for instance. And it is these seas that form the "man in the Moon".

After the initial trashing of the lunar surface by meteors and asteroids about four billion years ago, the Moon slowly began to heat up due to natural radioactive decay. The heating led to the melting of the lunar mantle and the material worked its way to the surface along the fractures left by the more massive impacts. These fractures would ring the large basins scooped out by the impact, causing these low lying areas to flood with the lava about 3 1/2 billion years ago.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\tsiolkov.sbm}It is interesting to note the while the "front" side of the Moon is loaded with the seas, the back side is almost completely devoid of any mare material. Only the crater Tsiolkovskii an another few smaller areas show any darkening at all. The heavy deposits left by the asteroids in the creation of the mare basins created a greater gravity on the front side, hence a greater attraction toward the Earth, which explains why it always keeps the same side pointed toward us all of the time. Many other solar system moons do the same with their parent planets.

If the Moon is out tonight, grab your binoculars and take a look. See what "seas" you can find and imagine an ancient lunar mariner sailing from one dusty shore to another.

Apollo, What Did We Learn?

On this date in 1969, the first men who walked on the Moon returned. Neil Armstrong, Buzz Aldrin and Michael Collins settled down into the blue Pacific Ocean after eight days of what President Nixon called "the greatest event since Creation".

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\ast_fl17.sbm}Some label Apollo a cold-war folly. Others consider it a triumph of man and technology. No matter what you think, 10,000 years from now when the United States is a dim distant memory, the Apollo project will still be talked about, as the time when mankind took its first hesitant steps out of its Earthly cradle.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\antares.sbm}While the initial science took a back seat to the engineering feats early on, and indeed the "test pilot" mentality of the astronauts limited their interest in the possible scientific return, tremendous knowledge was gained. Here was a pristine environment, untouched any living organism since its inception. It was not at all unlike the discovery of King Tut's tomb, which had remained untouched for 2500 years looking pretty much exactly like it did the day the Boy King was laid to rest. Over 830 pounds of samples were returned along with thousands of photographs. Six scientific stations were left on the Moon, some of which operated for five years beyond the end of Apollo. While the program was cut short, enough material was gathered for many years of study. Here we see Scientist astronaut Harrison Schmitt and Gene Cernan on the last of the Apollo missions collecting many of those samples, .

From Apollo, we learned that the Moon's internal structure is much like that of Earth. It has a crust of about 37 miles in depth, sitting on top of a 600 mile more fluid layer, the mantle. The core is probably molten as is the Earth's. The chemical makeup is roughly similar to that of Earth.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\ast_met.sbm}The oldest rocks returned were dated at about 4.5 billion years, indicating that they were created in the later stages of the solar systems creation. The youngest were "only" about 3 billion years in age, indicating that the Moon has been relatively dormant since then. Unfortunately, the origin of the Moon was left unanswered. Some think that it might have formed out of the Earth; others consider that it was created independently.

Whatever Apollo taught us about the Moon, it taught us much more about ourselves, our position in the Universe and that perhaps on occasion we can rise to greatness.

Scorpius, the Scorpion

Scorpius is one of those constellations that really looks like the object it represents, . Its deadly tail is clearly visible and mighty claws spread, ready for any clueless victim who might stroll by. In legend, the Scorpion was the downfall of Orion. The stories of his death vary greatly. According to one, Orion was boasting how he was the greatest of all hunters. However he made the mistake of stating this to Artemis the goddess of hunting and Leto her mother, claiming that he could kill any creature on Earth. Unwilling to tolerate such presumption, the Earth itself split open revealing a giant scorpion which stung Orion to death. Now he is placed opposite in the sky from Scorpius, so as the great scorpion begins to rise in the east, Orion makes his escape by ducking below the western horizon.

Located in Scorpius is Antares, the 16th brightest in the sky, the brilliantly red star is often mistaken for Mars, .

The stinger of the scorpion is immediately below the very center of the galaxy, and since we are looking straight into the heart of the Milky Way, expect a high concentration of star clusters and nebula. With only a pair of binoculars in becomes obvious that Scorpius suffers an embarrassment of riches, as a dozen or more different objects pop into view. Look for M6 and M7 to the north of the stinger, both open clusters, with the latter being a naked eye object. Near the bottom of the stinger is NGC6231 another naked-eye open cluster that resembles a "mini-Pleiades". If it is clear tonight use your own eyes to see for yourself if these things are true.

Antares, the False Mars

Alpha Scorpii, "Antares," is the 15th brightest star in the sky, . The name comes from Greek, and means "Rival of Mars" due to its pronounced reddish color. Antares is one of the largest stars known, estimated to be 700 times the size of our Sun. If placed in the center of the solar system, the star would reach beyond the orbit of Jupiter. Antares is also known for its odd shape. There is reason to believe that the star is not the traditional round shape, but very elongated and possibly even egg-shaped. Its polar diameter is only 63% of its equatorial diameter.

Step outside tonight; you need a break from the computer. See if you can find Antares. What color do you think it is?

Scorpius, Deep-sky Objects

In the mid-evening during the mid-summer, rising to its greatest heights is Scorpio, the scorpion, and enemy to Orion.

Scorpio is one of the richest areas if the sky, providing breathtaking sights for even the most conservative binoculars.

The stinger of the scorpion is immediately below the very center of the galaxy, and since we are looking straight into the heart of the Milky Way expect a high concentration of star clusters and nebula. With only a pair of binoculars in becomes obvious that Scorpius suffers an embarrassment of riches, as a dozen or more different objects pop into view. Look for M6 and M7 to the north of the stinger, both open clusters, with the latter being a naked eye object. M6 contains over 130 stars ranging between sixth and 11th magnitude. The central core of the cluster has been likened to a "butterfly" in shape and is about 20 light years across, .

An easy object even for the naked eye, M7 contains about 80 stars brighter than tenth magnitude, . The cluster is currently placed at about 800 light years distant and is about 270 million years in age.

Near the bottom of the stinger is NGC6231 another naked-eye open cluster that resembles a "mini-Pleiades", .

For telescope observers there is the globular cluster, M62 glowing forth at a magnitude of 8.1, . M62 is a "fine little" cluster, and is one of the most irregular such objects known. Being out in the galactic limb, M62 is dimmed by as much as 2 1/2 magnitudes due to intergalactic dust. The average magnitude of the brighter stars is around 16.

Then there is M4, one of the largest and nearest globulars, . It is a fairly loose collection of stars as compared to most others, and is an easy object even in binoculars, (and has been seen with the naked eye on some occasions). There seems to be a linear collection of stars bisecting the center. In small scopes this would give a "flattened" appearance.

Above Antares is M80, a very compact, but bright globular cluster about 50 light years in diameter, . Due to its density, some scientists have estimated that over its history, there have been nearly 3000 stellar collisions within its boundaries.

If it is clear tonight, use your own eyes to see which of these objects you can find.

The Delta Aquarid Meteor Shower

Meteors are small solid particles in orbit around the Sun and, in many cases, are believed to be debris left by passing comets. For this reason meteors tend to be grouped together in comet-like orbits and have often been linked to known comets. It is when the Earth passes through one of these streams that a meteor shower occurs as the particles burn up in our atmosphere. On any night, the average observer should be able to see about five stray meteors per hour. The typical shower will generally triple that rate while the best ones (such as the Persieds of August and Geminids in December) may have 50 or more.

The distribution of meteors along their orbits is not uniform. Therefore, what may have been a bland shower one year might be a memorable event the next. The most notable one of this sort is the Leonids of November. Usually they produce about 15 or 20 streaks an hour. But early one morning in November 1966, along the western coast of the United States, rates approaching *one-hundred fifty-thousand* per hour were reported. This was a repeat of the famous 1833 shower which prompted one 19th century writer to exclaim : "Never did rain fall much thicker than the meteors fell to the Earth. . .".

Occasionally, meteors the size of small rocks will join the fray, producing what is called a fireball. The bigger ones may be seen to break apart forming two or more fiery trails. The biggest of these might survive their entry and strike the Earth. These meteors are then called meteorites. The 4000 foot wide Barranger Crater in Arizona is a dramatic example of this.

The names of the showers are derived from the area of the sky from which the meteors appear to radiate (hence the name "radiant"), like spokes in a wheel. Therefore the "Lyrids" would appear to be coming from the summer constellation of Lyra.

The best time to observe a shower is after about 2:00 AM local time until dawn. Since the meteors can appear in any part of the sky, a telescope or pair of binoculars would only hinder the viewing by limiting the field of vision.

The date of the shower's peak will fluctuate a day or so, meaning you may want to call up the astronomy department of your local college and find out the best time for observing. A moonless night is also recommended, for a bright Moon will both destroy your night vision and wash out the dimmer meteors.

Tonight is the prime time for the "Delta Aquarid" meteor shower. This shower is considered "the greatest" in total numbers, but since it is stretched out for so many days (actually going from July 15 to August 29), it is far less spectacular than the more condensed ones. Comprised mainly of fainter, slower meteors, the delta Aquarids are actually made up of several different meteor streams. During their peak you should see about 20/hour.

Project - Seeing Sunspots

Project. . .

supplies : pencil and notepad, a piece of cardboard about 10 inches on a side, a white sheet of paper, push pin and a bright, bright sunshiny day. . .

Warning : This experiment will observe the Sun *indirectly*. **DO NOT EVER LOOK DIRECTLY AT THE SUN, OR SEVERE EYE DAMAGE WILL RESULT! AND DON'T SAY I DIDN'T WARN YOU!**

Sunspots are relatively cool areas in the Sun's "photosphere". They can range from 600 miles up to 25,000 miles in size, and in turn form groups which can cover hundreds of millions of square miles. The dark central part of a spot is called the "umbra", while the lighter border is the "penumbra". The umbra is about 2000 degrees cooler than the surrounding photosphere and the penumbra about 500 degrees.

It is felt that sunspots are caused by magnetic fields which lower the energy levels and consequently, cooling them down. Small spots can last a few hours, the largest over a month.

The quantity of spots is governed by the solar-cycle, an 11 year period in which days will pass with few if any spots are visible at the minimum up to the maximum which may have hundreds of times the numbers.

You can see the spots for yourself using a very simple tool called a "pinhole camera". The camera uses a tiny hole as a lens which will focus the light of the Sun onto a distant target. Pinhole cameras are ideal for observing solar-eclipses while protecting the eyes.

Take the piece of cardboard and poke a hole in the center with a push-pin. Now hold the cardboard aimed flat toward the Sun and project the solar image onto a white piece of paper. The disk you see is not the hole, but is in fact the Sun's disk. If it is hard to see you might want to find a spot inside your home in which the Sun shines through a window. you can then block up the window except for a small ray that can be focused with the camera. This should darken the area enough to make a usable image. If you can get the image to be about an inch in diameter you might see some sunspots. If it is near the solar maximum, it should be no problem, otherwise you may have to wait days or weeks to find something.

If the image is still rather dim you can enlarge the hole, but that will make the image go out of focus blurring the smaller spots and making them hard to see.

Once you find a patch, follow its progression over a period of days. See if you can determine the length of time it takes for the Sun to rotate (hint : it's not all that long).

Scutum, the Shield

It is now the end of July, that remarkable month that saw men first walk on the Moon, a comet strike into Jupiter and the first pictures returned from the surface of Mars. The evenings are beginning to grow shorter now, albeit it is about the hottest time of the year. Crickets come out in force and the droning of the nightly insect menagerie adds an aural layer to the never ending oppressive summer heat.

Scutum is one of the modern constellations, created by Johannes Hevelius who also gave us Canes Venatici, Lacerta, Leo Minor, Lynx, Sextans and Vulpecula. This was a time at which zealous astronomers were quick to honor friends or kings with a "new" constellation. Scutum was one such beast, created in 1684 in memory of King John III Sobiesci of Poland it is the only political constellation still being used.

Scutum is the fifth smallest constellation in the sky, . But don't let its size discourage you from taking a look for lies across one of the richest star fields in the heavens. Here lay the famous "Scutum Star Clouds".

Scutum is home to a number of deep-sky objects. M11 is described as an "exceptional" open cluster bordering the northern edge of the star clouds, . Resembling a globular cluster in binoculars M11 turns into a triangular swarm of scintillating stars containing hundreds of members brighter than 14th magnitude. The cluster is about 15 light years in diameter and considered to be about 500 million years old.

About four degrees to the south is M26, a small and condensed open cluster of about 100 total members, 25 of which are easily visible in a small telescope, . M26 is about 14 light years in diameter.

Grab your binoculars and take a tour across Scutum, see if you can make out the clouds. If it is a dark moonless night, it should be of little problem.

Project : Gravity on the Moon

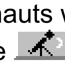
Project. . .

supplies : 3 buckets, a quart measuring cup, water

Gravity is a "property" of matter. That is, everything exerts gravity on everything else. You do. The mouse you're using right now does. The chair you are sitting in does. However, gravity is an extremely weak force, and requires lots of matter for it to become noticeable. The less matter, the less the gravity.

That is why things weigh less on the Moon, about 5/6ths less than on Earth. That is, something that might weigh 60 pounds on Earth would be only 10 on the Moon. Whereas on a large planet such as Jupiter it would weigh over 150 pounds (2 1/2 times!).

Say you have to go to a well and get some water. Take one of the buckets which will carry water from an Earth well. Fill it with one quart. Take the second bucket and fill it with about five liquid ounces of water. This is from your Moon well. Take the third bucket and put 2 1/2 quarts of water from your well on Jupiter. Imagine that the water in each pail is the same amount. Now pick them up one at a time. You can probably tell exactly which planets the buckets belong to. If you cover up the top the difference becomes even more dramatic since you can't predict which is which.

On the Moon, everything will weigh less. That is why the Apollo astronauts were able to carry around so much with relative ease and why they took such long steps. Click here , and see Astronaut Harrison Schmitt bound across the lunar plains on man's last visit to the Moon, Apollo 17, December 1972.

.

The Nearest Stars

Many people when contemplating the stars seem to fail to realize that the Sun itself is a star. The tiny pinpoints of light sparkling in the night are no different then the single big bright one during the day. Therefore the nearest star is, of course, our own Sun.

But what about the ones beyond? Were you to travel at the speed of light toward the constellation Centaurus it would take you about four years before you would meet up with the multiple star system of Alpha Centauri, . At about 4.3 light years away, Alpha Centauri and its neighbor Proxima Centauri are our next closest neighbors in interstellar space. Alpha Centauri, "Rigel Kentaurus," is one of the finest visual binaries in the sky with an orbital period of 80 years. The brighter star is very close to our Sun in size, etc. As seen from Alpha Centauri, our's would be a first magnitude star and the Earth much to dim too be visible. This is also the third brightest star in the sky, blazing fourth at magnitude -0.27. Only Sirius and Canopus are more intense. Also, this was the destination of the spacecraft Jupiter II in that "legendary" TV series, "Lost in Space."

Just a brief skip beyond that is Barnard's Star, the fastest moving star in the sky. Discovered by E. E. Barnard in 1916, "his" star is at once one of the least luminous known and one of the swiftest. It is a "red dwarf", a small cool star with only 1/2500th the power output of the Sun. But what it is really known for is its swift movement through the heavens. Called "proper motion" this is simply a measure of the movement of a star as viewed from Earth. The proper motions of the stars in the Big Dipper for instance will cause the bowl to flatten out in 20 or 30 thousand years.

Tiny Wolf 359 glows dimly from 7.6 light years distant and is the least luminous known. This little star is sends out only 1/63,000th the energy of the our own Sun and shines at a feeble 14th magnitude, about the same brightness as Pluto. Yet mighty Rigel (32 times the distance) blazes away at magnitude zero, with a luminosity of about of *57,000 times* the Sun. Rigel is one of the most luminous known stars in the galaxy and *3 1/2 billion* times brighter than Wolf 359!

At 8.1 light years out is Lalande 21185. Another red dwarf it, rivals Wolf 359 in its feebleness.

Six-tenths of a light year beyond we at last come to Sirius, the brightest star in the sky next the Sun, . Sirius is about 23 times the luminosity of our Sun, over twice the mass and at 1 1/2 million miles across is nearly twice the diameter. It is an unusual double star in that it has a tiny "white dwarf" companion (mag. 8.65) visible only in larger telescopes. The dwarf is only twice the size of Earth, but has as much mass as the Sun. This makes it so dense that a cubic inch would weigh over 2 tons.

One would think that the closest stars would be the brightest, but with the large variety available that is not always the case. In fact of the 100 nearest stars, over 2/3rds are the tiny red ones. If they are anything like Wolf 359, it means that without the aid of powerful telescopes we cannot see most of our nearest neighbors! Yet there are stars hundreds of times more distant that blaze merrily away in the evening sky.

Observing deep into our own local region will give us a good idea of what interstellar space in general looks like. Fainter stars which are visible nearby would be completely lost at greater distances.

Fomalhaut

I've included Fomalhaut in part because of its goofy sounding name which means : the Mouth of the Fish. The fish in this case is its home constellation, Pisces Austrinus, a rather dreary little patch of the sky just south of Aquarius.

Also called "the Solitary One", Fomalhaut is the brightest star (first magnitude) in what is otherwise a very boring piece of celestial landscape, . It is perhaps the least well known of the bright stars, lying in the in the southern skies it just barely skims to the horizon for far northern watchers.

As you gaze upon the Solitary One, take note that you are in fact looking directly up and out of the galaxy. In the summer you can peer inward, toward the very center of our city of stars looming 30,000 light years away. Millions of burning orbs make their presence known as ghostly clouds which reach high into the sky. So it stands to reason that the heavens would be teaming with swarms of brilliant objects. But as you look outward tonight toward Fomalhaut you are looking across the thinnest part of the Milky Way with very little to obscure your view. Thus this is a clear window into intergalactic space which lies a mere 1000 light years distant. A stones throw, cosmologically speaking. After that is nothing, nothing for millions of light years beyond.

Fomalhaut is about twice the size of the Sun and lies only 23 light years away. It should be visible in mid-evening. See if you can find it tonight.

Faster Than Light

One of the most vexing problems in astronomy is the fact that objects beyond our own solar system must be examined from afar. The shear unimaginable distances become a real barrier to the possibility of actually going "there" ourselves for a first hand look. Therefore we can only imagine what the dense companion to Sirius looks like, a sunset as seen from a planet nestled in the core of a globular cluster or what it would be like, immersed among the delicate clouds of Orion's nebula. Going there for real is simply the territory of science fiction. One might saw "piffle! So was flying to the Moon!". But going to the Moon didn't require us to sidestep the laws of physics.

The biggest barrier is that of the speed of light. It would appear that nothing can break the light barrier. So theoretically speaking the nearest star at 4.3 light years distant will take at least 4.3 years to travel to or 8.6 years total. A long time to be cooped up in a spacecraft. So, in other words, we are trapped on the third planet swinging around an average yellow star. Or are we...

Isaac Newton described basic laws of motion and reaction. This "Newtonian" physics works well for most of our needs but delve to the extremes and the laws of Newton fail miserably. By 1915 Albert Einstein had fully developed his famous theory of relativity. The fallout from this was tremendous. It explained any number of experiments that had yielded just slightly strange results and predicted the results of many more to come. In action the theory stated that the speed of light (called "c") was tightly coupled to matter and energy. That matter could never be accelerated beyond c and that as one went faster, mass increased and time slowed. Exactly at c mass would be infinite and time would grind to a halt. For astronauts travelling to nearby stars at say .99 times c their time would be so slow that it would be a relatively brief jaunt around the block. But when they returned they would find an entirely different world having aged hundreds or thousands of years.

But thanks to Einstein, there might be a way a way to beat this barrier using so called "wormholes" (*Deep Space 9* fans take note). Take a black hole, a sphere of matter so dense that light cannot escape. Now spin it up. This seems to have the effect of creating a passageway to another universe by "curving" or "warping" space and time so much that it could fold it back on itself. At the point which space-time touched another part of the Universe one could theoretically take a shortcut across billions of light years. Don't start packing your bags just yet. It would likely take a black hole of about 10,000 times the mass of our Sun or larger to permit safe travel. Smaller black holes would rip your spacecraft apart due to tidal action. The only place to find the supermassive objects would be at galactic cores. In our case, about 30,000 light years away. Next, wormholes are only one way. If you wanted to get back home you would have to travel to another galactic core to do so.

However in the 1980s astronomer Carl Sagan penned his novel "Contact" describing man's first encounter with extraterrestrial intelligence. In it he describes an advanced civilization that had itself discovered the remains of a still more advanced civilization. These ruins were in the form of stable wormholes that existed on their own apart from black hole theory. He had one of the foremost black hole theoreticians in the world, Kip Thorne reexamine Einstein's work to see if this was possible. Thorne discovered that a stable wormhole could in fact be built from a theoretical standpoint using materials denser than that of neutron stars, and that such a hole could be used for two-way travel.

So perhaps there exists a civilization that knows how to do just such a thing, and if so, maybe, just maybe one day a human will be able to see with his or her own eyes what secrets lie on the other side of the galaxy. In the meantime we must be satisfied with the likes of *Babylon 5* or *Star Trek*.

Occultations

One of the most common but overlooked celestial events is that of an occultation. Occultations happen when one object goes in front of another blocking it from view. Perhaps the most obvious kind of occultation is a solar-eclipse. However it is not at all uncommon to see the Moon occult a star or planet. Such events can bring to the viewer on the ground a sense of scale and reality to something such as the Moon.

For instance, astronomy clubs may take timings of the time of disappearance and reappearance of the object. If you are in the right location the object may just barely skim the northern or southern most limb winking in and out of view as it darts behind the lunar peaks, playing a form of celestial hide and seek. In fact it is possible to actually determine the altitudes of the lunar mountains by separating observers by only a few hundreds of feet. One might never see the star blink out, another may see a couple of flashes while a third just in the next block might see numerous flashes. If you have enough people stretched up and down the street it becomes possible to actually create an altitude map of a small portion of the Moon this way. Think about it. . . Here is something a quarter million miles away, but you can make measurements of objects only a few hundred feet across. In effect you are standing in the shadow of the Moon cast by a star.

Such "grazing" occultations are rather rare, but the other variety are not. In 1990 the Moon was in position that had it occult the Pleiades each month. Click here  to recreate one of those events.

In late 1995 and early 1996 we will be able to see it occult the Hyades right nearby. It ought to be a lovely sight.

One of the rarest forms of occultations is when one planet eclipses another. Such and event happened on January 19, 1591 when Mars passed directly in front of Jupiter. Telescopes had not been invented yet so the event was only witnessed as two bright dots melding briefly into one. But, with First Light you can see what this might have really looked like by clicking here . Beautiful isn't it?

How Stars Form

So, with any luck by now you've been immersed in astronomy for some time thanks to First Light. You are probably wondering just where these "star" things come from anyway?

Stars are merely balls of gas, very hot gas usually formed from clouds of hydrogen and helium. Many of these clouds are still with us today and visible as nebula. The Orion Nebula is one of the finest examples of these and has often been called a "stellar nursery" giving birth to many dozens of stars, . Over time, a cloud of gas may collapse on itself due to its own gravity. As it does, tremendous heat is generated, heat which may reach up to *10 million degrees*. This will in turn, increase the pressure pushing out and will at some point stabilize the mass into a hot glowing sphere, a brand spanking new star.

The internal energy comes from nuclear reactions. Atoms are stripped of their electrons and smashed together releasing enormous energy. Given the right conditions, the central core of a star may reach in excess of *100 million degrees*. This will cause the loose atoms to form into heavier and heavier elements such as neon, magnesium and silicon. Some say the the heavier elements that formed the planets came from aging stars that exploded billions of years ago, releasing this material from their cores.

Now go back about five billion years to when our own Sun was first formed. It would have at first been about 50 times its current diameter and 500 times the luminosity. Over a period of about 30 million years the star collapses and settles down for 10 billion years of relative stability. At this time it is on what is called "the main sequence", as it burns through its substantial supply of hydrogen.

As the star begins to exhaust its hydrogen it will once again begin to increase in size and brightness. At this point the surface temperature has dropped to half, and its size has increased up to 100 times that of the Sun. The cooler surface will in turn give the star a distinctive reddish color and the increased surface area will serve to increase its brightness up to a thousand times. Our star is now a "red giant", much like Antares or Arcturus. Finally when all of the hydrogen is burned it will begin to collapse yet again, generating more heat than ever before. This will cause the remaining helium to fuse into carbon atoms releasing even greater amounts of energy. When the helium begins to burn it happens so fast, in a matter of mere days, it is called the "helium flash". Having to adjust to the new energy source the star expands again, becoming so big this time that its outer layers just keep on going out into space forming an ever increasing shell of gas. From Earth we see these shells as planetary nebula such as M57. But the inner core remains, a tiny hot star called a white dwarf. In time it to will cool off and become a cold, solid, dead world called a black dwarf.

In the case of very massive stars, with more material to burn, the expansion and collapsing cycle can happen many more times, each time the core gets hotter leading to more and more periods of fusion. Lighter elements fuse into heavier ones. Eventually it will all stop when the core becomes iron, at which time any further fusion becomes impossible. Now will come a catastrophic collapse of the core, causing the star to disintegrate in one massive explosion called a supernova. And for a few brief days during its glorious dying moments it will outshine even its parent galaxy. The core will finally die, becoming a highly dense neutron star. Or if it is sufficiently massive, a black hole.

August

August 1 : Lyra, the Lyre
August 2 : Vega
August 3 : Project - Viewing the "Ring"
August 4 : Summer Triangle
August 5 : Sagittarius, the Archer
August 6 : Sagittarius - Several Nice Clusters
August 7 : Sagittarius and the Galactic Center
August 8 : Sagittarius - Trifid and Lagoon Nebulas
August 9 : Sagittarius - Star clouds and the Milky Way
August 10 : Project - Brightness of the Sun
August 11 : The Strange Odyssey of Le Gentil
August 12 : Perseids
August 13 : Project - Eclipsing Stars
August 14 : Solar Apex
August 15 : Project - Heliacal Rising
August 16 : Project - The Ultimate Challenge
August 17 : Serpens, the Serpent
August 18 : M5
August 19 : Eye Tests : M16 and M17
August 20 : Project - Planetary Speeds
August 21 : Galileo Studies Ida
August 22 : Altair
August 23 : Voyager 2, Where is it Now?
August 24 : Voyager 2 at Neptune
August 25 : Voyager 2 at Saturn
August 26 : Neptune, the Blue Giant
August 27 : Triton
August 28 : Saturn
August 29 : Rings of Saturn
August 30 : Moons of Saturn
August 31 : Project - Sizes of the Planets

Lyra, the Lyre

By mid-August, the sultry days of summer linger and high overhead on any evening you will find the delightful constellation of Lyra. Lyra is one of the smaller groupings but is extremely prominent thanks the the presence of Vega the fifth brightest star in the sky, .

In Greek mythology, the Lyre belonged to Orpheus. It was the first one ever made, having been invented by Hermes the son of Zeus. Carved out of a tortoise shell, Hermes gave it seven strings, one for each of the Pleiades (the seven sisters).

Orpheus is one of the most tragic of Greek heroes and was considered the most majestic musician of the time. Legends were told of how the magic of his songs could charm at once both the rocks and trees, man and animals. His music was said to have saved Jason and the Argonauts from that of the sea nymphs, drowning out their hypnotic melodies that had lead generations of sailors to sure death.

Many years later, as it is told, the lovely and devoted wife of Orpheus was killed trying to escape the passionate advances of one of the gods. Devastated and despondent, he traveled to the Underworld where he met up with Hades in an attempt to free her from death's hold. Hades, swept up by the beauty of Orpheus' music granted him this bold and astonishing request. Under one condition : Orpheus was not to look back while leading his wife to the overworld. So the journey commenced, but after a while he began to wonder if the person following really was Eurydice, his wife. Nearing the top he could no longer resist and turned around. Yes, she was there, but he broke his promise and could only helplessly stand by and watch as Eurydice was dragged back into the darkness forever.

Alone and lonely, Orpheus went from town to town singing his mournful songs. Many women offered him their hand in marriage only to be rejected. After a while they finally were so angry they gathered around him and began to throw rocks and spears his way. But his music so hypnotized even the weapons, it rendering them harmless against him. However, the wailing of the women eventually grew louder than his singing, drowning it out so that their arms at last were able to accomplished their mission. Orpheus was dead. But his harp was placed in the heavens by Zeus in honor of his great talent where it is seen even unto this day.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m57.sbm}Besides Vega, Lyra also plays home to the Ring Nebula, one of the most enchanting objects visible in either north or south. The Ring might be visible as a small ghostly disk in binoculars, but in a telescope it look much like a great cosmic smoke ring cast off by one of the gods. In reality it is a shell of gas and dust thrown off by an exploding star known as a nova.

Lyra also contains one of the most acclaimed and spectacular multiple star systems. Known as Epsilon Lyrae this grouping is actually made of four stars sometimes called the "double double". The two brighter ones may be easily split in a pair of binoculars, and each of them have a dimmer companion that a small telescope should reveal.

Now put down your mouse and step outside for a breath of fresh air. And providing that it is dark look straight overhead and see if you can make out the harp of Orpheus.

Sagittarius : Several Nice Objects

Tonight see if you can find the Teapot of Sagittarius. For northern observers, it should be dashing across the southern horizon.

With your binoculars you should be able to see a triumvirate of the fine stellar clusters, M23, M24 and M25. The first one contains over 150 stars, . A low power eyepiece is recommended in order to show the entire cluster since it's about the size of a full Moon. Located over 2000 light years away, the light striking your eyes tonight left before Christ walked the dusty roads of Palestine.

M24 is not a true cluster, but is in fact one of the densest and brightest parts of the Milky Way, plainly obvious to the naked eye. When you are gazing into M24 you see what at first appears to be a cloud of dust and gas. But in this case the "dust" is not comprised small particles of material, but is made up of individual stars! Stars not much unlike our own Sun. Several other small star clusters are nestled in the arms of M24, such as NGC6603 or the dark nebula B92 which looks like a doorway into nothingness.

And open cluster M25 contains over 100 stars, of which 50 or so are brighter than 12th magnitude, . This is about the same distance as M23 and stretches 20 light years across.

Besides these "open clusters" you'll find one of the most splendid globular clusters in the sky, M22, about half the size of the full Moon. Shining forth at sixth magnitude it becomes visible to the naked eye on the darkest of nights. Binoculars reveal a ghostly condensation of in orbit around the galactic core. Only three degrees away is the somewhat dimmer M28, another globular which suffers when compared to M22.

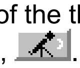
M55 is a "loose" globular cluster, nearer than most at a distance of 20,000 light years. It is an easy target even for the smallest scopes, with stars being resolved in six inch instruments. The majority of M55's stars are relatively dim, below 13th magnitude, giving the impression of gaps between the brighter stars. The cluster is about 80 light-years across and is 100,000 times more luminous than the Sun. With a magnitude of nearly 7, it should likewise be visible as a fuzzy star on binoculars.

Vega

On the seventh night of the seventh moon Vega glows in radiant splendor
On the edge of the River of Stars...

At .04 magnitude, Vega is the fifth brightest star, . As with all bright stars Vega has its share of myth and lore bound to it. The Greeks called it "Cithara," the Babylonians named it "Dilgan" and it was "Allore" to the Arabs. And it is toward this part of the sky that our solar system is rushing (the "Solar Apex"), at 12 miles-per-second. At this rate it will take us 450,000 years to reach the vicinity of Vega. But what a view we will have then!

Vega, about 27 light years away, is 58 times the luminosity of the Sun and 3 1/2 times the diameter.

Vega is the cornerstone of the enchanting constellation of Lyra, the Lyre, and is one of the three stars responsible for the Summer Triangle along with Deneb in Cygnus and Altair in Aquila, .

Most legends of the night descend to us from the Greeks, but most cultures have their own. One the few from China that has survived centers on Vega and Altair, calling them the "Weaving Girl" and the "Herd Boy". The two young lovers so entranced with each other forgot their duties to Heaven. So they were placed in the skies to be forever separated by the "Celestial River" of the Milky Way. However cruel this might appear, they was still a touch of mercy, for once a year on the "seventh night of the seventh moon" a bridge of birds stretches across the river enabling the lovers to join for a few brief hours.

Trifid and Lagoon Nebulas

Tonight, look for the distinctive "Teapot of Sagittarius", which should be hovering above the southern horizon for observers in the northern hemisphere. As with previous discussions like this, grab your binoculars and prepare for some observing.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m20.sbm}First look right above the lid of the Teapot and about five degrees to the right. There you will find M20, the Trifid Nebula, . A nebula is simply a cloud of interstellar dust and gas, the raw materials that stars are made of. If there are already stars embedded in the cloud it will glow with an eerie ghostlike appearance forming such vistas as the Great Orion Nebula, or this one, the Trifid. Sporting two patches of nebulosity, one red the other blue, this is one of the finest objects in the sky and very easy to find in binoculars. One generally needs an 8 or 10 inch instrument (that is the telescope's mirror must be about 8 or 10 inches across so as to gathering enough light) before the "trifid" or "three part" structure is visible. Color photographs show the main part M20 to be a strong reddish color with a soft blue patch of nebulosity on the side. It is a fascinating contrast.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m8.sbm}Better known as the "Lagoon Nebula", M8 is one of the best diffuse nebula for naked eye observers, surrounding the small young star cluster NGC6530. The nebula is known for having a number small dark "globules" of material believed to be stars at the very beginning of formation, sometimes called "protostars". Overall M8 is over 100 light years across, with its central regions a more modest 50 light years in diameter. It is also one of the largest in the sky, challenging the full Moon for size.

Sagittarius and the Galactic Center

Tonight see if you can find the Teapot of Sagittarius, . For northern observers, it should be dashing across the southern horizon. Observe the lower western corner, which lies immediately above the stinger of Scorpio, the scorpion. You are now looking straight toward the heart of the galaxy, the *galactic center*. The actual center is not visible to us due to the unimaginable amount of dust and stars blocking the way, but we do know something about it thanks to both radio and infrared radiation that is not so easily blocked.

Our Galaxy is about 100,000 light years across, fairly typical in other words. The Sun is located in one of the spiral arms about 30,000 light years from the center which it orbits every 20 million years. During the summer and winter our galaxy spreads its faint ghostly bands of light above our heads complete with hundreds of riddles and thousands of mysteries.

One of the most intense "radio objects" in the sky is called Sagittarius A, which marks a spot felt to be within a mere 3 light years of the galaxy's nucleus (closer than the Sun is from the next nearest star). Called a celestial "dustbin" the central region is likely an powerful maelstrom of material swirling round and round only to surrender to a tiny black hole probably far smaller than our own Earth. The radiation is then generated as stars and entire solar systems are torn apart atom by atom as they vanish in to oblivion.

Much has yet to be learned about this region and presently it forms one area of intensive study among the cosmologists. In fact we will probably learn more from observing the centers of *other* galaxies using the Hubble Space Telescope where we can actually see closer into the hub of activity because of more favorable viewing angles.

The Milky Way

Imagine a giant drain with water swirling round and round. Now imagine that water to be made of a billion stars instead. Place it in the dark void of space, sprinkle some dust and add a pinch of mystery and you have a spiral galaxy. Spirals are perhaps the most dramatic of all objects in the sky. There are literally millions of these vast cities of stars sprinkled across the heavens. One such galaxy, average in most every way has an average yellow star patiently orbiting about 30,000 light years from the center. Peer closer, and you will see a very interesting blue planet, third from the star spinning in its endless cycle year after year after year for billions of years to date. And the inhabitants of this sphere? Well, they call it. . . Earth.

From inside one of these swirling masses of stars we can only gaze outward. And stretched across the sky is a ghostly scrim made up of untold millions of stars, the Milky Way. A river of blazing nuclear furnaces ranging all the way from a few miles across, on up to hundreds of millions of miles in diameter. From a searing blue-white heat to dull cool red. These are our neighbors.

The Milky Way is most prominent during the summer with its most visible regions delicately ornamenting the constellations of Sagittarius and Scorpio. City dwellers rarely see the sight, but out in the country away from the blinding mercury vapor streetlamps, away from stuttering red neon signs the sky is finally seen as ancient man saw it. A vast fabric of the blackest black strung from horizon to horizon, heavy laden with star dust. First time viewers of the Milky Way frequently mistake it for clouds. Clouds? In a matter of speaking, but clouds not of water particles or dust or lint, but of entire stars of which the Sun is a member, a single dust particle.

Looking toward Sagittarius on a balmy summer evening and you are looking into the very center of the galaxy. What goes on there is still on the very edge of the science and may never be known. Most likely there is a tiny black hole smaller than the Earth acting as a cosmic drain. It will shred star after star and solar system after solar system apart, their death throes visible only as subtle, brief bursts of radio waves rising up against an already noisy background.

The Milky Way is not a remarkable place, but some of its inhabitants are quiet remarkable. And who knows, perhaps in some unidentified galaxy, hundreds of millions of light years away, there might be another blue planet with another being, looking out and wondering what lies beyond his darkness.

Project : The Brightness of the Sun

Project. . .

supplies : *a dark night, several styrofoam balls about an inch or two in diameter (available at craft supply stores), 8 inch skewers, one for each ball, a 100 watt lamp (desklamps should work OK), long tape measure.*

As it may be expected, the intensity of the Sunlight on a particular planet depends on its distance. In the experiment you will get a feel for just how it might look like to be standing on Mercury under a hot (and I mean HOT) noonday Sun, vs. say, Pluto.

Take the desklamp and place it out in the driveway at night and turn it on, this is your Sun. Make sure you have a lot of room for your solar system to move away from the light. Take one styrofoam ball, write "M" for Mercury on its side, and place it on one of the skewers. Put it one foot away from the lamp and stick it into the ground if you can. If there is no ground, but only asphalt or concrete make a little stand out of the clay by rolling a small ball of about an inch in diameter and sticking it to the ground to hold the skewer.

Now at about three feet away place another ball and write "E" on the side for Earth. Notice the brightness of the Mercury as compared to the "Earth". At 4.5 feet place another ball into the ground. This is Mars. We're now going to skip the rest of the planets and head straight for Pluto. Take "Pluto" go 120 feet away and place it in the ground the same way as before, and make sure that it's a clear shot to the lamp.

If you want to fill in the rest of the planets, place Venus at two feet distant, Jupiter at 15 1/2, Saturn at 28 1/2, Uranus, 57 1/2 and Neptune gets stuck into the ground a full 90 feet from the lamp.

Now feel free to walk back and fourth through the solar system and compare the illumination on all of the planets. Even out at Pluto as distant as the Sun is, there should still be plenty of light. In fact the real sunlight at Pluto will still be 400 times the brightness of that from a full Moon as seen on Earth.

The Strange Odyssey of Le Gentil

As with all fields of endeavors, astronomy has its share of fascinating stories. Few elicit more "awwww"s than the that of one Guillaume Le Gentil, a nearly heroic figure in his efforts to observe a Venusian transit. A transit occurs when a planet crosses the face of the Sun. A solar eclipse on one painfully obvious example, but either Venus or Mercury can do the same however much less dramatically as their tiny forms creep across the solar disk.

The two transits were going to take place in 1761 and 1769. Due to the peculiar times, Le Gentil had to travel far from his homeland in France to catch this rare event, not unlike solar eclipses. His first destination was to have been a French colony in India. However the British captured it forcing the hapless astronomer to observe the show from from a rocking ship in the middle of the Indian ocean. Observations which were completely useless. While "on the road" he decided to hang around for the second performance which was not to take place for a full eight years. After taking an extended stay in the Phillipines, Le Gentil returned to India in 1768 since the colony had been recaptured by the French. The weather was perfect right up to the transit, but it clouded over only to clear immediately afterwards. Shortly afterwards he took ill and was bedridden for nine months.

Not to be outdone, in 1770, Le Gentil was able to book passage on a French cargo ship only to wind up back in the Indian ocean after a rather nasty Hurricane. From the island of Mauritius he caught up with a Spanish warship and at last reached Europe in 1771. Landing in Spain he had to cross the Pyrenees on foot but finally, 11 1/2 years after he left, he arrived back at home. But wait, there's more! After his harrowing journey through hurricanes, wars and disease he comes back home only to find out that he had been officially declared dead with his estate looted by relatives and creditors.

Oh well. . .

First Light can show you what Le Gentil missed. Click here, , then advance the time with the  button on the toolbar, and you will travel back in time to witness Venus sweeping over the face of the Sun. Sure beats going to India (not that there is anything wrong with India).

Open Cluster M34

M34 is a bright open cluster best viewed with low power eyepieces. The cluster contains about 80 stars total and is about 1400 light years away and about 100 million years old. Can you find this with your binoculars? How many stars can you see?

The Perseid Meteors

It is now mid-August, and as all amateur astronomers know, it is time for the finest of all meteor showers : the Perseids. Through the 1980s the Perseids had slowly declined as the thick part of the debris stream passed on by our orbit. However, it was predicted that in 1993 the Earth might pass through a tightly condensed knot of particles resulting in not just a meteor shower, but a meteor *storm*!

Typically an astute observer would be able to see around 50 meteors per hour but the increased activity might yield hundreds each hour at the peak. Well, activity was up, but the predicted storm never came. "Just you wait!" the astronomers said, "wait until next year!". Believing that their assumptions could have been off, 1994 was thought to be the year to watch. And this time they were right. The shower peaked right in the early morning hours along the West Coast of the United States. In some cases the rates were so high, observers simply lost count! Many reports placed the hourly numbers at several hundreds of meteors per hour!

Over the next few years the Perseids could be equally spectacular and I would encourage you to take the time out to observe them. The shower goes from August 10 to 15 and typically peaks on the 12th (the date may vary by a day, so watch the newspapers or call up your local college astronomy department to find out the precise time of peak).

This shower is also known for having a wide variety of meteors, the fainter ones being white of yellow, brighter ones, green, orange, deep red and in some cases violet. About 1/3 leave trails. There will be occasional fireballs often ending in bursts. Some of the larger ones have been known to split or explode half way through.

Showers are best observed in between 2 am and sunrise. Having a thermos with some hot chocolate, a bag of popcorn and some of your favorite tapes can make for a pleasurable time.

Project : Eclipsing Stars

Project. . .

supplies : *a dark night, your eyes, some graph paper*

During the mid-summer months the magical little constellation of Lyra rises high in the sky for northern hemispherians. In it you will find Vega, the fifth brightest star in the sky and one corner of the vast "Summer Triangle" (the other two being Altair in Aquila and Deneb located in Cygnus, the Swan). Use First Light to locate Lyra, and then find it for yourself this evening. Notice that the constellation is made up of a triangle with Vega as the anchor. Attached to that is a lopsided rectangle. It is the base of this rectangle we want to look at tonight. It is made up of two fairly bright stars, both hovering close to third magnitude. Beta Lyrae is what we want to observe, for this is what is known as an "eclipsing binary" or "eclipsing variable" star, . Just as the Moon can move in between us and the Sun, giving us an eclipse so one star can cover another. And with binary stars, two stars orbiting together, this becomes a fairly common event. Beta Lyrae is one of the finest examples of these.

The brightest star in the system, the "primary", is believed to be about 19 times the diameter of the Sun, but 3000 times as bright. The orbiting companion is slightly smaller and somewhat dimmer as well. It orbits so closely that the two are in all likelihood touching each other, locked in an embrace within their eternal dance. The distance from center to center is a paltry 22 million miles, less than the that from Mercury to the Sun.

Now imagine what we see from Earth when the dimmer star passes in front of the brighter. Right! You would see the brightness change. And with Beta Lyrae, the change is quite rapid and should be easily seen merely by paying some attention.

The variation in brightness is called a "light curve". Beta Lyrae jumps between magnitude 3.4 and 4.2 with a period of just under 13 days. If you were to plot the curve you would see two dips as to be expected. The deeper one happens when the dimmer star obscures the brighter, while the shallower one takes place as the brighter moves in front since the other member contributes less light overall.

For the project, observe the star night after night and see if you can detect any change in brightness. When at the peak, Beta should equal the nearby Gamma Lyrae, but at the minimum it would be only half as bright. Try and draw your own light curve graphing the intensity on a daily basis. Can you find the two dips? What does this tell you about the relative sizes of the stars?

Solar Apex

If you have been following any of the recent daily activities, you are now quite familiar with the constellation of Lyra, high in the skies during mid-summer.

As with all stars, the Sun itself is moving through the vast reaches of space. Now look toward Lyra tonight, . That is where we are headed!

This is called the "Solar Apex", but at the paltry speed of only 12 miles per second it will take a long time to get there from here. Now sit back and imagine the ride! Not only are we on a planet spinning around, which in turn is whirling around the Sun. The Sun then travels its leisurely quarter billion year cycle about the galactic center while it zips on its own toward Vega. But then the galaxy itself is sliding through space toward an uncertain destination billions of years from now. Welcome to the cosmic carousel! But there's no getting off of this one!

Oh, did I mention continental drift?

Project - Heliacal Rising

Project. . .

supplies : an alarm clock

Due to the motions of the Earth around the Sun, certain stars and constellations appear and different times. In the summer the winter constellations are behind the Sun, blocked by its substantial glare. Six months later we are on the other side of the orbit and it is the summer skies that are up only during daylight. The skies change four minutes every day, a star that rises at exactly 10 o'clock tonight will rise at 9:56 tomorrow. And so it goes.

To the ancients, the stars were as celestial cairns, signposts, markers warning them of what to do and when. Various events were greeted with celebration as new seasons began and old ones pass on, all indicated by the year parade of the stars. None were more important than Sirius, the brightest in the sky. To the Egyptians its arrival in the heavens was critical and marked with grand ceremony as it foretold the time of the Nile's rising. An event which the Empire's agriculture relied upon, indeed, all Egyptian society. No wonder Sirius was called the Nile Star, or the Star of Isis. To this end, some temples dating as early as 1500 BC have been oriented based on the first sightings of Sirius.

Sirius is one of the hallmarks of the glorious winter's sky, along with Orion the Hunter, Taurus and many others of the great astral precession. But you may actually catch a glimpse of this winter wonder while it is yet summer, as it gradually comes out hiding from behind the Suns fierce countenance. And in so doing you place yourself in the positions of the ancients as they would rise early in the morning and breathlessly wait for this first appearance, an event which we now call the "Helical Rising".

The actual date of helical rising varies depending on your latitude, but suffice it to say, for most of the middle latitudes in the northern hemisphere, the date of August 15 is about the best. On this date Sirius will rise round one hour before the Sun. So for tomorrow, set your alarm clock appropriately and see if you can make out Sirius as the ancient priests did in the fragrant early morning hours. If not, try several days in a row. What date is best for you? How close to sunrise can you still see it? Can you follow it with binoculars even after the Sun comes up?

Altair

In the waning days of August, the air is just starting to whisper a change, and soaring high up into the evening sky you will find great eagle, Aquila.

The brightest star of Aquila is Altair, which is one corner of the Summer Triangle. Vega in Lyra and Deneb in Cygnus are the other two, . Using First Light, center Aquila and see if you can find the Triangle without the aid of the constellation names. At magnitude 0.76 it is the 11th brightest in the sky.and also one of the closest at a pedestrian 16 light years distant. The star shines away with a luminosity nine times that of our own Sun, and at about 1.2 million miles in diameter it is about 1 1/2 times the size. As with almost everything else in the Universe, Altair rotates on its axis and has one of the fastest rotations known. It takes only 6 1/2 days to make a complete spin. But compare that to over 25 days required for the Sun. Because of this, it must be highly squashed with an equatorial diameter about twice the polar diameter. This is not unlike Jupiter which likewise rotates very fast for its size and as a result is visibly flattened, but not nearly as much as Altair must be. Were you on the equator of Altair, you would be rotating at a whopping 160 miles per second. Compare to the Earth, where your velocity would be a relatively tame 1/3 of a mile per second.

See if you can find Altair tonight. What do you think it might look like to be on a planet orbiting this strange object?

The Ultimate Challenge!

Project. . .

supplies : dark skies, Jupiter, great eyesight

There are many different challenges one can assume in astronomy, (astronomical bar-bets perhaps?) One of the toughest is the naked-eye viewing of Jupiter's moons.

A number of people over the years have claimed to have seen the moons of Jupiter without the aid of instruments. Technically speaking, this should be possible. The moons are bright enough to be naked eye objects. Usually about fifth magnitude on up to fourth at times. And their separation from the planet should be plenty. The most distant, Callisto will be as much as a third of the diameter of the Full Moon away from Jupiter. That would be a little less than the width of your little finger held at arm's length. The tough part is being able to see the tiny objects while they are buried in the overwhelming glare of the giant planet.

During the mid-summer for the next couple years, Jupiter will in the western skies. Use First Light to locate it for tonight. And without cheating step on outside and see if you can make out the Jovian moons. Dark skies will be a must, so if the full Moon is out, forget it. Skylight, even from a small town will probably wash out the tiny glimmers, so make sure to get out into the country if possible. Don't use binoculars or First Light to see where they are ahead of time. Simply look for one or more tiny stars hovering near the planet. If you see something use the binoculars to verify your sighting. And if correct, you may count yourself one of the few deserving of legendary status among the astronomical world.

Serpens, the Serpent

There appears to be very little mythology behind Serpens. The constellation is usually seen as a monstrous snake being held, tamed perhaps, by Ophiuchus. Serpens is an oddball among constellations in that it is in two parts. Serpens Caput is the head, and Serpens Cauda represents the tail. In between is Ophiuchus, the son of Apollo and healer, . Supposedly he was able to restore to life the dead by using an herb placed on the back of a snake.

Serpens plays home to M5, one of the finest and brightest globular clusters in the sky. At sixth magnitude, it should be visible to the naked eye as a fuzzy star. Near the tail you will find M16 a nice little open cluster located right on the border of the Milky Way. It is here where the spectacular Star Queen Nebula is located. Unfortunately is is one of those objects better seen in pictures due to its overall faintness.

Now turn off the computer, step outside and see if you can make out this sky-serpent.

M5 : A Nice Globular Cluster

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m5.sbm}Located in the "head" half of the split constellation, Serpens, you will find the smashing globular cluster, M5. These are round, concentrated clusters of old stars which usually collect into halos surrounding galaxies. They contain between 100,000 to 10 million stars and are typically 100 light years across. Globulars are wonderful objects in small telescopes due to their perfectly rounded shape and the delicate glistening of the nucleus.

Omega Centauri in the southern skies is by far the best. northerners can relish M13 in Hercules, M3 and now M5 which is considered one of the finest in the sky, . Its 13 billion year age makes M5 one of the oldest clusters known. Easily visible in binoculars it takes at least a four inch telescope to be able to resolve some of its 1/2 million stars.

Speaking of M5, astronomer Mary Proctor in 1924 wrote so poetically : "Myriads of glistening points, shimmering over a soft background of starry mist illumined as though by moonlight. . .for few blissful moments. . .it suggested a veritable glimpse of the heavens beyond".   Who said scientists are cold and analytical?

With a magnitude of 6.2, M5 is just ever so barely visible to the naked eye. If you are far away from any cities or towns (say, adrift in a liferaft off the shore of Bora-Bora) you might be able to see it sailing high overhead. A fuzzy star, itself adrift in a "river frozen in time".

Naked Eye Deep-sky Objects

Scattered to the celestial winds much like myriads of diamonds in the dust lie the various star clusters, nebulae and galaxies, just waiting to reveal their secrets to whomever should stumble across them. Unlike the stars, the deep-sky objects as a rule are rather dim. Most need binoculars at least to even begin to see them while telescopes are required to make out the more delicate features.

There are a few which rise above the background clutter to naked eye visibility. At two million light years distant, the Andromeda galaxy is considered the furthest such object. Others include the globular cluster M13, the Pleiades, the Orion Nebula and so on. A number of the objects are actually quite large, some well beyond the size of the full Moon, but with surface intensities so dim as to slide back into invisibility.

Tonight see if you can catch two objects : M16, a star cluster and site of the Star-Queen nebula in Serpens and M17, the Swan nebula located in Sagittarius, .

Around mid-evening in the latter parts of August, both objects will be above the southern horizon. Near the tail of the serpent you will find M16. Rated at 6.5 magnitude it is just at the limits of visibility. YOU will probably have to site it first with the binoculars. M16 is a nice little open cluster located right on the border of the Milky Way. It is here where the spectacular Star Queen Nebula is located. Unfortunately the nebular is far dimmer than the cluster so you will need mass quantities of carrots before you can hope to see it, but look for the cluster.

Located slightly less than two degrees (a fist's width) south is M17, the Swan nebula and one of the brightest nebula that you might almost be able to see. At magnitude six it is well within naked eye range under the darkest skies. Look for a long "comet like streak" of a soft misty glow somewhat larger than the full Moon (about equal to the width of your thumb held at arm's length). As you gaze upon the ghostly swan take note that the light reaching your eyes tonight left there about 5700 years ago.

If you can't seem to find that, try for the Lagoon Nebula in Sagittarius. You will find it listed as "M8". It is about twice as bright as M17 and well over twice the size of the full Moon.

If you can find it, compare your seeing over several nights, with and without the Moon visible. How is seeing affected from the country vs. that in a town or city. Can you see it with your eyes closed (just kidding)?

Planetary Speeds

Project. . .

supplies : a yo-yo

Warning : perform this experiment outside where you can't hit anything.

One curious thing about orbits is that the closer an object is, the faster it must go to stay in orbit. So, in one sense of the word, if the space shuttle wants to go to a higher orbit, it must speed up to slow down. Huh?

For instance, Pluto is 40 times the distance from the Sun than the Earth is, but requires about 250 times as long to loop around the Sun! In very simple terms it requires less energy to orbit farther out due to the lower effects of gravity. (It's actually more complicated then this, but is beyond the scope of the text).

Anyway, this can crudely be demonstrated by use of the yo-yo. Take it outside and hold the string only one foot from the spinner. Now swing it around vertically and see how much energy and how fast you have to whirl it around to get it to stay at the very end of the string. Now double the length so you have two feet and spin it again. Notice how must less effort it requires. Why is this?

Galileo and Ida

Called "minor planets" asteroids have been roaming the solar system ever since the beginning, the original nomads of the sky. Raw material from planets that could never quite "get their act together", asteroids provide an opportunity to peer back to the very start of it all, literally billions of years ago. Until the advent of NASA's deep space probes, these tiny wanderers, over 6000 known to date, have been mere pinpoints of light, all alone in the dark.

On this date in 1993, one of those pinpoints became a real world as the Jupiter-bound Galileo probe swept toward the potato-shaped asteroid known as Ida.

{ewl ewdll.dll,ewBitmap,ew_bmps\ast_etc\ida.bmp}Heavily scarred and pitted, the 32 mile long Ida is was originally thought to be part of a larger object that broke apart over 200 million years ago. But if it was that young its surface would be relatively crater free. Such was not the case, and therefore Ida remains either an interloper from the outside, or scientists know less about asteroids than they first thought.

But that was not the most interesting discovery. After the initial pictures were returned, Galileo had more surprises hidden away on its tape recorder. For months after the flyby during the slow process of "downloading" yet another Ida image, a small object was spotted nearby. A one mile in diameter rock apparently travelling with the larger Ida. It was a moon! A moon of an asteroid! how charming (astronomically speaking of course), as it tagged along like a puppy after its master.

Now called Dactyl, Ida's moon is probably a chunk of the asteroid knocked off by a collision aeons ago as it lazily circles its bigger brother about 60 miles away.

It is now believed that double-objects like this are actually quite common. In 1992 a small asteroid called Toutatis flew by Earth and was "photographed" by radar. It too was a double body, two large rocks one about a mile across and the other about four miles across, orbiting so close that they might actually be touching. Closer looks at craters on both the Earth and the Moon show many double craters, usually one larger than the other. Could it be that they were likewise created by double objects?

Now using First Light, reset the time to now and find out where Ida will be tonight. Even with a potent instrument, it will still be a faint whisper of light so don't plan on actually looking for it outside. But don't worry, it's out there.

Where oh Where is Voyager 2?

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm}Beyond Mars, lay the "outer planets."   Before the age of space travel, they remained enigmatic telescopic blurs only grudgingly giving up their secrets. It wasn't until the Pioneer spacecraft and later the phenomenally successful Voyagers 1 and 2 that the real nature of these distant worlds became known.

What had up until than been merely pinpoints of light first seen by Galileo in 1610, Jupiter's four largest moons became real worlds, each strikingly different, each with a different story to tell.

{ewl ewdll.dll,ewBitmap,ew_bmps\jupiter\jupiter1.sbm}In 1979 the second of the two sister vehicles crossed into "Jovian"   space following Voyager 1 by 4 months time, . It went on to further survey unimaginably hellish world of Io, the sulfurous orange moon literally turning itself inside out through dozens of active sulfur volcanoes. Then there is Callisto, the third largest moon in the solar system, the second largest around Jupiter. Unlike many of the other moons, Callisto seems to be completely "dead" with no noticeable geologic activity whatsoever. The mysterious Red Spot was also not be be missed, .

Nex{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\saturn3.sbm}t came Saturn who surrendered her secrets 1981, . After Saturn Voyager I completed her planetary investigations and was sent out of the solar system to sail on forever to the inky blackness of space. However Voyager 2 wasn't done, not by a long shot. Using a technique known as "gravitational assist" the spacecraft quietly stole a just little bit of energy from Saturn and was shot toward her next stop, Uranus which wouldn't come into view for another 5 1/2 years,
.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\neptune3.sbm}From Uranus she then went on to Neptune and for the first time witnessed the Great Dark Spot, , and the bizarre twisted face of the moon Triton. A few days later her mission was over, and scientists had yet another room full of data, material for dozens of doctoral papers and great new photos for the cover of Astronomy magazine.

But the little spacecraft that could journeyed on into the great unfathomable vastness of interstellar space. And unless she is struck by an asteroid or comet, the odyssey will likely continue for millions of years, perhaps even until the very end of the Universe. Once Voyager leaves the "Heliopause" the vast region surrounding the solar system it plunges deep into the blackness of space until its next encounter, *81,900* years from now. At that time a tiny red dwarf star called Ross 248 will scuttle on by, still about 1 1/2 light years way so it is a mere brief encounter in the night. By far the the most spectacular flyby must wait until the year 359,900 AD. At that time the giant star Sirius, the brightest in our sky, will be looming ahead a shining beacon in the emptiness of space. The little satellite now beaten and pockmarked with thousands of tiny holes from hundreds of thousands of years worth of interstellar dust will sweep on by Sirius only .6 light years away. After that, who knows. Should Voyager ever be picked up by some future intergalactic traveler, it carries a record of who we are. A golden album is attached to the side along with diagrams of how to play it. It contains pictures of human culture, music from the greatest composers and voices of Earth sending their greetings. Possibly one day we might encounter a similar probe, pockmarked and beaten by perhaps millions of years of space dust. On on its side might be a golden album one with voices, music and pictures of a civilization long passed into history.

So where is Voyager 2 now? Click here and let First Light show you! Notice how it is heading far below the solar system, thanks to its final encounter with Neptune.

Voyager 2 at Neptune

Beyond Mars, lay the "outer planets." Before the age of space travel, they remained enigmatic telescopic blurs only grudgingly giving up their secrets. It wasn't until the Pioneer spacecraft and later the phenomenally successful Voyagers 1 and 2 that the real nature of these distant worlds became fully known.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm}Voyager 2 was simply the greatest unmanned exploration of all time. In the space of 10 years she swept by the four "gas giants" of the solar system, one right after another, and like a row of dominoes, their secrets began to fall away. In 1979 it was Jupiter that loomed ahead, followed by Saturn two years later. It took another 5 1/2 years of coasting, but in January 1986 Uranus had its first manmade visitor when the mysteries of the giant blue planet came to the light of day. And in 1989 on this date, Voyager made its final call with the ever so spectacular Neptune encounter. Afterwards it would silently sail on into the vast darkness of interstellar space. Next stop? Sirius in the year 359,900 AD.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\neptune3.sbm}Unlike the dull atmosphere of Uranus, Neptune provided much scientific entertainment. The spacecraft was targeted to fly only 3000 miles above the cloud tops of the eighth planet, the closest approach to anything since it left Earth over a decade earlier.

First it photographed the planet itself and the "Great Dark Spot", similar to Jupiter's Red Spot, a massive storm over 9000 miles long, . Next, clouds on the terminator rolled into view with images so sharp their shadows could be seen stretched out across the cold blue atmosphere.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\nep_ring.sbm}As with Saturn, Jupiter and Uranus, Neptune has a set of rings, only detectable from Earth when the planet moves in front of a star. These rings are different from all others due to the clumpiness. The system is so faint, a long time-exposure was needed to capture them, hence the brilliant central image of Neptune.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\triton1.sbm}Then came the last phase, the flyby of Neptune's largest moon Triton. Discoveries and surprises came up to the very end in dramatic fashion. The 12 years of anticipation could not prepare the scientists for the improbable world of pink glaciers and nitrogen geysers. This only whetted their appetite for the last unexplored territory in the solar system : Pluto. But one that would likely remain an enigma for years to come.

You can use First Light to investigate this flyby, as with all of the Voyager explorations. Click here and you will see Voyager as Neptune's massive gravity grabbed her and flung her pathway around. Feel free to place your eyepoint on the spacecraft and see what it saw during encounter. Try to match this up with the pictures.

Voyager 2 at Saturn

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm}Saturn was the second domino to fall in the wondrous odyssey of the Voyager 2. Launched in 1977, encountering Jupiter in 1979, the spindly little spacecraft that could, had been going at it for four years now.

On this date in 1981 the enchanting ringed planet loomed ahead suspended in space, frozen in time, . August would be a busy month for Voyager 2, eight years later to the week it would make its last encounter in a spectacular flyby of Neptune, at that time the furthest planet from the Sun.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\saturn3.sbm}Slightly smaller than Jupiter, Saturn is no doubt the most visually striking planet. Its rings described as "ears" by early astronomers are perhaps the most intriguing objects in the solar system. Until the accidental discovery of the Uranian ring system in 1977, Saturn was the only known ringed planet. Now we know that all four of the gas giants, Saturn, Uranus, Jupiter and Neptune sport ring systems. But only Saturn's is visible from Earth.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\spokes.sbm}One of the enigmas of Saturn's rings were the mysterious "spokes", . It was later determined that they were caused from extremely fine dust caught in between the larger particles. Saturn's magnetic field apparently then distorts the dust plane and gave scientists a lot to talk about over lunch.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\mimas1.sbm}Saturn's incredibly complex system of moons came under very close scrutiny. Looking like a miniature model of the solar system several of the moons were examined up close. There was tiny Mimas nickednamed the "Death Star" due to its uncanny resemblance to the superweapon from *Star Wars*, and Calypso, most likely a captured asteroid. Then there was the heavily cratered Dione, and the rocky Enceladus.

After wildly snapping pictures like a tourist with only a single afternoon in London, Voyager sailed on by . Using Saturn's massive gravity, engineers quite literally aimed it toward its next target 5 1/2 years away : Uranus.

Neptune

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\neptune3.sbm}Silently lumbering around the Sun, 30 times further than the Earth, is the last of the "gas giant" planets, Neptune. Colored a cold sky blue, it is currently the furthest planet from the Sun due to Pluto's eccentric orbit. Such will be the case until 1999 when Pluto once again takes the title.

The ancients knew of five planets in the solar system : Mercury, Venus, Mars, Jupiter and Saturn. It wasn't until 1781 when the sixth planet was added to the great pantheon thanks to the dedicated work of William Herschel who discovered Uranus during a routine star survey. This was a tremendous achievement, leading one celestial map maker to add a new constellation commemorating Herschel's telescope. After this discovery, the hunt continued for still further planets. Close observation of the Uranian orbit showed that it had slight irregularities suggesting that there was still another unknown body gently tugging it out of a pure orbit. From this information two different mathematicians independently predicted the location of the unseen planet. Finally on September 23, 1846 French astronomer J. Galle and his assistants located Neptune, near where it was predicted to be, (even though it is now known that Galileo himself saw Neptune all the way back in 1613, but failed to recognize it for what it was).

Neptune is the smallest of the giant planets, weighing in at a "mere" 30,000 miles across while Jupiter the largest hovers around 88,000. A single Neptunian year takes nearly 165 Earth years, and a Neptunian day 18 1/2 Earth hours.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\nep_ring.sbm}Until the accidental discovery of rings around Uranus in 1977, only Saturn was believed so blessed. But if Uranus sported rings, perhaps Neptune would also. And sure enough, a simple system was likewise discovered, but was only visible by the careful observation of a star's subtle flickering as it passed behind them.

Not unexpectedly, Neptune also has a system of moons. Only two were known until the Voyager flyby in 1989, the 1700 mile in diameter Triton, the much smaller Neried which stretches a mere 210 miles across. After Voyager, six more were added to the record books ranging from 250 down to 34 miles.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\triton1.sbm}Triton is the only of the moons investigated close up. This bizarre world surprised even the most imaginative scientists, what with its pinkish glaciers and frozen nitrogen geysers, it proved a potently extraordinary place.

Unlike the visually similar Uranus, Neptune gives off heat and energy much in the same way as Jupiter which radiates more energy than it receives. While Uranus is a cold world with a silent atmosphere, Neptune is a very lively place. It sports a gargantuan storm like Jupiter's Red Spot, along with a small white storm which whirls around the planet so fast it earned the nicknamed "Scooter", . Neptune's clouds are a mixture of hydrogen, helium, methane and a stuff called "hydrocarbon ice" formed by the sunlight on the methane. In effect, Neptune's upper atmosphere was blue smog.

You don't need a satellite to see Neptune up close. Merely click here and let First Light do all of the work for you.

Saturn

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\saturn3.sbm}Slightly smaller than Jupiter, Saturn is no doubt the most visually striking planet, . Its rings described as "ears" by early astronomers are perhaps the most intriguing objects in the solar system. Until the accidental discovery of the Uranian ring system in 1977, Saturn was the only known ringed planet. Now we know that all four of the gas giants, Saturn, Uranus, Jupiter and Neptune have ring systems. But only Saturn's is visible from Earth.

Saturn is now visible throughout the night in the waning days of summer. With its unhurried orbit that takes it around the Sun once for every 29 1/2 of our years, Saturn will remain a summer object for years to come. One of the many oddities about this planet that astronomer enjoy pointing out is just how light weight it is, for Saturn, as they will tell you, is actually less dense then water. If you had a hottub large enough (at least 75,000 miles in diameter) and could place the planet in it, it would float along with your rubber duckies and toy boats (be careful though, as it is likely to leave, er, rings). Earth's average density is about 5 1/2 times that of water, Jupiter is 1 1/3 times, but Saturn wonder is only 7/10ths that of water.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\satring9.sbm}The rings are made up of fine particles of ice and dust, and are likely no thicker than a mile or two. One of the enigmas of Saturn were the mysterious "spokes" visible along the surface of the rings, . Astronomers were at a loss to explain what was going on since standard ring theory had not predicted them. It was later determined that they were caused from extremely fine dust caught inbetween the larger particles. Saturn's magnetic field apparently then distorts the dust plane which shows up as light and dark areas while giving scientists a lot to talk about over lunch. Thanks to Saturn's 27 degree tilt, we generally get a very good face on view of the rings from Earth, but every 15 years the Earth and Saturn are positioned so the paper-thin rings are edge on two us and appear to vanish. This is the case from 1995 to 1996. They will next be at their largest in about 2003.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\dione5.sbm}Saturn also has an incredibly complex system of moons. Looking like a miniature model of the solar system several of the moons were examined up close by the Voyager probes. There was tiny Mimas nickednamed the "Death Star" due to its uncanny resemblance to the superweapon from Star Wars. Then there was Calypso, most likely a captured asteroid. The heavily cratered Dione, and the rocky Enceladus.

If you ever have a chance to see this most splendid of planets through a telescope don't even pass it up. You will remember it all the rest of your life.

Now using First Light see where Saturn is for tonight. Grab your binoculars and see if you can make out the rings. Because of the narrow tilt it may be difficult until 1996, but it can't hurt to try.

Triton

Triton : The capstone on the fantastic voyage of Voyager 2. Launched in 1977, Voyager 2 is regarded as the most successful and productive of all of NASA' s deep-space probes. First sweeping by Jupiter in 1979 and Saturn in 1981, Voyager 2 completed its officially tasked mission. If it could hold out long enough, last longer then its designed lifetime, it might be possible to nurse it on to Uranus in 1986. And so it did. Limping on by with its main radio transmitter down, using a backup, and a fussy camera system, Voyager 2 returned a wealth of data about the planet which was the first to be discovered in modern times.

But now the scientists really had to have their fingers crossed. Could they possibly squeeze enough life out of it for a final task? A Neptune flyby, 3 1/2 years down the road? Their hopes were realized as no other major failures plagued the spindly little spacecraft. And during the last week of August in 1989, Neptune received an ambassador of mankind. After flying no higher than 3000 miles above the frozen blue cloudtops, Voyager used Neptune's powerful gravity to sling it around just right so it would pass by Triton, the largest of the planet's eight moons. And after an extraordinary journey lasting more than 12 years, Voyagers "last hurrah" was certainly a stunner. For what was once a rather dim speck visible only in the world's most potent telescopes was revealed to be a fantastic world of pinkish ice flows and nitrogen geysers. Click here and you will see Voyager at its closest approach to this frozen world, .

At about 1700 miles across, Triton is believed to have been captured by Neptune sometime in the long distant past. This implies that it could be similar to the planet Pluto (which itself was thought to have been a lost moon of Neptune). Triton orbits about 200,000 miles from the surface of Neptune, and with a diameter not much smaller then our own Moon, it would appear about the same visual size to a Neptunian inhabitant.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\tri_clo2.sbm}This image shows the southern region of Triton. The coloring most likely comes from methane based material. The light areas are nitrogen or methane snows.

The dark streaks are deposits from the gaseous geysers, some which were observed in the *actual process* of erupting. The plumes carry darker material from within the planet to the lighter surface. This makes Triton only the third object after the Earth and Jupiter's moon Io, to have active volcanoes. The streaks are about 100 miles long and were enhanced by Triton's thin nitrogen atmosphere.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\triton1.sbm}This image was pieced together from 14 individual pictures. Three very different regions are visible. The newest is also the roughest, along the bottom of the screen with the oldest area to the right. Triton's surface is considered one of the youngest in the solar system and is felt to be only 100 million years old or less.   Most of the surface consists of water ice which at the low temperatures behaves very much like rock.

{ewl ewdll.dll,ewBitmap,ew_bmps\neptune\triton5.sbm}The closeup image shows a 300 mile diameter basin, possibly from a meteor impact, which has since been flooded. A solitary impact crater in the basin shows just how young the surface is.

Upon leaving Triton, Voyager's main mission was now complete. For the next several years it will continue to return data on interstellar space beyond the solar system until its power runs out about the year 2000. From there on out it will drift silently, swiftly, into the cold dark void of infinity. Its next stop will be not a planet, but a star, Sirius. But don't hold your breath. The Sirius flyby isn't scheduled until the year 359,900 AD. The little satellite now beaten and pockmarked with thousands of tiny holes from hundreds of thousands of years worth of interstellar dust will sweep on by Sirius only .6 light years away. After that, who knows? Should Voyager ever be picked up by some future intergalactic traveler, it carries a record of who we are. A golden album is attached to the side along with diagrams of how to play it. It contains pictures of human culture, music from the greatest composers and voices of Earth sending their greetings. Possibly one day we might encounter a similar probe, pockmarked and beaten by perhaps millions of years of space dust. On on its side might be a golden album one with voices, music and pictures of a distant mysterious civilization long since passed into history.

Rings of Saturn

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\saturn3.sbm}Few sights in the solar system are more splendid and sublime than the rings of Saturn, . When first discovered they were called "ears". Until the accidental discovery of the Uranian ring system in 1977, Saturn was the only known ringed orb. Now we know that all four of the gas giants, Saturn, Uranus, Jupiter and Neptune have ring systems. But only Saturn's is visible from Earth.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\spokes.sbm}The rings are made up of fine particles of ice and dust, and are likely no thicker than a mile or two. One of the great enigmas of Saturn were the mysterious "spokes" visible along the surface of the rings, . Astronomers were at a loss to explain what was going on since standard ring theory had not predicted them. It was later determined that they were caused from extremely fine dust caught in between the larger particles. Saturn's magnetic field apparently would   distorts the dust plane which then shows up as light and dark areas. Thanks to Saturn's 27 degree tilt, we generally get a very good face on view of the rings from Earth, but every 15 years the Earth and Saturn are positioned so the paper-thin rings are edge on two us and appear to vanish. This is the case from 1995 to 1996. They will next be at their largest in about 2003.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\satring9.sbm}As seen from the Earth, there appeared to be 5 main rings with two spaces or "divisions". But when examined up close by the Voyager 1 and II spacecraft in 1981, it was seen that the system was vastly more complex than imagined. In one imaginative experiment the Voyager observed a star as it passed behind the rings. The resulting fluctuations in its brightness gave an extraordinarily detailed view of the system showing that there were literally tens of thousands of tiny ringlets.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\bradring.sbm}There are two main theories of the rings' beginnings. One suggests that the rings were made out of an unfortunate moon that ventured too close to the planet. What happens is almost to horrible too describe. As the moon draws closer, the planet's gravity is going to be stronger on the front of the moon than it is on the back. When far away, this difference is relatively minor. When close, it can exceed the ability for the moon's structure to hold it together, tearing it apart rock by rock. In effect, the front of the moon wants to orbit at a different rate than the back side. The rule of thumb is an object must be further than 2 1/2 times the planet's radius. This is called the "Roche Limit". For the Earth, the Roche limit would be about 10000 miles. This is irrelevant for small objects such as the Space Shuttle, but were our Moon to come that close it would no doubt be torn crater by crater, breccia by breccia and form into a ring much like Saturn's.

The other main theory is that the rings are made up of Saturn's own leftovers, material that never made it into the main body of the planet when it was formed 4 1/2 billion years ago.

For the next several years, Saturn is a late summer object. See if you can find it tonight, and check out them rings!

Moons of Saturn

Even though the fifth planet from the Sun is primarily known for its breathtaking system of broad, brilliant rings, Saturn also comes with a complex network of moons at no extra charge, .

Before the grand journeys of NASA's Voyager probes in the 1980s, only 10 moons were known. To date that number stands at 19, ranging from the mammoth Titan which is larger than Mercury, down to mere rocks only 10 miles across. In this computer generated film, Voyager 1s seen as it blazed its trail through the Saturnian system, like a tourist in Paris for one day with unlimited free film, .

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\bradring.sbm}Several of the moons were discovered actually embedded *inside* the rings and are believed responsible for a knotted, or braiding effect. These are now called "sheparding moons" since they act as shepherds for the smaller ring particles. The moons have since been named Atlas, Janus, Epimetheus, Pandora and Prometheus in keeping with the traditions of using Greek mythical characters.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\titan.sbm}Perhaps the most interesting of the moons is Titan. With a diameter of 3200 miles it is larger than two of the solar system's planets : Mercury (3000 miles) and Pluto (1600 miles). It also has the unique distinction of being the only moon with a fully developed atmosphere. When the Voyager probes wheeled by the yellow orb, scientists eagerly awaited the images of the surface which would be used to determine the age and makeup of the object. However they were met with a view of a bland, solid, cloud obscured world intent on holding on to her secrets a little bit longer. The atmosphere is actually denser than that of our own and is composed of Nitrogen, Methane, Helium, Ethane and a number of lessor gases. The ultraviolet light from the Sun then converts the methane mixture into something resembling smog. From the surface with temperatures less than -300, one can only imagine a world of yellowish methane laden slush, methane rivers, methane icebergs lazily drifting in a methane ocean. In the early part of the next decade the European Titan probe, Huygens, will parachute through the atmosphere and might give a brief glimpse of these wonders. Titan orbits about 760,000 miles above the Saturnian clouds and takes about 16 days to make it's loop.

Compared to Titan, most of the other moons are rather dull, primarily composed of water ice and rock. But visually they are actually quite interesting.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\mimas1.sbm}When first seen, Mimas was nicknamed the "Death Star" due to its uncanny resemblance to the superweapon from *Star Wars*. The moon is a mere 242 miles in diameter but has a whopping big crater right on the equator. The crater, Herschel, is 80 miles in diameter and sports a central peak that rises 4 miles into space. One would expect that whatever created Herschel should have blown the entire moon apart. However such was obviously not the case.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\dione5.sbm}The moon Dione looks much more like a moon should: heavily cratered with pits of a variety of sizes. As with several of the other moons, Dione is made of a mixture of rock and water ice. Named after the mother of the goddess Aphrodite, the 700 mile in diameter moon has three tiny "co-orbital" moons, no larger than 22 miles in length. The large crater on the left is Amata, and is 150 miles across.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\encelad2.sbm}As with Dione, Enceladus is a mixture of water ice and rock. Discovered by the great astronomer William Herschel, Enceladus is 310 miles in diameter and orbits 148,000 miles from Saturn. It has a much smoother face than Dione, with flat plains and mountains nestled in among all of the craters.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\tethys3.sbm}Tethys was discovered in 1684 and named after the wife of the Greek god Oceanus. The most unusual feature of Tethys is the valley, Ithica Chasma, which stretches all of the way from the North Pole to the South. Tethys is 650 miles in diameter and orbits 184,000 miles from Saturn.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\rhea2.sbm}Named after the wife of Kronos, Rhea is the second largest of Saturn's moons measuring a hefty 951 miles across.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\hyperio1.sbm}Hyperion, named for the father of Helios, is unusual due to its irregular shape. Small moons are expected to be oddly formed looking more like large rocks than anything else. However Hyperion is nearly 250 miles long and 150 miles wide seemingly much too large for its appearance. The larger moons would seem to naturally collapse into the traditional spherical shape due to their increased gravity.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\phoebe.sbm}Phoebe is the furthest known moon of Saturn. It was discovered in 1898 by astronomer William Pickering. What sets Phoebe apart from all other moons is its wild orbit. First it orbits BACKWARDS, and second, its orbit is tilted 150 degrees from the plane of Saturn. That is, it will go above and below the planet, while all other moons will glide above the equator. This suggests that Phoebe is not native to the Saturnian system, but could be a captured object such as comet or asteroid.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\iapetus.sbm}With a diameter of 900 miles, Iapetus is the third largest of Saturn's moons. Its most confounding feature is the large black region covering nearly an entire hemisphere, while all of the rest is white from water ice. Since that area seems to be untouched it must be regularly replaced by new material from beneath the surface.

NGC457 in Cassiopeia

About mid-evening now in October, the lopsided "W" known as Cassiopeia is reaching its highest point in the sky. One of the more easily recognizable constellations, Cassiopeia is the location of a fine star cluster called "NGC457", . At magnitude 6.4 it is barely visible to the unaided eye under the best seeing, but with a pair of binoculars it should be quite easily found. See if you can locate it at about two degrees "below" the left part of the "W". Use First Light to show you exactly where it is.

NGC457 is an "open cluster", a loose association of stars usually numbering anywhere from a dozen on up to several hundred. This one contains about 60 known members of which two dozen should be visible in a small telescope. There are a couple of very bright foreground stars that form a nice pair which resemble a couple of eyes peering out from from the depths of space with the fainter stars forming what some think looks like an owl.

NGC457 is about 9000 light years away and 30 across.

One of the "eye" stars seems to show evidence of being an actual member, and if so would have to be one of the most luminous known to be so bright at that great distance. It would rival Rigel in Orion, shining through with the brightness of *275,000 Suns*!

If you can find this cluster, why not try for a double-header and look for M103 only a degree away from bottom of the left half of the "W" and three degrees from the other cluster. Open cluster M103 was the final entry into the original "Messier" catalog of objects. Over 40 stars have been counted in the cluster which is 15 light years across. This is over two times dimmer and only half the size as NGC457.

Project - Sizes of the Planets

Project. . .

supplies : several friends, two popcorn kernels, a pea, two M&Ms, a couple of tomatoes (two inches in diameter), an apple 4 1/2 inches, a cantaloupe, and a beach ball that can be blown up to about 2 1/2 feet. Also for the second half you will need a long stretch of road or parking lot.

There are two main kinds of planets in the solar system : The gas giants and the rocky variety. Jupiter, Saturn, Uranus and Neptune comprise the "gas giant" family. All large, all primarily balls of, well, gas. They are not unlike small stars that were never quite large enough to ignite. The rocky planets are Mercury, Venus, Earth, Mars and Pluto. Earth is the largest of the rocks at about 8000 miles in diameter, while Neptune is the smallest of the giants at 30,000 miles across.

In this exercise you will create your own model of the solar system showing the relative sizes of each of the planets.

For the Earth and Venus use M&Ms and place them side by side on your table. Next take two unpopped popcorn kernels. Those are Mercury and Pluto and set them down. For Mars use a pea. These are the small rocky planets. The tomatoes are Neptune and Uranus, the apple is Saturn and the largest of all planets, Jupiter, is going to be the cantaloupe.

(How many Mercurys do you think can fit in the cantaloupe?)

Take the beach ball and inflate it. Let that a be the Sun. How many Jupiters do you think would fit in the beach ball?

(Due to the difficulty of the next part you will probably only want to construct the inner part of the solar system, unless of course you are extremely ambitious.)

Now in order to do the second half you will need a large parking lot or perhaps empty street outside your home along with several friends, one for each of the planets. (An abandoned airstrip would be close to perfect, or a long straight beach). Find a place for the "Sun" with a very nice *long* clear view down the road or parking lot. Now place "Mercury", a person holding the popcorn kernel, 188 feet from the Sun. You may want to measure how long each of your steps are and then figure out how many steps it would take to reach 188 feet. (Hint : Normal walking steps are typically 1 1/2 to 2 feet, so Mercury would be between 90 and 125 paces away). After placing Mercury, go another 161 feet for Venus. Earth will be an additional 136 feet distant for a total of 485 feet from the Sun. When you are at the "Earth", looking back at the solar beachball, the size should be about equal to what the Sun really is. To verify this, you should be able to about cover the ball with your thumb held at arm's length. Now go back and see how big it is when viewed from Mercury.

To complete the inner planets, place Mars 242 feet beyond Earth, or 727 feet from the Sun.

Do you want to do the rest? If so, you will probably need a car and some walky-talkies to communicate with your planets. Jupiter will be about 1/2 mile from the Sun, and Saturn, 9/10ths of a mile. Uranus is at 1 3/4 miles, Neptune, 2.7 miles. Are you tired yet? No? Then go a full *3.9 miles* from your Sun for lowly, lonely Pluto. You now have a solar system built with *both* planets and planetary distances to perfect scale. Quite an extraordinary feat if you do the entire thing. (If anyone actually does the entire set of planets, please write me and tell me about it. Send some pictures and I'll include them in the next version of the program).

For extra credit, if you do go out as far as Jupiter, look at the cantaloupe from the "Earth" with a pair of binoculars. Then compare the size you see with the real thing some evening and see if they are the same.

You might want to add a few moons as well. Place another kernel about 16 inches from the Earth to represent our Moon. Out at Jupiter, use another kernel to be Callisto, the furthest of the four "Galilean" moons. Have someone else hold it about 73 inches (6 feet) away. From Mars, now look back at the Earth. How easily visible would the Moon be? Could you see it without a telescope?

When done, gather your planets back up from your friends and feel free to eat them. You deserve it.

Oh, by the way, in this scale if you want to do the next nearest star, grab a plane ticket and place another beach ball about 4400 *miles* away.

messier catalog :
The premier catalog of deep-sky objects: star clusters, nebula and galaxies. Compiled by Charles Messier in the 1780s it was to serve as an aid to comet hunters, showing them which fuzzy balls of light were not comets. There are 110 objects in the catalog. Messier objects are referred to by the letter "M" and a serial number, such as "M31" for the Andromeda Galaxy.

Sculptor

Besides mythological beasts and heroes of old, the night skies are also populated with bits of man-made machinery and miscellaneous stuff. Sculptor is one such constellation. Another would be Circinus the compasses, Fornax the furnace and Horologium the pendulum clock.

Most of these constellations are rather small and uninteresting and were introduced in the 18th and 19th centuries by various zealous astronomers who wanted to honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient constellations.

Sculptor is one such creation, added by the French astronomer Nicolas Louis de Lacaille in the mid-1700s. Lacaille was also responsible for Antlia, Caelum, Circinus, Fornax, and several other machine-based arrangements. Of the two other modern era astrocartographers, Pieter Keyser concentrated on creating animal constellations such as Dorado the goldfish or Pavo the Peacock. While Johannes Hevelius preferred a mixture of animate and inanimate objects and tried to link them in to the existing Greek constellations if possible.

Originally Sculptor was meant to be an artists studio with tools, called "Apparatus Sculptoris", a nearly finished marble head on top of a wooden platform. A lot of detail to work into such a faint collection of stars, .

Sculptor has no myths surrounding it or no major stars. It does have one fairly bright galaxy, NGC253 which should appear as an elongated cigar-shaped patch of fuzz in binoculars.

Since it is in the southern skies, Sculptor will be low on the horizon for northern observers, but see if you can find it tonight.

Columba, the Dove

Columba is one of the newer constellations, created in 1592 by Petrus Plancius to fill in the gaps in the southern skies. This is one of the few recent additions that actually makes some reference back to the Greek stories. Originally, Plancius implied that this was the dove Noah sent forth from the ark to determine if there was any dry land. However, in the Greek stories, the dove also had a bit part in the story of Jason and the Argonauts.

Columba is one of five bird constellations, with Cygnus the Swan, Aquilla the Eagle, Corvus the Crow and Grus the Crane being the others.

Columba is a rather faint grouping of stars lying right beneath Lepus, the brightest being magnitude 2.6. There are no objects of interest to a novice observer, except for "Mu Columbae", which is one of the three "Runaway Stars". These stars are all heading rapidly away from the Orion nebula at about 265,000 miles/hour. Tracing back along their pathways, it appears that these stars were actually ejected from the nebula region, possibly by a nearby supernova. The other two stars are in the constellations Auriga and Aries.

SETI

"SETI", pronounced "set-ee", is the shorthand form of the term "Search for Extraterrestrial Intelligence". Over the years there have been numerous SETI projects. One early one proposed in the 19th century suggested that Earth communicate with the people who surely inhabited Mars. His method was to cover a large area of white sand with black blinds that could be rolled back all at once to "flash" the Martians. That way it might be possible to send morse-code signals across space.

It has been pretty much discounted that there is life on other planets within our own solar system. But astronomers are quick to point out that with each galaxy containing literally millions of stars like our Sun, the chances of intelligent life elsewhere is deemed to be pretty high. The problem with the whole deal is that chances are we will never able to communicate to other stars due to the vast distances involved. If there was another civilization at the next closest star, it would take over four years for a signal from Earth to reach them. So in 1996 we send them "Hello, how are you!", it reaches them in 2000, and it wouldn't be until 2004 until we hear "yenom dnes", which when translated from Alpha Centaruian means, "what?". So for the time being we must be content to look merely for evidence of ET and forgo communication. Chances are if we hear anything, it would be thousands or millions of years old, by which time the civilization that sent it would likely be long gone.

Some contend that if there were extraterrestrials, we would have already been contacted by them (in ways more substantial then their abducting up some toothless old duck hunter in Arkansas named "Homer-Joe"). They use this lack of hard evidence to show that perhaps we are alone in the Universe or at least not very interesting. However our presence has only been telegraphed for about 90 years. Every time a radio station sends out a signal, that signal goes straight into interstellar space. And with sensitive enough equipment someone else could conceivably be listening in to our history being told through radio and television. However such signals have so far gone only 90 light years distance, not very far at all.

In Carl Sagan's novel, *Contact* (recommended reading), a very authentic SETI project is described. The first signals from an interstellar source are discovered to be Earth's own television transmissions which had been captured and repeated back to us essentially saying "hey! Look what we got from you!".

In order to detect alien signals it becomes necessary to listen to as many channels as possible. The receivers currently being developed can monitor millions of channels at once. Those must be tied into computer that would filter out garbage from real signals, and determine what are man-made (from secret spy satellites or the neighbors microwave) and what are natural (from pulsars for instance) and what are intelligent but from beyond the solar system.

The whole question provides much room for both science and philosophy to investigate. And the discovery of ET's messages would be one of the most profound and soul shaking events ever. Even more so than the death of Elvis.

Sculptor Galaxies

Tonight we are going to journey midway into the southern skies. Our target? The constellation of Sculptor. Even though it is somewhat south of the celestial equator, Sculptor should be visible to most eyes in the northern hemisphere, skipping along the southern horizon.

Invented in the 1700s, originally Sculptor was meant to be an artists studio with tools, called "Apparatus Sculptoris". It depicts a nearly finished marble head on top of a wooden platform. A lot of detail to work into such a faint collection of stars.

Even though it is unremarkable as far as constellations go, Sculptor has a number of fine galaxies, one which might be visible through binoculars, the rest via a small telescope.

Considered one of the crown jewels of the southern skies is NGC253, the brightest spiral galaxy after M31 in Andromeda. Blazing fourth like a beacon on the night, it shines at a magnitude of 7.1. The cigar shaped object is seen nearly edge on and reaches across the sky a length almost the width of a full Moon. In binoculars you should see a faint warm glow from the central nucleus, whereas larger eight inch telescopes show dust lanes like long arms meandering up a cascading river of stars. The galaxy is rotating at close to 360 miles/second, and is a fairly strong radio source.

About 4 1/2 degrees away is the somewhat dimmer NGC247. It is a poorly defined spiral with an off-center core. Because of its low luminosity, use a low-power eyepiece when looking for this object. NGC247 has an estimated absolute magnitude of around -20. In the telescope it should show a faint mottled smear of light. If you are able to find NGC247, note that the light the entering your eyes tonight left about *6 million* years ago.

Positioned about 12 degrees to the south of NGC253 is NGC55, one of the finest galaxies in the southern skies. Similar to the Large Magellanic Cloud in structure, large instruments may resolve individual stars of 17th and 18th magnitude. Faint radio emissions have been detected. The galaxy is believed to be about 46 billion times the mass of the Sun, and is around 70,000 light years across. And as with the previous galaxies, this one is to, seen nearly edge-on making it similar to a cosmic cigar. With a magnitude of 8.2, it is one of the brightest galaxies in the sky, and should likewise show up in binoculars on vary dark clear nights.

Moving about five degrees up and to the left is NGC300, one of the largest galaxies in the sky, next to the Andromeda galaxy, M31, and NGC253. Individual stars and nebula are visible in photographs decorating its spiral arms like ornaments on a Christmas tree. It is believed to have a mass of about 25 billion suns and resembles M33 in appearance through a small telescope. Unlike the others, NGC300 is almost face on, showing the classic although faint, spiral structure in two main arms that each make over a single lap around the central core. This object is considered quite a challenge even for telescope users. Although the core is relatively bright the surrounding disk of stars and dust is very faint. With this and all of the above objects, you would be best to use averted vision.

Project - Rings of Uranus

Project. . .

supplies : fairly stiff black wire (go to Radio Shack, hanger wire is way too stiff), a two inch diameter styrofoam ball from a crafts shop, a 12 inch skewer, some clear tape, a desk lamp and a penlight.

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\urings.sbm}Many of the great astronomical discoveries have been accidental. A scientist is looking for one thing and discovers another, completely unexpected. Such an event took place in 1977 when astronomers while observing a star pass behind Uranus (called an occultation) noticed that it flashed several times right before vanishing. After it reappeared it flashed several more times in the exact reverse order, precisely as one would predict it there were rings about the planet. (Later on a similar experiment was done with Neptune, and the star flickered on only one side of the planet but not the other. It was finally explained when Voyager 2 showed that while the rings did encircle the entire planet, they were quite blobby in spots. The lumpier sections on one side would obscure the light more than the other side).

It is interesting to note that the rings were able to block out the star's light even though they were only a *few miles wide!* In one case, the ring was only slightly more than a mile across.

You can recreate that experiment by building a model of Uranus. Take the styrofoam ball and stick the skewer through the center. Take the wire and form 5 loops which will be the rings, taping the ends together. The diameters in inches should be 3 1/2, 3 3/4, 4, 4 1/8 and 4 1/2. Don't worry about getting them exactly round, just so long as they can fit inside each other. When done place them on a table evenly aligned with the smallest one inside the next smallest, etc, out the the largest. Take four strips if the tape and stretch them across the rings evenly spaced around to hold them. Now you should be able to flip the set and put some more tape on the opposite sides to cover the first strips. Place the rings so the ball is in the middle and add some extra tape to attach them to the vertical skewer (clumsy, but it works). You now have "Uranus on a stick". If you want some extra detail you may want to paint the ball a light blue.

When it is night, go outside and place the desk lamp on the ground or a table. Have your volunteer move about 30 feet away and hold up the planet. You should not be able to see the rings, only the ball. Then can then take the penlight as the "star" and move it back behind the planet. What happens? What if the penlight is moved right below the ball?

For an extra authentic touch see if you can get your volunteer to hold the planet up against the sky and try to get an real star behind it.

Movies : 2001 A Space Odyssey vs. Star Trek

One thing that adds a slight melancholy touch to the whole science of astronomy, is that most astronomers know that they will never be able to go and see first hand what they have dedicated their life to. Unless perhaps it is the Moon or maybe even Mars, the possibility of man one day witnessing a hundred-thousand blazing Suns from inside a globular cluster, or skipping among the stars of the Trapezium, is pretty darned near zero.

That's where science-fiction has filled the void. With artists and writers over the years turning out a plethora of interstellar stories, we can at least have a starship for the imagination.

Star Trek has done more than anything else to popularize the concept of space travel and interstellar space travel in particular. Unfortunately the "science" as portrayed in the program is superficial at best and seriously flawed at worse. That doesn't mean it can't be entertaining, but it should never be used as a science lecture.

On the other, hand there is the film *2001-a Space Odyssey*. Scorned at first as pseudo-mystical nonsense, or as an incomprehensible mess, "2001" is now considered as one of the best films ever made, in part due to its near pathological adherence to known physics and technology. While the mysterious ending is still the subject of much debate, realize that the depiction of spaceflight was about as authentic as could be, which is especially interesting since the film was started three years before men ever walked on the Moon. Travelling to the outer planets was a long torturous journey, not a quick hop into their local "worm hole". There was no sound to be heard in the vacuum of space, compared to the low rumbles or massive explosions commonly heard in Star Trek, or any other science fiction shows for that matter.

In 2001, zero-gravity was depicted as a realistic problem and dealt with in a believable fashion. In "those other shows", gravity is conveniently created with some future miracle technology that is not quite adequately explained.

Despite the technologically correct elements, 2001 does have its flaws most notably little inconsistencies from scene to scene. For instance, the Moon Shuttle Aries is landing on the Moon, its "phase" is that of a thin crescent, but the phase of the Earth behind it is nearly full. That would be impossible. Why? See if you can find the others.

Tonight's assignment is to rent the film and compare it to Star Trek, and see which "feels" more correct.

September

September 1 : Uranus, Another Blue Planet
September 2 : Miranda
September 3 : Viking 2 Lands on Mars
September 4 : Mars - the Legend
September 5 : Mars - The Reality
September 6 : Mars - The Moons
September 7 : Mars - Olympus Mons
September 8 : Mars - Valles Marineris
September 9 : Project - Terraforming Mars
September 10 : Capricorn, the Sea-Goat
September 11 : Gravity
September 12 : Cepheus
September 13 : Cepheid Variable Stars
September 14 : Venus
September 15 : Cassiopeia, Wife of Cepheus
September 16 : Gravity Lens
September 17 : Vulpecula, the Fox
September 18 : The Dumbbell Nebula
September 19 : Olbers Paradox
September 20 : Can You Really "Buy a Star"?
September 21 : Fall Begins
September 22 : Fall Skies - Pegasus, Andromeda, Aquarius
September 23 : fall Skies - Aries, Pisces, Perseus
September 24 : fall Deep-sky Objects
September 25 : Solar Wind
September 26 : Stonehenge
September 27 : Project - Lunar Eclipse, 1996
September 28 : Van Allen Radiation Belts
September 29 : Edwin Hubble
September 30 : Viewing the Young Moon

Uranus : Another Blue Planet

Throughout the history of man the skies have always provide a seeming constant he could count on. We can look up at the same moon that Columbus gazed upon as he crossed the ocean, we can read about the constellation Orion in the Bible, writings that are two thousand years old. Thus from ancient times the concept of there being five planets : Mercury, Venus, Mars, Jupiter and Saturn was likewise one of those comforting constants, until. . . until that William Herschel fellow and his homemade telescope came on the scene in the 1780s.

William Herschel was a musician by training and an astronomer by hobby, spending every clear evening at the eyepiece of his handmade telescope searching for nebula, comets, charting the positions of the stars, etc. On this date in 1781 while cataloging double stars he came across an unusual bluish object. Thinking it might have been a comet at first he logged it and checked it a few days later noticing that it had moved slightly proving that it was a member of the solar system. A little more study showed him that it wasn't a comet after all but in fact a planet, the first one not known to the ancients. Named Uranus, this planet would lead him to become the official court astronomer of King George III at which time he left music for astronomy full time. Using his new found fame and financial backing he constructed the largest telescope of the world: a 40 foot long monster with a four foot in diameter mirror and earned the reputation of being one of the foremost observers of all times. To see what Herschel saw on that fateful evening, click here : .

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\uranus2.sbm}Uranus itself is about 32,000 in diameter, making it the third largest planet in the solar system; behind Saturn and right ahead of Neptune. A Uranian year lasts 84 of our own, and a Uranian day, slightly over 17 hours. Before the Voyager 2 flyby in 1986, Uranus had just five known moons to its credit, now there are 15, . All of the new ones are more like tiny asteroids than moons as they are all within 31 and 50 miles in diameter, except for 1985U1 which is about 100 miles. The other moons vary between 217 miles (Miranda) to just shy of 1000 miles in diameter (Titania).

Uranus is a very cold, inactive world, unlike the dynamic, dramatic and colorful atmosphere of Jupiter, the pale blue sheath of Uranus is completely featureless. Only after intense computer processing the photographs revealed very slight cloud bands. As with the other "gas giants", the atmosphere is made up mainly of Hydrogen and Helium, with trace amounts of Sulfur, Methane and Ammonia. The Methane is what gives it the blue-green color. The lack of internal energy is why the atmosphere is so smooth, whereas Jupiter, Saturn and Neptune all have internally generated heat that stirs things up.

One way Uranus stands out from the other planets is that it is quite literally tilted on its side. All planets are tilted slightly, the Earth is at 23 degrees, Mars, 25 degrees and so on. But the blue giant is tilted 98 degrees! That means that when a pole is aimed toward the Sun, as it is now, one half the planet is always in daylight and will remain so for years.

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\urings.sbm}As with the other three large planets, Uranus has a ring system. Originally discovered in 1977, the rings total 11 and are extremely narrow, the largest being only 60 miles wide and the rest between one and seven miles across. And as with the other planets the rings were probably created by either a moon which was torn apart by the planet's gravity as it wandered too close, or by raw planet stuff that was never absorbed by Uranus when it was formed.

Click here to see Uranus as it appears right now.

Viking 2 Landing

On this date in 1976, the second of two NASA Mars landers, the Viking 2 successfully touched down onto the rusty-red surface of the fourth planet. Following in the footsteps, er, landing pads, of the Viking 1, the second spacecraft came to rest on a rocky plain in Utopia Planitia near the crater Mia.

The Viking 1 lander came down uncomfortably close to a number of large boulders, any{ewr ewdll.dll,ewBitmap,ew_bmps\mars\boulder.sbm} one which could have destroyed it. Much work went in to choosing a much smoother landing site for the Viking 2. However once the cameras turned on it was clear that the second area was in many ways more dangerous than the first because of many good sized rocks evenly distributed across the plain. The large rock on the left is about three feet long and is only a few feet distant. In fact the lander had touched down on top of a rock and was tilted eight degrees as a result.

Now the 13 Viking experiment teams had their hands full with four spacecraft : Two orbiters and two landers.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\ars_mons.sbm}While the landers were on the surface, the two orbiters would return 50,000 thousand photographs for nearly four years. From these, Mars was seen going through its seasons. Clouds were observed forming inside craters and the ice-caps grew and shrank as the temperature would change. The first orbiter was deactivated in 1978 due to mechanical problems, but the second churned away until August of 1980 when it finally ran out of fuel. This computer animation was created from the Viking orbiter images, and shows what future Mars travelers might see as they zoom down into Valles Marineris and on up to Olympus Mons, the solar system's largest volcano, .

Back on the surface, the landers likewise saw the seasons changed. Viking 2 even saw frost form on the ground deep into the Martian winter. In 1980 it died, possibly due to a battery failure. The first lander continued her mission until its transmitter fell silent on November 13, 1982. One interesting footnote to this is the fact that at one point about 1979 or 1980 NASA was planning on shutting down the spacecraft to save the few extra million a year it cost to continue supporting the project (due to congressional cutbacks). A grass roots movement welled up to collect private donations to continue the Viking project. Called "The Viking Fund", founder Stan Kent, a youthful British aerospace engineer, raised several hundreds of thousands of dollars from grandmothers and schoolchildren alike. However, the government could not legally accept money for a specific purpose, instead it would have to go into the "general fund". Thanks to Kent's efforts a bill was introduced to permit NASA to take the money directly and apply it to the Viking research. Awaken by the enormous wide-spread support, the government continued NASA's own Viking financing until the spacecraft died of natural causes.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\vall_mar.sbm}With thanks to Viking, the tremendous variety of the Martian landscape was at last revealed. Channels resulting from water flooding billions of years ago were seen along with complicated networks of runoff channels. Other features revealed meteor impacts apparently in areas that had once been muddy, still others showed erosion due to ice flows. Large volcanoes loomed high slicing the thin Martian atmosphere.

Click here to see Mars as it appears at this very moment.

Miranda

The seventh planet from the Sun is Uranus. At about 32,000 in diameter it the third largest in the solar system, behind Saturn and right ahead of Neptune. Before the Voyager 2 flyby in 1986, Uranus had just five moons to its credit, now there are 15. All of the new ones are more like tiny asteroids, than moons as they are all within 31 and 50 miles in diameter, except for 1985U1 which is about 100 miles across. The other moons vary between 217 miles (Miranda) to just shy of 1000 miles in diameter (Titania).

Even though it is the smallest of the five major moons, Miranda is perhaps the strangest and the one most closely investigated in the Voyager flyby.

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\miranda.sbm}One explanation to the bizarre surface Miranda proposed that it is a rebuilt planet. It may have been a much different or much larger object in the distant past which was shattered by a powerful impact. Over a period of time pieces slowly came back together and reformed into what we see today.

{ewl ewdll.dll,ewBitmap,ew_bmps\uranus\mir_clo2.sbm}In this close-up view, we see some of the few small craters on Miranda. The flowing area on the left is "Elsinore Corona" with "Inverness Corona" on the right.

The smallest features seen here are less than 1/2 mile across. Imagine that! Voyager 2 travels through space for eight years to the farthest reaches of the solar system, and returns pictures of objects that a person could walk across in five minutes.

As with most of the small rocky moons, Miranda is made up of water ice (about 50%) and silicate rock.

Click here  to see Uranus and Miranda as they are at this very moment.

Mars - the Reality

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\marsglo2.sbm}Few things can evoke the feelings of mystery and awe that the planet Mars can. When you gaze at Mars, the ruby red jewel sparkling in the night, you are crossing a bridge forged of enormous legends.

Mars was named after the Roman god of war, perhaps due to it resembling a distant bloody battlefield. While much is made of Venus for being Earth's "twin", it is our twin in size only. Whereas Mars, while only 1/2 the diameter of Earth is nearly identical in many more areas. The length of its day is only 41 minutes longer than our own. Its year is almost exactly twice that of ours. It has seasonal changes visible from Earth, polar caps that grow and shrink, storms and clouds.

The first flyby of Mars took place in 1964 when the Mariner 4 stopped in for a look and returned 2 dozen images. Those pictures at first revealed a world not unlike the Moon with wide plains and deep craters. By 1972 the entire surface had been mapped revealing that Schiaparelli was correct : there were channels on Mars, but not man-made. It now became clear that Mars at once had a great deal of water, more so than any other planet except Earth, as evidenced through a vast network of channels and dry riverbeds. One of the great questions raised now is : where did that water go?

The Martian atmosphere is about 1/1,000ths the density of Earth's, but is still substantial enough to support clouds and massive hemisphere-wide sandstorms. In fact, when Mariner 9 first went into orbit in 1971 around Mars, a storm was in progress, making it all but impossible to see any detail on the surface for months on end. Some feared that the spacecraft would run out of fuel before the ground would become visible.

The atmosphere is made up of carbon dioxide with only trace amounts of oxygen.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\olympus.sbm}Many volcanoes were discovered, one of them, Olympus Mons is so large it is even visible from Earth on rare occasion. Olympus Mons is truly a titan among volcanoes, for it stands nearly *three times* the height of Mt. Everest and has a base that is *370 miles* across! Click here and see a computer generated film of what it might look like to fly around inside the volcano.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\vall_mar.sbm}Besides the tall mountains Mars is also site of massive "rift canyons", the largest of which is Valles Marineris. Stretching over 3000 miles long and four times deep than the Grand Canyon, Valles Marineris is the largest feature on all of Mars, and was caused by seismic activity.

From the surface, the Viking landers discovered that the soil was made in large part an {ewl ewdll.dll,ewBitmap,ew_bmps\mars\boulder.sbm}iron-rich clay (hence the red color, Mars has literally rusted), with 20% silicon, 5% magnesium, 13% iron and some sulfur, chlorine and other stuff. The weather on Mars was studied and showed an average temperatures ranging from -88 degrees C to -12 degrees and mild breezes of only a few miles per hour.

Mars is a fascinating planet, worthy of much more study. During the latter part of the 1990s and into the next millennium it will receive much attention as several different unmanned expeditions will be headed its way. Among them will be mini-rovers, tiny robots not much larger than a shoebox that will roam around the surface like giant metallic insects. Another one will have balloon drifters. During the day the warmth from the Sun will inflate the balloons lifting the instrument packages off of the ground to another site. At night, the cold will collapse the balloon causing it to land for the evening. It is an exciting time and will be much more so when man can finally join in person, but that will likely not happen for a long time to come. In the meantime take a look at Mars some evening and share in the rich history of legends and lore that envelope it.

Click here to see Mars as it appears at this very moment.

Mars - The Legend

Few things can evoke the feelings of mystery and awe that the planet Mars can. When you gaze at Mars, the ruby red jewel sparkling in the night, you are crossing a bridge forged of enormous legends.

Mars was named after the Roman god of war, perhaps due to it resembling a distant bloody battlefield. While much is made of Venus for being Earth's "twin", it is our twin in size only. On the other hand, Mars, while only 1/2 the diameter of Earth, is nearly identical in many more areas. The length of its day is only 41 minutes longer than our own. Its year is almost exactly twice that of ours. It has seasonal changes visible from Earth, polar caps that grow and shrink, storms and clouds which come and go.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\mars_old.sbm}Because of the many similarities, Mars became the subject of more wild speculation than perhaps any other planet. None more so than the that caused by famous "canals". In the 1800s Italian astronomer Giovanni Schiaparelli observed what appeared to be lines crisscrossing the Martian surface. These he called "canali", the Italian word for "channels". The western press picked that up to mean "canals", or *artificial* channels. Other leading astronomers began to likewise see canals, more elaborate and numerous than Schiaparelli ever imagined. So clear were they, maps were made and names given them. Extravagant stories were created telling of how there was a dying civilization on Mars, trying desperately to milk the last remaining droplets of water from the polar icecaps through an intricate network of canals and aqueducts thousands of miles long. Other observers claimed to have seen green patches come and go with the seasons, suggesting that these were the last patches of vanishing agriculture as Martian farmers struggled valiantly against drought and dustbowls. The canal theory hung on until the 1960s when spacecraft finally got a close look at the planet, and it was discovered that they were nothing more than the emanations of very fertile minds seeing what the popular thought wanted them to see. Mars was a dead world whose "lands sang not the springs of life".

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\marscrtr.sbm}Untold legions of stories depicted Martians in all shapes and forms invading Earth for any one of thousands of reasons. None is more well known then "The War of the Worlds" written by H.G.Wells in 1897. Here Wells depicts insect-like Martians trying to conquer Earth so as to satisfy their thirst for blood. They proved immune to the most powerful weapons that man could offer, but finally met their fate due to their lack of resistance to the the smallest of Earth's organisms, namely bacteria. The story was later retold in the infamous 1938 Orson Wells Halloween radio drama, a program written to simulate a series of live news reports from across the country. Even though it had plenty of disclaimers wrapped around it, the broadcast was said to have caused a number of suicides and mass hysteria.

In the meantime take a look at Mars some evening and share in the rich history of legends and lore that surround it. And if its cloudy, pop some popcorn and crack open a copy of Ray Bradury's "The Martian Chronicles".

Click here to see Mars as it appears at this very moment.

Mars - the Moons

In his book, *Gullivers's Travels*, published in 1726, author Jonathan Swift describes the discovery of two moons of Mars. He further went on to give details on both their orbits and sizes. The interesting thing about his was that the moons of Mars would not actually be discovered for *150 years*! In 1877 astronomer Asaph Hall announced his discovery of two tiny pinpoints of light orbiting around the red planet. The larger of the two was named Phobos, the smaller, Deimos, both after the horses of Mars, the god of war.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\pho_crat.sbm}Phobos orbits a mere 5800 miles above the rusty surface, and with a size of about 15 miles across would appear about a third the size of our Moon as viewed from the surface. It takes around eight hours to orbit the planet. The largest feature is the crater Stickney which is nearly half the size of the entire planet, and named after Hall's wife.

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\deimos.sbm}On the other hand, Deimos is only about seven miles across with a much smoother surface. Orbiting about 14,500 miles away it would appear more as a speck of light than as a real body.

Both are thought to be captured asteroids, and therefore provided the first up close views of such objects.

The moons were used at one point to determine the exact landing site of the Viking 1 spacecraft. The Viking orbiter snapped a series of photographs of Phobos' shadow creeping along the Martian surface while the Viking took pictures of the surrounding terrain as the eclipse was happening. Combining the two, scientists were able to place Viking 1 to within 6/10ths of a mile.

Click here  to see Mars as it appears at this very moment.

Mars - Olympus Mons

{ewl ewdll.dll,ewBitmap,ew_bmps\mars\olympus.sbm}Olympus Mons is the largest known volcano in the solar system, located in the Amazonis Planitia region of Mars. It rises to more than 15 1/2 miles above the surrounding plains making it the tallest known mountain in the *entire* solar system and three times the height of Mt. Everest. With a base width of 370 miles, it has 50 times the volume of Mauna Loa in Hawaii and could cover the entire state of Arizona. In fact, it is so large it is actually visible from Earth on rare occasions.

The central crater, or "caldera", is itself 50 miles across. Even though it looks foreboding on the pictures, the slopes along the side are a very gentle four degrees. Much of the Martian plains are thought to have been created by Olympus Mons and numerous other volcanoes.

About 500 miles to the south-east are three smaller volcanoes,   Ascraeus Mons, Pavonis Mons and Arsia Mons.

Click here and see a computer generated film of what it might look like to fly around inside the volcano. This film was created with another product from Virtual Reality Labs, called VistaPro. Using actual landscape data, VistaPro can let you create realistic landscape images and change them around as desired. You may even "terraform" Mars for instance by planting trees and adding lakes.

Click here to see Mars as it appears at this very moment.

Mars - Valles Marineris

The planet Mars is a study in contrasts, most notably in the fact that not only does it have the tallest known mountain in the entire solar system (Olympus Mons) but it also has the longest canyon as well. Valles Marineris is called a "rift canyon" and is the result of an active {ewr ewdll.dll,ewBitmap,ew_bmps\mars\vall_mar.sbm}geologic past as the crust of Mars would shift and slide apart. This is how our own Atlantic Ocean basin was formed. A complex system of smaller faults and canyons spread on out from each side. The valley is the largest single feature on the planet and stretches over 3000 miles in length. It would be the equivalent of having an entire canyon going from San Francisco to New York and beyond.

Valles Marineris is four times deeper than Grand Canyon and 12 miles wide in spots. It suddenly makes the Grand Canyon seem less grand, doesn't it?

Click here for a computer simulation of what a future observer might see flying down to the valley.

Terraforming Mars

Project. . .

supplies : *VistaPro from Virtual Reality Laboratories (yes, this is a bit of an advertisement for another one of our products, but it is a good program. Really!)*

In this project you will use one of the other products manufactured by Virtual Reality Labs, VistaPro.

VistaPro will take real terrain data and permit you to create realistic looking images from any angle, and generate animations of flybys.

Click here for a film of what a future Mars explorer might see flying around the inside of the Olympus Mons volcano. A film created by VistaPro.

"Terraforming" is the process of taking an inhabitable planet and making it more Earth-like. (Try filling out the environmental impact report for that!) So for this project, terraform Olympus Mons, the largest volcano in the solar system. Add a central lake, scatter some trees about maybe even some clouds. You might almost want to consider dusting the upper ridges with snow. Be creative in whatever you do. Since the CD-ROM version of VistaPro comes with an extensive Mars database this should be a relatively easy task.

When done you might want to do the opposite for the Grand Canyon. Turn the canyon into a dry, dusty red Martian valley.

Capricorn, the Sea Goat

This sight of a goat with a fish's tail should bring giggles to most any right thinking person, but that's exactly what the constellation of Capricorn is. This peculiar looking hybrid is one of the oldest constellations known, having come from the ancient Sumerians who called it "The Goat Fish". (Does this sound familiar to you Macintosh programmers out there??)

The Greeks considered this to be Pan, the playful and rather lusty character who was half-man, half-goat. Pan is the inventor of the so-called "Pan Flute", a collection of pipes one blows across to produce a rather lyrical tone. The story is told that one day he tried to seduce a sea-nymph, Syrinx, who turned herself into a bunch of reeds. As Pan held on to the reeds, the wind blew across them generating an absolutely mesmerizing music. From this he connected them together with wax and created the flute popularized by Zamfir, the master of the Pan Flute.

Pan earned his position in the heavens after he came to the rescue of the gods on two occasions.

Capricorn is now at its highest in mid-evening,but being a fairly dim constellation it does not stand out nearly as well as its neighbors Aquila or Sagittarius, . It also has nothing of interest for amateur astronomers, except perhaps being the brightest star which is a "naked eye" double. It is not a true double star, but merely two stars that are visually close to each other. Go on out tonight and see if you can find the constellation just to the right of Sagittarius. Can you make out the double?

Gravity

Gravity is called a "fundamental property of matter". That is, everything has gravity, no matter how small. You are gravitationally attracting the computer monitor in front of you. Your home exerts gravity on everything in it. In fact, very large ships are so massive that at times it becomes necessary to take into account their own gravity, such as during repairs. Two large oil tankers floating side by side at port can exert enough force on each other (a ton or more) to slowly drift together.

Gravity is a very weak force but is very powerful in that it determines the motions of the planets, stars, and everything else in the Universe as opposed to the other known forces that have very short ranges.

There are two main theories of gravity. The first, proposed by Sir Isaac Newton, was a force travelling through space that acted on all bodies. It could not be blocked in any way (the gravity from Earth is not lessened by being on the back side of the Moon), but it would decrease the further you were from an object. Using this basic theory, Newton was able to explain how one object could orbit another.

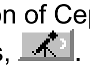
The other theory comes from none other than Albert Einstein, who described gravity not as an actual force, but as a distortion in the shape of space. Think of a planet as being at the bottom of a curved funnel. The closer you get to the planet, the steeper the walls and the harder it is to get out. This is called the "gravity well". The well around a small object is usually going to be shallow and easy to escape, a well around something like a black-hole is eventually going to get so steep that nothing can ever supply enough energy to get out. Space distortions explain why light bends in gravity. In fact very distant objects that would not otherwise be visible to us have been magnified by such "gravity lenses". These are either black-holes or entire galaxies that warp distant light around themselves and focus it our way.

Due to the all pervasive nature of gravity, it is unlikely for a while at least, that we will ever create true anti-gravity devices, or for that matter, artificial gravity as seen in Star Trek.

Cepheus

According to the Greek mythology, Cepheus was the king of Ethiopia and married to the unendurably conceited and shallow Cassiopeia. One day while combing her hair as she often did, Cassiopeia was overheard to boast that she was more beautiful than any of the "Nereids", the daughters of Poseidon the god of the sea. As punishment for this wanton act of sacrilege Poseidon sent the sea monster Cetus to destroy the coast of Ethiopia.

In order to save his land, Cepheus was instructed to offer up his daughter, Andromeda, as a sacrifice to the monster. But along came Perseus one of the greatest of the Greek heroes who killed Cetus and asked for Andromeda to be his bride.

While the constellation of Cepheus is fairly large and bright, it is devoid of any good deep-sky objects for amateur astronomers, . Its main claim to fame however is the star "delta Cephei". This is a variable star which varies its brightness by a factor of two over a very precise period of time. It was discovered that the period is an exacting indicator of the overall brightness of the star. Therefore you can find the absolute brightness of any other "cepheid" type variable stars by simply measuring its period, and if you know how bright it should be then you can figure out how far away it is. This gives astronomers a very accurate "standard candle" which as been useful for measuring distances out to about 30 million light years which would include many nearby galaxies.

To this day, Cassiopeia may still be seen tormenting her husband as she strokes her hair, making them the only couple honored in the heavens.

Project - Cepheid Variables

Project. . .

supplies : a clear night

Located in the otherwise dull constellation of Cepheus is one of the most important stars in the skies : *Delta Cephei*. What makes this so important? Because Delta Cephei is a "variable" star which varies its brightness by a factor of two over a very specific period of time. It was discovered that the period is a precise indicator of the overall brightness of the star. So theoritically, if you find another "cepheid" type star and measure its period you can find the absolute brightness. And by knowing that, you can figure out how far away it is by comparing it to its brightness as seen from Earth. This gives astronomers a very accurate "standard candle" which has been useful for measuring distances out to about 30 million light years .

These cepheids vary their brightness due to a changing of size by as much as 30%. Periods are usually between two and 40 days. They are yellow stars about five times the mass of the Sun.

You should be able to see delta Cephei change its magnitude with the naked eye. If it is clear tonight, use First Light to help you locate the star. Make a note as to how bright it appears when compared to the neighboring stars. At its brightest it will be magnitude 3.6 about the same is the nearby star "xi Cephei", about two degrees to the right. To the south of xi by about 1 1/2 degrees is "epsilon Cephei" which shines at magnitude 4.2, a little brighter than the minimum of delta. These two stars now show you the range. Chart its brightness over the next few days. How long is its period? (hint : it is less than a week). Is the "light curve" symmetrical? Or does the rate that it dims differ from the rate it brightens?

click here for the answer (but resist the temptation until you try this for yourself)

answer :

Five days 9 hours. It brightens faster than it dims.

Venus

The second planet from the Sun, Venus, is named for the Roman goddess of love. Venus is both the closest planet to the Earth in both distance and size. Sometimes called our "sister" planet, Venus is anything but the Earth in nature as it presents one of the most menacing environments of any of the small planets. Its average daily temperatures approachs 900 degrees with an atmospheric pressure 10 times that of Earth, all smothered in an eternal twilight. Venus may appear the goddess of love on the outside, but is most certainly Dante's Inferno on the inside.

Venus, is frequently the third brightest object in the Sky. Only the Sun ('natch) and the Moon are brighter. Because Venus changes phases much like the Moon its brightness will vary substantially depending on whether it is "new" or "gibbous" phase. It also depends on its distance form the Earth, not to mention the brilliant white clouds that eternally shroud the yellowish surface.

The sight of a white fire Venus suspended low over the horizon with a thin lunar crescent dangling nearby is nothing short of breathtaking. A times like this the planet is so bright it can cast a shadow. It is so bright that some people have reported it as a UFO. And it is so bright that it is even visible during the *daytime.* At its best, the white planet will outshine everything else in the night sky (except the Moon) with a searing -4.5 magnitude.

{ewl ewdll.dll,ewBitmap,ew_bmps\venus\venclds.sbm}One reason for this brightness are those mysterious clouds. Composed mainly of carbon dioxide with trace amounts of water vapor, Nitrogen and Carbon Monoxide the 100 mile layer reflects almost 65% of the sunlight that hits it. Compared this to the Moon's paltry 12% or the Earth's 37% albedo.

{ewl ewdll.dll,ewBitmap,ew_bmps\venus\venera13.sbm}For all of their problems with interplanetary space travel, the Soviet engineers deserve much praise for their Venera series of spacecraft. Despite the hellish conditions on the surface, the Venera program managed to assaulted the planet with a battalion of 10 successful soft landings. Although the landers could survive for only a few minutes, photographs were taken and the surface was sampled.

The United States sent a number of spacecraft of her own. One landed and survived for over an hour while a number of others orbited the clouded world for long term studies. The most recent probe, Magellan, orbited the planet for 3 years taking highly detailed radar maps of the surface and returning images as clear as any photographs. First, take a look at Venus with the clouds, . Now, First Light will strip away the couds,
using the Magellan data. From the spacecraft we learned that the surface of Venus is dominated by lava flows and volcanic remains. It is estimated that up to 90% of the surface features have been shaped by volcanism.

{ewl ewdll.dll,ewBitmap,ew_bmps\venus\volcano.sbm}This picture of a Venusian volcano was produced by computers simulating what a sideways view might look like based on the Magellan data. The colors are not real, but are based on the information returned from the Soviet's Venera probes.

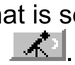
Radar data from the Magellan spacecraft was used to create this simulation of a low flyby over the surface of Venus.

The diameter of Venus is 7500 miles, just slightly less than the Earth. Its distance from the Sun averages 66 million miles. A Venusian year is 225 Earth days, and interestingly enough, a Venusian day is 243 Earth days, making its day *longer* than the year! My oh my!

Cassiopeia, Wife of Cepheus

According to the Greek mythology, Cassiopeia was the shockingly conceited and spoiled wife of Cepheus, king of Ethiopia. One day while fussing with her hair as she often did, Cassiopeia was overheard boasting that she was more beautiful than any of the "Nereids", the daughters of Poseidon, god of the sea. As punishment for this wanton act of sacrilege, Poseidon sent the sea monster Cetus to destroy the coast of Ethiopia and to put this mortal back in her place.

In order to save his land, Cepheus was instructed to offer up his daughter, Andromeda, as a sacrifice to the monster. But along happened Perseus, one of the greatest of the Greek heroes, who first politely asked for Andromeda to be his bride, then killed Cetus with an almost bored ease.

Cassiopeia is a bright constellation that is seen all year round from the northern hemisphere, and resembles a somewhat lopsided "W", . It has numerous bright star clusters such as "NGC457". At magnitude 6.4, it is barely visible to the unaided eye under the best seeing, but with a pair of binoculars it should be quite easily found. See if you can located it at about two degrees "below" the left part of the "W". Use First Light to show you exactly where it is.

Over near the right border you will find M52, a rich open cluster of nearly 200 stars that is about 15 light years across.

If if is clear tonight step on outside with your binoculars and see if you can find either of these objects. Also take a look at "eta Cassiopeiae". This is a considered one of the most agreeable double stars in the heavens due to the sharp difference in colors between the two members. Some have stated that the brighter member is yellow and the dimmer red, others with greater vocabularies describe them as "topaz and garnet". The two members shine with magnitudes of 3.5 and 7.2 and orbit around each other with a period of 526 years. This is also one of the closest stars at a scant 18 light years away.

To this day, Cassiopeia may still be seen tormenting her husband right next door as she strokes and fiddles with her hair for all eternity, making them the only couple honored in the heavens.

Four Fine Fall Objects

Tonight is as good a night as any to investigate four of the finest deep-sky objects. The first is the star Algol in Perseus.

Algol, "the Demon Star" is a what is called a "binary" or "double" star, . A double star is a stellar system made up of two or more individual stars which orbit around each other. In fact, some have said that if Jupiter had a little more mass to it, the nuclear fires would have ignited make our own Sun a double. Algol is an "eclipsing binary", the fist known, in which the dimmer member eclipses the brighter which varies the overall brightness as seen from Earth. These are also called eclipsing variables, and usually have periods of only a few days. Algol can be see to dip down to magnitude 3.4 from 2.1 in only about 10 hours. A change of brightness of nearly *three times*! The main star is over 2 1/2 million miles in diameter and the dimmer companion, over three million. The two stars are separated by a minuscule 6 1/2 million miles, so close their shapes are probably not true globes, but more likely egg shaped or tear drops. The total time between "minima" or the dimmest point of the light curve is about four days 16 hours. See if you can find Algol and compare it to nearby stars. Is it at minimum?

Next stop is also in Perseus : the Double Cluster. One of the most famous objects in the sky, you will find the Double Cluster in the northern corner. A bright fuzzy double-patch to the naked eye it explodes into a dazzling assembly of dozens of stars in even the smallest telescopes and hundreds in larger ones. The clusters are among the oldest of the deep-sky objects known,   having been spoken of as early as 150 BC. At an estimated distance of 7500 light years it is thought that they lie in the next spiral arm of our galaxy. And at those distances our own Sun, in fact most average stars, would be extremely dim at about 18th or 19th magnitude. The brilliance of the cluster then takes on additional importance since the stars must be of almost unfathomable glory. Check them out tonight if you can. With each cluster the size of the full Moon it can be a spectacular sight. And if its cloudy tonight click here and First Light will show it to you.

In Pegasus you will find M15,   one of the brightest globular clusters in the sky and a fine binocular object. Compact M15 is known for its brilliant and slightly oblate central core. Compared to others, this has a rather large number of variable stars, numbering well over 100. Out on the edge a small planetary nebula was discovered in 1927. M15 is also a source of X-rays which may indicate that a supernova was once housed within its borders.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m31.sbm}For our last stop this evening, swing on over to Andromeda. where you will find the most glorious of all deep-sky objects : M31, the Great Galaxy, . At two million light years distant it's regarded as the furthest thing visible to the unaided eye and is frequently called a sister galaxy to our own. Easily witnessed as a fuzzy elongated patch four degrees long (eight times the diameter of the full Moon), it is one of the most famous objects in our sky. Imagine now being on a planet in M31, gazing up one evening, and you would likely see our home as a fuzzy patch looking much the same.

When you find the galaxy, hold out your hand and cover it up. You have just hidden an estimated 300 *billion* stars and at nearly 200,000 light years across it is one of the largest galaxies known. The whole mass slowly rotates around the central hub, the core takes about 11 million years while the outer arms 90 million years or more. There is a small satellite galaxy, M32 which orbits M31 similar to our own Magellanic Clouds visible in the southern hemisphere.

Remember, as bright as these objects are their light is still very delicate so you will still need to have a moonless night and be away from city lights. But if you can arrange that, be prepared for some sublime and glorious sites.

Gravity Lens

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\gravlens.bmp}According the Albert Einstein, space is "curved" by gravity and the measure of the curvature is the amount of gravity an object has. This implies that light itself could be bent around very strong gravitational fields. Because of that some theorized that extremely distant and faint objects might become visible if their light is bent and actually focussed around a large mass such as a galaxy. This was first stated in 1937 but was proved in 1979 when two identical quasars where spotted very close together. It was extremely unlikely that there would be identical twin quasars, so it must be the light from a single quasar being warped around an invisible galaxy. Imagine that! *What we have in effect is a telescope made out of an entire galaxy!*

Since then, many other lensed objects have been discovered. In some cases the galaxy is bright enough to be seen. In one case the quasar images are slightly different due to the fact that the path of the light from one side is a bit longer then from the other by several light years. That means we have two images of the same object, but at *different times*.

quasars :
First discovered in 1963, quasars are among the most enigmatic objects in the Universe, the most distant and most energetic.

Vulpecula - The Fox

Vulpecula is one of the modern constellations created by Johannes Hevelius in the late 1600s, . Other he created include Canes Venatici, Lacerta, Leo Minor, Lynx, Scutum and Sextans.

Since it is new, it carries no mythology about it. And since it is so small and dim (one of the dimmest of all constellations) it has only one important object, namely the "Dumbbell Nebula". The Dumbbell is what is known as a "planetary nebula", a circular expanding shell of gas either due to a star having exploded ("gone nova") or thrown off gas as it changes from one state to another.

What makes the Dumbbell Nebula so remarkable is that it's one of the brightest known, easily visible in binoculars, about 1/4 the width of the full Moon.

Also in Vulpecula near the bottom is a novel little binocular star cluster sometimes called "The Coathanger". It is comprised of 6 stars about sixth magnitude in a straight line with four other stars that form a hook extending from the middle.

If it is clear tonight, step outside and see if you can make out the fox. Take your binoculars and look for that celestial Coathanger while you're at it.

Can You Really "Buy a Star"?

Over the past decade a number of businesses have flourished, offering customers a chance to have a star "named" after themselves or a loved one as a holiday gift. But can a private business really sell a stellar name? No, not really.

Astronomical names are decided by the International Astronomical Union (the IAU) which meets once every three years. The IAU was started back in 1919 for the purpose of standardizing constellation boundaries, naming policies for newly discovered objects and organizing communications between astronomers and observatories. Therefore, in order to be regarded as "official" a name must be approved by the IAU. Names for newly discovered planetary moons for instance must come from mythological characters. Comets are named after their discoverers while asteroids can be named whatever their discoverers desire (which explains why there are asteroids "Elvis" and "Spock").

When it comes to proper names for stars, generally Arabic terms are used. But you cannot actually "buy" a name that will be officially recognized. And with several such organizations, all using official sounding titles, you can be sure that the each star is probably named for several different people.

What does your $30 get you? A fairly nice packet sent out which is actually quite attractive, including a star chart and a small pamphlet on the stars. Feel free to purchase one, but don't be fooled into thinking that daring space explorers in the 24th century will be talking about a supergiant named "Bob" sending probes to invistage the "Dweezil" Star System.

answer :
His assumptions are wrong. Space is not infinite (mathematically speaking) and the stars are not uniformly distributed. Nor is the Universe sufficiently old for all of the existing stars to become visible to us. Plus the expansion of the galaxy ensures that the most distant objects are dimmed to our eyes by various laws of physics summed up in their "red shift".

Olbers' Paradox

Olbers' Paradox is one of those interesting "thought experiments", proposed by Heinrich Olbers in 1826. Olbers was a self-admitted "celestial policeman", an avid amateur astronomer who was responsible for discovering two of the first four asteroids ever found along with numbers of comets.

Olbers asked a rather silly question : "Why is the sky dark at night?". He mused that if space were uniformly filled with stars and infinite, no matter what direction a person would look they would be looking at the surface of a star. Therefore, shouldn't the sky be as bright as the Sun?

How would you solve this?

Whey ready, click here for the real answer.

The Dumbbell Nebula

Now situated high in the black late summer's sky is the constellation Vulpecula, one of the faintest in the sky. Few things are remarkable in Vulpecula, except for one object : M27, the "Dumbbell Nebula", . The Dumbbell is what is known as a "planetary nebula", a circular expanding shell of gas due either to a star having exploded ("gone nova") or thrown off gas as it changes from one state to another.

What makes the Dumbbell Nebula so remarkable is that it is one of the brightest known. At a magnitude eight, it is easily visible in binoculars and stretches about 1/4 the width of the full Moon.

The nebula is illuminated by a blue dwarf central star, which is one of the hottest known registering a searing 150,000 degrees F! The cloud is believed to be under 2.5 light years across, and is expanding at such a rapid rate (17 miles/second) that has visibly changed size over the years. With an estimated distance of 900 light years, the light you see tonight left when Louis VI reigned France, the Third Pueblo Period began in what is now the American southwest, and the Crusaders captured Jerusalem.

If the skies are dark and clear tonight, grab your binoculars and see if you can find this heavenly Dumbbell.

Fall : the Autumnal Equinox

As Earth continues its gentle slide around the Sun, there should be the ripple of chill in the air. The days and nights share an equal billing on the clock. The morning stillness is broken with the rumble of schoolbusses eagerly trolling up and down the streets for their prey. Fall has begun.

The beginning of fall is marked by the passage of the Sun from the northern sky to the southern.

Click here  to center the Sun. The yellow line is the ecliptic, the pathway the Sun travels on its year long journey through the heavens. Notice how the Sun is on the zero declination point, the celestial equator, a heavenly projection of the Earth's own equator. Everything above is said to be in the northern skies, those below, in the south. This point also marks "12 hours right ascension", the halfway point around the sky.

As the Sun crosses this point it is directly overhead at the equator making the days and nights the same length of time. As it progresses south, the days get shorter for the southern hemisphere and shorter for the northern. Use the Hover mode to look at the Earth from space and you will notice that the line separating the day and night sides is exactly vertical as to be expected, . If you jump ahead in time even a few days the line tilts toward the south dragging the South Pole into sunlight for the first time in six months, but leaving the north polar regions alone in the dark.

As the Sun continues southward its rays get less and less direct, less concentrated than they were when it was high on the horizon, hence the days get cooler even though the Earth is actually closer from the Sun then in the summer. The opposite to the Autumnal Equinox is the Vernal Equinox as the Sun moves back into the northern skies signaling that the warmer weather is soon to settle upon us.

right ascension :
The celestial form of longitude, but which is given in hours and minutes instead of degrees. So an object might be at "3 hours 12 minutes" right ascension or "RA" for short. The celestial latitude is "declination", identical to Earthly latitude which goes from -90 to +90 degrees.

Fall Skies : Pegasus, Andromeda, Aquarius

As the first hint of fall ripples swiftly through the air, it is time to start becoming familiar with the lavish celestial tapestry now weaving its way in the evening's sky.

First there is the mighty Pegasus, the Winged Horse, gliding higher and higher as the days grow shorter, . The main body of Pegasus is outlined in the "Great Square", four brilliant stars forming a window opened to the heavens. The Winged Horse came forth from the dead body of Medusa and was found by Bellerophon, a brave mortal prone to adventurous exploits. On one such occasion he used Pegasus to fly him up above the Earth to Mount Olympus the home of the gods. However Bellerophon fell off the horse and back to Earth before he reached the home of Zeus, but Pegasus went on without him. Zeus took the horse as his own and made him a carrier of thunder and lightning, later placing him among the stars as one of the greatest of constellations.

Despite is large size, Pegasus has few objects of interest to amateur astronomers. The only deep-sky object of any note is M15, one of the brightest globular clusters in the sky and a fine binocular object, .

Next to Pegasus is Andromeda, the love of Perseus and daughter of the vainglorious Cassiopeia, . Andromeda had the misfortune to be sent as a human sacrifice to Cetus the sea monster by her own father ("thanks Dad!"). This in an effort atone for the boastings of his wife, her mother. If Andromeda was to be forgotten for everything else, let it be remembered for just one thing : The great Andromeda Galaxy (M31),
. At two million light years distant its regarded as the furthest thing visible to the unaided eye and is frequently called a sister galaxy to our own. Easily witnessed as a fuzzy elongated patch, it is one of the most famous objects in the sky.

Immediately to the southwest of Pegasus is one of the faintest constellations in the sky, Aquarius, who also happens to be one of the least significant characters in Greek lore, .

In the Greek stories, Aquarius, after being kidnapped by Zeus (for reasons left unsaid as this is a family program), ends up becoming a waiter, serving up a mixture of water, wine and a special nectar to the gods.

Aquarius has a number of decent deep-sky objects. M2 is a "fine" globular cluster, its sixth magnitude intensity making it an easy object for binoculars and small telescopes. Then there NGC7293, the "The Helix Nebula", and is considered to be one of the nearest and largest planetaries.

So, if you have a few minutes, step outside and see if you can find these three constellations. Look for M31 in particular. And if you find it just imagine what the spot you are standing on right now must have looked like when the light entering your eyes began its long journey over two million years ago.

Fall Skies : Aries, Pisces, Perseus

In the second of our talks on the fall skies we'll cover Aries the Ram, Pisces the Fishes and Perseus the Hero.

Aries is none other than the Ram whose golden fleece gave rise to the quest of Jason and the Argonauts, . Aries' moment in the Sun was when he saved Phrixus the son of Athamas who was about to be sacrificed to Zeus. This is one of the dimmer constellations with few objects of any note. The only real claim to fame was that back in Greek times, Aries was the location of the Vernal Equinox, the point at which the Sun crossed from the southern skies to the northern announcing the start of spring. Due to precession, a slow wobble of the Earth's axis, the point has progressed to Pisces.

The two fish as illustrated in Pisces are said to have saved the goddess Aphrodite and her son Eros from the repellent creature Typhon, . They came out of the Euphrates river and carried the two on their backs to safety. Pisces is another one of the dimmer constellations made up primarily of fourth magnitude stars. While a larger constellation as with Aries it has few interesting objects since it lies far from the plane of the galaxy and away from the concentration of objects. There are some nice double stars, visible in binoculars.

Perseus is one of the greatest of the Greek heroes, second only to Hercules, . A total of six (count them, six!) constellations represent characters dotting his adventures. Perseus is known as the savior and lover of the beautiful Andromeda. Unlike the other two constellations above, this one is very bright and is endowed with a goodly number of objects for home enthusiasts. Perhaps the most famous is the Double Cluster in the northern corner. A bright fuzzy double-patch to the naked eye it explodes into hundreds of stars in telescopes. Check them out tonight if you can. With each cluster the size of the full Moon it can be a spectacular sight. And if its cloudy tonight click here
and First Light will show it you.

Solar Wind

When one thinks of space, the term "vacuum" comes to mind. But there is actually a lot of stuff out there and some of comes in the form of a "wind" straight from the Sun.

The solar wind is formed from a stream of protons and electrons constantly blown away from the Sun in all directions. It is in effect the highest part of the solar corona, that glowing circle of light seen surrounding the Sun during a total eclipse. The speed of the wind has been measured at between 150 and 500 miles per second and it contains about 150 particles per cubic inch.

The wind is thought to extend out as far as twice the distance of Pluto where it then becomes so weak it is stopped by interstellar gas.

Although weak, effects of the wind can readily be seen in a comet's tail as it is propelled away from the Sun. Likewise the solar-wind particles when they hit the Earth, will excite tenuous gasses in the upper atmosphere around the poles causing beautiful auroral displays. This is not at all unlike what happens inside a neon sign. From space, the aurora are seen as a ring of fire, a feverish necklace surrounding the magnetic north and south poles. Unfortunately, most observers are too far away from the poles to ever see much auroral activity, but sometimes when the Sun is extremely energetic, they might be visible down near the equatorial regions of the planet.

The aurora are located between 50 and 370 miles in altitude, meaning that orbiting space shuttles can actually fly right through them. The lower aurora tends to be reddish, while the higher ones are green or blue.

The Mystery of Stonehenge

Astronomical observatories have been around for a long time, well before the invention of the telescope. Before then, man had to use his own eyes and a highly developed sense of observation to study the heavens. Planetary positions were measured and discussed. Locations for the Sun and the Moon were precisely determined for both scientific reasons as well as religious and practical reasons. The position of the Sun could tell an ancient farmer when to plant his crops for instance, and therefore become a vastly important part of any society's daily culture and life.

Perhaps the oldest and most wonderfully enigmatic of these structures is none other than Stonehenge, located in the plains of southern England. Part temple, part science laboratory, Stonehenge was built in four stages between 2200 and 1900 BC (during the time of Egypt and the Old Testament).

It is made up three primary rings. The inner one is about 75 feet across and forms a horseshoe out of five sets of vertical stones capped with a crosspiece. The second is a continuous circle of 30 pillars, each weighing about 15 tons or more. The outer ring is comprised of 56 evenly spaced "Aubrey" pits that form a circle about 550 feet across. Adding to the Stonehenge mystery is the fact that these rocks are not local, but had to be moved from a site of 20 miles away. How did the do that? And how did they lift such heavy objects on top each other?

The purpose of Stonehenge is still shrouded in history. It is not the only such object, as many other similar sites have been uncovered, but it is certainly the largest and most well preserved. In recent years, some have thought that Stonehenge was in effect, a mammoth *computer*! Based on the sightlines and placement of various other stones in the area it is now commonly believed that this was possibly an eclipse predictor. The ancients would keep track of the eclipse cycles by moving various rocks amount the Aubrey pits, and when they aligned up at certain points it might be possible to foretell upcoming events. And considering how frightening eclipses were to many of the ancient cultures, knowing ahead of time when one would happen could give a person significant power and influence.

Other stones are placed to pinpoint the Vernal Equinox, the beginning of spring, which makes Stonehenge a multitasking computer. I don't think Stonehenge was Windows compatible, however, as no ancient mouse has been found.

Lunar Eclipse : 1996

Project. . .

supplies : *a grapefruit, a golfball, room lamp with the shade removed, penlight flashlight.*

On this date in 1996 there will be a total Lunar Eclipse visible from all of Europe, Africa and the Americas. On the East Coast of the United States, it will be in the mid to late evening, in the west it will be early evening.

A lunar eclipse happens whenever the Moon passes into the shadow of the Earth right at the exact moment of full Moon. In that case you might be asking why we don't see these things every month? That is due to the simple fact that most of the time the Moon will go a little above or below the shadow since its orbit is tilted slightly to the plane of the Earth's. The orbit itself rotates slowly bringing the crossover points, called "nodes", into alignment with both the Sun and Earth. When the nodes are not aligned no eclipses are possible.

A lunar eclipse begins as the Moon wanders into the "penumbra" of the Earth's shadow. When viewed from the Moon this is where only part of the Sun would still be visible. The deeper you into the shadow, the less of the Sun is seen. Finally you hit the "umbra", the area of maximum shadow where the Sun is completely covered by the Earth. Depending on conditions in the Earth's own atmosphere, the light in the umbra can be pitch black, or blood red. The coloring will vary from eclipse to eclipse and is caused by small particles of dust or smoke in the atmosphere. This is the same reason we have brilliant red sunsets from time to time. So if a volcano has recently erupted, prepare for a beautiful event.

In this project you can see how the shadows work. The grapefruit will be the Earth and the golf ball the Moon. Turn out all of the lights except the shadeless lamp. Hold the grapefruit about 10 feet from the and move the golfball in and out of the "Earth's" shadow, about two from the grapefruit. Notice that the shadow is not very sharp, and that there will be a fuzzy halo around the central dark area. That is the penumbra. Take the piece of cardboard and project the shadow onto it. Now move it in and out. The closer to the Earth, the smaller the penumbra, the larger the umbra. That is caused because the visual size of the Earth is changing relative to the Sun. The closer you are, the "smaller" the Sun would appear and hence the smaller the penumbra. This can also be shown by using a the penlight instead of the larger bulb. The smaller dimensions of the light will cause it to cutoff sooner making an extremely sharp shadow as compared to the room light.

Click here  and First Light will show you the 1996 eclipse. The larger circle is the penumbra, the inner is the umbra, the area of maximum shadow. Shift the time back and forth to see how the Moon moves through the shadow. Now jump into Hover mode and look how the three bodies are aligned. You may want to jump to the next full Moon and see how far it misses the shadow. Is it above or below?

Van Allen Belts

The Van Allen radiation belts were discovered by the United States' very first satellite, Explorer 1. Launched in 1958, the Explorer discovered two large doughnut shaped regions of charged particles between 1,900 and 14,000 miles above the Earth's equator. These particles, mainly electrons and protons, came from solar emanations called the "solar wind" and were trapped by the Earth's own magnetic field. Neither Mars or Venus have similar regions, but Jupiter with its powerful magnetic field has a radiation belt 10,000 times the intensity of our own.

The radiation in the belts are hazardous to any spacecraft as the charged particles can cause electrical shorts in the delicate electronics or scramble a computer's memory. Spacecraft must be heavily shielded to prevent such events.

There are "holes" in the magnetic field at the north and South Pole letting the particles to strike the Earth's atmosphere. When this happens the tenuous upper regions can become excited and glow a ghostly light that we see as an aurora.

Edwin Hubble - Galactic Explorer

Edwin Hubble was an American astronomer whose studies into the nature of galaxies completely redefined our understanding of the Universe, its size and our place in it.

After leaving the military in 1919, Hubble signed on with the Mt. Wilson observatory in Southern California and soon focussed his attention on the beautiful world of spiral "nebula." Spirals were thought to have been swirling disks of gas and dust in the process of forming solar systems much like our own. By using the new 100 inch Mt. Wilson telescope, the largest in the world at that time, Hubble was able to show that the clouds of gas in the Andromeda galaxy, M31, were actually clouds of *individual stars*! So many in fact that this object might possibly be outside of the Milky Way. Further studies showed that he was right, and the M31 was probably a lot like our own galaxy, millions of light years away. This knowledge showed that the Universe was far larger than previously thought. Hubble also classified the galaxies into their spiral, elliptical and irregular categories still in use today. (However, even up to the 1970's the Andromeda Galaxy was still referred to as the "Great Nebula in Andromeda").

He went on to develop the theory that the Universe is expanding, apparently away from a single point in space eventually leading the the Big Bang theory of the Universe's creation.   His "Hubble's Constant" that describes the rate of expansion is still the subject of much debate, the age and size of the Universe hinge on the final resolution.

Hubble's importance to cosmology cannot be underestimated. It is no wonder that the space telescope was so blessed with his name.

Viewing the Young Moon

The Moon is "young" when it is at its early phases right after it is new. The first appearance of the Moon is important to traditional Jewish and Muslim calendars which are lunar based rather than solar based, and hence determine the dates of various holy days and events.

One of the great and most fun challenges of visual astronomy is trying to find the Moon as early after new as possible. You will be doing extremely well if you find it younger than 24 hours. The naked eye record is currently set at around 14 hours by two housemaids during World War I, while one observer with a telescope found it at only 13 hours past new.

Viewing the young moon depends on may factors : the separation of the Moon from the Sun, the weather (even a slight haze can obscure this most fragile of objects), and whether the Moon is at its closest or furthest point of the orbit. If it is at perigee, the closest it will be travelling somewhat faster and therefore would be slightly further from the Sun for a given time. Also the best time of year is late spring through early fall while the angle of the ecliptic is fairly steep for the northern hemisphere, hence the sky will darken a bit faster then in the winter.

You can use First Light to exactly determine the time of new Moon and from that compare it to the time of the next moonset. If that takes place anywhere after the Moon is 12 hours old, you just might have a chance to see it. Make sure that the horizon is clear of any obstructions, that the air is clean and that you know *exactly* where to look.

You can also do the same with the very old Moon, in this case you will have to get up right before sunrise if the Moon is only a day or so away from being new.

How old is the Moon right now? When will the next young Moon be visible?

A Season for Eclipses

A solar eclipse is caused as the Moon passes in between the Earth and the Sun at the exact moment it is "new". If that is the case, why then don't we get an eclipse every time the Moon is new? That's because its orbit is tilted slightly to that of the Earth's. Twice each lunar month, the Moon will cut across the plane of the Earth's orbit at what are called "nodes". Only when these nodes take place at the times of the new of full Moon eclipses can happen, otherwise it will be either too slightly high or low for the exact alignment needed.

So how do the nodes get into alignment? First the nodes themselves are fixed in space. As the Earth-Moon system moves around the Sun, changing the position of the Sun, a node crossing that was out of alignment months before will in effect "move" into position. So, twice each year eclipses are possible in what is called an "eclipse season" which last about two weeks. If the node crossing happens right at either a new or full Moon (called "syzygy") three eclipses are possible. One solar and two lunar or two solar and one lunar. Now to further complicate this, the nodes are not truly fixed, but are slowly rotating about 18 degrees a year. This shortens the time between seasons a few days so on rare occasions it is possible to have a portion of a third season during the year and catch one more eclipse. So up to seven eclipses are possible in a single year such as as the case in 1973.

A full rotation of the nodes takes about 18 years and afterwards the whole eclipse pattern repeats. This is called a "saros". But since the Earth will be rotated, different areas on the Earth will see the eclipses.

November

November 1 : Pisces, the Fishes
November 2 : A Season for Eclipses
November 3 : Meteor Shower - S Taruids
November 4 : The Lovely Mira
November 5 : The Universe is Big
November 6 : Celestial Navigation
November 7 : Project - Jupiter from the Galileo Probe
November 8 : Absolute Magnitude
November 9 : Craters on the Earth! Next on Oprah!
November 10 : Light Distances
November 11 : Tycho's Star
November 12 : Voyager 1 at Saturn
November 13 : Machina Electrica
November 14 : Apollo 12 - Second Lunar Landing
November 15 : Project - Dimensions of the Sky
November 16 : Mercury
November 17 : Observing the Sky - What to Bring?
November 18 : Meteor Shower - The Leonids
November 19 : Pegasus - The Winged Horse
November 20 : Pegasus - The Great Square
November 21 : Pegasus - M15
November 22 : White Dwarfs vs. Red Giants
November 23 : Vesta - The Sixth Planet?
November 24 : Andromeda
November 25 : M31
November 26 : Project - Make Your Own Galaxy
November 27 : Planets - gas giants vs. stony
November 28 : Mariner 4
November 29 : Hunt'n for Comets
November 30 : Phoenix

Pisces, the Fishes

It is now the beginning of November and we are well into fall. The leaves by now have likely left their homes, providing the Earth with a soft brown carpet and piles for playful children. The ground is moist with the November rains and Pisces reaches its high point in the early evening.

One of the dimmest constellations, Pisces represents two fish tied together with a cord around their tails, .

The two fish are said to have saved the goddess Aphrodite and her son Eros from the repellent creature Typhon. Typhon in turn was unleashed on the gods by the Mother Earth in a last ditch effort to defeat them during a struggle for control. While cowering in the river Euphrates, Aphrodite called for help and was surprised when two fish came to her rescue. Clutching on to her son, the two fled from the monster riding on their backs. The meaning of the cord is unknown. Because of the setting in the Euphrates, this is probably a Babylonian constellation and most likely, the cord was a holdover from earlier traditions.

While a larger constellation, it has few interesting objects, since it lies far from the plane of the galaxy and away from the concentration of objects. There are some nice double stars, visible in binoculars. Rho Piscium should be visible as two fifth magnitude stars. Also Zeta Piscium is a good object for even the smallest telescopes, with magnitudes of 4.2 and 5.3 and exhibit the colors "yellowish and pale lilac".

Step on out and see if you can find the fish tonight swimming through their celestial ocean.

Meteor Shower - Leonids

This shower is legendary for producing some of the greatest showers in history.
Associated with Comet Tempel-Tuttle, showers in 1867, 1868 and 1883 hit rates of 10,000/hour. The morning of November 17,1966, produced the greatest recorded shower with rates estimated at 150,000/hour! (The author of this program slept through it, and has regretted it since). Look for another peak in 1999 when the comet returns.

The Leonids are so-called because the meteors come from the direction of the constellation of Leo (although they can appear in most any part of the sky).

see also : Meteor Showers

Meteor Shower - S Taruids

Tonight should be the peak for the S. Taurids meteor shower. The Taurids are leftover stuff from Comet Encke, and while few in number they produce many fireballs. This shower was one of the greatest in the 11th century, but has slowly declined since then. The meteors are quite slow, usually less than 18 miles/sec and currently number about 15 an hour.

See also meteor showers.

Meteor Showers

Meteors are small solid particles in orbit around the Sun and, in many cases, believed to be debris left by passing comets. For this reason meteors tend to be grouped together in comet-like orbits and often have been linked to known comets. It is when the Earth passes through one of these streams that a meteor shower occurs as the particles burn up in our atmosphere. On any night, the average observer should be able to see about five stray meteors per hour. The typical shower will generally triple that rate while the best ones (such as the Persieds of August and Geminids in December) may have 50 or more.

The distribution of meteors along their orbits is not uniform. Therefore, what may have been a bland shower one year might be a memorable event the next. The most notable one of this sort is the Leonids of November. Usually they produce about 15 or 20 streak an hour. But early one morning in November 1966, along the western coast of the United States, rates approaching *one-hundred fifty-thousand* per hour were reported. This was a repeat of the famous 1833 shower which prompted one 19th century writer to exclaim : "Never did rain fall much thicker than the meteors fell to the Earth. . .".

Occasionally, meteors the size of small rocks will join the fray, producing what is called a fireball. The bigger ones may be seen to break apart forming two or more fiery trails. The biggest of these might survive their entry and strike the Earth. These meteors are then called meteorites. The 4000 foot wide Barranger Crater in Arizona is a dramatic example of this.

The names of the showers are derived from the area of the sky from which the meteors appear to radiate (hence the name radiant), like spokes in a wheel. Therefore todays shower, the Lyrids would appear to be coming from the summer constellation of Lyra which is currently low in the east during the evening.

The best time to observe a shower is after about 2:00 AM local time until dawn. Since the meteors can appear in any part of the sky, a telescope or pair of binoculars would only hinder the viewing.

The date of the peak will fluctuate a day or so, meaning you may want to call up the astronomy department of your local college and find out the best time for observing. A moonless night is also recommended for a bright Moon will both destroy your night vision and wash out the dimmer meteors.

The Lovely Mira

Mira ("the Wonderful"), located in the constellation of Cetus, is one of those kinds of stars called "variables". Variables disturb ones comforting notion of the "constant and stable" Universe. Variable stars do as their name implies : they vary their brightness. This can happen in two main ways : by either being eclipsed by a dimmer star, or by some physical process that changes the light output.

The eclipsing variety have very steady output most of the time, but suffer sharp declines in brightness for short periods. This is as one would expect since the darker body will cover the brighter for only comparatively brief moments. The others are usually much longer and somewhat irregular in their changes. Mira was the first and the brightest of these "long period" variable stars and one of the most dramatic. It peaks out above fourth magnitude, sometimes attaining a fairly bright second (brighter than Polaris), but then plummets down to a pitiful ninth magnitude or less. This is a total luminosity change of over 250 times! The period averages 331 days but that to can also change.

Over 4000 "Mira like" stars have been found and are known for having tremendous ranges, periods extending from 60 up to 700 days, the variations are somewhat irregular and all of the stars are red giants.

The reasons for the pulses are not quite clear, but as the star changes from one phase to another, it is in effect "sputtering" as it runs out of one type of fuel (hydrogen) before it is able to start burning the next kind (helium).

Variable star observing is one of those specialties in amateur astronomy in which hobbyists prove a boon to the professionals. Since time on the large telescopes around the world is precious and costly, it is foolhardy to use them for the more time consuming but necessary tasks of long term observations. Observations which may be done with small telescopes, ideal for amateurs. There is no other hobby in the world in which the participants and the professionals work so closely together.

Click here and First Light will center Mira for you. And if it is clear, why not try and find it for yourself. See if it might be at maximum. If not try observing it week after week. Is it changing? Is it getting brighter or dimmer?

red giant :
Older stars, with diameters 10 to 500 times that of the Sun. Most stars become red giants as they start to run out of fuel. Altair and Antares are splendid examples, their ruddy colors clearly visible to the naked eye.

The Universe is Big

In his book *Hitchhiker's Guide to the Galaxy*, author Douglas Adams sums up the Universe this way :

Space is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is. I mean, you may think it's a long way down the road to the [pharmacy], but that's just peanuts to space.

And so it is. Consider a light beam travelling at 186,000 miles a second leaving the surface of the Sun when your morning alarm- clock rings. It is 6:00 am, Monday, April 20, 1995. By the time you've finally just started to consider rolling out of the sack at 6:08 the beam is sweeping through the orbit of the Earth as it heads outward bound toward the edge of the solar system. After you're done showering, and ready to sit down to a bowl of Rice Krispies it's 6:41, and Jupiter will be catching sight of the ray. It'll be midmorning, 11:12, when it sweeps past the orbit of Pluto (and you thought that you had a busy morning!). But it won't be until the following Saturday afternoon, 5 1/2 days later, when the beam finally reaches the hypothesized halo of comets, the Oort Cloud, said to surround the Solar System. At this point the light leaves the Solar system, but is only just beginning its long journey beyond infinity.

Now you won't have to bother thinking about the ray until the very beginning of the, next millennium, 2000. However after all this waiting, it has only reached the nearest star next to the Sun, Proxima Centauri. In 2001 it reaches Barnard's Star, followed by tiny Wolf 359 just in time for the 2002 presidential elections. By 2006 it will be racing by Tau Cetii with a full 20 stars left behind in its wake. In the following year it will overcome BD5-1668, L725-32, Kapteyn's Star and Kruger 60A. Taking a backward glance, the Sun itself would appear as a rather bland yellowish star slowly receding into the galactic darkness.

Jump to the end of the next century, your great-great-grandchildren will be alive as the light passes beyond the likes of Sharatan, Hamal, Algol and Aldebaran. Likewise it will have overtaken Regulus, Talitha, Miaplacidus and Arcturus.

In 2219, the Sun's light would just be reaching the open cluster The Pleiades in the constellation of Taurus. The Starship Enterprise is just beginning its five year journey into television history. But even after all of this, our journey is still just beginning.

Now in your imagination leave this age behind. Leave everything you've ever done, or known behind. Leave your CD collection behind. Were the beam directed toward the constellation of Sagittarius it would be headed to the center of our galaxy the Milky Way. However it won't reach this point until about the year 32,000 AD. Yet there is still another 50,000 years before the ray can exit the other side of the galaxy. When it does, it will be leaving over *100 billion* stars behind. Yet this galaxy is an unremarkable one of unremarkable size with many, many others beyond. And yet the journey is still beginning.

By 200,000 AD the beam will be passing by the Magellanic Clouds in the constellation Tucana, satellite galaxies to our own. And after this is nothing, nothing for the next 1.8 million years. Back on Earth, we would see the Sun as somewhat larger turning a reddish hue as it begins the process of burning out. But now, looming ahead is the Andromeda galaxy, our "sister" galaxy and a member of the local group. Looking back toward the Milky Way, you would see a view similar to what the Andromeda galaxy looks like on a fall evening : a fuzzy elliptical patch. Another couple of million years will finally see this beam escaping our corner of the Universe, travelling out to the open regions of space. Douglas Adams said it was big.

Now advance again, not another few million years, but a full 20 billion years from the present. The light beam from the Sun has at last reached the edge of the known Universe. If the solar system still exists it'll likely be a rather cold and uninviting place, the Sun having burned itself out 15 billion years previously. Out here, what the beam would encounter is a giant unknown. Long ago however scientists were able to see some objects they said were out here, quasars. But these too remain a mystery as do so many other things.

****

One of the amazing things in the Universe is the range of both times and distances. For instance, in the above example we dealt with distances measured in trillions times trillions of miles. Yet, at the same time, some of the most interesting objects such as black holes or neutron stars may measure only 5 to 10 miles in diameter. Or we commonly measure stellar processes in terms of millions of years. Yet there are stars, pulsars, which flash 30 times a second!

As you can see, the Universe has no shortage of variety. It is my hope, that First Light will serve to introduce you to this variety, and perhaps encourage you to explore further on your own.

Celestial Navigation

Besides being friends to lovers or scientific curiosities, the stars serve a very useful purpose to travelers of the sea. The first recorded use of the stars for navigation was in 34 AD, when it was discovered that the altitude of Polaris could tell a person's latitude. However it would be about 1400 years before celestial navigation really matured with the invention of the compass, "quadrant" and other various devices.

As before the latitude could be determined from the pole star, Polaris. If you were in the southern hemisphere where Polaris was invisible, you could use the length of the Sun's shadow at noon instead. While the latitude was a no-brainer, it was deemed close to impossible to tell the person's longitude, as there were no fixed points of reference. As ship traffic around the world increased in the 16th century, this problem was raised to such urgency that several countries offered up large prizes to whoever could solve it.

Finally by the 1700s technology and science progressed far enough to make two of the methods practical. Both required knowing the exact time based on the universal "Greenwich Mean Time" standard. By comparing this world time with the local time it was possible to figure out the longitude. The further away from Greenwich, England, the greater difference in the two times, hence the greater difference in longitude.

The first method used the distance of the Moon from known stars. Since that value would not change as you moved, this was a good basic standard of measurement and was listed in charts at three hour intervals. The "sextant" was created for this "lunar distance" method. The other technique was popularized as the accuracy of clocks increased. Ship's clocks would be synchronized with the Greenwich clock and would loose only a few seconds a week, making lunar sightings unnecessary to get the correct time. Even then, lunar distance charts were produced up to the beginning of the 1900s.

In 1837 another method was discovered quite by accident by Thomas Sumner. He noted that there is an imaginary line across the ocean such that the altitude of an object above the horizon will be the same no matter where you were on that line. That is, there are a number of locations in which the star Vega, for example, could be viewed by many observers at, say, 30 degrees above the horizon at the same time. But a single observation doesn't help because you would still have a bunch of possible locations. However if you take a sighting on a second object at the same time and calculate the "position line" for it and plot it on a map along with the first, the line will cross at your current location. That is because there is only one spot on the entire Earth that will see both objects at those particular altitudes a that exact time. In algebra this would be "solving two equations for two unknowns" (latitude and longitude).

This basic method lasted until the advent navigational satellites in the 1960's. Nowadays, handheld navigational computers using the "GPS" series of satellites are so small and cheap even cars are being outfitted with them. And their accuracy is so great that they can be linked to interactive streetmaps to show you exactly where you are or what would be the shortest way to get to your destination. Sure beats drawing lines on a map.

Project - Jupiter from the Galileo Probe

Project. . .

In the cold lonely depths of space tonight, sailing toward the golden gas giant of Jupiter is the space probe Galileo.

Launched in 1989 the Galileo probe encounters its target in December of 1995. Galileo is the largest, most complicated interplanetary spacecraft ever flown. Originally it was meant to be launched in 1986 onboard the space shuttle. Using a powerful new booster rocket it would have sped on its way to Jupiter taking only about three years where it would then spend 18 months in orbit, making close up observations and taking hundreds of thousands of pictures. However due to the Challenger accident, the new booster was deemed too dangerous to launch onboard the shuttle so a lower powered substitute was used instead. And now instead of taking a direct route to the planet, Galileo was required to spend twice as much time in its journey. Over a period of six years it would have to "steal" a little bit of extra energy from other planets to sling it on out to Jupiter using the well proven "gravitational assist" technique. So now instead of three years in space, it would require six years taking a torturous path that would spin it by Venus once and Earth twice.

Click here and use First Light to observe the path of Galileo over the past several years. This first view shows where it is right now (if you are reading this after orbital insertion on December 7, 1995, it will not appear until you change the date back to before December 7). Move back to the launch date of October 18, 1989 and use the fast-forward button on the toolbar to advance the spacecraft. Notice how it swings around Earth and Venus and gains a little bit of speed each time. As Galileo approaches Jupiter, see how it is actually "in front" of the planet, but goes slower so Jupiter can catch up with it.

Reset the time back to *now* and click here . You should see Jupiter centered in the middle of the screen. Your eyepoint is now placed on the spacecraft, and you are actually seeing Jupiter as Galileo would *at this very moment*!

Now go back to Earth and see where the probe is up in your night sky, .

With less than a month before encounter (December 7), you may want to keep track of this every night and see as the planet grows in size.

Absolute Magnitude

A star's brightness or magnitude is based on a number of factors: what kind of star it is and how much interstellar stuff (dust) is in the way dimming its light, size, age and distance. That is why astronomers call the brightness that we see "apparerent magnitude". However, this is a rather meaningless value. What is more useful is the "absolute magnitude," or the brightness it would shine if placed at a known distance of about 32 light years.

The ten brightest stars by apparent magnitude after the Sun are as follows :

name	apparent magnitude	distance (light years)	constellation
Sun	-27.4	0.00002	---
Sirius	-1.46	8.70	Canis Major
Canopus	-0.72	117.36	Carina
Alpha Centauri	-0.29	4.35	Centaurus
Arcturus	-0.06	35.00	Bootes
Vega	0.04	26.30	Lyra
Capella	0.08	45.60	Auriga
Rigel	0.14	815.00	Orion
Procyon	0.37	11.40	Canis Minor
Achernar	0.48	127.14	Eridanus
Hadar	0.60	391.20	Centaurus

Compare this to the ten brightest stars by absolute magnitude:

name	absolute magnitude	distance (light years)	constellation
S Doradus	-9.4	180,000	Large Magellanic Cloud
Deneb	-7.3	1630	Cygnus
Wezen	-7.1	1956	Canis Major
Epsilon Aurigae	-7.0	3200	Auriga
Kappa Orionis	-7.0	2100	Orion
Zeta Puppis	-7.0	2300	Puppis
Rigel	-6.9	815	Orion
Epsilon Orionis	-6.8	1530	Orion
Zeta Orionis	-6.7	1600	Orion
c Puppis	-6.3	???	Puppis
Sun	4.8	.00002	---

Notice that there is only one star, Rigel, that shows up on both lists, not counting the Sun of course. Interesting, no?

absolute magnitude :
The brightness a star would shine if placed at a known distance of about 32 light years. Our Sun would be a fairly bland fifth magnitude object (barely visible to the naked eye), while the most brilliant star known, S Doradus, would be -9.4.

Craters on the Earth!

If you have spent any time watching the Moon through binoculars or a small telescope, you are no doubt familiar with the rough craggy, raw, crater-strewn surface. You have probably wondered about its horrific past and wondered why the Earth doesn't look like that, "Where are *OUR* craters?" you've no doubt asked.

Well, relax Impact Breath. The Earth did in fact go through much of the same treatment that the Moon did. But over the aeons the Earth's dramatic weather and continental drift has gone a long way to erase and erode the evidence of its early history. And, yes, there are craters on the Earth, some pretty big ones too.

The main era of heavy cratering was from 4.6 to 3.9 billion years ago by debris left over from planetary formation. However, there was still enough pieces of stuff to create quite a ruckus over the next three billion years or so, and not all of it hit the Moon.

The size of a crater is based on the mass, speed and size of the meteor. But as a rule of thumb, you can assume the impact power of an object is equal to about 100 times its weight in TNT. A 12 mile in diameter crater would require a blast equivalent to 60,000 megatons of TNT, or three million times the size of the Hiroshima bomb.

For craters about a mile or less, the meteor itself is would be vaporized and mixed with the local material so as to become unrecognizable. At 38 of the North American impact sites, only three have had confirmed meter debris.

The most clearly evident crater, the one that really LOOKS like one, is the Barringer Meteor Crater in Arizona. Lying on a plain between Flagstaff and Winslow Arizona, Barringer's is pretty paltry compared to the whoppers on the Moon. But its unmistakably round shape and raised rim make it a dramatic sight. The crater is about 4000 feet in diameter, 600 feet deep and is thought to be about 50,000 years old. The object that created it was likely a 240,000 ton, 250 foot diameter iron asteroid that smote the ground at about 10 miles per second.

Larger meteorites, say in the 1/2 mile size would penetrate the ground for about two miles, resulting in an explosion that would generate internal temperatures of *36,000 degrees*, six times that of the Sun's surface! It would vaporize everything for a mile, melt everything to 1 1/2 miles, and dig a hole 14 miles across and 1 1/2 miles in depth. The shock wave and resulting earthquakes would shatter cities and towns for hundreds of miles around. The Ries Basin in Germany is an ancient crater from just such an object.

Arthur C. Clarke speaks of possible large impacts so well in his classic book *Rendezvous with Rama*, when in the opening chapters he describes the potential of a stray object striking the Earth. In Rama the Earth of the future establishes an organization called SPACEGUARD so as to predict such an event. Recently, scientists created a real life SPACEGUARD (named after the organization in the book) in order to discover and track potentially dangerous asteroids, and, if possible, destroy or deflect them preventing impact.

While most asteroids stay in their place, snuggly between the orbits of Mars and Jupiter, a few do venture in closer to the Sun, giving rise to the fears that someday we may in fact witness a collision. At the time of this writing, only about 30 of these "Apollo" type asteroids are known. It is estimated that major events nowadays are going to be extremely rare. Impacts like the one described above are likely to happen at the rate of one for every 7 1/2 million years. So don't hold your breath.

Most of the other craters on Earth are now usually somewhat round lakes, bays or subtle depressions, visible only from the air. There is Clearwater Lake in Quebec, 14 miles across, Lake St. Martin, Manitoba, 15 miles across, or Steen River, Alberta, now buried 600 feet below the ground. Part of Hudson Bay is also thought to have been the result of a massive impact hundreds of millions of years ago.

Light Distances

This is a fun "imaginary experiment just to give you a feel for the size of space. If the Moon is up this evening, step outside and aim a flashlight at it. Blink the light and count two seconds ("1001, 1002"). At slightly over two seconds that beam arrives at the Moon. Chances are you won't notice anything, nor would anyone on the surface (although in 1967 the Surveyor spacecraft on the lunar surface photographed a laser as seen from the Earth).

Using First Light, find Saturn which should be high in the sky at this time of the year and blink your light at it. This time go back inside, watch a Star Trek rerun and come back out in an hour and 15 minutes. Your photons have just struck the ringed planet.

Now find the star Aldeberan in Taurus, and flash your light one more time in its direction. This time go back inside and wait about, oh say, 62 years. . . .

Well, you get the idea.

Tycho's Star

Tycho Brahe was one of the preeminent astronomers of the pre-telescope era. On this date in 1572, he wrote in his journal :

> *"...I was contemplating the stars in a clear sky...I noticed that a new and unusual star, surpassing the other stars in brilliancy, was shining almost directly above my head; and since I had, from boyhood, known all the stars of the heavens perfectly, it was quite evident to me that there had never been a star in that place in the sky...I was so astonished at this sight that I am not ashamed to doubt the trustworthiness of my own eyes...A miracle indeed, one that has never been previously seen before our time, in any age since the beginning of the world."*

What Tycho had just been witnessed to was one of the rarest of celestial events : A supernova in our own galaxy. A supernova is the destructive explosion of a star, one of the most spectacular and most cataclysmic events in the Universe (aside from the marriage of Michael Jackson). A star is often in delicate balance between its own force of gravity and the pressure caused by the heated gasses. If this pressure is increased (caused usually as it begins to burn out) it can increase its size from that of our Sun to that of the entire solar system in only a *day or two*. It will shine brilliantly for a few weeks, often visible in daylight, then collapse back on itself to finally die a slow and invisible death.

Supernova are frequently seen in other galaxies, usually once or twice a year. In some cases this single star will *outshine* its entire galaxy of *100 billion stars* for a few days. During this millennium, only three supernova have been seen in the Milky Way. One in 1054, Tycho's star in 1572 and Kepler's star in 1604. But Tycho's is thought to have been the most brilliant.

Located in the constellation Cassiopeia, , the nova must have been a ravishing site hitting a maximum brightness of -4 magnitude for about two weeks. Brighter than even Venus at its most brilliant, Tycho's star would have been visible in daylight and probably could have cast a shadow at night. However, by the third week it began to fade and changed colors from white, to yellow, and eventually to red. 16 months after the first explosion it faded from sight never to be seen again.

Try as they might, astronomers have yet to locate the remnant of the star, which would likely be a white dwarf slowly dying out, although they have spotted some very faint gases in the region.

It is estimated that the star was about 10,000 light years away, extremely far for a single star to be seen. Therefore at its most brilliant it would have outshown the Sun by 300 million times and have had an absolute magnitude of -16.5!

It is now thought that the heavier elements in the Universe were created and distributed by such explosions. This debris is then scattered about, to some day form into new planets and new life. So as astronomer Carl Sagan is so fond of saying "We are quite literally made out of 'star stuffffffff'".

Voyager 1 at Saturn

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\voyager.sbm}Saturn was the second domino to fall in the wondrous odyssey of the Voyager 1. Launched in 1977, encountering Jupiter in 1979, the spindly little spacecraft that could had been going at it for four years now.

On this date in 1980 the alluring ringed planet loomed ahead suspended in space like a delicate jeweled bauble, frozen in time, .

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\saturn3.sbm}Slightly smaller than Jupiter, Saturn is no doubt the most visually striking planet. Its rings described as "ears" by early astronomers, are perhaps the most intriguing objects in the solar system. Until the accidental discovery of the Uranian ring system in 1977, Saturn was the only known ringed planet. Now we know that all four of the gas giants, Saturn, Uranus, Jupiter and Neptune have ring systems. But only Saturn's is visible from Earth.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\spokes.sbm}One of the enigmas of Saturn's rings were the mysterious "spokes", . It was later determined that they were caused from extremely fine dust caught inbetween the larger particles. Saturn's magnetic field apparently then distorts the dust plane and gave scientists a lot to talk about over lunch.

{ewl ewdll.dll,ewBitmap,ew_bmps\saturn\rhea2.sbm}Saturn's incredibly complex system of moons came under very close scrutiny, . Looking like a miniature model of the solar system, several of the moons were examined up close. There was tiny Mimas nickednamed the "Death Star" due to its uncanny resemblance to the superweapon from Star Wars, and Calypso, most likely a captured asteroid. There was the heavily cratered Dione, and the rocky Enceladus.

After wildly snapping pictures like a tourist with only a single afternoon in San Jose, Voyager sailed on by, sweeping below the rings and whipped around the back of the planet like a person at the end of a conga line. The massive gravity of Saturn then shot it up above the plane of the solar system out into the deep void of space forever.

You can use First Light to investigate the Voyager 1 flyby. Use the planets/flyby feature and compare it to the Voyager 2 flyby that took place about 9 months later. In that, the planet was used to send the spacecraft on toward a future rendezvous with Uranus in 1986 followed by Neptune in 1989.

When done, exit flyby and click here, . What you are now seeing is the entire solar system as seen from the Voyager 1 at *this very moment*.

Machina Electrica - The Electrical Machine

How many constellations are there? Currently there are a total of 88. However, this has not always been the case. The classic Greek based constellations number only 48, and these include those of the Zodiac for instance, or Orion, Canis Major, Hercules and so on. . .for the most part mythological beasts and heroes of old. However in the mid-18th and 19th centuries numbers of over zealous astronomers and celestial mapmakers introduced "new" constellations in order honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient patterns. While one astronomer would try and popularize one of his own, a competitor would ignore him and add *his* own. And as such the skies are littered with odds and ends of constellations that once were. Most of these are rather small and uninteresting.

Forty of the new ones have been officially recognized and remain to this day on the charts. These bits of celestial flotsam include such noteworthy spectacles as Caelum, the chisel, Circinus the compasses, Fornax the furnace and Horologium the pendulum clock. Few have with any interesting objects, and all are rather dim. However there are many more of these that never made it in to regular use or were absorbed by larger neighbors. One such grouping is Machina Electrica, in honor of that new miracle of modern technology : Electricity. The constellation depicts an electrostatic generator and leyden jar which were popular devices for scientific entertainers. It was added by Johannes Bode in 1801 and was located between Sculptor and Fornax, .

Apollo 12 -   J

Apollo 12 - Nov. 14 to 24, 1969

On this date in 1969, man lifted off toward his second lunar landing. While Apollo 11, four months earlier, had completed President Kennedy's challenge, it could still be considered a "test flight" as were all previous ones. The idea was simply to land on the Moon and return to Earth. That's all. The moonwalk was so brief as to almost have been an afterthought. But now the Apollo hardware was proven from liftoff to splashdown. And Apollo 12 would really put it to work.

At first it seemed as if Apollo 12 would end almost as soon as it had begun. The NASA launch officials approved liftoff even though the Cape was in the middle of a wet Florida thunderstorm. To postpone liftoff would cost millions of dollars and risk damage to the equipment during the extended stay on the launch pad, not to mention the fact that President Nixon was attending, the first time ever for a sitting president. So at 11:22, through very marginal weather, Pete Conrad, Dick Gordon and Alan Bean sailed on what they hoped would be a 10 day mission to the Ocean of Storms. But only 36 seconds after liftoff, the mighty Saturn 5 rocket had become a giant 365 foot tall lightning rod, and was hit not once but twice by two sharp bolts. For a brief while the spacecraft lost all power, but the rocket was safe and the mission continued. While in Earth orbit, the crew managed to reset the systems, check everything out and head on toward the Moon.

{ewl ewdll.dll,ewBitmap,ew_bmps\moon\surveyor.sbm}Apollo 12 would be different than 11 by having two long moonwalks instead of a single short one, and by perfecting the "pinpoint" landing technique. It had been thought impossible that the Apollo could ever land exactly where the planners wanted it. Apollo 11 overshot their landing area by several miles. There were just too many little unknowns, but thanks to some navigational trickery, Apollo 12 settled down within mere feet of their quarry: the 2 1/2 year old unmanned Surveyor III spacecraft.

The mission was highly successful except for one annoying mishap. After the Apollo 11, called the "greatest week since creation" by President Nixon, NASA was criticized for giving their moon walkers a chintzy little black and white TV camera for the moonwalk, one of the most historic events of all time. But this time, Apollo 12 would be in living color. However, after only 45 minutes into the moonwalk, Bean moved the camera out to a tripod placed away from the lander. And in the process he aimed the camera right at the low, brilliant Sun burning out the image tube and rendering it useless. We would have to wait another 1 1/2 years before we were able to once again see live TV from the lunar surface. After realizing that the current television technology really wasn't suited for the harsh conditions on the Moon, NASA started a crash program to develop a new kind of camera that could not be burned out. This knowledge worked its way into the commercial market, eliminating one of the great weaknesses inherent in TV technology.

Meanwhile, the two astronauts sampled the soil, placed a sophisticated experiments package out on the surface and clipped off parts of the Surveyor to return them to Earth for study. Ten days later they returned to the gentle blue waters of the Earth, showing the world that Apollo 11 wasn't a fluke or dumb luck.

Pete Conrad would fly once more as the commander of the United State's first space station, Skylab 1. His partner would command the second such mission, Skylab 2, both in 1974. While Conrad would leave the space program to go into private industry, Bean would retire to take up his other passion in life : painting. And through the years his tremendous skills as an artist would permit him to recreate his experience on the Moon on the canvas with such grace and beauty that his originals would eventually easily command $30,000 or more.

Click here to see the Moon on the night Bean and Conrad landed. Notice that the landing site is right on the lunar terminator. The lighting was always very critical to ensure that the rough areas would cast long enough shadows, making them visible from high altitudes.

Boston Tea Party, 1773
Project. . .

On this night in 1773 a band of angry Bostonians, poorly disguised as Indians, slipped onto three ships in the Boston harbor. Here in protest of Britain's Tea Act from that previous May, which was misinterpreted as forcing the colonists to drink taxed tea from a monopoly, the Bostonians dumped 342 chests of tea overboard. In retaliation, the British parliament passed "The Intolerable Acts" against Massachusetts in 1774, which further fueled the colonies resentment over foreign rule. Other colonies came to their defense, 9 months later in the Continental Congress of 1774, and denounced the British rule, calling for virtual independence of America.

One of the most famous paintings of this event showed a gibbous moon hanging low in the sky. Why don't you see if the artist was correct? How much light did the Moon provide for the colonists?

Dimensions of the Sky
Project. . .

When one says that something is one degree wide or, "12 minutes across" in the sky, what does that actually mean? It is easy to think of things as mere pinpoints of light, if they have to be seen through a telescope, but many distant objects in the sky are actually quite large.

Use First Light to center the Pleiades star cluster, , one of the larger objects in the heavens. When you look at the Pleiades, you are looking at "one degree."

Now center the Moon. When full, it stretches across "only" 1/2 degree of the sky or about the width of your thumb held at arms length. But even then it still looks pretty big. Many deep-sky objects : nebula, galaxies, etc, stretch across areas of the sky big enough to cover significant areas even when even compared to the Moon.

Angles less than a degree are usually expressed in "minutes" and "seconds". There are 60 minutes to a degree and 60 seconds to a minute

Look for Jupiter. With the naked eye it would look like a large dot of light, but it is actually about 30 seconds wide, 1/60th of the Moons visual diameter and the size of the some of the Moons larger craters. You can almost imagine Jupiter up against the Moon by spotting some of its craters with your eyes. It is not going to be much smaller than the ones you see.

Orion should be rising in the later hours. Locate the famous Orion Nebula. As a distant "deep sky" object, it should be quite small shouldn't it? Wrong. It is 65 minutes across, over twice the size of the full Moon. Now image if your eyes had the light gathering power of a telescope, but could still see the full vista they normally could. What a truly amazing sight it would be! Floating in the sea of stars like a delicate flower in a pond you would see this massive fiery red cloud of gas, a stellar nursery, twice the width of your thumb held at arms length.

Now check out the Andromeda galaxy, the furthest thing you can see with the unaided eye. It reaches almost five full degrees across, the width of your entire fist and then some. If only our eyes could truly be opened, and see the skies for what they really are : *"a beautiful see of light, with glories all around"*.

Mercury

In Roman mythology, fleet-footed Mercury was the messenger to the gods.   No name would be more appropriate for the swift moving glimmer of light hovering close to the Sun.

{ewl ewdll.dll,ewBitmap,ew_bmps\mercury\mercury1.sbm}Besides being the closest and hottest planet in the solar system, Mercury is one of the most dense, second smallest and least known. Only a single spacecraft has visited Mercury, the Mariner 10, in 1974 when it flew within a mere 430 miles of the planet's night side.

This image is a composite of 18 images each taken 42 seconds apart.

Mercury swings around the Sun at only 35 million miles away. At a diameter of 3000 miles it is a little larger than the Moon but not by much. A Mercurian day is equal to 58 Earth days, and a year, slightly longer at 88 Earth days.

Due to its proximity to the Sun, the tiny planet is elusive to say the least, for Earth based observers, as it ventures no further than 27 degrees from the Sun. As with Venus, Mercury can be seen as either an "evening" or "morning" star, but rarely is it far enough away from Mr. Sun to be seen in anything but twilight.

{ewl ewdll.dll,ewBitmap,ew_bmps\mercury\cal_basi.sbm}Since there is no atmosphere to hold in the heat or equalize the temperatures, Mercury is truly a hellish world. Its sunlit side can reach a toasty 630 degrees F (but it's a dry heat), while the night side dips down to -346 degrees.

Mercury is also a very heavy world, made up of 70% iron with the rest silica rock similar to Earth or the Moon.

At one time, the thought that there was another planet still closer to the Sun was used to explain some odd motions in Mercury's orbit. This hypothetical planet was called "Vulcan" (yup, Vulcan), but was discredited when Einstein's Theory of Relativity in one stroke of a pen, explained the discrepancies.

Using First Light find out the next time Mercury will be visible and take a look for it yourself.

Click here  and First Light will take you out to see this fascinating little world. The blank spots in the map are areas that were out of range for the Mariner 10 spacecraft.

White Dwarfs vs. Red Giants

Stars are merely balls of gas, very hot gas usually formed from clouds of hydrogen and helium. Many of these clouds are still with us today and visible as nebula. The Orion Nebula is one of the finest examples of these {ewl ewdll.dll,ewBitmap,ew_bmps\dso\m42.sbm}and has often been called a "stellar nursery" giving birth to many dozens of stars. Over time a cloud of gas may collapse on itself due to its own gravity. As it does tremendous heat is generated which may reach up to *10 million degrees*. This will in turn increase the pressure pushing out and will at some point stabilize the mass into a hot glowing sphere, a new star.

As the star begins to exhaust its hydrogen fuel it will begin to increase in size and brightness. At this point the surface temperature has dropped to half and its size has increased up to 100 times that of the Sun. The cooler surface will in turn give the star a distinctive reddish color and the increased surface area will serve to increase its brightness up to a thousand times. Our star is now a "red giant", much like Antares or Arcturus. Finally when all of the hydrogen is burned it will begin to collapse once again, generating more heat than ever before. This will cause the remaining helium to fuse into carbon atoms releasing even greater amounts of energy. When The helium begins to burn it happens so fast, in a matter of days, it is called the "helium flash". Having to adjust to the new energy source the star expands again, becoming so big this time that its outer layers just keep on going out into space forming an ever increasing shell of gas. From Earth we see these shells as planetary nebula. The inner core remains, a tiny hot star called a white dwarf.

Red giants and white dwarfs represent two extremes in the world of stars. While a red giant can easily be hundreds of millions of miles across, white dwarfs are typically the size of Earth or smaller. No white dwarves are visible with the unaided eye, and few are visible in amateur telescopes. "Van Maanen's Star" in Pisces is one such animal. Located at about 2 degrees south of Delta Piscium it reluctantly "shines" at a feeble magnitude 14 about the same brightness as Pluto, even though it is one of the closest stars known. Its diameter of 7800 miles it one of the smallest stars visible. However with a mass similar to the Sun, a single cubic inch would weigh *20 tons!*

Now look for Aldeberan, over in Taurus, and a red giant. Aldebaran ("the Follower"), is the 13th brightest star in the sky. The star has from earliest days been called "The Eye of the Bull" (Taurus), which makes its distinctive reddish color more significant. The star itself is about 68 times the luminosity of the Sun, and 40 times its diameter or 32 million miles.

If you want to go to further extremes you will find "red supergiants" the largest and most luminous stars known and "neutron stars" the smallest. Supergiants like the summer's, Antares, are the largest stars known, estimated to be 700 times the size of our Sun. If placed in the center of the solar system, Antares would reach beyond the orbit of Jupiter! Whereas neutron stars are typically the final remnant of a supernova, which having collapsed so tightly on itself, it in effect becomes a single atomic nucleus measuring only six miles in diameter! Its density is so great a single teaspoon full would be, well, really really REALLY heavy (on the order of a *1000 million tons*).

So as you can see, the Universe is a most diverse and interesting place to live. Personally, I wouldn't want to live anywhere else.

Observing the Sky - What to Bring?

By now if First Light has been doing its job, you have probably gone out to do some first-hand observing. There are a number of things that you should bring to make your evening more comfortable. First, have something to sit in or on. A simple beach chair is about the best. And don't forget some blankets to keep you warm along with a sweater and jacket. Flashlights with red cellophane taped of the front, and star charts from First Light would be helpful. Tote along a radio to keep you company, along with tapes of some of your favorite music.

("Appropriate" works would include Gustav Holtz's "The Planets", Bach's "Brandenburg Concertos", or some Wagnerian opera. Creepy, but good, is the soundtrack to the movie *2001-A Space Odyssey*, or you might also pick up the soundtracks to *Star Trek, Babylon 5, X-Files, Space Rangers* or any other science fiction show.)

If you are in the south, remember the bug spray. A descent pair of binoculars, say 7x50s at least for just sweeping across the star fields, and a pad and pencil. Don't forget some munches. Popcorn works really good. And remember the thermos for coffee, hot chocolate or tea.

The best times to observe are Moonless nights, which represent about two weeks out of the month. And try to get away from city lights. A city or town can wash out the dimmest 50% of the stars, preventing you from ever really seeing the eternal pageant playing out above your head. Be prepared for awe.

Pegasus - The Winged Horse

One of the largest constellations in the fall skies is the mighty Pegasus, the Winged Horse, . You can see him gliding higher and higher as the days grow shorter. The main body of Pegasus is outlined in the "Great Square", four brilliant stars forming a window opened to the heavens. The Winged Horse came forth from the dead body of Medusa and was found by Bellerophon a brave mortal prone to adventurous exploits. On one such occasion he used Pegasus to fly him up above the Earth to Mount Olympus the home of the gods. However Bellerophon fell off and back to Earth before he reached the home of Zeus, but Pegasus went on without him. Zeus took the horse as his own and made him a carrier of thunder and lightning, later placing him among the stars as one of the greatest of constellations.

As with Taurus, Pegasus is only partly shown, and upside-down at that. Possibly in the dim past, Pegasus was subdivided into several other constellations because he was just too large.

The four stars of the great Square are named Scheat (for "upper leg"), Algenib ("the wing"), Markab ("the saddle"), and Alpha Andromedae (an interloper borrowed from the neighboring constellation of Andromeda).

Despite is large size, Pegasus has few objects of interest to amateur astronomers. The only deep-sky object of any note is M15, one of the brightest globular clusters in the sky and a fine binocular object.

Pegasus - The Great Square

Soaring high in the skies of mid-fall is the winged horse Pegasus, . One of the most recognizable features in the sky is the asterism known as Great Square, which forms the main body of this stellar steed.

The four stars of the great Square are named Scheat (for "upper leg"), Algenib ("the wing"), Markab ("the saddle"), and Alpha Andromedae (an interloper borrowed from the neighboring constellation of Andromeda). Originally Alpha Andromedae was actually shared with Pegasus and called "Delta Pegasi" in older star atlases, but it ownership is now officially with Andromeda.

The Square is novel not only for its strong geometric form, but also for its close resemblance to a grid square on a star atlas, since it is almost exactly 15 degrees on a side.

Think of the Great Square as a "window" into the Universe, for within its four giant stars is a microcosm of the entire sky. The corners are themselves between 71 and 480 lights years distant. Now take up your binoculars and look out through the window. You are looking out below the plane of the galaxy into the deep vastness of space. With binoculars you should see hundreds of stars, or thousands with a small telescope. Scattered about are several galaxies, tens of millions of light years distant. Further out yet near Algenib the lower left star, is the quasar 3C9 one of the most energetic and enigmatic objects in the heavens.

Using the two stars on the left of the Square you can also locate the Vernal Equinox, that special point in the sky where the Sun crosses from the southern to the northern hemisphere, heralding the start of spring. Mentally draw a line through the stars Alpha Andromedae and Algenib below it. Extend The line about equal to the distance between the stars, and that will be the point of the Equinox.

M15 - A Fine Globular

{ewr ewdll.dll,ewBitmap,ew_bmps\dso\m15.sbm}Tonight go back to the constellation Pegasus where you will find M15,   one of the brightest globular clusters in the sky and a fine binocular object, . Compact M15 is known for its brilliant and slightly oblate central core. Compared to others, this has a rather large number of variable stars, numbering well over 100. Out on the edge a small planetary nebula was discovered in 1927. M15 is also a source of X-rays which may indicate that a supernova was once housed within its borders.

With a magnitude of 6.3, M15 might just be visible to your unaided eye on the darkest of nights. If you have the good fortune of being out in the country see if you can make it out yourself, it should be quite a challenge. M15 is a little more than 1/3rd the width of the full Moon. Chances are you will only be able to see the brighter central core as a small ghostly "star", the outer halo or fringe of stars will only be visible in a telescope. Typically the human eye can see no dimmer than magnitude 6.5 although some have reported seeing stars down to 7.0. So M15 peaks just above visibility and should provide a good point of reference to just how sensitive your eyes are.

When you find M15 you are looking back in time, 42,000 years in the past. The cluster is about 130 light years across.

Vesta - The Sixth Planet?

The asteroid Vesta was the fourth discovered. It is the brightest of the known asteroids, visible to the naked eye on rare occasion. Found in 1807 it is estimated to be slightly over 300 miles in diameter and orbits the Sun between the orbits of Mars and Jupiter.

{ewl ewdll.dll,ewBitmap,ew_bmps\ast_etc\vesta.bmp}

Vesta is the most geologically diverse of the large asteroids and the only known one with distinctive light and dark areas -- much like the face of our Moon. Previous ground-based observations of Vesta show regions that are "basaltic", which means lava flows once occurred on its surface. This is surprising evidence that the asteroid once had a molten interior, like Earth does.

One possibility is that Vesta was formed from smaller material that includes radioactive debris that was incorporated into the core. This radioactive "shrapnel" probably came from a nearby supernova explosion. (In fact a supernova might have triggered the birth of our solar system.) This hot isotope may have melted the core, causing the asteroid to differentiate: heavier, dense material sank to the center while lighter rock rose to the surface. This is a common structure for the terrestrial planets. After Vesta's formation, molten rock flowed onto the asteroid's surface. This happened more than four billion years ago. The surface has remained unchanged since then, except for occasional meteoroid impacts.

One or more large impacts tore away some of the crust exposing a deeper mantle of olivine, which is believed to constitute most of the Earth's mantle. Some of the pieces knocked off Vesta have fallen to Earth as meteorites, which show a similar spectral fingerprint to Vesta's surface composition.

Astronomers will not have to wait for a NASA expedition to Vesta in order to examine it close up, as nature has already handed us a sample at no extra charge.

{ewl ewdll.dll,ewBitmap,ew_bmps\ast_etc\vestamet.bmp}In October 1960, two fence workers in Millbillillie, Western Australia, observed a fireball heading toward the ground, and pieces of the fallen meteorite were found ten years later. The fragments stood out from the area's reddish sandy soil because they had a shiny black fusion crust, produced by their fiery entry through Earth's atmosphere.

Unlike most other meteorites, this sample can be traced to its parent body, the asteroid Vesta. The meteorite's chemical identity points to Vesta because it has the same unique pyroxene spectral signature. Pyroxine is common in lava flows, meaning that the meteorite was created in an ancient lava flow on Vesta's surface. The structure of the meteorite's mineral grains also indicates it was molten and then cooled. The isotopes (oxygen atoms with varying number of neutrons) in the specimen are unlike the isotopes found for all other rocks of the Earth, Moon and most other meteorites.

The meteorite also has the same pyroxene signature as other small asteroids, recently discovered near Vesta, that are considered chips blasted off Vesta's surface. This debris extends all the way to an escape hatch region in the asteroid belt called the Kirkwood gap. This region is swept free of asteroids because Jupiter's gravitational pull removes material from the main belt and hurls it onto a new orbit that crosses Earth's path around the Sun.

The Australian meteorite probably followed this route to Earth. It was torn off Vesta's surface as part of a larger fragment. Other collisions broke apart the parent fragment and threw pieces toward the Kirkwood gap, and onto a collision course toward Earth. Meteorites found in other locations on Earth are probably from Vesta too. At the time of the observation Vesta was 156 million miles (252 million km) from Earth.

Andromeda

Next to Pegasus the Winged Horse is Andromeda, who was the love of Perseus and daughter of vainglorious Cassiopeia, . Andromeda had the misfortune to be sent as a human sacrifice to Cetus the sea monster by her own father ("thanks Dad!"). This was an effort to atone for the boastings of his wife, her mother, Cassiopeia.   But along happened Perseus, one of the greatest of the Greek heroes, who first politely asked for Andromeda to be his bride, then killed Cetus with an almost bored ease.

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m31.sbm}For our last stop this evening, swing on over to Andromeda. where you will find the most glorious of all deep-sky objects : M31, the Great Galaxy, . At two million light years distant, it is regarded as the furthest thing visible to the unaided eye and is frequently called a sister galaxy to our own. Easily witnessed as a fuzzy elongated patch 4 degrees long (8 times the diameter of the full Moon), it is one of the most famous objects in our sky. Imagine now being on a planet in M31, gazing up one evening, and you would likely see our home as a fuzzy patch looking much the same.

When you find the galaxy, hold out your hand and cover it up. You have just hidden an estimated 300 *billion* stars and is nearly 200,000 light years across making it one of the largest galaxies known. The whole mass slowly rotates around the central hub. The core takes about 11 million years for a rotation, while the outer arms take 90 million years or more. There is a small satellite galaxy, M32, which orbits M31 similar to our own Magellanic Clouds visible in the southern hemisphere.

Project - Make Your Own Galaxy

Project. . .

supplies : hot chocolate, cake sprinkles, milk

In this project you will make a simple "spiral" type of galaxy.

There are three kinds of galaxies : Spiral, elliptical and irregular.

The spiral galaxies are those carrying the classical vortex or whirlpool shape. The have a bright central region of older stars and a disk of gas a newer stars orbiting around. Spirals are typically 100,000 light years in diameter and 2000 light years thick. Spirals are then subclassed as to the shape of the bulge, number of arms and so on.

Elliptical galaxies have no strong disk but still maintain a rounded form made up mainly of older stars with no dust clouds at all. Their sizes can go all the way from a whopping 300,000 light years (three times the Milky Way) in diameter down to a relatively puny 100 light years, not much different than a globular cluster.

The third class, irregular galaxies, are usually smaller than spirals and have no discernible form at all. They contain both young and old stars. The Small Magellanic cloud in the southern skies is an example of this kind. Irregular galaxies may form that way, or may be other kinds disturbed by either an explosive core or disruption by nearby galaxies.

Spiral galaxies are created by the normal tendency of matter to spiral into the center of gravity.

In order to make a spiral, take the cup of hot chocolate and stir it up. While it is still spinning around pour in some of the milk and watch the pattern that it makes. Think of this as the galactic gas. Now as the chocolate is still spinning, drop in some of the "stars" (cake sprinkles) and observe their pattern.

When done, feel free to drink your galaxy, share and enjoy!

M31 - The Great Galaxy

{ewl ewdll.dll,ewBitmap,ew_bmps\dso\m31.sbm}This evening you are going to travel millions of mile out into the depths of space. Our stop? The great Andromeda Galaxy, . This is clearly one of the most glorious and resplendent of all deep-sky objects.   At 2 million light years distant its regarded as the furthest thing visible to the unaided eye and is frequently called a sister galaxy to our own. Easily witnessed as a fuzzy elongated patch 4 degrees long (8 times the diameter of the full Moon), it is one of the most famous objects in our sky. Now take a few minutes and imagine being on a planet in M31, gazing up one evening, and you would likely see our home as a ghostly elongated patch high above in the alien skies.

When you find the galaxy, hold out your hand and cover it up. You have just hidden an estimated 300 *billion* stars and is nearly 200,000 light years across making it one of the largest galaxies known. The whole mass slowly rotates around the central hub, the core takes about 11 million years while the outer arms 90 million years or more. There is a small satellite galaxy, M32 which orbits M31 similar to our own Magellanic Clouds visible in the southern hemisphere.

M31 was the first object positively identified as being located outside the Milky Way. Previously the Universe was thought not to extend beyond our own Galaxy, and the galaxies where felt to be disk shaped clouds of gas, possibly in the process of forming a new solar system like our own. This discovery in 1926 complete redefined our understanding of the Universe, its size and our place in it.

Remember, as bright as these objects are their light is still very delicate so you will still need to have a moonless night and away from city lights. But if you can arrange that, be prepared for some sublime and glorious sites.

see also Kinds of Galaxies

Planets - Gas Giants vs. Stony Planets

There are two main kinds of planets in the solar system : The gas giants and the rocky variety. Jupiter, Saturn, Uranus and Neptune comprise the "gas giant" family. All large, all primarily balls of, well, gas. Much like small stars that were never quite large enough to ignite. The rocky planets are Mercury, Venus, Earth, Mars and Pluto. Earth is the largest of the rocks at about 8000 miles in diameter, while Neptune is the smallest of the giants at 30,000 miles across.

The planets come as a byproduct of star formation from the leftovers and start out as small balls of gas and rocks themselves. Close to the parent star the heat is so strong as to evaporate the gases and volatile material leaving an inner belt of rocky planets. Further away where it is cooler the planets can acquire and keep their early gaseous envelopes giving us planets like Jupiter and Saturn. Going out to the very edge in the deepest regions of the system the gases will freeze to ice giving us comets. If a gaseous planets is large enough its gravity will collapse the shroud of gas with such force as to cause an internal heating that could eventually lead to the stellar fires. You would then have "double star" system which are quite common. Many have said that had Jupiter been a little larger it too would have formed into a star shining like a brilliant diamond in the black the of night.

All of this means that other solar systems probably resemble our own : the small planets near the star, large ones further out, and a halo of comets shielding the entire region.

Hunt'n for Comets

One of the wonderful things about astronomy is that there is no other science in which the hobbyist can make significant contributions. Armies of amateurs are typically enlisted to do the time consuming observations that must be done but would be a foolish waste of time on large expensive telescopes.

One such aspect is that of comet hunting. Hunting for these elusive icy interlopers from the outer reaches of the solar system is at once one of the most tedious but one of the most rewarding tasks of all.

Most comets are "non-periodic", that is once they fly by the Sun and head on outward, they are gone forever. And most comets are not visible to the naked eye as compared to Comet West, Bennett or Halley which are rarities. But if you should discover a bright comet that is visible you will no doubt go down into astronomy myth and legend. Bands of amateurs will genuflect toward you chanting "We're not worthy! We're not worthy!"

The big trouble with comet hunting is that is requires much discipline. The rule of thumb is that each comet takes about *1000 hours* of dedicated sky scanning before discovery. For someone who has a life, this might translate to at best an hour or two a day and a few on the weekend when the Moon isn't visible, yielding perhaps three years or more of constant searching.

So, how is it done?

Big telescopes aren't necessary, only small to moderate sized instruments with low power eyepieces. Some use tiny three inch reflectors that can see large regions of the sky, but might miss the dimmer comets. A larger eight inch model will see far dimmer objects, but might take five times longer since the field-of-view is so much more narrow.

Observe only when the Moon is well below the horizon, and then from the country far away from the city lights.

Comets can come from any direction in the sky, so there is no preferred location to hunt in. Using First Light and some star charts you can probably work out a regular program based on your time schedule and what directions are favorable to your location.

When you finally get down to work, it means sweeping slowly back and forth in slow gentle movements, slightly overlapping each observed strip of the sky. Top comet hunters say that keeping a rigorous daily schedule is absolutely necessary. It is a lot better to hunt one or two hours a day than 10 hours in a stretch. Over the months and years you should become very familiar with the skies, knowing just where the various galaxies and star clusters reside so a strange object is immediately apparent. New comets will typically be faint smudges of light, possibly with a slight tail.

If you think you've found one, take careful notes and look for it the next day. If it is a comet it would have moved a fraction of a degree. Compare with currently known comets to make sure you didn't "discover" someone elses. Information on new discoveries or recovered comets are sent out regularly by the International Astronomical Union (IAU). (Write them at the Smithsonian Astrophysical Observatory, Cambridge, MA 02138 for more information).

If you have to report you will be instructed to send the exact positional data to the IAU, and if you are one of the lucky few the new comet will be named after you. Should there be multiple discoverers, it will be given up to three names such as "Comet Oprah-Uma-Dave". So just maybe you might in a small way be immortalized in the heavens along with the likes of Andromeda, Orion or the asteroid Elvis.

Mariner 4 - First Look and Another World

The Mariner series of spacecraft ranks as one NASA's many early success stories and was the United States second venture out beyond the orbit of Earth. On this date in 1964 the Mariner 4 spacecraft was lofted toward the distant red planet, Mars.

Mariner 4 would be man's first successful mission to Mars. The 320 million mile journey took only eight months using the star Canopus for interplanetary navigation. The spacecraft could not carry any onboard booster engine to place it into Mars orbit, so the mission was merely to flyby Mars, snap a few pictures and sail on into orbit around the Sun where it will remain for the better part of eternity.

The Mariner had a crude black and white television camera on board. It would return a picture that was only 200 x 200 dots (pixels) on a side. By comparison the computer display you are looking at right now is probably 800x600 pixels resolution or greater.

Around midnight on July 25, 1965 the Mariner began its brief 26 minute picture taking session, storing the images on 270 feet of magnetic tape. Over the next few days the images were slowly sent back to the Earth, one dot at a time taking about *8 hours each* to be received and reconstructed over the next few days.

So slow was the process that engineers set up a handmade wall-sized "image" that was a giant grid similar to the camera's video tube. As each value for each pixel came it, they would fill in one of the grid squares with the proper value of gray, displaying the image as it was received instead of having to wait for the sluggish automatic processor to do its job.

The first pictures were rather dark, but by image 11, the scarred and heavily cratered surface faded into view and mankind had his first ever, closeup look at the face of another world. The view showed a large crater, now called Cimmerium, with newer smaller craters encircling it. Possible ground haze was seen rimming the ancient basin.

As primitive as they were this first fuzzy images increased our sum total knowledge of Mars in one gigantic leap, and became one of those sharp moments where our concept of the Universe took a sudden, near instantaneous change in direction.

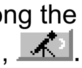
The Mariner program continued. The fifth probe in the series snuggled up to Venus in 1968, while Mariner's 6 and 7 repeated the Mars flyby but with much better cameras sending back not 21, but over 3100 high quality pictures. Mariner 8 exploded on liftoff, but the ninth spacecraft returned to Mars and spent over a year in orbit. Mariner 10 was the last in the series, giving us the first ever closeup look at the enigmatic little planet Mercury.

The legacy of Mariner would lead eventually to NASA's crowning glory in interplanetary ventures : Voyager 1 and II, which would reveal the secrets of the solar system's largest worlds.

Phoenix

Phoenix is one of the "modern" constellations added to star atlases in the 16th century by two Dutch navigators, Pieter Keyser and Frederick de Houtman. The two also gave us the constellations of Apus, Chameleon, Dorado, Grus, Hydrus, Indus, Musca, Pavo, Triangulum Australe, Tucana and Volans. The far southern skies were unknown by the Greeks, so were devoid of any classic constellations.

The phoenix was a symbol of the rising and setting of the Sun in Greek mythology. It was a strikingly beautiful bird with a plumage of red and gold and a 500 year lifespan. At the end of its life it would construct a funeral pyre on which it would lay down and be consumed by fire. Out of its ashes a new phoenix would rise and continue the cycle for the next half millenium.

To viewers in the northern hemisphere, Phoenix is seen just barely skipping along the southern horizon, although it is one of the brighter constellations so should not be too hard to find, . Try it for yourself!

Reddest Star in the Sky

As moderately large stars grow old, they become what is called a "red giant", expanding to hundreds of times the size of our own Sun and cooling down at the same time to achieve the ruddy red color. The dim star "U Camelopardalis" has earned the honors as the "reddest" known star in the sky. Probably a supergiant, fluctuating its size as it attempts to burn off of the last of its fuel, the star is about 1,600 light years away. U Camelopardalis is a variable star that travels from magnitudes 7.7 on down to 9.5 over a period of 412 days.

Seeing this object will probably need a telescope, although it might be visible in a high power set of binoculars. Use First Light and locate the star "SAO 12874". Notice that it is the rightmost star in a small arc about 1 degree across. Immediately below this star by about 1/2 degree you will find U Camelopardalis. It color ought to give it away.

Triangulum, the Triangle

Triangulum is one of the smallest constellations in the northern fall skies, . Nudging up against the larger and brightest Andromeda, this tiny grouping is frequently ignored for its more prominent neighbors. In Greek mythology, Triangulum is felt to have represented the island of Sicily which explains an earlier name of "Sicilia". Sicily had one time been called Trinacria and was the home town of the goddess of agriculture, Ceres. On January 1, 1801 the very first asteroid was discovered here, and was therefore named Ceres.

The two brightest stars are both third magnitude and fairly close to the Sun. Alpha Trianguli is 64 light years away, and Beta Trianguli about 110 years distant. The light you see tonight from Beta left at the time the Grover Cleveland becomes the 22nd president, the Boston Pops symphony was born, and the "safety cycle", the first modern bicycle, is introduced to replace the dangerous penny-farthing bikes.

Even though it is small, Triangulum does play host to one significant deep-sky object : M33, the Pinwheel Galaxy. M33 is the third largest galaxy in our local group, with the Milky Way and M31 larger. M31, the Great Andromeda Galaxy had for a long time been considered the only naked eye galaxy in the northern skies. However some have reported seeing M33 when the conditions are just right. If you live out in the country and have a clear moonless sky tonight you might want to try it for yourself. It is about the width of two firsts held at arm's length below M31 which itself should be clearly evident. M33 is not much further out, but has its face toward us so the light is spread out and therefore dimmer whereas M31 is nearly edge on concentrating the light much more. You will probably have to use averted vision, that is, you won't be able to see looking straight on, but only out of the corner of your eye which is somewhat more sensitive to dim objects. Its overall size is twice that of the full moon, about a thumb width across, but you should only be able to see the brighter central core. And if you do find it! Congratulations! Its magnitude of 6.5 puts it right at the very edge of visibility so it is quite a catch. And if you can't? Well, feel free to cheat with your binoculars. I won't tell.

averted vision :
A technique used to see fainter objects. The central part of the eye is less sensitive that the corners. Therefore you might not be able to see dimmer targets straight on, but only by looking slightly to the side.

M52 - A Nice Little Open Cluster

Located in a fertile region of the Milky Way you will find M52, a nice little open cluster, . Tonight, step outside and find Cassiopeia. Draw a line from the star Alpha, through Beta and extend it the length equal to the distances between the two stars. It will end right where M52 hangs out.

Through binoculars you should see a small grouping of a few stars surrounded by a fuzzy glow. The fuzz represents more stars which come into view with a telescope, for about 200 total. It is estimated to be over 5000 light years away and 10 -15 light years across.

M52 was discovered by Charles Messier in 1774 while he was searching for comets.

open cluster:
A loose cluster of stars, containing from a dozen to several hundreds of members or more. The Pleiades is a fine example.

6,000,000,000 AD

Tonight we are going to jump into the future. Not to the next millennium or the next 10,000 years, but instead *6 billion* years from now.

Current estimates place the Earth at about 4.5 to 5 billion years old. So at 6 billion AD our fair little planet will be more than twice this age, and looking every bit of it. The Sun is currently at the "main sequence" phase, the comfortably long period in which a star is powered by hydrogen and stays extrememly stable. But as the hydrogen begins to burn out, the Sun will slowly move into the red giant phase of its existence. It will grow redder and cooler and larger, increasing its size by over 20 times. In the year 6 billion, the Sun will reach out more than halfway to the planet Mercury.

Step outside and look up into the sky. Hold your fist at arm's length and imagine the Sun spanning twice that size. That is how big it will appear in the the year 6 billion.

Even though it is cooler the larger surface area will radiate 300 times more energy, enough to sear the surfaces of Mercury, Venus and the Earth. A future weather report might have the summer's high hitting over 1200 degrees. By now all water would have evaporated and blasted away into space, leaving a severe parched rock where once orchestras played Beethoven, Humpback whales sang their mournful songs, and Barry Bonds hit over 40 homers in a season.

While the inner planets are dying, the moons of the outer planets are now witnessing their very first summers. Out at Jupiter, the majority of the moons have substantial amounts of water permanently locked up in ice. As the Sun now grows, the glaciers begin to thaw, water starts to drip and pool at their bases, and lakes begin to form. Atmospheres will appear that might briefly turn these tiny bodies into miniature Earths. And in time, 6 billion years from now, a light spring's breeze might kiss the surface of a brand new ocean on the moon Europa.

As the hydrogen wanes, the Sun will experience the "helium flash", a near instantaneous (1 or 2 *day*) collapse driving up the temperatures high enough so that the helium can now ignite. The overall luminosity drops to about 1/16th of the red giant phase as the Sun shrinks, but it gets hotter and bluer and stays this way for about 100 million years.

When the helium burns, carbon forms at the core and the star begins to grow once again, quickly surpassing its previous size. Soon the Sun's surface will reach the planet Mercury, devouring it andmaking it "one with itself". Next in line is Venus, and possibly the Earth. All remnants of mankind's sojourn on the formerly blue planet will finally be vaporized. Although some say the planet may still survive, it will exist just barely as a real-life hell. Over the billions of years, the Sun will loose a significant mass, causing the Earth to increase its orbit just a bit. So we might still be slightly out of range of the red monster's grasp.

As the Sun increases its diameter to 100 million miles, its brightness will likewise increase as before. It is now a red supergiant. Mars will have a molten surface, and even the likes of Neptune's moon Triton, the coldest body yet, will have balmy summer-like temperatures. Both Triton and the distant mysterious Pluto will probably be the last refuges of liquid water.

Another phenomenon to occur involves the ever-expanding shell of dust thrown off by the Sun. This dust will envelop the entire solar system, and when illuminated by the intense solar light it will softly glow with a continuous twilight blue. This means that *night itself would have been consumed*.

By the year 7 billion, as the Sun casts off its remaining layers, the tiny hot central core will finally be unveiled. This is the white dwarf stage. Our once large and friendly star is now a tiny body no larger than the Earth with a density of over 10 tons per cubic inch. Like a dying ember in a flickering campfire it will slowly cool and become a dead black body encircled by a residue of small rocky objects drifting ceaselessly in their lazy orbits for as long as time shall last. Their frozen lifeless surfaces illuminated only by the light of distant suns.

Meteor Shower - Orionids

Tonight should be the peak of the Orionid meteor shower. The exact date and time of the peak varies from year to year, so if you are going to do some observing you might want to check with your local college's astronomy department for the exact times.

The Orionids are believed to be the other side of the stream which produces the eta Aquarids in May. Better for observers in low latitudes or in the southern hemisphere, this shower produces fast meteors (40 miles/sec). About 20% leave trails. While the rate is stated to be 25/hour but can vary between 10 and 70.

The Orionids are so-called because the meteors come from the direction of the constellation of Orion (although they can appear in most any part of the sky).

see also : Meteor Showers

Magellanic Clouds

Named in honor of Ferdinand Magellan, the two Magellanic Clouds resemble detached portions of the Milky Way. But they are galaxies in their own right, and the closest ones to our own. They are so close as to be considered satellite objects, orbiting in a massive, lazy circles taking tens of millions of years to loop around through space. Unfortunately, the clouds are too far in the southern skies to be seen by observers in North America.

Estimated to be about 200,000 light years away, the Large Magellanic Cloud (LMC) in Dorado is about 50,000 light years across (half of the Milky Way), and the Small Magellanic Cloud (SMC) is about 30,000 light years and located in the constellation Tucana.

The clouds are classified as irregular galaxies (as compared to the spiral and elliptical types), due to their formless nature. However there seems to be the faint beginnings of long streaming arms spanning out from the center of the LMC suggest that it is a spiral galaxy actually in the very beginning of formation.

The total mass of the LMC is about 1/10th that of the Milky Way, and it glows with the light of two billion Suns, although it is thought to have over *25 billion* individual stars.

The LMC is home to some of the most brilliant stars known. S Doradus is the king of the luminosity hill, with an estimated absolute magnitude of -9.4, over 6 times greater than the next brightest known, (Deneb in Cygnus) and over *500,000 times* the luminostiy of the Sun! At magnitude 8.9 it is bright enough to be clearly visible in small telescopes. Were the Sun at that distance it would be a pathetic 24th magnitude object, barely visible to the Space Telescope. *Inconceivable!!*

Because these are full fledged galaxies, they have their share of star clusters and nebula alike. Over 700 open clusters have been found in the LMC along with 60 globular clusters and 450 nebula. It is one of these nebula which is the largest known example in the Universe. Rising head and shoulder above all others is the Tarantula Nebula, a gargantuan cloud of dust and stars which dwarfs to insignificance any other such object. Visible to the naked eye, where this placed where the Orion nebula is it would span 1/6th of the entire sky and registering such glory as to outshine the planet Venus. The Tarantula is some 800 light years across as compared to the now puny Orion nebula at only 30 light years.

Nothing comparable has been found in the Milky Way, although some nearby galaxies have similar objects, none are quite the magnitude of the Tarantula.

NGC1528 - Open Cluster in Perseus

Turn your attention toward the constellation Perseus this evening. About a degree away from Lambda Persei is the open cluster NGC1528, . At a magnitude 6.4 it is barely visible to the naked eye but through binoculars it should appear as a fuzzy ball of light about the size of the full Moon with a couple of stars. In a telescope, up to 50 stars become visible.

NGC1528 is about 2600 light years distant.

Naming of the Stars

Each star has a bewildering number of different names and identifiers. First there are the proper names, such as Rigel, Antares or Chort. While the constellations come form Greek traditions most star names are Arabic. During the 15th and 16th centuries as the first modern star charts were being created, the stars were given Greek letter identifiers based on their brightness. The brightest is called Alpha, (the first letter of the Greek alphabet), the next brightest is Beta, and so on. The letter is then followed by a Latinised form of the constellation name. So the brightest star in Orion is "Alpha Orionis". But this method would work for only a couple of dozen objects, so obviously more generalized forms of identification were needed.

There are several different general catalogs in use today. The Henry Draper catalog was introduced in 1924 and contained 225,300 stars down to eighth magnitude. The stars are identified by "HD" followed by a serial number, and was the first catalog to identify the stars by spectral types (colors). Star comment files are keyed in to the HD numbers, so if you want to add in your own comments, create a file name with the HD number followed by ".cmt". For example, a comment for HD2001 would be in a file named "2001.cmt".

In 1966 the Smithsonian Astrophysical Observatory (SAO) published a slightly larger catalog containing 259,000 stars down to nineth magnitude.

Beyond that, stars are broken up into various catalogs according to type. Variable stars have their own, while x-ray stars have another, while super-giants will have a third catalog.

Project - Satellite Observing

Project. . .

supplies : a clear dark night, tape player, lawn chair and a blanket, some satellites

When the Soviet Union launched the first satellite into Earth orbit in 1957, the whole world cowered in fear as they could see Sputnik 1 sailing high overhead.   Looking like a tiny star, it would ever so silently drift across the sky from east to west in a matter of a few minutes. (For all they knew it could have been some devious weapon that could be dropped on their heads without a moment's warning!)

Few realize that Earth satellites are quite visible from the ground, depending on the time and lighting conditions. The Space Shuttle with its gleaming white exterior is a very bright object indeed. In the project you will look for satellites yourself, all you need is a little bit of time.

This works best on a moonless night, so if the Moon is anywhere near full, wait a few days and try again.

First, find a position where you can observe a large part of the sky without obstruction. The best time is about an hour after sundown, ensuring that the spacecraft will still be visible in sunlight even though you are in darkness. Now adjust your glasses, turn on some music and stare out into the black void of space. In about 20 minutes your eyes will adjust and the full vista of the heavens will be unveiled. Let your eyes jump from star to star, from constellation to constellation, and imagine what it must have been like as ancient peoples gazed upon the very same sights. And as your mind begins to wander, you will notice out of the corner of you eye, something moved! One of the stars moved!

A typical satellite will be about second magnitude, fairly bright, but not enough to require sunglasses. Some will be very steady, others will rise and fall in brightness as they tumble. These are probably spent rocket stages, cosmic litter, rolling end over end their usefulness over long ago. Most satellites will go from west to east and will be seen to vanish as they enter the Earth's shadow. Some will go from north to south (or vice-versa). These are polar orbiting spacecraft, typically used for weather and spy satellites. Transit time for a low orbiting spacecraft is about 7 minutes maximum.

Once you know what to look for you will be able to spot them every few minutes with very little effort. In one hour at Yosemite, I saw about 20, two or three at the same time.

When you find one, imagine being onboard watching the clouds drift underneath. Over in the west the Sun will rapidly set enveloping you into a cold darkness. But as your eyes adjust the great landscape of the Earth glows, teeming with city lights spread out like a blanket underneath, or silent lightning storms dancing around far below. A thin delicate layer of the atmosphere is always visible, and if you look close, you might see a meteor burning up *below* you. And above you the stars shine steadily on, no twinkling here as there are no air currents to disturb their ancient light.

Astrology

From time to time when I tell people that I write astronomy software they reply : "Oh really? Well, I'm a Libra, what can you tell me about myself?". Then I must patiently respond through clenched teeth "no, Astronomy, not astrology!".

Astrology is called "the oldest science". The use of "science" is open to debate, but it did precede astronomy probably by thousands of years and served to make man aware of the stars and planetary motions. Astrology is the belief that the alignment of stars and planets at your time of birth dictates your various character traits. These alignments occurred in the zodiac, a narrow band of the sky in which the Sun, Moon and Planets can all be found. There are 12 (actually 13) constellations that make up the zodiac and are probably among the most ancient of all.

But why should that be? An astrologer might justify it by saying it has to do with the combined gravitational effects of the various planets on you at birth. But the doctor who delivered you exerted much more gravity than Mars did.

Why do the planets influence a person at birth anyway? Why not at conception? Is there something magical about the mother's body that shields a person from astrological rays? If so, theoretically the mother could completely surround the newborn infant by several people for a day or two if the planets were not favorable at the actual time of birth. So if you are an "Aries" you are now actually a Pisces, and if you're a "Taurus", congratulations! You are now an Aries!

And why do astrologers never deal with the planets Pluto, Neptune or Uranus? They would certainly have more influence on a person than Mercury. Ahhhh, but they didn't know about them before the invention of the telescope.

Since astrology and the myriads of complicated tables and charts were developed thousands of years ago, the positions of things have changed in the skies. Through a process called precession, the Earth has been wobbling like a child's top. This changes the positions of the constellations in the sky. The ancient astrologers did not know that, so are not their conclusions wrong for the current era?

Not only that, but there is also a 13th zodiacal constellation unaccounted for. For the planets actually spend more time in the constellation of Ophiuchus, more so than in the neighboring Scorpius. And since the constellations are not uniform the Sun spends more days in some and fewer days in others, so how can the signs be so precisely subdivided so each is a month?

Astrologers offer no scientific foundation for their beliefs. Science is the study of cause and effect. Astrology states an "effect", but is unable to make a credible case about the "cause". Why should a random arrange of rocks in space specify if you are going to be "lucky in love" today? Look at astrology as entertainment, and entertainment only. But after all, I am a Pisces, and Pisces don't believe in astrology.

What Makes a Year?

When an astronomer friend tells you that he or she is so many years old, ask them exactly what kind of year they are talking about. For there are at least five different kinds to be concerned with.

First is the anomalistic year. The is the exact time it takes for the Earth to go from one perihelion to the next. The perihelion is the closest point in the Earth's orbit to the Sun, since the orbit is not exactly circular. And since the orbit itself rotates very slowly, the position in space of the perihelion moves bit by bit, an anomalistic year is the longest one of all, at 365.259641 days.

Next comes the sidereal year. This is the time it takes for the Earth to make a single revolution relative to the fixed stars. It comes about 283 seconds less than the anomalistic year, or 365.256365 days.

Now comes the calendar year, the one we are all familiar with. This is usually 365 days, except on leap years where it is extended to 366 days.

And don't forget the tropical year. This is the exact period that the Sun requires to "move" completely around the sky to end up at the same point, at 365.2422 days. The .2422 extra days or about 6 hours is made up by the leap day every four years.

The final kind is the Besselian year, which is the same length as the tropical year, but begins when the Sun is exactly at a right ascension of 18h 40m.

Calendars of the Ages

We are all used to the calendar on the wall, but over the years there have been many various calendars scattered throughout the ages. Most peoples attempted to divide the year into 12 segments based on the Moon's orbit, ("a lunar month") while at the same time marking years based on the Sun's position. Since neither of them are related to each other elaborate means were created to synchronize the two together, leading to eventual confusion many years or centuries down the road.

The ancient Chinese calendar was made up of 60 periods, each being 60 days in length. Beginning in the seventh century BC, the calendar was based on the position of Jupiter during its 12 year sojourn through the zodiac, one of the few not to use the Sun or Moon.

Over in India 3500 years ago, the year was divided up into 12 months, each 30 days long. But this gave a year of only 360 days. Every five years an "intercalary" month was added of 30 days in length giving an average yearly length of 366 days.

In ancient Mesopotamia, the Sumerians had "years" that were six lunar cycles long, or slightly less than six months. The year was eventually made 12 months long but was still short by 11 days. It was then synchronized to the time of harvest. But as time went on, the crops would eventually be ready in the "wrong" month, so the year would be readjusted with a short intercalary month. The days would begin at midnight, and were divided into 24 hours : 12 in the morning, 12 in the evening.

The old Jewish calendar is one of the most complicated of all, based first not on a calculated value for the Moon, but on the time the Moon is first sighted at the start of each month which would lead to a one day error. Finally, by around 900 AD, this was removed in favor of calculated lunar cycles, but still the times of the new year and length of months varied to give the most favorable dates for the many religious holidays. And as the year would slip, as with all of the other calendars, an occasional extra month or day would be added. Thus they ended up with a year of six possible lengths : 354 days, 355, 383, 384 and 385 days.

The Muslim calendar, still in use today, is the only true lunar calendar. Whereas the other civilizations tried to synchronize the irregular lunar months with the regular motion of the Sun by adding extra months and days, the Muslims would put up with no such nonsense. They use 12 months, alternating between 30 and 29 days averaging out to roughly the lunar month of 29 1/2 days. This makes a year 354 days long with an extra day tossed in from time to time to ensure the month begins with the new Moon. This means that each year starts about 11 days earlier then the previous one. Year 1 commemorates the beginning of the Muslim era in 622 AD when the prophet Muhammad fled Mecca with his followers, known as the "hijra".

Over in Egypt, the beginning if the year was originally based on the first sighting of the star Sirius, which would coincide with the flooding of the Nile. There were three seasons: flood, sowing and harvest (compared to California's four seasons : flood, fire, earthquakes and OJ), of four 30 day periods each. An extra five days were tacked on the end of the year, making it 365 days long. The years were numbered from the date of some nationwide decree, usually a census. However since the true year is about 365 1/4 days, the Egyptian calendar rotated backwards over the centuries.

The earliest Roman calendar was an absolute mess. The months could vary from 22 to 31 days, and were divided into halves and periods of eight days. The second half of the month was counted from the beginning of the next, so March 20 would be, using Roman reckoning, "11 days before June". Extra days were added based on the whims of the Priests, and by the time of Julius Caesar in 46 BC the entire year was three months off. Caesar consulted with his Egyptian astronomers who had experience with these floating calendars (see above), and they developed the Julian year. This consisted of 12 months varying between 30 and 31 days with the second month of only 28 days. Every fourth year an extra day would be added to February (there would be two February 24s) to make up for the extra 1/4 day. When Caesar was killed the next year, the seventh month of Quintillis was named Julius (now July). Similarly the eighth month of Sextilis was named in honor of Caesar Augustus. All was well and good, for about 1600 years. . .

However, the year is still not exactly 365 1/4 days as the Julian calendar assumed, more precisely it is about 365.2425 days long. Consequently, by the 1500s the calendar had shifted 10 days ahead. Therefore in 1582 Pope Gregory XIII decreed that the day following October 4 would be October 15, and that three leap days every 400 years would be eliminated. This affected century years (1700, 1800, etc), making only those years divisible by 400 leap years. So the year 2000 will add an extra day, whereas the year 1900 did not. The Catholic countries immediately adopted the new calendar, but the outlying areas would take their time about it. Scotland waited until 1600 and England until 1752. Russia was among the last to adopt it, waiting until the Russian revolution in 1917.

But wait! There's more! There are still tiny errors that can creep in since the year is actually *365.24225 days*. So additional leap days will have to be dropped from any year that is divisible by 4000 (4000 AD, 8000 AD, etc). This will lead to an error of only one day in 20,000 years.

In light of the various irregularities, astronomers are more likely to use "Julian dates" to isolate events more accurately. A Julian date is simply the number of days from January 1, 4713 BC. So the for instance, January 1, 1980 was JD 2444240, or about 2 1/2 million days from the beginning date chosen in 1582 by an Italian Protestant scholar, Joseph Scaliger. Since 4713 BC was considered to be the year of creation according to popular interpretations of the time, any day before that time could not possibly be of use to us mere mortals. Then there is the Astronomical calendar. This is identical to the current Gregorian version, except it has a year "0", whereas the other jumps from -1 BC to 1 AD. This shifts the date of ancient times by a year.

Cetus the Sea Monster

The story of Perseus, Cetus and Andromeda is perhaps one of the greatest in Greek tradition. The beautiful Andromeda had the misfortune of being sent as a human sacrifice to Cetus the sea monster by her own father. This in an effort atone for the boastings of his wife, her mother, Cassiopeia. Cetus is described as a repellent creature with a tail like a fish, front legs as a lion and a huge ungainly head with a face only a mother could love. As the creature spotted Andromeda and bore down on her, the great hero Perseus strolled by. Smitten by her beauty, Perseus politely asked for Andromeda to be his bride, then hopped on Cetus, killing him with an almost bored ease.

Sometimes called "the whale", Cetus is the fourth largest constellation, but contains no bright stars, . The only object of note is the classic variable star Mira.

Variable stars do as their name implies : they vary their brightness. This can happen in two main ways : by either being eclipsed by a dimmer star, or by some physical process that changes the light output.

The eclipsing variety have very steady output most of the time, but suffer sharp declines in brightness for short periods. This is as one would expect since the darker body will cover the brighter for comparatively brief moments. The others are usually much longer and somewhat irregular in their changes. Mira was the first and the brightest of these "long period" variable stars and one of the most dramatic. It peaks out above fourth magnitude, sometimes attaining a fairly bright second (brighter than Polaris), but then plummets down to a pitiful nineth magnitude or less for a total luminosity change of over 250 times! The period averages 331 days but that too can change.

Can you find the Sea Monster tonight? Is Mira visible?

Grus, the Crane

Grus, the crane, is one of the modern constellations. It was invented by those two prolific Dutch navigators, Pieter Keyser and Frederick de Houtman as they were mapping the southern skies. These two are also responsible for an entire menagerie which includes Apus, (bird of paradise), Chameleon, Dorado (the goldfish), Hydrus, Musca (the fly), Pavo, (the Peacock), Phoenix, Tucana and Volans (the flying fish). They gave us only two non-animals, Indus named after the native American indians, and Triangulum Australe, the southern triangle.

Many of the more recent constellations were created not in an effort to outdo those Greek fellas, but simply because the Greeks could not see the far southern stars.

Grus is a fairly bright little constellation and should be visible scooting along the southern horizon by observers in the United States, . However when you are looking at Grus, you are gazing out into intergalactic space, so there are no bright objects for amateur observers to be concerned about.

Halloween Objects

It is now October 31, and in various countries, costume clad tykes wander up and down the streets loading up on the sugary goodies that will destine them to a night of churning stomachs.

So tonight I thought you would like to see some appropriate objects. . .

The first stop is to the "The Demon Star" in Perseus. More commonly called Algol, this is what is called a "binary" or "double" star, . A double star is a stellar system made up of two or more individual stars which orbit around each other. In fact, some have said that if Jupiter had a little more mass to it, the nuclear fires would have ignited make our Sun a double. Algol is an "eclipsing binary", the fist known, in which the dimmer member eclipses the brighter which varies the overall brightness as seen from Earth. These are also called eclipsing variables, and usually have periods of only a few days. Algol can be see to dip down to magnitude 3.4 from 2.1 in only about 10 hours for a change of brightness of nearly *three times*! The main star is over 2 1/2 million miles in diameter and the dimmer companion, over three million. The two stars are separated by a minuscule 6 1/2 million miles. They are so close their shapes are probably not true globes, but more likely egg shaped or tear drops.The total time between "minima" or the dimmest point of the light curve is about four days 16 hours. See if you can find Algol and compare it to nearby stars. Is it at minimum? At this time of the year, Algol is about halfway in between the horizon and the roof of the sky by mid-evening.

Next stop is the tiny constellation called Delphinus, the Dolphin, once known as "Job's Coffin", . By mid-evening the distinctively shaped Delphinus is low in the western skies, just waiting for the word to dive below the horizon and swim around to the other side.

While Delphinus is leaving us, Orion the mighty hunter has recently come into view over in the east. Find the star Rigel, it is the lower right "foot" of the giant. Now move about 2 1/2 degrees to the right. If you had a large enough telescope you would find the faint Witch's Head Nebula, an oddly shaped cloud of dust and gas.

And finally for this evening, if you have a telescope you might try to find the planetary nebula NGC3242 in the constellation of Hydra, . This is also known as the "Ghost of Jupiter" due to its modest resemblance to the planet. As a nineth magnitude object it will be out of range for binoculars but should be clearly visible in telescopes. Unfortunately Hydra is more of a summer constellation, meaning that it doesn't rise until 3 or 4 AM at this time of year.

December

December 1 : Aries, the Ram
December 2 : Hubble Space Telescope Repair
December 3 : Pioneer 10/Jupiter Flyby
December 4 : Perseus
December 5 : Double Cluster
December 6 : The Aurora
December 7 :   Horologium, the Pedulum Clock
December 8 : Open Cluster M34
December 9 : Lepus, the Hare
December 10 : Project - Why is Winter Cold?
December 11 : Galileo Encounters Jupiter, 1995
December 12 : Fornax, the Furnace
December 13 : Meteor Shower - Geminids
December 14 : Columba, the Dove
December 15 : The Last Men on the Moon
December 16 : Boston Tea Party
December 17 : Michalson-Morley Experiment
December 18 : Length of Shadows
December 19 : Dorado, the Goldfish
December 20 : Spacey Christmas Gifts
December 21 : Winter Begins
December 22 : Meteor Shower - Ursids
December 23 : Winter Objects
December 24 : Apollo 8
December 25 : The Christmas Star
December 26 : Winter Skies - Orion, Taurus, Canis Major
December 27 : Future Mars Programs
December 28 : Ptolemy
December 29 : Quarks
December 30 : What Temperature is it?
December 31 : Winter Circle

To the Earth and Moon

In this section, we'll learn about the Earth and Moon system. Simply click on any of the topics and by all means, have fun.

Viewing the Sky
Earth and the Seasons
Earth, Closest to the Sun
Midnight Sun
The Great Eclipse of 1991
Earthrise!
Apollo 13
Phases of the Moon
Copernicus and Tycho
Backside of the Moon
Lunar Eclipse
The Moon Right Now

Aries, the Ram

Aries is none other than the ram whose golden fleece gave rise to the quest of Jason and the Argonauts. Aries' moment in the Sun was when he saved Phrixus, the son of Athamas who, was about to be sacrificed to Zeus. Riding the ram to a distant land, Phrixus escaped with his life. Phrixus in turn sacrificed Aries to Zeus and presented the beautiful fleece to the local king of the land, King Aeetes. Here is where Phrixus lived out the rest of his years. Back home his cousin, Pelias, had taken the throne which rightfully belonged to Jason. Pelias wanted the fleece and Jason wanted the throne, so they made an agreement : If Jason could recover the fleece from King Aeetes he could gain the throne. Thus came the epic voyages of Jason and his Argonauts (the ship Argo was once itself a constellation, the remnants still honored with the constellations of Puppis, Carina and Vela).With the help of the King's daughter Medea, Jason was able to steel the treasure and return home, placing it in Zeus' temple.

This is one of the dimmer constellations, with few objects of any note. The only real claim to fame was that back in Greek times, Aries was the location of the Vernal Equinox, the point at which the Sun crossed from the southern skies to the northern, heralding the start of spring. Due to precession, a slow wobble of the Earth's axis, the point has now progressed onward to Pisces.

Geminids

Slowly improving since 1960, the Geminids have knocked the Perseids out of first place for overall quality. Bright (average magnitude of 2.7) and medium in speed, this shower comes from a dead comet discovered by the IRAS satellite. Most Geminid meteors are white, with few producing trails. This is one of the few showers which is good before midnight. Typical rates are 50 per hour. The shower goes from December 12 to the 16th with a peak on the 13th.

The Geminids are so-called because the meteors come from the direction of the constellation of Gemini (although they can appear in most any part of the sky).

see also : Meteor Showers

Winter begins

By now the ice-skates have been sharpened and the wood stacked outside the back porch. The nights are long and brittle with the chill of winter calling from a distance. Stoke the fire and break out the hot chocolate, and prepare for some fine observing. Just don't stick you tongue to a cold telescope!

December 21 (or 22) marks the point in the year when the Sun is at its lowest point along its pathway in the sky. Click here  and you will see it just riding at the very bottom of the "ecliptic", the pathway it traces through the sky during the year. Once past this period you will notice the Sun slowly getting higher in the sky each day until it hits the highest point around June 21, known as the *Summer Solstice*.

The line is the ecliptic and marks the plane of the solar system. It is tilted due to the Earths own 23 1/2 degree tilt, called the "obliquity". And at the start of winter the Earth's North Pole is "aimed" as far away from the Sun as it will be all year. Using First Light, go into Hover mode around the Earth to see this. Advance the time by 6 months to summer and notice how the North Pole is now tilted toward the Sun and the South Pole is stuck in perpetual darkness. (Bringing winter to the Aussies for instance).

One might think that this would be the coldest time of the year since the Sun's rays are at their least direct. But actually there is about a four to six week delay due to the complex heating and cooling patterns of the Earth. So the coldest time of the year in the north will usually be in February and the hottest lands in August.

Ursids

Best for northern observers, the Ursids produce medium speed (20 miles/sec) meteors. Some bright, many faint. The Ursids are derived from Comet Tuttle, and are felt to be decreasing over the past few years. Typical rates are 15 per hour. The shower will usually span December 21 to the 23rd with a peak on the 22nd.

The Ursids are so-called because the meteors come from the direction of the constellation of Ursa Minor (although they can appear in most any part of the sky).

see also : Meteor Showers

Project - Why is Winter Cold

Project. . .

supplies : a teaspoon of salt, dark dinner plate, small dark bowl

As we head deeper into December, if you are an inhabitant of the northern hemisphere, you have no doubt noticed that the days are growing shorter and a chill is settling down softly upon the landscape. Winter will soon descend up us.

This is the time when the Sun is at its lowest point along its pathway in the sky, known as the ecliptic. Interestingly enough, this is about the time when the Earth is closest to the Sun in its slightly elongated orbit. So, one might ask the question, "Why is it cooler, when we're closer?"

In Winter, the Earth's northern hemisphere is "aimed" away from the sun, and the rays of our nearest star are much less direct then they are during the summer, spreading them out and lessening their effect. This will then counteract the slight increase in heating due to the closer distance.

To illustrate this, take the bowl and the salt. Pour the salt into the bowl and notice the distribution of the grains. Each grain will represent a single unit of sunlight spreading out over the ground. Now pour the salt from the bowl into the dinner plate. Notice how the grains are spread out much further apart. Will this increase or lessen the heating effect of the sunlight?

Pioneer 10 at Jupiter

Long before pictures from NASA's Voyager probes graced the covers of Astronomy magazine and science textbooks from around the world, Pioneer was the star of interplanetary travel. The Pioneer 10 and 11 spacecraft members of an astonishingly successful series of probes dedicated to finding out about space beyond the vicinity of the Earth. One of the earliest probes was the first United States spacecraft to ever return an image of the planet from space. In 1968 it was decided that a mission to Jupiter was possible, and the vision became real when on March 2, 1972, Pioneer 10 left the third planet from the Sun on a 600 day trek through the vast shapeless desert of space. Pioneer 10 became man's first reach out beyond the orbit of Mars and through the asteroid belt. It also became man's fastest, having to be accelerated to 82,000 miles per hour. At such speeds it reached the Moon in only 11 hours when Apollo spacecraft took 3 days for the same journey.

And on this day in 1973, Jupiter received its first ever visitor from Earth. Lacking the powerful breaking rockets it would have needed drop into Jovian orbit, Pioneer's mission was a simple one. Simply flyby the gas-giant, take some pictures, measure the magnetic fields, radiation, cosmic rays and trapped dust.

On November 8, Earth's spindly little ambassador glided silently into Jupiter space as it passed the orbit of Sinope, the outermost moon. 16,000 commands were sent up to the spacecraft, covering the entire 60 day "encounter period". By November 29, it had passed all eight of the outermost moons, and was readied for its plunge towards the planet itself. On December 2, the day before closest approach, the photographs finally exceeded Earth based images. And on the following day, Pioneer dipped down to within 81,000 miles of Jupiter's turbulent cloud tops, taking measurements all the way, and being off its predicted schedule by only a single minute. The television was carried live to San Francisco viewers, earning NASA's Ames Research Center (home base for Pioneer), a special Emmy award.

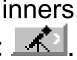
When the party was over, Pioneer did what it had been called to do. It proved that man could make a spacecraft that would survive the radiation saturated region of Jupiter. That NASA was able to accurately target planets and objects well beyond the orbit of Mars. In return, knowledge of Jupiter increased many fold, and the trail had been blazed for its sister spacecraft, Pioneer 11, to visit the mammoth golden planet four months later.

oops!
Click on the button in the program's toolbar, this one won't do anything.

Apollo 8 : To the Moon at Last

Originally the Apollo 8 mission was meant to be the first test of the lunar module in Earth orbit. But since the lunar spacecraft was not quite ready yet (the radar was being redesigned) with only one month to go it was decided to send the mission to the Moon instead. All this gave only a few weeks left to replan the flight and retrain the crew.

So on December 21, 1968, just 4 days before Christmas, for the first time men headed toward the ageless nightlight of the Moon. It was a magical time! Coming after the social turmoil of '68, with the war in Viet Nam continuing, cities burning down, the Pueblo crew captive in north Korea, at last it seemed as if something *right and virtuous* was happening. And the lunar landing seemed within our grasp, a mere 7 years after John Glenn first orbited the Earth, and here we were, going to the Moon!

As with the first Apollo mission only 2 months earlier, this one carried a small black and white television camera. All of humanity were witness to this greatest of journeys. We saw the Earth from 100,000 miles out, a small, delicate (and blurry) globe. But it wasn't until Christmas eve, as the crew was nearing the end of their lunar stay of 10 orbits, the spell was finally cast. On this date Jim Lovell, Bill Anders and Frank Borman turned the tiny 7 pound camera out their window to give the world a tour of that ever so ancient, pocked surface. And as they approached the lunar terminator, with many families around the country just tuning in after opening Christmas gifts or having family dinners, they brought us what is now considered one of the most memorable in the entire space program : .

A few minutes later they would be behind the Moon for the last time, firing up the engine and heading on home. In 3 days the Apollo 8 was to settle gently into the Pacific ocean, its three unshaven pioneers the first humans to come from another planet.

Man was to return to the Moon by May of 1969 in Apollo 10, the final dress rehearsal for the lunar landing. By then orbiting the Moon was "old hat", with some of the mystery removed. And only two months later, Neil Armstrong was to make his "small step", completing the challenge set forth by President Kennedy 8 years earlier, and by the hearts of men, thousands of years before that.

Apollo 17 : The Last Men on the Moon

The text for this still needs to be written, but check out this video as the crew were investigating a large boulder : !

Or this one as Harrison Schmitt hops across the surface : .

And this one, as Gene Cernan says goodbye to his temporary home : .

And this one, as the Lunar Module Challenger lifts off from the scarred lunar landscape : .
And this one when man was leaving the moon for the last time : .

{ewl ewdll.dll,ewBitmap,a17bldr.sbm}

Jupiter

Jupiter, the Gas Giant
Voyager 1 At Jupiter

Nightly Grabbag

The Grabbag is a collection of astronomical tidbits and projects which are accesses via the main menu of First Light or the "Grabbag" button on the Sky Tonight window. Each day of the year has a different item, so share and enjoy!

January
February
March
April
May
June
July
August
September
October
November
December

Monthly Celestial Highlights

This section points you toward various interesting objects for each month of the year.

To the Edge of the Solar System

In this section, we shall take wing and use First Light to travel throughout the solar system.

Mercury
Venus
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Asteroids
Halley's Comet

Ecliptic
Conjunctions
Planetary Eclipses
Retrograde Motion

To the Stars and Beyond

Beyond the solar system lies the unimaginatively vast Universe. If you were to travel the speed of light and launch off of the Earth, it would take only a few hours to reach Pluto, but over four years to reach the next nearest star. Now imagine if that were equal to 1 inch. The edge of the Universe would be out *beyond the Moon.*

Using First Light you will now take a tour, beyond the Moon, beyond Pluto, and finally, beyond infinity.

The Nearest Stars
Sirius : the Brightest Star
Polaris : the North Star
Mizar and Alcor
"Tycho's Star"
Variable Stars
Southern Cross
Splendor of the Pleiades

M13 and Globular Clusters
M57 and Planetary Nebula
The Wonderous Orion Nebula
The Center of the Galaxy
M31 : The closest Galaxy
Virgo Galactic Cluster

Saturn

[Saturn, the Ringed Wonder]
[Voyager 2 at Saturn]

Uranus

Uranus - The planet on its side
Voyager 2 at Uranus

Neptune

Neptune - Sometimes the Furthest Planet
Voyager 2 at Neptune

The March of the Seasons

Few things are as regular in our lives as the changing of the seasons. Like clockwork we observe the days change their length, getting warmer and colder with comforting precision. The warmth of the summer, the chill of the fall, winter's glassy cold and spring's renewal of life.

The beginning of spring is marked by the passage of the Sun from the southern sky to the northern.

Click here to center the Sun. The yellow line is the ecliptic, the pathway the Sun travels on its year long journey through the sky. Notice how the Sun is on the zero declination point, the celestial equator, a heavenly projection of the Earth's own equator. Everything above is said to be in the northern skies, those below, in the south. This point is also the zero point for right ascension.

As the Sun crosses this point it is directly overhead at the equator making the days and nights the same length of time. As it progresses north the days get longer for the northern hemisphere and shorter for the southern. Use the Hover mode to look at the Earth from space and you will notice that the line separating the day and night sides is exactly vertical as to be expected. If you jump ahead in time, even a few days, the line tilts toward the north bringing the North Pole into sunlight for the first time in 6 months, but leaving the southern polar regions in the dark.

As the Sun continues northward its rays get more and more direct, more concentrated than they were when it was low on the horizon, hence the days get warmer even though the Earth is actually *further* from the Sun then in the winter. When summer arrives, the Sun is the highest it will be, notice how the Earth is now tilted directly toward the Sun, . North Pole dwellers are experiencing the midnight Sun.

The opposite to the Vernal Equinox is the Autumnal Equinox as the Sun dips into the southern skies signaling that the cooler weather is soon to be upon us. Now the Sun's rays are stretched out having to share the same amount of warmth over a greater area of land. In winter the Earth is tilted away, , the northern half cools down, but in the southern regions, its "surfs up!" as they enter into summertime.

Earthrise!

{ewl ewdll.dll,ewBitmap,ew_bmps\earth\erthrise.sbm}In the early morning hours of December 24, 1968. The Apollo 8 astronauts were the first humans to witness an earthrise. As they rounded the eastern limb of the Moon on man's first ever lunar mission, they were permitted to gaze upon the blue-green orb we call home as it slowly peeked out from behind the ancient lunar landscape. The crew was caught off guard, never once having really considered the sight, so no film was "officially" allocated to taking such a picture. Finally after several moments of friendly discussion the camera was wrestled away from the official mission photographer, Bill Anders, and the results are now history. When first released a few days after splashdown, this photograph was called "the picture of the century". And it probably is. Shortly after, a first class 8 cent stamp was issued based on this image.

First Light will show you an earthrise of its own. Click here, , and the date and time will be set to exactly the time all those years ago, when the Jim Lovell, Frank Borman and Bill Anders captured this magical moment for all mankind.

Lunar Eclipse

On September 27, 1996 there will be a total Lunar Eclipse visible from all of Europe, Africa and the Americas. On the East coast of the United States, it will be in the mid to late evening, in the west it will be the early evening.

A lunar eclipse happens whenever the Moon passes into the shadow of the Earth right at the exact moment of full Moon. In that case you might be asking why we don't see these things every month? That is due to the simple fact that most of the time the Moon will go a little above or below the shadow since its orbit is tilted to the plane of the Earth's. The orbit itself rotates slowly bringing the crossover points, called "nodes", into alignment with the both the Sun and Earth. When the nodes are not aligned no eclipses are possible.

A lunar eclipse begins as the Moon wanders into the "penumbra" of the Earth's shadow. When viewed from the Moon this is where only part of the Sun would still be visible. The deeper you into the shadow, the less of the Sun is seen. Finally you hit the "umbra", the area of maximum shadow where the Sun is completely covered by the Earth. Depending on conditions in the Earth's own atmosphere, the light in the umbra can be pitch black, or blood red. The coloring will vary from eclipse to eclipse and is caused by small particles of dust or smoke in the atmosphere. This is the same reason we have brilliant red sunsets from time to time. So if a volcano has recently erupted, prepare for a beautiful event.

Click here  and First Light will show you the 1996 eclipse. The larger circle is the penumbra, the inner is the umbra, the area of maximum shadow. Shift the time back and forth to see how the Moon moves through the shadow. Now jump into Hover mode and look how the three bodies are aligned. You may want to go to the next full Moon (add about 28 days) and see how far it misses the shadow.

The Moon Right Now

With all of these discussions on the Moon, I thought I would add a simple module to show you the Moon right at this very moment. Simply click here,  and First Light will transport you out into space toward our nearest neighbor.

Earth

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\earth.bmp} The Earth seen from the space-shuttle as it silently glides by, 150 miles below.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\earthrot.bmp} The Jupiter-bound Galileo probe created this stunning sequence of Earth's rotation. Look closely, can you see the clouds change?

Moon

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\ranger.bmp} In preparation for Apollo, NASA sent a series of camera laden "Ranger" probes to photograph the craggy lunar surface close up. In this sequence we see a "meteor's eye" view of the central region of the Moon, as the Ranger 9 screams toward the surface at thousands of miles per hour.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a8gen.bmp} On Christmas Eve, 1968, Apollo 8 astronauts Jim Lovell, Bill Anders and Frank Borman turned their tiny 7 pound camera out the window to give the world a tour of that ever so ancient, pockmarked surface of the Moon. Just a few hours earlier they became the first humans to ever travel to another world, providing as much wonder as they did technical satisfaction. On their second to the last orbit, as they approached the lunar terminator, with many families around the country just tuning in after opening Christmas gifts, the astronauts brought us what is now considered one of the most memorable moments in the entire space program.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11lnch.bmp} Apollo 11, man's first attempt to land on the Moon, lifts off into the crisp morning skies on July 16, 1969. Those who witnessed it compared it to watching Columbus leaving for the new world.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11earth.bmp} On their way toward the Moon, the Apollo 11 glanced back at the planet from which they came.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11lmtur.bmp} Buzz Aldrin shows the folks back home his moonwalk helmet.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11lndg.bmp} Fulfilling thousands of years of man's dreams and fantasies, Eagle settles down on the ancient plains of the Moon.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11step.bmp} Neil Armstrong takes his giant leap. There was some confusion over what Armstrong really said. He meant to say "that's one small step for A man. . .", but it appears that he said, "that's one small step for man. . .", somehow dropping the "a". Without that one word his statement really doesn't make much sense. For years he argued that he really did say it correctly, but the communications must have dropped out briefly losing the all important "a". Finally he had to admit that maybe he really did screw up the most important words spoken in the 20th century.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11plque.bmp} After Buzz Aldrin joined Neil on the lunar surface they unveiled a plaque on the front leg of the lunar module.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11hop.bmp} Buzz Aldrin demonstrates how one "walks" in the low gravity of the Moon.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a11call.bmp} Neil and Buzz take time to chat on the phone.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a13iva.bmp} After two successful lunar landings, fate would catch up with NASA on Apollo 13, when over 100,000 miles from home an oxygen tank detonates. The crew had to nurse their nearly fatally injured spacecraft around the Moon and back home in the most dramatic space rescue ever.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a15gal.bmp} Apollo 15 commander Dave Scott demonstrates the laws of acceleration, proving an assertion made by Galileo over 350 years earlier.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a17bhop.bmp} Astronaut Harrison Schmitt bounds across the lunar plains on man's last visit to the Moon, Apollo 17, December 1972.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a17smpls.bmp} Astronauts Harrison Schmitt and Gene Cernan gather samples on man's last visit to the Moon, Apollo 17, December 1972. Originally NASA scheduled 3 additional lunar landing missions, but the shortsighted congress canceled Apollos 18, 19 and 20, and even attempted to cancel missions 16 and 17 as well.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a17bldr.bmp} One of the goals of Apollo 17 was to study some of the many large boulders visible in photographs taken from lunar orbit. The larger the rock, the closer it would have to be to its source crater. Small rocks could be thrown thousands of miles, but large ones, only a few miles, giving the geologists confidence in its origin. In this clip Gene Cernan and Harrison Schmitt investigate a split house-sized boulder, the largest visited by man. Samples were taken from the center which were in areas where quite literally "the Sun don't shine". This "permanently shadowed" area meant that the samples were uncontaminated by particles thrown out by the Sun.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a17gdbye.bmp} Astronaut Gene Cernan, the last man on the Moon, says his goodbyes to an "old" friend, December, 1972.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a17ltoff.bmp} Apollo 17 lifts off from the Moon as witnessed by the color TV camera left on the lunar rover. Who would have thought that it would be nearly 25 years later without a return mission so much as planned.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\a17moon.bmp} After a successful rocket firing, the Apollo 17 crew turns their television camera on the Moon, giving us the only live TV of the lunar backside. Here they focus on the massive crater Tsiolkovskii, the most prominent feature on the far side.

Solar System

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\ven_anim.bmp} Radar data from the Magellan spacecraft was used to create this simulation of a low flyby over the surface of Venus. The colors are based on images returned from the Soviet Venera landers.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\marsanim.bmp} Mars data sent back from the Viking orbiters included altitude readings. Those values were then matched with the returned photographs and processed through a computer to create this simulated Martian flyover.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\marsanim.bmp} Olympus Mons is the largest known volcano in the solar system, located in the Amazonis Planitia region of Mars. It rises to more than 15 1/2 miles above the surrounding plains making it the tallest known mountain in the entire solar system and three times the height of Mt. Everest. With a base width of 370 miles, it has 50 times the volume of Mauna Loa in Hawaii and could cover the entire state of Arizona. In fact, it is so large it is actually visible from Earth on rare occasions. Here we are in a simulated flight around the center caldara of Olympus Mons. This film was created with another product from Virtual Reality Labs, called VistaPro. Using actual landscape data, VistaPro can let you create realistic landscape images and change them around as desired. You may even "terraform" Mars for instance by planting trees and adding lakes.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\jup_rot.bmp} In this sequence you can see the rotation of Jupiter filmed as Voyager approached the giant planet. The small dot that comes speeding in on the left is one of the many moons of Jupiter. Even though the planet is 10 times the diameter of Earth, it rotates much faster making Jovian day only about 10 hours long. Because of this, the planet is actually "squashed" a bit at the poles.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\jup_spot.bmp} Scientists were able to create time-lapse animations of Jupiter by putting together series of still pictures taken over a period of days. Notice the complex swirls and eddies along the border of the Red Spot.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\sat_anim.bmp} This is a computer generated simulation of a Saturn flyby mission.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\spokes.bmp} One of the enigmas of Saturn's rings were the mysterious "spokes" seen here. It was later determined that they were caused from extremely fine dust caught in between the larger particles. Saturn's magnetic field apparently distorts the dust plane.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\urananim.bmp} The complicated 1986 flyby of Uranus by Voyager 2 is illustrated in this computer simulation. Click here
and First Light will simulate the flyby for you.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\neptspot.bmp} Here we see a time-lapse image of Neptune's "Great Dark Spot" as photographed by the Voyager 2 as it approached the blue-planet for its last flyby in 1989. Click here
and First Light will simulate the flyby for you.

Space Shuttle - Hubble Repair

First launched in 1981, the Space Shuttle has been the cornerstone of the United States space policy. Originally intended to be merely one part of the first great post-Apollo space project, the shuttle became the entire project due to funding cutbacks. While suffering under the barbs of her many critics for being too expensive, too cumbersome to use, etc. the shuttle has proven herself to still be a versatile spacecraft. And no matter what the problems, it is all we have at the time.

In this series of films I've elected to show segments of the Hubble Space Telescope repair mission, showing the shuttle at its finest.

Launched in April of 1990, The Hubble Space Telescope was to be the crowning jewel of NASA's "Great Observatories" program. However due to a series of embarrassingly basic design errors, the HST was "optically challenged" from day one. All was not lost as it was designed to be repaired and upgraded in orbit, and so the first such mission was scheduled earlier then planned to correct the problems.

(Contrary to the many frantic reports and screaming headlines published in the news, the telescope was not "a billion dollars of useless scrap". It was extremely useful even in its damaged state and returned tremendous science. Some experiments didn't rely on the sharpness of the optics, but mainly on the fact that it was above the Earth's atmosphere. Those were then given priority scheduling while the others were backed off a couple of years until the repairs could be made).

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hsteva1.bmp} On December 2, 1993, space-shuttle mission STS-61, lifted off on what was billed as NASA most complicated mission ever, even surpassing those of Apollo. Five spacewalks were planned to refurbish the ailing solar-panels, install a set of "glasses" to clear up the fuzzy optics, replace a computer and some gyros. In this video clip we see both the liftoff of mission STS-61 on December 2, 1993, and segments of the first spectacular spacewalk.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hstengtv.bmp} This is a view of a shuttle liftoff rarely seen by the public. NASA has literally dozens of cameras scattered about the launch complex covering all aspects of the countdown and ignition

-----

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hstcrew.bmp} Here we see the STS-61 crew of Dick Covey, Ken Bowersox, John Akers, Jeff Hoffman, Story Musgrave, Claude Nicollier and Kathy Thornton. Hoffman and Musgrave formed one spacewalk pair, making three total, while Thornton and Akers performed two, and made the critical optics repair on the seventh day of the mission.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hstanim.bmp} In this animation, the solar-array repair is demonstrated. The solar-panels needed to be replaced as the original ones would flex too much when they went from the frigid cold of the darkness of space, to the boiling temperatures of broad daylight in its 90 minute orbit around the Earth. This flexing would then shake the telescope blurring the images even more.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hstsuitn.bmp} Astronauts Story Musgrave and Jeff

Hoffman are seen here as they wait in the airlock for the start of their second space walk.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hsteva5.bmp} The fifth and final spacewalk concentrated on replacing the Space Telescope's main computer. Originally designed in the early 1980's, the computer was not much more powerful than a Nintendo. Also additional work was performed on the solar-panels, the magnetometers and a spectrograph. When over, the four spacewalkers had accumulated over 35 hours, 28 minutes of EVA time, breaking the previous record held by the Apollo 17 astronauts over 20 years earlier.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hstrels.bmp} The next day, the shuttle released the restored telescope into a 320 mile high orbit. In only a matter of days, ground controllers learned that the repairs were an unqualified success, making the telescope even better then originally designed.

{ewl ewdll.dll,ewBitmap,ew_bmps\moviebmp\hstland.bmp} On December 13, 1993, Endeavour glides to a midnight touchdown after succeeding beyond the beliefs of even the most optimistic space watchers.

Constellations

name	*abbreviation*	*meaning*
Andromeda	And	Daughter of Cassiopeia
Antila	Ant	The Air Pump
Apus	Aps	Bird of Paradise
Aquarius	Aqr	The Water-bearer
Aquila	Aql	The Eagle
Ara	Ara	The Altar
Aries	Ari	The Ram
Auriga	Aur	The Charioteer
Bootes	Boo	The Herdsman
Caelum	Cae	The Chisel
Camelopardalis	Cam	The Giraffe
Cancer	Cnc	The Crab
Canes Venatici	CVn	The Hunting Dogs
Canis Major	CMa	The Big Dog
Canis Minor	CMi	The Little Dog
Capricorn	Cap	The Horned Goat
Carina	Car	The Keel
Cassiopeia	Cas	The Queen
Centaurus	Cen	The Centaur
Cepheus	Cep	The King
Cetus	Cet	The Whale
Chamaeleon	Cha	The Chameleon
Circinus	Cir	The Compasses
Columba	Col	The Dove
Coma Berenices	Com	Berenice's Hair
Corona Australis	CrA	The Southern Crown
Corona Borealis	CrB	The Northern Crown
Corvus	Crv	The Crow
Crater	Crt	The Cup
Crux	Cru	The Cross
Cygnus	Cyg	The Swan
Delphinus	Del	The Dolphin
Dorado	Dor	The Goldfish
Draco	Dra	The Dragon
Equuleus	Equ	The Little Horse
Eridanus	Eri	The River
Fornax	For	The Furnace
Gemini	Gem	The Twins
Grus	Gru	The Crane
Hercules	Her	Son of Zeus
Horologium	Hor	The Clock
Hydra	Hyd	The Male Water Snake
Hydrus	Hyi	The Female Water Snake
Indus	Ind	The Indian
Lacerta	Lac	The Lizard
Leo	Leo	The Lion
Leo Minor	LMi	The Little Lion
Lepus	Lep	The Hare
Lynx	Lyn	The Lynx
Lyra	Lyr	The Lyre
Mensa	Men	Table Mountain

Microscopium	Mic	The Microscope
Monoceros	Mon	The Unicorn
Musca	Mus	The Fly
Norma	Nor	The Square
Octans	Oct	The Octant
Ophiuchus	Oph	The Serpent-bearer
Orion	Ori	The Hunter
Pavo	Pav	The Peacock
Pegasus	Peg	The Winged Horse
Perseus	Per	Rescuer of Andromeda
Phoenix	Phe	The Phoenix
Pictor	Pic	The Painter
Pisces	Psc	The Fishes
Piscis Austrinus	PsA	The Southern Fish
Puppis	Pup	The Stern
Pyxis	Pyx	The Compass
Reticulum	Ret	The Reticle
Sagitta	Sge	The Arrow
Sagittarius	Sgr	The Archer
Scorpius	Sco	The Scorpion
Sculptor	Scl	The Sculptor
Scutum	Sct	The Shield
Serpens	Ser	The Serpent
Sextans	Sex	The Sextant
Taurus	Tau	The Bull
Telescopium	Tel	The Telescope
Triangulum	Tri	The Triangle
Triangulum Aust.	TrA	The Southern Triangle
Tucana	Tuc	The Toucan
Ursa Major	UMa	The Great Bear
Ursa Minor	UMi	The Little Bear
Vela	Vel	The Sails
Virgo	Vir	The Maiden
Volans	Vol	The Flying Fish
Vulpecula	Vul	The Fox

Obsolete Constellations

Antinous	Lover of Hadrian
Argo Navis	The Ship
Cerberus	Three Headed monster
Felis	The Cat
Gallus	The Cockerel
Globus Aerostaticus	The Balloon
Honores Friderici	The Glories of Frederick
Jordanus	The River Jordan
Lochium Funis	The Log and Line
Machina Electrica	The Electrical Machine
Quadrans Muralis	The Mural Quadrant
Rangifer	The Reindeer
Robur Carolinum	Charle's Oak
Telescopium Herschelii	Herschel's Telescope

Turdus Solitarius The Solitaire

Table - Meteor Showers

shower	date	rate (per hour)	peak
Quadrantids	January 3-4	40	--
Lyrids	April 20-24	15	April 22
nu-Aquarids	May 1-7	20	May 4
delta Aquarids	July 23 to August 1	20	July 28
Perseids	August 10-15	66	August 12
Orionids	October 20-22	25	October 21
S. Taurids	November 3	15	--
Leonids	November 18	15	--
Geminids	December 12-16	50	December 14
Ursids	December 21-23	15	December 22

See Meteors for more information.

Major Planets

name	dist	day	year	ecc	inc	diameter	albedo	gravity
Mercury	.387	58.6	87.9d	.206	7.0	.38	.11	.38
Venus	.723	243.0	224.7d	.007	3.4	.95	.65	.91
Earth	1.00	1.0	365.2d	.017	0.0	1.0	.37	1.00
Mars	1.52	1.0	686.9d	.093	1.8	.53	.15	.38
Jupiter	5.20	.41	11.9y	.048	1.3	11.2	.52	2.54
Saturn	9.53	.44	29.5y	.056	2.5	9.4	.47	1.08
Uranus	19.18	.72	84.0y	.047	0.8	4.0	.51	.91
Neptune	30.06	.77	164.8y	.009	1.8	3.9	.41	1.19
Pluto	39.44	6.38	247.7y	.250	17.2	.24	.50	.05

----

dist : distance in astronomical units
day : in Earth days
year : in Earth days or years
ecc : eccentricity
incl : inclination
diameter : as compared to the Earth's diameter
albedo : how much sunlight the planet reflects, 1.0=pefect reflectivity
gravity : as compared to the Earth's gravity

Stars

The 15 Nearest Stars. . .

distance*	magnitude	name
-	-27	Sun
4.22	11.05	Proxmia Centauri
4.35	-0.01	Alpha Centauri
5.91	9.54	Barnard's Star
7.7	13.53	Wolf 359
8.2	10.50	BD+36.2147
8.4	15.46	L-726-8A
8.6	-1.42	Sirius-A
8.6	11.2	Sirius-B
9.4	13.14	Ross 154
10.4	14.78	Ross 248
10.8	6.14	Epsilon Eridani
10.9	13.47	Ross 128
11.1	7.56	61 Cygni

The 15 Brightest Stars. . .

magnitude	distance*	name
-27	-	Sun
-1.46	8.6	Sirius
-0.72	39	Canopus
-0.29	5.91	Alpha Centauri
-0.06	375	Arcturus
0.04	26.27	Vega
0.08	45.92	Capella
0.14	815	Rigel
0.37	11.41	Procyon
0.48	127	Achernar
0.60		Beta Centauri
0.76	16.6	Altair
0.80	520	Betelgeuse
0.85	68.5	Aldebaran
0.87	4.35	Alpha Centauri

----

distance is in <u>light years</u>

Ursids

date : Dec. 21 to Dec. 23 (Dec. 22)
duration : 2 days
rate : 15/hour
RA : 14:28
dec : +76

Best for Northern observers, the Ursids produce medium speed (20 miles/sec) meteors. Some bright, many faint. The Ursids are derived from Comet Tuttle, and are felt to be decreasing over the past few years.

Geminids

date : Dec. 12 to 16 (Dec. 14)
duration : 2.6
rate : 50/hour
RA : 7:32
dec : +32

Slowly improving since 1960, the Geminids have knocked the Perseids out of first place for overall quality. Bright (ave. magnitude of 2.7) and medium in speed, this shower comes from a dead comet discovered by the IRAS satellite. Most Geminid meteors are white, with few producing trails. This is one of the few showers which is good before midnight.

Leonids
date : Nov. 18
duration : ?
rate : 15/hour
RA : 10:08
dec : +22

This shower is legendary for producing some of the greatest showers in history. Associated with Comet Tempel-Tuttle, showers in 1867, 1868 and 1883 hit rates of 10,000/hour. The morning of November 17, 1966, produced the greatest recorded shower with rates estimated at 150,000/hour! (The author of this program slept through it, and has regretted it since). Look for another peak in 1999 when the comet returns.

S. Taurids

date : Nov 3
duration : ?
rate : 15/hour
RA : 3:32
dec : +14

The Taurids result from Comet Encke. While few in number they produce many fireballs. This shower was one of the greatest in the 11th century, but has slowly declined since then. The meteors are quite slow, usually less than 18 miles/sec.

Orionids
date : Oct 20 to 22 (Oct 21)
duration : 2 days
rate : 25/hour
RA : 6:20
dec : +15

The Orionids are believed to be the other side of the stream which produces the eta Aquarids in May. Better for observers in low latitudes or in the Southern hemisphere, this shower produces fast meteors (40 miles/sec). About 20% leave trails. While the rate is stated to be 25/hour but can vary between 10 and 70.

Perseids

date : Aug 10-15 (Aug 12)
duration : 4.6 days
rate : 66/hour
RA : 3:04
dec : +58

Once considered the finest and most reliable of the major showers, the Perseids are slowly declining from a peak during the 1970s. Rates may exceed 100/hour. There is a wide variety of meteors, the fainter ones being white of yellow, brighter ones, green, orange or red. About 1/3 leave trails. Occasional fireballs often ending in bursts. This is a very good photographic shower.

delta Aquarids

date : July 23 to Aug 1 (July 28)
duration : 7 days
rate : 20/hour
RA : 22:36
dec : -17

This show is considered "the greatest" in total numbers, but since it is stretched out for so many days (actually going from July 15 to August 29), it is far less spectacular than the more condensed ones. Comprised mainly of fainter, slower meteors, the delta Aquarids are actually made up of several meteor streams.

nu Aquarids

date : May 1 to May 7 (May 4)
duration : 3 days
rate : 20/hour
RA : 22:24
dec : 0 degrees

Producing very swift meteors (40 miles/sec), the Aquarids are believed to be derived from none other than Halley's comet. They generate long, glowing trails, many bright meteors, often yellow. The rates may exceed 40/hour. The Aquarids are best seen in the southern hemisphere. The Orionids in October are believed to be from the same meteor stream, crossing our orbit a second time.

Lyrids

date : April 20-24 (April 22)
duration : 2 days
rate : 15/hour
RA : 18:16
dec : 34

The earliest recorded of all major showers, the Lyrids produce a fairly consistent display. The meteors are medium fast (28 mile/sec) with the hourly rates rarely going above 20. There have been exceptions with 1803 and 1922 giving rates of 96/hour, and a burst of 250/hour (for a few minutes) in 1982.

Quadrantids
date : Jan. 1 to 6 (Jan. 3-4)
duration : 1 day
rate : 40/hour
RA : 15:28
dec : +50 degrees

This is a brief, but very intense shower. In northern latitudes the radiant doesn't reach a usable altitude until 2:00 am, so there isn't much time to catch it. In the past 15 years the shower has had as many as 235 meteors per hour (1985), so if the moon isn't too bright, and if you can stand the January weather, give this a shot.

eccentricity
The "shape" of an orbit. A perfectly circular orbit has an eccentricity of 0. The higher the number, the more elliptical the orbit.

inclination :
The angle of tilt of an orbit. Most of the planets are in the same plane with very small inclinations, except for Pluto, which implies that it may be an object captured by the Sun aeons ago and not a part of the original solar system.

fireball :
The largest and most brilliant meteors which leave a lingering trails in the sky and can rival the Sun in brightness.

proper motion:
The natural motion of the stars as the travel on their own through space.

Apollo 13 : The One That Didn't Make It

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\a13_ptch.bmp}Imagine being in a spacecraft over 100,000 miles from Earth and finding out that your oxygen tanks have been destroyed and you are losing all of your electrical power. Such was the case with Apollo 13 on the 13th day of April, 1970. What started out as America's third manned mission to the Moon turned into a dramatic life and death struggle.

The mission started off well enough with a beautiful launch on April 11 at 2:13 PM, despite the naysayers who warned NASA to skip the number "13". Since the United States proved that a manned landing was in fact possible, the novelty had begun to wane. This mission would be little different than Apollo 12, except for the fact that the landing site would be in the lunar highlands, the oldest part of the lunar surface. Network coverage would be minimal. Veteran astronaut Jim Lovell was the commander and the first person to go the Moon a second time. With him came Fred Haise and Jack Swigert (a last minute replacement when Tom Mattingly was exposed to the measles only 4 days before the flight).

On the 13th, shortly after an evening TV broadcast home to the families, a large explosion violently rocked the spacecraft. Click here, ., and you will see the Earth and Moon at that very moment. Over the next hour the news became worse and the carefully constructed mission unraveled like an old sock. The meters onboard Apollo rapidly sank down to zero. Apollo was losing all electrical power and had apparently lost its oxygen. While the "service module" (that holds all of the oxygen, power supplies and main rocket engine) was apparently a goner, the Lunar Module was still in good health. Its meager supplies would have to be stretched to take care of three men for three days when it had been designed to handle only two men for two days. The spacecraft would have to limp back home using less power than it was ever designed for. The Command Module that must return the astronauts to the Earth was in good health, but had never been completely powered down in space before. Would the cooling system freeze up? Would other systems be destroyed, systems required for reentry?

Over the next three days the temperature would drop down to freezing as the spacecraft swept around behind the Moon, . Water would be in short supply, causing the crew to get dangerously dehydrated. Sleeplessness would have Jim Lovell mistype a critical command to the computer system. And one of the mission controllers confessed that he doubted the men would return home alive but instead miss the Earth and go into an eternal orbit around the Sun, an orbiting tomb that would likely exist long after we were gone.

{ewl ewdll.dll,ewBitmap,ew_bmps\misc\a13_sm.bmp}But somehow they managed, and as Apollo 13 fell toward the Earth with only four hours to go, the crew released the dead service module finally getting a first hard look at the carnage. Jim Lovell shouted "and there's one whole side of that thing missing!" stunned and shook mission control. A couple of hours later, the Lunar module was released and the Command Module revived from its cold slumber. It all worked well and the crew returned to the warm waters of Earth.

The next Apollo mission was to wait nine months to fly as the problem was determined and fixed. Apollo 14 flew the mission that Apollo 13 was supposed to fly, successfully landing in the Fra Mauro region. Interestingly enough, after scientists got their looks at the lunar material that took two missions to collect the conclusion was "we need to select our landing sites more carefully" as the hoped for ancient material never quite appeared.

Lepus, the Hare

Lepus the Hare, seems to have little role to play in the majestic and tumultuous and often bawdy Greek legends. It is said that the Hare received a place among the stars for both its swiftness in running, and reproduction. One fable that is told informs us of a Greek island which was devoid of hares. One day a visitor brings a single representative of the species and soon everyone was raising the creatures for food and fur. But in no time, they got out of control and the entire land was teaming with the rodents, bringing the population to the cusp of starvation as the animals destroyed their agriculture. After much effort, the hares were themselves all destroyed, except for one which was placed in the heavens as a reminder that too much of a good thing is simply, well, too much.

Lepus is one of the fainter constellations, its brightest star being only magnitude 2 1/2. You will find it immediately below the mighty Orion.

It has one noteworthy double star for novice observers, Gamma, which has good color contrast. One effusive astronomer described the colors as "pale yellow and garnet". The star is just around the block, astronomically speaking, at a distance of only 29 light years. One Messier object, M79, is also located here, a fairly average globular cluster, 50,000 light years away.

See if you can find Gamma Leporis tonight with your binoculars. Do you see one star, or two? What colors are they?

Aurora

Winter is a time of fa-la-la'ing in the crystalline air. The time of warm fires, mornings frozen solid by the chill of the shortened days. And for some areas of the world it is also, the time of the ghostly apparition known as the Aurora. Depending on your location, these are either the Northern or Southern lights, delicate glowing tenticles grasping at the silent darkness above.

The aurora are caused by a stream of protons and electrons constantly blown away from the Sun in all directions called the "solar wind". It is in effect the highest part of the solar corona, that irredecscent circle of light seen surrounding the Sun during a total eclipse. The speed of the wind has been measured at between 150 and 500 miles per second and it contains about 150 particles per cubic inch.

Although weak, effects of the wind can readily be seen in a comet's tail as it is propelled away from the Sun. Likewise the solar-wind particles when they hit the Earth, will excite tenuous gasses in the upper atmosphere around the poles causing beautiful auroral displays.This is not at all unlike what happens inside a neon sign. From space, the aurora are seen as a ring of fire, a feverish necklace surrounding the magnetic north and south poles. Unfortunately, most observers are too far away from the poles to ever see much auroral activity, but sometimes when the Sun is extremely energetic, they might be visible down near the equatorial regions of the planet.

The aurora are located between 50 and 370 miles in altitude, meaning that orbiting space shuttles can actually fly right through them. The lower displays tend to be reddish, while the higher ones are green or blue.

Double Cluster in Perseus

One of the most famous objects in the sky, you will find the Double Cluster in the northern corner of the constellation of Perseus. A bright fuzzy double-patch to the naked eye it explodes into a dazzling swarm of dozens of stars in even the smallest telescopes and hundreds in larger ones. The clusters are among the oldest of the deep-sky objects known, having been spoken of as early as 150 BC. At an estimated distance of 7500 light years it is thought that they lie in the next spiral arm of our galaxy. And at those distances our own Sun, in fact most average stars, would be extremely dim at about 18th or 19th magnitude. The brilliance of the cluster then takes on additional importance since the stars must be of almost unfathomable glory. Check them out tonight if you can. With each cluster the size of the full Moon it can be a spectacular sight. And if its cloudy tonight click here  and First Light will show it to you.

SAO:
Smithsonian Astrophysical Observatory

Perseus

Perseus is one of the most celebrated of all Greek figures. In all, 6 constellations are dedicated to telling his story. Perseus, son of Danae, was passionately disliked by King Polydectes who wanted the young man's mother as his wife. As a decoy, the king lavished his attention on another and announced their plans to wed. As a wedding gift, Perseus was required to bring the snake-adorned head of Medusa, one of the three Gorgons, whose icy stare would literally turn men into stone. This was a sure fire way to get rid of the pesky youth, and let Polydectes marry Danae.

Perseus used his family connections with the gods to his clear advantage. Outfitted with a cloaking helmet of invisibility from Hades, a diamond sword from Hephaestus, winged sandals borrowed from Hermes and a bronze shield from Athene, the young warrior made his way to the Atlas Mountains. His helmet hid him from Medusa's view. The polished sword reflected enough of her image for him to see, but not enough to turn him into stone. He swiftly decapitated her in one powerful motion, and placed the prize head into his sack. While working his way back home he happened upon the comely Andromeda, who was being sacrificed to the poisonously ugly sea monster, Cetus. Smitten by her beauty, he hopped on Cetus, killing him with an almost bored ease after his adventures with the Gorgons. He returned home with Andromeda, his future bride, the head of Medusa, and the desire for revenge. Crashing unexpectedly into a party the king was holding, Perseus held up his prize, turning Polydectes and his guests to stone. The kings honorable brother, Dictys then assumed the throne, and Perseus wedded his beloved Andromeda.

In the evening skies, Perseus is usually depicted as holding Medusa's head. He is surrounded by others from his journeys : Andromeda, Cetus, Pegasus, and his parents-in-law, Cepheus and Cassiopeia.

The brightest star in the constellation is Algol, known chiefly as one of the finest "eclipsing variables" in the sky. Algol, is composed of two stars orbiting around each other. Every 2.9 days one will pass in front of the other dropping it's intensity by nearly 3 times. The name Algol comes from the Arabic for "the demon's head", and is usually seen as being the evil eye of Medusa herself.

Next stop in Perseus is the Double Cluster. One of the most famous objects in the sky, you will find the Double Cluster in the northern corner. A bright fuzzy double-patch to the naked eye it explodes into a dazzling congregation of dozens of stars in even the smallest telescopes and hundreds in larger ones. The clusters are among the oldest of the deep-sky objects known, having been spoken of as early as 150 BC. At an estimated distance of 7500 light years it is thought that they lie in the next spiral arm of our galaxy. And at those distances our own Sun, in fact most average stars, would be extremely dim at about 18th or 19th magnitude. The brilliance of the cluster then takes on additional importance since the stars must be of almost unfathomable glory. Check them out tonight if you can. With each cluster the size of the full Moon it can be a spectacular sight. And if its cloudy tonight click here and First Light will show it to you.

On the border of Andromeda you will find M34, a bright open cluster best viewed with low power eyepieces. The cluster contains about 80 stars total.

Fornax, the Furnace

Besides mythological beasts and heroes of old, the night skies are also populated with bits of man-made machinery and miscellaneous stuff. Horologium is one such constellation. Another would be Circinus the compasses, Fornax the furnace and Sculptor, the artist's studio.

Most of these constellations are rather small and uninteresting and were introduced in the 18th and 19th centuries by various zealous astronomers who wanted to honor their kings or favorite pets, or to merely fill in perceived gaps between the ancient constellations.

Fornax, the Chemical Furnace, is one such creation, added by the French astronomer Nicolas Louis de Lacaille in the mid-1700s. Lacaille was also responsible for Antlia, Caelum, Circinus, Horologium and several other machine-based arrangements. Of the two other modern era astrocartographers, Pieter Keyser concentrated on creating animal constellations such as Dorado the goldfish or Pavo the Peacock. While Johannes Hevelius preferred a mixture of animate and inanimate objects and tried to link them in to the existing Greek constellations if possible.

Fornax is one of the faintest constellations, its brightest star shining weakly at a fourth magnitude. It has no deep-sky objects of any interest to amateur astronomers and no named stars. It does have a nice cluster of galaxies, the Fornax Group, reaching up to 10th magnitude. One member, NGC1365, is one of the brightest of its type in the southern skies.

Since it is in the south, Fornax will be low on the horizon for northern observers, but see if you can find it tonight, lying in the crook of Eridanus.

Dorado, the Goldfish

Dorado is one of the series of animal based constellations created by Pieter Keyser and Frederick de Houtman in 1598, to fill in the southern skies. This pair are also responsible for 11 others, which include Grus the Crane, Pavo, the Peacock, Phoenix, Tucana the Toucan and Volans, the Flying Fish.

As with many of the newer constellations, Dorado is rather unremarkable. It is deep in the southern skies, and would be visible only to observers below about 25 degrees north latitude. For North American observers, this limits visibility to areas in southern Texas and Florida.

Dorado does have one major feature : The Large Magellanic Cloud, our closest neighboring galaxy.