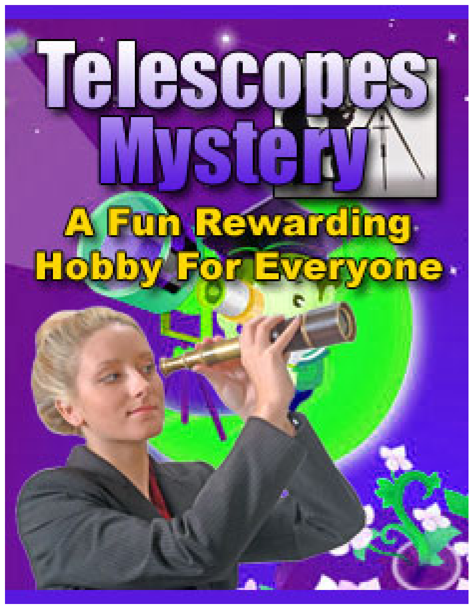


# Telescopes Mystery

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## A Fun Rewarding Hobby for Everyone

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# INTRODUCTION

Many, many people are fascinated with stars in the night sky. On a clear night when you can see a sky full of tiny lights, it can truly be an overwhelming and beautiful experience. After all, with the vastness of space, it becomes very obvious how truly small we are in the big scope of the world.

When we look at the stars with the naked eye, they are simply twinkling lamps that make for a pretty night. But when you are able to look at the stars and planets through the lens of a telescope, you'll see a much different sight.

With the help of a telescope, you can see crevices and craters on the moon, the brilliance of the stars, and so much more. There are many, many constellations in the sky – all with a storied history rooted in mythology and with their own stories.

Without telescopes, there are many discoveries that wouldn't have been made. New planets and moons are being discovered as are new galaxies and solar systems. You don't have to be interested in space necessarily to enjoy using a telescope. What you do need, however, is a desire to learn something new about the world we live in.

Everyone can enjoy the fun and rewarding hobby that telescopes can provide. Young people can learn about the brilliance of space, older people can pass on their knowledge as they continue to find more and more new and exciting discoveries with telescopes.

Telescopes have a long history dating back to the early 1600's and continuing even today. They have matured from simple devices to high powered tools that allow scientists to gaze into our world and find new things to amaze and delight.

You can even build your own telescope if you're so inclined! What a wonderful way to discover not only the satisfaction of your own scientific mind, but also to more fully enjoy what you can find out in the brilliant night sky.

In this book, we'll explore several different topics that have to do with telescoping as a hobby. You'll learn the history of the telescope and how they have evolved to where we are today. We'll show you some of the constellations that can be found along with the history behind those constellations. Plus, we'll guide you toward the right kind of telescope for the uses you have in mind.

It's a big world out there with many discoveries to be made. The vastness of the universe is an amazing concept – one that can probably never be fully understood. But when you start to look at the universe with a telescope, you'll come to realize that it truly is a big world we live in.

So let's explore telescoping – a fun and rewarding hobby for anyone!

# Chapter 1 - History of Telescopes

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## The Early Days

In 1609, an Italian mathematician named Galileo Galilei peered through an odd new device he had invented to look at the stars in the night sky. Suddenly, this well known and familiar place revealed itself as a barely exposed mystery. It was then that Galileo knew this was a ground breaking device.

The moon is a gray-white orb to the naked eye. Looking through this new instrument, Galileo was able to see shadows and bright spots on the surface of the moon. He could see that the moon also had mountains and valleys.

At the time, the planets were thought to be odd stars that "wandered" the sky. Through Galileo's device, he could see that the planets were accompanied by moving pinpoints of lights which were moons of their own!

Galileo quickly published his discoveries in a bulletin he titled "Message from the Stars". His claims, at first, were met with wonder and excitement. He presented his new device to the leaders of the time including the Catholic Church in Rome.

Eventually this device would be named "telescopio". In Greek, telescopio means "to see at a distance". This would eventually evolve into the word telescope, but it certainly was an apt name for this new invention.

Galileo's telescope was a simple instrument compared with the ones we use today. It was a tube with two lenses: the convex primary lens that curved outward and the concave eyepiece lens that curved inward. He built the device after hearing about the newly invented spyglass which was an instrument used by the military to peer into enemy camps.

This first telescope used the same principle that all telescopes would eventually rely on. That principle held that the combination of the two lenses gathered more light than the human eye could collect on its own. The lenses would focus that light and form an image. Because the image was formed by the bending of light, or refraction, these telescopes came to be known as refracting telescopes, or simply, refractors.

Galileo's best telescope magnified objects about thirty times. Because of flaws in its design such as the shape of the lens, the images tended to be blurry and distorted. However, the early telescope was good enough for Galileo to explore the sky.

Even though the introduction of the telescope was met with excitement, as his investigations progressed, Galileo began to make enemies. Some people argued that the telescope made people see illusions. Others claimed that the planets' details couldn't be seen with the naked eye and therefore didn't matter.

The hostility arose from a dispute about the way the universe worked. After all, this was a radical new concept that refuted the accepted norm of how people looked at the world. Remember at one time, people thought the world was flat until Christopher Columbus provided proof that it wasn't!

At the time, one belief about the universe was outlined by the astronomer Ptolemy a long time prior. His belief was that the Earth was the center of the universe and that everything revolved around it. Another astronomer, Copernicus, put the sun in the center of the universe.

The politically powerful Catholic Church promoted the belief that the Earth was the center of the universe. They also believed that the celestial bodies were perfect spheres – smooth and round devoid of any mountains or valleys. You can imagine the controversy the telescope generated with the new theories Galileo was putting forth.

In fact, Galileo was uncovering evidence supporting the Copernican theory. For instance, he saw that Venus has phases just like the moon which showed that the planet was moving around the sun and not the Earth. Also, he could see that Jupiter’s moons were clearly moving around Jupiter and not Earth.

Galileo knew that he had to be careful with his discoveries. If he said the sun was at the center of the known universe, he would be disagreeing not only with an old belief but also with stories in the Bible. Contradicting the Bible would be the same as saying the church was wrong and the church, at that time, dealt harshly with those who challenged it.

However, the more Galileo observed, the more convinced he became that the Copernican idea was correct. He felt so compelled to share his belief that he risked punishment by sharing his thoughts in an unrelated publication about sunspots.

The church, which had once supported Galileo, challenged his claim and ordered him to stop teaching his ideas. Instead, Galileo wrote a book about a fictional debate that strongly favored the Copernican theory.

As you can imagine, this was not met with great delight by the Catholic Church. Galileo was brought to trial by the church and forced to say he was wrong about the Copernican theory in order to avoid severe punishment. His book was banned and he was condemned to life imprisonment in his home.

Despite the church’s harsh treatment of him, Galileo never thought that he and his religion were in conflict. He argued that the human ability to experiment and reason was a great gift.

At one time, he wrote, “I do not believe that the same God who has given us senses and language and intellect would want us to set aside the use of these gifts and deny our senses and reason even in the case of those physical conclusions that are placed before our eyes and intellect….”

In the end, Galileo’s approach would prevail. He has used an instrument to extend human senses, made observations, and interpreted their meaning. The telescope and the wonders it revealed would become the driving force behind astronomy. Experimentation would become the foundation for scientific knowledge.

Galileo’s telescope revealed the first hint of the depths of space. His dedication and approach to explaining what he saw revolutionized astronomy. The best part is that even though Galileo is the one who began it all, the evolution of the telescope would continue toward new heights.

## Mid 1600’s

Though the Catholic Church had tried to silence Galileo, his ideas caught fire. Word about the telescope spread across Europe along with a new philosophy of basing scientific judgments only on measurable evidence.

The next step in the technology of refracting telescopes occurred because of a man who would never actually build one. Johannes Kepler, a German born astronomer who studied optics was the first to understand how a glass lens focuses the light.

Kepler suggested changes in the shape and placement of the lenses to both widen the field of view as well as improve the quality of the image. First, he replaced the concave eyepiece lens with a convex lens. This change let the telescope see a much larger area. Because of these advances, people would stop using Galileo's design and start to adopt Kepler's two-convex lens design.

However, Kepler's telescope design wasn't perfect. He was unable to solve the issue of chromatic aberration which consisted of circles of color that would appear around bright objects due to the way the lenses bend light. Lenses bend different colors of light by different amounts creating a different focal point for each color.

But, he did discover a way to get rid of the blurry images produced by Galileo's telescope. Kepler found that this problem was caused by the spherical shape of the primary lens. Spherical lenses cause light rays to bend so that they never meet at one point. This blurriness became known as spherical aberration.

By studying the lenses of the human eye, Kepler learned that a more complicated shape than a sphere would be needed to make a lens focus perfectly. Astronomers at the time didn't have the technology to grind lenses of different shapes, but they could make spherical lenses with a more gradual curve which caused the light to bend less.

This made the light rays come closer to a meeting at a single point and eliminated much of the blurriness. Unfortunately, the light rays met much further away from the eyepiece. The greater distance between the lenses meant the telescope had to be longer.

Astronomers began to design and build longer and longer telescopes achieving further discoveries in the night sky. But then the designs began to get a bit out of control. Some of the telescopes expanded to over 100 feet in length – so long, in fact, that they could no longer be enclosed in tubes or handled easily.

The designers' enthusiasm far outweighed their sense of practicality. Some of these wild contraptions were simply bare lenses attached to poles or controlled by ropes and pulleys. One person even suggested building a 1,000 foot long telescope that would be able to see animals on the moon!

Even though the longest refracting telescopes were certainly impressive garnering a lot of attention, the reality was that they didn't work very well. They frequently suffered from mechanical failure because of their size and were difficult to keep steady. Observations were often interrupted by the swaying and shaking of the telescope.

In this era, most of the important astronomical discoveries were made with 30 to 40 foot refracting telescopes. Not quite as impressive as their hundreds longer counterparts, the people who made these shorter ones certainly had more of a sense of idea as to how the telescope should work.

## Late 1600's

With refractors growing to over a hundred feet long and becoming increasingly difficult to handle, it would be necessary for the design of telescopes to change. With such large devices, it was more and more difficult for people to use.

This is where Sir Isaac Newton comes in. Known as a "natural philosopher" Newton studied the natural world. He used observation, evidence, and calculations as a basis for his conclusions. Sometime in the 1680's, he built a small but powerful telescope that created images free from chromatic aberration.

All he did was changing the telescope's primary lens – its most basic element. Newton replaced the convex glass lens with a spherical mirror that reflected and focused the light. .By changing the primary lens to a mirror, he launched a new class of telescopes called reflectors.

You see, Newton understood that chromatic aberration was caused by refraction. Other scientists thought this effect was caused by light bouncing off flaws in the glass. Newton found that the glass itself was causing the light to separate into colors. When the light passed through the lens there is different colors of light bent by varying degrees. Violet light bent the most and red light bent the least.

When Newton removed the glass and replaced the primary lens with a concave mirror, the mirror would collect light and reflect it back through the telescope. The mirror focused lights much like a glass lens, but because the light was reflected and didn't pass through glass, it wouldn't be split into colors.

No one knew, at that time, how to make glass mirrors that would work in telescopes so Newton made his mirror out of a metal alloy of copper and tin. He left the eyepiece – the second glass lens – alone. That would still cause chromatic aberration as the light passed through, but the lens was so small that the chromatic aberration was not noticeable.

In order to avoid blocking the light's path with his head as he looked through his telescope, Newton had to add another smaller, flat mirror inside the telescope. This was called the secondary mirror. This secondary mirror reflected the gathered light out through the side of the telescope into the eyepiece.

Perhaps the best part about Newton's new telescope was its size. Only six inches long, his reflecting telescope magnified objects almost 40 times. This was the same magnification as refractors that were three to six feet long and Newton's telescope had a mirror that was just six inches in diameter.

However, Newton's telescopes weren't without problems. In fact his design had many of the same difficulties as earlier telescopes. While the chromatic aberration was gone, the spherical aberration was still there. Newton knew that the spherical shape of the mirror caused the blurry image, but the technology of that time left him unable to grind a mirror into any other shape.

There was another brand new problem that Newton's telescope presented. The copper and tin mirrors tarnished quickly and had to be polished often. Plus, the mirrors reflected only 16 percent of the light they encountered. The refractors still produced much brighter images.

Nonetheless, Newton had launched a whole new branch of telescope design with his reflecting telescope. From that point on, reflecting and refracting telescopes would be in constant competition – a technological battle for the best view of the sky.

## Early 1700's

By using mirrors to reflect light rather than glass lenses to refract light, astronomers were able to design shorter, more powerful telescopes. This was an important improvement as astronomers wanted to be able to maneuver a telescope easily. They didn't want to waste most of the night fighting to adjust the telescope's position or line up the lenses.

The industrial revolution began in the 18th century and manufacturing and industry was spreading across Europe. Innovations in technology made people turn to machine to accomplish tasks including – in the case of telescopes – lens and mirror grinding.

Scottish mathematician and astronomer James Gregory first envisioned a parabolic mirror that curved differently than a spherical mirror. The light rays that bounced off the edges and the center would all meet at the same point and thus create a clearer image.

Once astronomers learned to make parabolic mirrors, they were able to create reflecting telescopes that had neither spherical nor chromatic aberrations. Not only were these the first telescopes to produce clear images of the sky, they had shorter focal lengths, were more compact, and easier to use.

But of course, just as before, it wasn’t long before telescopes were being built bigger. This was because astronomers were constructing larger and larger primary mirrors. The bigger the mirror, the more light it could collect. Large mirrors enabled telescopes to see increasingly distant and dim objects.

The size of the primary mirror – not the length of the telescope – would indicate how powerful the telescope was. The reflecting telescopes got bigger, but only because the mirrors that had to fit inside were being made larger.

These large reflecting telescopes became quite popular in this era. The glass lenses of the refracting telescopes were improving, but it was easier to make a metal mirror than a glass lens. Mirrors simply had to be shiny and in the correct parabolic shape in order to work in a telescope. However, glass lenses had to be free of any imperfections in the glass or errors in shape or else the light would be distorted as it passed through.

Even though the reflecting telescopes were growing in popularity, they weren’t without their flaws. The tin and copper alloy used to make the mirrors tarnished which meant the mirrors needed frequent polishing. The metal mirrors didn’t reflect as much light as the glass lenses transmitted, so reflecting telescopes produced dimmer images than similarly sized refracting telescopes.

There was also some difficulty involved with manipulating large telescopes. Sure, the mirrors were large, but they had to be enclosed in large casings that were difficult to move around and explore the night sky with.

By the mid-1800's, the largest metal mirror reflectors had become powerful enough that atmospheric distortion would become an obstacle. This distortion occurs because of moving pockets of air in the atmosphere. As light passes through these shifting pockets, it bends in unpredictable ways. As a result, the stars appear to twinkle if you look up at the night sky with your eyes alone. If you use a telescope, the image will appear blurry.

## Mid 1700's to Late 1800's

Refracting telescopes, with their long, difficult-to-handle design, were quickly being outpaced by the more practical reflecting telescopes. They might have dropped out of the race altogether. However, discoveries about light and the way glass lenses work led to innovations that solved two nagging problems.

By the mid-1700's, astronomers understood that glass would separate or disperse white light into a rainbow of colors. In refracting telescopes, this effect created a problem called chromatic aberration – circles of color surrounding bright objects. Chromatic aberration occurs because lenses bend different colors of light by different amounts. Red light bends the least and violet light bends the most creating a focal point for each color.

Astronomers also realized that some kinds of glass bend light more than others. In 1729, Chester Moor Hall of England, a hobbyist experimenting with lenses, realized he could use this effect to solve the problem of chromatic aberration. He combined a concave lens of dense, clear "flint glass", the type used to make cut-glass decorations, with a convex lens of "crown glass", the type used in windows.

The convex lens would bring light rays together, whereas the concave lens would spread light rays apart. The combination of different shapes and substances made chromatic aberration disappear. Basically, the way one lens splits the colors of light is cancelled out by the way the other lens combines them.

Another Englishman, John Dolland, extended Hall's technique to create a similar set of lenses. By changing the curve of the lenses and fitting them together, Dolland managed to bend the light enough to cancel out spherical aberration which was another major problem in refracting telescopes.

Even with these advances, the techniques of glassmaking at the time were not able to produce a useful primary lens larger than four inches in diameter. There were imperfections and bubbles in large pieces of glass that refracted light unevenly making them unsuitable for telescopes.

It became increasingly more obvious that new techniques for making telescope lenses would have to be created. In the late 1700's and early 1800's, a Swiss artisan, Pierre Louis Guinand, teamed up with a German optician, Joseph von Fraunhofer to work on the process of casting glass for lenses.

By adding certain chemicals to the molten glass and inventing new stirring techniques, the men were able to create large pieces of glass that contained fewer flaws and refracted light uniformly. This would prove to be groundbreaking in telescope technology.

Now that chromatic aberration was no longer present with the larger glass lenses, the telescopes known as achromatic refractors began to grow in popularity and size. As the diameter of the primary lens increased, refractors again expanded in length to accommodate the larger lenses. Essentially, the larger the lens, the more light it could collect thus making fainter objects easier to see.

The refracting telescopes provided the sharpest view of the sky because their lenses were much better at collecting light than the tin and copper mirrors of reflecting telescopes. They began rising in popularity among astronomers as well as the casual hobbyist.

As photography became popular in the early 1800's, a new era for telescopes opened up as well. In 1840, an English-American chemist and photographer, John William Draper, focused the Moon's image on a light-sensitive photographic plate. He used a clockwork device to keep the light in place even as the Earth rotated and the moon moved through the sky. After an exposure of 20 minutes, he had taken the first ever photograph of the moon!

Within the decade, the technologies of photography and of tracking celestial objects would migrate to telescopes, enhancing them dramatically. No longer would endless sketching be needed to represent what was seen. Image could be recorded to film and faint objects could be more easily observed.

However, by the end of the 1800's, refracting telescopes had reached their peak. The lenses had reached 40 inches and couldn't grow any larger. The reason for this growth halt is threefold:

1. The casting process used to create even bigger lenses introduced imperfections such as bubbles into larger pieces of glass making them unusable in telescopes.

2. Larger lenses had to be so thick that they absorbed much of the light they were collecting. That meant the image wasn't any brighter than the one produced by smaller mirrors of reflecting telescopes. Those mirrors were less expensive and easier to build than glass lenses.

3. In order for a refractive telescope to be effective, light has to pass through the whole lens. The lens can only be supported by its thin edges. There is no support at the center where the glass is thickest thus the glass sags in the middle deforming the lens. In any lens larger than 40 inches, the

sagging would be so invasive that the lens would be useless for astronomy.

The large refracting telescopes were no longer being built by the 1890's. But, before then and for some time afterward, refractors were the most popular instruments around. In fact, by the mid-1800's, almost all British observatories used refractors, and even today, there are still some observatories who utilize refracting telescopes.

## Solar Telescopes

Telescopes were invented and honed so that people could see planets and stars. Astronomers began to see the need to focus on one star largely ignored – the sun. This however would not be able to be achieved with a regular telescope.

Usually telescopes are built to see objects that are too faint and far away to be easily visible. The mirrors or lenses used in regular telescopes collect more light than the human eye can see on its own.

Solar telescopes – those designed to see the sun – have the opposite problem. Their target emits too much light and in order to study the sun, astronomers need to be able to filter out much of the bright light it gives off in order to study it. The telescope itself doesn't have to be extremely powerful. The instruments attached to it do most of the work.

Solar telescopes are ordinary reflecting telescopes with some important changes. Because the sun is so bright, solar telescopes don't need huge mirrors that capture as much light as possible. The mirrors only have to be large enough to provide good resolution.

Instead of light-gathering power, solar telescopes are built to have high magnification which depends on focal length. The longer the focal length the higher the magnification, so solar telescopes are usually quite long.

Since the telescopes are so long, the air in the tube becomes a problem. As the temperature of the air changes, the air moves which causes blurry images. Scientists initially tried to keep the air inside the telescope at a steady temperature. They would paint the telescopes white to reduce heating since white surfaces reflect more light and absorb less heat. Today, the air is simply pumped out of the tubes creating a vacuum.

Solar telescopes are designed not to move. That's because it's so necessary to control the air inside the telescope plus the instruments used to operate it are large and bulky. Therefore, these telescopes stay in one place while a moveable mirror at the end of the telescope – a tracking mirror – follow the sun and reflects its light into the tube. These mirrors are mounted high above the ground to minimize the effect of heating.

In the 1890's, when the American astronomer George Ellery Hale was still a student in college, he combined the technology of spectroscopy and photography and came up with a new and better way to study the sun. He called his device a spectroheliograph.

This instrument allowed astronomers to choose a certain type of light to analyze. For example, they could take a picture of the sun using only the kind of light produced by calcium atoms. Some types of light make it easier to see details such as sunspots and solar prominences.

In 1930, French astronomer Bernard Lyot designed the coronagraph that uses a disk to block much of the light from the sun revealing features that would otherwise be erased by the bright glare. Close observations of the sun's corona, certain comets, and other details and objects are made possible by the coronagraph. They also allow scientists to study features like solar flares and the sun's magnetic field.

Today, the world's largest solar telescope is the McMath-Pierce Solar Telescope located on Kitt Peak in Arizona. There is also a solar telescope in space called the Solar and Heliospheric Observatory Project. This studies the sun's interior and corona along with solar wind in ultraviolet and X-rays as well as visible light.

## Early to Mid 1900's

In many ways, reflecting telescopes were the ideal instrument for studying the sky. They were easier and cheaper to build than the large refractors which were much more popular. However, as we've talked about, the mirrors would tarnish reflecting less light as time passed. Unless the telescope had a backup mirror that could be moved into place, all observations would have to come to a halt until the mirror could be polished.

Glass mirrors with a metal backing like the mirrors typically found in homes were being made and used. But those mirrors wouldn't work in telescopes. The light would bend as it traveled through the glass, bounced off the metal backing and traveled through the glass again blurring the image.

In the 1850's, a German chemist named Justus von Liebig made a new kind of mirror. He used a newly discovered chemical reaction to cover the surface of a piece of glass with a thin film of silver. The silver could easily be polished to create a mirror. Astronomers began to realize that this method would be perfect for telescope mirrors.

Before this advancement, it had been too expensive to make telescope mirrors out of silver, but this chemical technique used so little silver that cost was no longer an issue. This was an inexpensive, lightweight glass mirror that reflected 50 percent more light than metal mirrors. The silver still tarnished, but it was easier to replace the silver coating than it was to polish a metal mirror.

As in earlier times, astronomers began making giant mirrors at a fraction of the price which made some telescopes absolutely huge. Some of the mirrors were up to 200 inches in diameter! Previous experience with early reflectors taught them about atmospheric distortions that can affect observations. The lights from cities and the pollution produced by their factories also impeded viewing.

What this would come to mean is that the location of the telescope was almost as important as the mirror size. To avoid obstacles that would impede observations, giant telescopes were being built on high mountains where the air was thin enough that the twinkling effect caused by atmospheric distortion was reduced and the lights and pollution of cities were far away.

Higher areas were also advantageous for astronomers because of photography that would allow them to create a fast and accurate record of their observations with having to draw everything they saw. Pictures were also a way for astronomers to observe objects that were too faint to be seen by the human eye – even a human eye using a huge telescope.

You could stare at the night sky for hours through an eyepiece, but there is no way you will able to see stars that are too faint for your vision. But a photograph records all the light it is exposed to no matter how faint. Even a light too dim to make a mark at first will eventually make one if the exposure continues for long enough time.

If the telescopes were moved to faraway mountaintops where the skies were so dark that the only light came from the heavens, astronomers discovered that photographs would reveal faint stars and celestial objects that could not be seen with the human eye. Eventually all telescopes would use photography.

During this time frame, astronomers began adding new scientific instruments to their old telescopes. Soon they were building new telescopes with specific instruments in mind. These instruments were designed to break up the light from stars and planets so astronomers could further analyze what they saw. Before long, the quality of a telescope's instruments would be as important as its ability to gather light and its resolution.

Telescopes were starting to resemble the ones we are familiar with today, but obstacles remained. There was still enough atmospheric distortion in the mountains to cause blurriness although it certainly was less than that caused in the cities.

## Late 1900's to Now

For centuries, telescopes had grown bigger and better and the view had become clearer and sharper. Once telescopes had reached a size that allowed them to see well, astronomers found themselves faced with a problem completely unrelated to the telescope's design. That problem was the Earth's atmosphere.

As light passes through the atmosphere, it can be bent in unpredictable ways by warm and cool air pockets. Therefore, astronomers were constantly studying the skies through a shimmering field – almost as if they were trying to see objects through a heat haze.

When we look at the stars with our naked eyes, the atmosphere makes it look as though the stars are twinkling. When astronomers use telescopes to take a picture of a celestial object through the atmosphere, the details are blurry. This blurriness prevented astronomers from realizing the full potential of the powerful telescopes that they had built. It limited the view from the ground no matter how large the telescope was.

The atmosphere becomes a bigger problem when astronomers want to study the skies by viewing other types of radiation. Visible light and radio waves are allowed to pass through the atmosphere, but most other radiation such as X-rays and gamma rays are blocked and infrared or ultraviolet rays are partially blocked.

There was a solution, however. The world was in the early stages of space flight which made astronomers very hopeful when it came to combating the problems they were having with telescopes. If the atmosphere couldn't be defeated, then it would have to be left behind. And the birth of the space telescope had begun.

By placing telescopes in space, astronomers could be rid of the distorting and shielding effects of the Earth's atmosphere. However, producing these observatories in space made it necessary for significant advances in the telescopes, their instruments, computers, and the spacecraft used to launch them.

Large, ground-based observatories work together with space telescopes to further our understanding of the universe. The space observatories have higher resolution and can look at tiny regions of the sky in great detail. Ground-based telescopes collect more light with their huge mirrors and can be used to survey large portions of the sky. Using both parts can help astronomers get a more complete view of an object.

Even though there have been great strides made with adaptive optics in the ground-based telescopes, space telescopes are still the best option for avoiding the blurriness caused by the atmosphere. NASA's Great Observatories program constructed four orbiting telescopes:

- The Hubble Space Telescope
- The Compton Gamma Ray Observatory
- The Chandra X-Ray Observatory
- The Spitzer Space Telescope

Space telescopes are not without their drawbacks. They are much more expensive to build and launch than ground-based observatories. Because they are launched into space, they cannot be as large as the ground-based observatories. They are difficult to near impossible to fix and upgrade because they remain in orbit. When they break down, they're gone forever.

Now, there are millions of people who really enjoy going out on a clear night and looking at the stars, the moon, and the constellations. If Galileo hadn't had the desire to make the first telescope, we would simply be relegated to looking with our naked eye. Luckily, we don't have to.

Telescopes have come a long way over the years and has truly become a rewarding hobby for many people. Of course, the first thing you'll need is --- a telescope! What should you look for when you go to buy your first telescope?

# **Chapter 2** - Buying a Telescope

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There are actually some technicalities that go into buying your first telescope. Many times what people think they want and what they really want are two very different things. Just like with any other large purchase, you have to ask yourself two simple questions:

1. What do you really want to do with your telescope?
2. How much money do you want to spend?

It's often a good idea to start out small and work your way up to "bigger and better". If you don't have much money to invest, you may want to start out with a pair of binoculars. Even the cheap ones will amaze you with how much you can see of the night sky.

Binoculars are classified according to their optics (7 x 10 for example). The first number is the magnification factor and the second number is the size in millimeters of the objective lens. Obviously, the larger the first figure is, the larger the magnification is, but you will have a smaller field of view. The larger the second figure, the more light is gathered by the binoculars and therefore fainter objects become visible.

Seven to ten times magnification is the optimum you should look for in a pair of binoculars for general use. The objective lenses should be between 40mm and 50mm. If there is anything less then the light grasp may be insufficient, anything greater and (apart from the additional expense) the binoculars will start to become too heavy to easily hold by hand.

Many binoculars suitable for astronomical use start in the 7 x 40 to 10 x 50 bracket. If you do decide to buy something larger, say 10 x 70, you will almost certainly have to consider mounting them on a tripod - they will be difficult to hold by hand. Up to 20 times magnification may be considered in a set of binoculars but again, a tripod will become a necessity. In any event do find out if the binoculars have the facility to be tripod mounted - not all of them can!

Binoculars will bring into view the brighter star clusters, galaxies and nebulae. They can be used to help locate an object with a telescope, identifying the chosen target before bringing the telescope to bear on it. Bright variable stars, comets, satellites and large scale night sky features are all well suited to observation with binoculars. The bright planets can also be spotted in twilight with binoculars so overall they are a useful instrument for both the beginner and the experienced astronomer.

A good pair of binoculars will run you anywhere from $50 to $250. Of course, this will depend on where you buy them and your area, but this is a good general number to expect to pay.

There are two types of telescopes: reflectors and refractors. Depending on what you will be using your telescope for will determine which type you want. Here are some things to consider when choosing either a reflecting telescope or a refracting telescope.

**<u>REFRACTORS - ADVANTAGES:</u>**

- Optics holds their alignment (collimation) well.
- No reflecting surfaces (mirrors) to maintain.
- Image definition and contrast is generally good.
- No central obstruction (as in reflectors).
- Simple eyepieces work well.
- Good for solar, lunar and planetary views.
- Good for resolving close double stars.

## REFRACTORS - DISADVANTAGES:

- Only smaller aperture instruments are easily portable.
- Bulkiest type of telescope per inch of aperture.
- More difficult to mount rigidly.
- Not always suitable for photography without filters.
- False color fringes appear with cheaper lens systems.
- The eyepiece is often in an awkward position.
- Costs more per inch of aperture than any other type of telescope.

## REFLECTORS - ADVANTAGES:

- The cheapest instrument per inch of aperture.
- Suitable for visual and photographic use.
- Can be readily purchased in sizes much larger that other types.
- Eyepieces are usually conveniently placed.
- Compact - does not need a tall mount.
- Good choice if faint objects (via a large instrument) are the target.
- Small reflectors are good instruments for the beginner.

## REFLECTORS - DISADVANTAGES:

- Mirror surfaces are prone to deterioration over time.
- The secondary mirror/mount blocks some light and reduces image contrast.
- Mirrors are sensitive to optical alignment, especially if the telescope is frequently moved.

Do not buy a telescope based on power alone.  Even the best telescopes are limited to about 50x to 75x per inch or 24.5mm of aperture.  For an inexpensive

60mm refractor, that equals 120x. Sometimes boxes will boast “650x of power” on the box and it is a marketing ploy designed to get your mind thinking you are getting a super duper powerful piece of equipment when you aren’t.

The diameter of the lens or mirror is called the aperture and it is generally the most important attribute to consider in a telescope. The larger your aperture, the more you’ll be able to see and the further away you’ll be able to see. Larger aperture refractors can be very expensive, but buy the largest aperture telescope that your budget can afford.

If you are serious about your interest in astronomy, realize that you will be making an investment in a piece of equipment that you will need to enjoy this hobby. You won’t want to take this lightly and will want to test out your telescope as much as possible before buying it. Here are some things you should do:

- Look down the tube through the main lens. Is there a stop - a disc with a small hole in it - a short way down the tube? (This should not be confused with light baffles, which are a series of rings of decreasing diameter positioned at intervals down the tube).

  Such a 'stop' is an attempt to sharpen the image, like using a small f-stop on a camera. Unfortunately it drastically reduces the effective aperture, and hence the image brightness. Many small telescopes have these 'stops' fitted but they are difficult to see; it is a fair bet that a telescope with stops fitted are of inferior quality and should be avoided.

  Telescopes of this sort will show you only a little more than you can see with the naked eye. If they claim to use the full size of the lens, they are being fraudulently advertised.

- If possible, observe the Moon at night. Its edge should be sharp and free from obvious false color. Make sure you observe from outside, and not through a window, closed or open.

- Look down the tube or part where the eyepieces (often mistakenly referred to as lenses) would normally be placed. This part is often referred to as the 'focuser' or 'drawtube'. Is there a stop - a disc with hole in it - a short way down this assembly?

  Such a stop is often an attempt to sharpen the image due to poorly made mirrors. Many small cheap reflecting telescopes have these 'stops' fitted and they may be indications of poor build quality and should be avoided.

If possible, make the following checks on the telescope's mounting...

- Lightly tap or push the telescope up and down and side to side. Is there is any excessive movement or play in any of the parts about which the telescope is pivoted?

  Many telescopes are completely let down by poorly made mountings. A bad mounting can make a telescope difficult, even impossible, to use properly. The slightest movement of the telescope can cause it to vibrate badly, in a breeze for example. Also, such play can make aiming the telescope accurately a very frustrating process. If there is any excessive play or undue stiffness in any part of the mounting the instrument should be avoided.

- Move the telescope about as if you were going to point it at an object. Is the motion smooth, with only moderate friction?

> If the movement is stiff or jerky the telescope will be difficult to aim. If the movement is too slack the problems listed above will arise.
>
> The mounting is the area where many telescopes will fail a test. Quite often I have seen quite well made telescopes rendered next to useless because the mount is of poor quality!

If the telescope fails any of these tests, do not buy it, or return it for a full refund.

The magnification of a telescope depends on the eyepiece used. Telescopes usually come with a selection of eyepieces that offer low, medium and high powers. Do not get carried away by advertisements for small telescopes that claim magnifications of many hundreds of times. Too high a magnification will show less rather than more, since an over-magnified image will be faint and indistinct.

Some small telescopes are advertised as being able to magnify up to 400 times when in reality, even under exceptionally good conditions, the telescope could never deliver a good image at anything over 200 times magnification. The figures quoted for some telescopes are excessive and very misleading. So, a general rule of thumb is... If you see a telescope advertised as able to magnify, say, 300 times - halve that figure and you will be closer to the truth!

The best simple guide to the true, usable magnification of an instrument is: twice the aperture in millimeters, or 50 times for each inch of aperture. Of course, if the telescope's aperture is stopped down, the maximum usable magnification is correspondingly reduced.

The atmosphere itself places a limit on the highest magnification you can use, because air currents make the images of stars and planets unsteady, an effect known as 'seeing'. No matter how large a telescope you own, from a normal ground-level site the maximum usable magnification will be about 300 to 400 times. Beyond this, an eyepiece just magnifies the distorting effect of the atmosphere, creating a useless "boiling" image.

Telescopes, like cameras, have 'f' numbers. The focal length of a telescope is the length of the light path from the main lens or mirror to the eyepiece. The focal ratio (or f/ratio) of a telescope is its focal length divided by its aperture. For example, a telescope of 100 mm aperture with an 800 mm focal length is an f/8 instrument.

You will also want to have a mounting device for your telescope in order to have the best performance.  There are many different kinds of mountings for you to choose from.

**Altazimuth:** The simplest type of mounting, used by many small refractors and reflectors, is the altazimuth design.  This requires you to move the instrument simultaneously about both axes (altitude and azimuth) to keep an object in the field of view. In essence, the telescope can be moved up and down (altitude, or angle above the horizon - 0°to +90°) and left and right along the horizon (azimuth, or angle along the horizon - 0° to 360°, North, East, South, West, and back to North, and vice-versa).

**Equatorial:** Larger telescopes often incorporate an equatorial mount, which needs to be set up more carefully with the polar axis pointing to the north celestial pole, near Polaris (assuming that you are observing from the Northern Hemisphere).

In reality the equatorial mount has 4 axes. Two of these are generally adjusted then fixed before the telescope is used. These two axes align the mount so that the pole-ward pointing axis is aligned parallel to Earth's axis. These 2 axes are in effect the altitude and azimuth axes.

The other two axes can then be used to move the telescope to correspond with Right Ascension and Declination co-ordinates. An equatorial mount is more expensive and complex but has the advantage that objects can be kept within the field of view as the Earth rotates by turning the telescope around the pole-ward pointing axis only.

**Dobsonian**: In recent years the Dobsonian mount has become increasingly popular as a low-cost portable alternative to equatorials. It incorporates a modified altazimuth design, and is best suited to reflectors used with low power eyepieces for wide-angle viewing of the sky, in which precise tracking is not essential.

Despite this last remark some Dobsonians, especially larger ones, are fitted with a driving system and computer control. This driving system may also be fitted at a later date to the unmodifed mount.

This type of mount is usually made from wood. The base of the Dobsonian mount is rather like two stacked discs: one is in contact with the ground and the other is able to swivel about upon this. This enables the mount to pivot left and right in azimuth. Upon this moving disc is a 'U' shaped structure which has two large semi-circular grooves at the top parallel to each other.

Two circular discs mounted along the length of the telescope tube complete the set-up. These two discs on the telescope tube mean that the telescope can then be placed on the mount, the discs sitting in the two semi-circular grooves on the mount. This enables the telescope to point up and down in altitude.

The Dobsonian mount has become so popular since the mounting is simple to make (and use), well within the realms of D.I.Y. skills. Also, the telescope and mount can be quickly assembled together (and dismantled) making the whole thing easily portable.

Not only that but a large reflecting telescope can be used on a Dobsonian mount and since the azimuth pivot is close to the ground there may be no need for steps or stools to reach the eyepiece. Also, because the telescope's center of gravity is closer to the ground the 'footprint' of the base can be smaller than that of a tripod mounted telescope.

Such is the popularity of this mount that many telescopes are sold simply as 'Dobsonians' but that is to say that they are actually reflectors (usually) using a Dobsonian mount. The Dobsonian takes its name from the inventor, John Dobson.

**GOTO**: A most recent addition has been the advent of the GOTO mount to the telescope. Many of these telescopes are becoming more affordable and available. They are popular in that they are in effect computer controlled.

In its simplest form the GOTO is a telescope (usually a Cassegrain) integrated with a hi-tech Dobsonian mount. A handheld computer control unit contains a database and simple up/down, left/right control buttons (plus a few other buttons) and digital readout.

A simple process of aligning the telescope with two stars can then be made to tell the control unit how to control the telescope so that it can track an object or find one - polar aligning, 'GOTO', and find - without too much fuss! GOTO telescopes are sold with the ability to be tripod or pillar mounted, or they can simply be placed on any steady, flat surface. The portability and versatility of such an instrument is fairly obvious.

There are some warnings that must be made about mountings, however. Department store and mail-order-catalogue telescopes often employ notoriously unstable, badly made and clumsy desktop tripod mountings.

There is no point in buying a telescope with a shaky mounting, as you will be unable to see anything properly, particularly when it is windy outside. Also, remember that comfort and ease of use are vital. You will not enjoy using a telescope if you have to kneel down and crane your neck round to look through the telescope.

It must be said that in recent years the quality of some telescope mountings have improved markedly but there are still a lot of poorly made tripods and mountings out there. Regrettably, there are several telescopes that in themselves were well made and fairly good value for money - only to be completely let down by their tripods and mountings which were next to useless.

So what is the best telescope for you? The simple answer is: it's the one that you think you'll use the most often. Ease of set-up, simplicity of use and portability should be key factors in your decision.

Move up to larger equipment only when you have proved to yourself that you can get out observing on a regular basis. Also, make contact with your local astronomical society who may be able to give you advice on equipment and its use. Their address should be available from your local library or the internet.

So, you've finally gotten your heart set on a telescope you want. You take a deep breath and shell out the cash and – IT'S YOURS! But now what? You have only a basic idea of how to use this new contraption, so where do you go from here?

Let's start with some terminology you will want to know about in the next chapter.

# Chapter 3 - Terminology

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Beginners often have trouble describing distances on the sky. The problem is that distances on the sky can't be expressed in linear measures like feet or inches. The way to do it is by angular measure. Astronomers might say the two stars are 10 degrees (10°) apart. That means if lines were drawn from your eye to each star, the two lines would form a 10° angle at your eye.

Hold your fist at arm's length and sight past it with one eye. Your fist from side to side covers about 10° of sky. A fingertip at arm's length covers about 1°. The Sun and Moon are each ½° wide. The Big Dipper is 25° long. From the horizon to the point straight overhead (the **zenith**) is 90°.

There are finer divisions of angular measure. A degree is made up of 60 **arcminutes**, and each arcminute is made up of 60 **arcseconds**.

If two objects appear a quarter degree apart, astronomers might note that as 15 arcminutes (abbreviated 15' ). The brightest planets usually appear just a few dozen arcseconds across as seen from Earth. A 5-inch telescope can resolve details as fine as 1 arcsecond (1" ) across. This is the width of a penny seen at a distance of 4 kilometers (2½ miles).

Seen from Earth, the night sky looks like a huge dome with stars stuck on its inside surface. If the Earth beneath us vanished, we'd see stars all around us — and we'd have the breathtaking sensation of hanging at the center of an immense, star-speckled sphere. Astronomers designate the positions of stars by where they are on this **celestial sphere**.

Picture the Earth hanging at the center of the celestial sphere. Imagine the Earth's latitude and longitude lines ballooning outward and printing themselves on the celestial sphere's inside. They now provide a coordinate grid on the sky that tells the position of any star, just as latitude and longitude tell the position of any point on Earth. In the sky, "latitude" is called **declination** and "longitude" is called **right ascension**. These are the standard **celestial coordinates**.

Declination is expressed in degrees, arcminutes, and arcseconds north (+) or south (–) of the celestial equator.

Right ascension is expressed not in degrees, but in hours (h), minutes (m), and seconds (s) of time, from 0 to 24 hours. Astronomers set up this arrangement long ago because the Earth completes one turn in about 24 hours. So the celestial sphere, with its coordinate grid permanently printed on it, appears to take about 24 hours to complete one turn around Earth.

There's a slight complication. A star's celestial coordinates gradually change over the years, due to a slow shift of the Earth's orientation in space called **precession**.

When right ascension and declination are given in books and atlases, you'll often see them accompanied with a year date such as 2000.0. (The ".0" means the beginning of the year: midnight January 1st.) This is the moment for which the coordinates are strictly correct. For most amateur purposes this refinement is too small to matter.

The brightness of a star (or anything else in the sky) is called its **magnitude**. You'll encounter this term often.

The magnitude system began about 2,100 years ago when the Greek astronomer Hipparchus divided stars into brightness classes. He called the brightest ones "1st magnitude," meaning simply "the biggest." Those a little fainter he called "2nd magnitude," meaning second biggest, and so on down to the faintest ones he could see: "6th magnitude".

With the invention of the telescope, observers could see even fainter stars. Thus 7th, 8th, and 9th magnitudes were added. Today binoculars will show stars as faint as 8th or 9th magnitude, and an amateur's 6-inch telescope will go to 12th or 13th. The Hubble Space Telescope has seen to about 30th magnitude — which is nearly 10 billion times fainter than the faintest stars visible to the unaided eye.

On the other end of the scale, it turns out that some of Hipparchus's "1st-magnitude" stars are a lot brighter than others. To accommodate them, the scale now extends into negative numbers. Vega is zero (0) magnitude, and Sirius, the brightest star in the sky, is magnitude –1.4. Venus is even brighter, usually magnitude –4. The full Moon shines at magnitude –13, and the Sun, magnitude –27.

The Earth orbits (circles around) the Sun once a year at a distance from the Sun averaging 150 million kilometers, or 93 million miles. That distance is called one **astronomical unit (a.u.)**. It's a handy unit for measuring things in the solar system.

The distance that light travels in a year — 9.5 trillion km, or 5.9 trillion miles, or 63,000 a.u. — is called a **light-year**. Note that the light-year is a measure of distance, not time . . . just like kilometers or miles.

Most of the brightest stars in the sky lie a few dozen to a couple thousand light-years away. The nearest star, Alpha Centauri, is only 4.3 light-years away. The Andromeda Galaxy, the nearest large galaxy beyond our own Milky Way, is 2.5 million light-years distant.

Professional astronomers often use another unit for big distances: the **parsec**. One parsec equals 3.26 light-years. (In case you're really wondering, a parsec is the distance where a star shows a parallax of one arcsecond against the background sky when the Earth moves 1 a.u. around the Sun.)

A kiloparsec is 1,000 parsecs, and a megaparsec is a million parsecs.

# Chapter 4 - Astronomy 101

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If you want to learn the basics of the night sky, the first thing you should get is a planisphere or a rotating star finder. Be sure to get one for the right latitude zone where you will be observing from. With the help of this planisphere you will be able to identify the constellations on any night during the year. Use this planisphere together with beginner's books on the subject for easier identification of constellations and planets.

When going outside with your planisphere and beginner's book, the only additional equipment you need is a red LED flashlight. This will enable you to read in the dark and preserve your dark adaptation. With these three basic tools you will not only learn to recognize the constellations, you will also learn about planets, comets, the moon, asteroids, meteors, stars and all the different types of deep sky objects.

You will also want to join some astronomy clubs, newsgroups, or Internet chat boards. A great one I've found is on Yahoo called Starrynights. Here you can chat with other astronomy buffs and find the locations of some things you may have never even considered. The camaraderie you can find in these groups can be very helpful and help you meet new people.

Another good idea is to spend some time with maps and guidebooks. They'll reveal dozens of star clusters, galaxies, and nebulae. They'll show the ever-changing positions of Jupiter's moons and the crescent phases of Venus. You can identify dozens of craters, plains, and mountains on the Moon. You can split scores of interesting double stars and follow the fading and brightening of numerous variable stars: IF you know what to look for.

Plan indoors what you'll do outdoors. Spread out your charts and guides on a big table, find things that ought to be in range of your equipment, and figure out how you'll get there. Plan your expeditions before heading out into the nightly wilderness.

You will also need to gain a bit of knowledge about celestial coordinates, what they mean, and how to find them. Newcomers to astronomy can get thrown for a loop when they first encounter declination and right ascension, the terms astronomers use to define coordinates in the sky. Why are the positions of stars that are light-years away in the depths of space stated in a system that's tied to latitude and longitude here on Earth?

The celestial coordinate system, which serves modern astronomy so well, is firmly grounded in the faulty world-view of the ancients. They believed the Earth was motionless and at the center of creation. The sky, they thought, was exactly what it looks like: a hollow hemisphere arching over the Earth like a great dome. What about the stars? They're like fireflies stuck to that big, blue-black thing up there according to Timon from The Lion King.

The celestial dome with its starry decorations had to be a complete celestial sphere, early sky watchers realized, because we never see a bottom rim as the dome tilts and rotates around the Earth once a day. Part of the celestial sphere is always setting behind the western horizon, while part is always rising in the east. At any time half of the celestial sphere is above the horizon, half below.

Even today this is how the cosmic setup actually looks. Never mind that we're on a moving dust mote orbiting a star in the fringe of a galaxy. In astronomy, appearances and reality are more different than in any other area of human experience.

Perhaps for this reason, astronomers are quite comfortable living with both — as long as the two are kept in their proper relationship. The celestial sphere, with its infinitely large radius, appears to turn daily around our motionless Earth, from which we use telescopes to examine wonders painted on its inside surface.

Whenever you want to specify a point on the surface of a sphere, you'll probably use what geometers call spherical coordinates. In the case of Earth, these are named latitude and longitude.

Imagine the lines of latitude and longitude ballooning outward from the Earth and printing themselves on the inside of the sky sphere, as shown at right. They are now called, respectively, declination and right ascension.

Directly out from the Earth's equator, 0° latitude, is the celestial equator, 0° declination. If you stand on the Earth's equator, the celestial equator passes overhead. Stand on the North Pole, latitude 90° N, and overhead will be the north celestial pole, declination +90°.

At any other latitude — let's say Kansas City at 39° N — the corresponding declination line crosses your zenith: in this case declination +39°. (By custom, declinations north and south of the equator are called + and – rather than N and S.) This is the declination of the bright star Vega. So once a day, Vega passes overhead as seen from the latitude of Kansas City.

Lines of both right ascension and declination stay fixed with respect to the stars. That's why they can be permanently printed on star maps. (This does mean that the one-to-one connection between right ascension and longitude is broken the moment after you imagine the lines ballooning out from Earth and printing themselves on the sky; the two systems rotate with respect to each other.)

Now let's move on to the fun part – using your telescope.  You will see many exciting things in the night sky, and we're sure you'll want to know what you're looking for.

## Chapter 5 - What to Find in the Sky

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The easiest planet for a beginning astronomer to observe is the moon. The Moon has so many features and details that if you observed it each possible night for the next decade, you wouldn't see everything.

The Moon is a brilliant object when viewed through a telescope. You actually may want to use a neutral density filter to reduce the Moon's light. A better method is to do what many observers do to help them observe the Moon in comfort: Turn on nearby white lights when you're observing the Moon between First Quarter and Full.

The addition of white lights suppresses the eyes' tendency to dark adapt at night and, in fact, causes the eye to use normal (scotopic) vision, which is of much higher quality than dark-adapted (photopic) vision.

Of the 1,940 named features on the Moon, 1,545 (nearly 80 percent) are craters. There are many more craters in the highlands than in the maria. The size range of craters is large, and some observers make it a personal challenge to see either (1) how small a crater they can see, or (2) how many small craters in a given area they can observe with a particular telescope. A detailed map of the Moon is, of course, a necessity for a project of this type.

When observing larger craters, note whether you can see "rays" emanating from them. These features were formed when crushed rock sprayed out from a meteor impact. They form streaks in a radial pattern, which can be a great distance from the crater itself.

Next to the Sun and Moon, the celestial object with the greatest detail is Jupiter. Even small telescopes will show Jupiter's four largest satellites. They appear as bright stars on either side of Jupiter and are generally in a straight line (although some interesting triangles and other forms are possible).

In addition to the moons, several dark stripes can easily be seen on the planet. These stripes, on either side of the equator, are known as the North and South Equatorial Belts. With larger telescopes operating at greater magnifications, more belts are visible.

At higher magnification, you can see that Jupiter is flattened, a result of its rapid rotation rate coupled with the fact that it is not a solid planet. Jupiter's equatorial diameter is more than 5,000 miles larger than its polar diameter.

Watching Jupiter night after night can be a rewarding pursuit. In addition to the changing positions of its moons, the planet's rapid rotation brings nearly all of its visible area into view in a single night. At times, individual belts and zones become more or less prominent. Some have even disappeared for extended periods of time.

All observers should use filters to bring out fainter detail not visualized in integrated (white) light. A blue (e.g., Wratten 38A) filter will enhance the dark reddish-brown belts over the planet. A red (e.g., Wratten 23A) filter will bring out the blue features (festoons) within the Equatorial Zone (EZ) of Jupiter as well as the northern and southern borders of the major belts.

Jupiter is a great object to sketch. Sketching will make you a better observer because you'll study small areas more intently. Two words of caution when sketching Jupiter: Draw quickly! Jupiter rotates quite rapidly, and some of the features you'll be sketching may rotate out of view if you take longer than about 20 minutes.

Sketch the positions of the equatorial belts and Polar Regions first. Carefully estimate their widths and extent and where, in terms of latitude, they begin and end. Next, place the less apparent belts and zones on your sketch as they appear on the planet. Work on one hemisphere at a time.

Next, place features within the belts and zones using Jupiter's central meridian (an imaginary line from top to bottom) to help you gauge the distances. Finally, carefully shade your sketch to duplicate what you see. One technique some observers say works to bring out additional detail on Jupiter is to focus the eye on a spot halfway between one of the poles and the equator — but don't actually look at the spot. Concentrate on seeing and sketching detail in the polar area. Repeat for the other hemisphere.

Astronomers estimate that 60 percent of all the stars in the Milky Way Galaxy are double or multiple stars. These stars appear as one to the unaided eye, but many may be resolved into pairs with the help of a telescope. I don't think there's an amateur astronomer I know who doesn't enjoy observing double stars. It is fun, easy, rewarding, doesn't take a complicated setup, you can observe from within a city, and challenging objects exist for every size of telescope.

In addition to where the double star is in the sky and how bright each component is, there are two quantities with which a double star observer should be familiar. The first is the "separation" of the pair. This number is given in arc-seconds, and it is simply the distance between the two stars.

The second quantity is the "position angle." This is the angle, measured from north through east, of the fainter of the pair (the "companion," or "secondary") from the brighter (the "primary"). For instance, if the companion is due north of the primary, its position angle is 0°. On the other hand, if it is due east, 90°, and if midway between south and west, 225°.

To determine the directions in your field of view, just let the stars drift for a while. If your telescope has a motor drive, turn it off for this check. The stars will enter the field of view from the east and exit to the west. Determine the longest path for the stars you see drifting through the field. This is your east-west line.

The north-south line is perpendicular to it, and to find it, turn the drive back on, center a reasonably bright star, release the declination lock on your drive, and move the telescope by hand toward the north. As you observe the field of view, the bright star will be heading out, toward the south. Reverse this if you are located in the Southern Hemisphere.

The technique is only slightly more complicated if you own a telescope on an alt-azimuth mount. To move this type of telescope "north," you have to adjust the altitude and azimuth motions simultaneously.

The size of your telescope will influence which double stars you observe. The resolution of a telescope only depends on its size. Double star observers often refer to a rule of thumb called "Dawes Limit." The formula for Dawes Limit is $r = 4.56/D$, where r is the separation (in arc-seconds) of the closest resolvable double star, and D is the diameter of the objective in inches. Alternately, you can use $r = 114/D$, where D is the diameter of the objective in millimeters. And remember, Dawes Limit is only a guideline.

One reason for the popularity of double stars is that many of them show color. Colorful double stars are a joy to behold. It does take some time at the telescope before you begin to see colors easily, but the payoff is big. Close double stars often help us see color. The contrast between two or more stars in close proximity brings out subtle color tones that normally would be lost if each was viewed separately.

Some of the enjoyment in amateur astronomy is in sharing observations with friends. You will find, however, that color perception at the eyepiece is about as personal and subjective as any phase of our hobby. Colors that you see apply to your eyes, period. One person may see a particular star in a color different from that which you see.

Charles Messier (1730 - 1817) was a French comet hunter. In his searches, he occasionally encountered celestial objects that had the appearance of comets. These objects appeared fuzzy in his small telescope but did not move against the background of stars. The astronomers of the day called these objects "nebulae, " a word whose definition is much more specific today.

During his searches, he discovered a comet-like patch in Taurus on August 28, 1758. This non-moving object later became the first entry — M1 — in his famous catalog of nebulous objects that might be mistaken for comets. Messier published three versions of this catalog. The final tally of objects amounts to 110 and is the catalog we recognize today.

Working your way through Messier's list will introduce you to some of the brightest deep-sky objects in the sky. You'll also learn about several types of deep-sky objects: star clusters, nebulae, and galaxies. There are 110 objects on Messier’s list and space constraints prevent me from listing them all here. But you can find many different resources either on the Internet or at your local library that can guide you to all of Messier’s objects.

If you've seen all, most, or even just a few of the Messier objects, it may be time for you to participate in a Messier marathon — trying to see as many Messier objects as you can in a single night. Because Messier compiled his list from northern latitude, it is not possible to view all of the objects from a southern hemisphere location.

Although a Messier marathon can be attempted from any northern latitude, low northern latitudes are best. In particular, latitude of around 25° north lends the best possibility to complete a Messier marathon at the right time of year.

At low northern latitudes, particularly around latitude 25° north, it is possible to observe all Messier objects in one night during a window of a few weeks from mid-March to early April. In that period the dark nights around the time of the new moon are best for a Messier Marathon.

Typically an observer attempting a Messier marathon begins observing at sundown and will observe through the night until sunrise in order to see all 110 objects. An observer starts with objects low in the western sky at sunset, hoping to view them before they dip out of view, then works eastward across the sky.

By sunrise, the successful observer will be observing the last few objects low on the eastern horizon, hoping to see them before the sky becomes too bright due to the rising sun. The evening can be a test of stamina and willpower depending on weather conditions and the physical shape of the observer.

Particularly crowded regions of the sky (namely, the Virgo Cluster and the Milky Way's galactic center) can prove to be challenging to an observer as well, and a Messier marathon will generally budget time for these regions accordingly.

But the number of nights on which you can see all the Messier objects is limited due to the way the objects are distributed around the sky. The beginning of the season is about March 17. The Messier marathon season ends on April 3. Remember, however, that you can't just go out and observe the Messier objects on all those dates. The second limiting factor is the Moon. Its phase must be within a day or so of New Moon.

Can you see them all in one night? The quick answer is "yes." Many people have viewed all the Messier objects during a single night. All the Messier objects can be seen from a dark site on a good night with a good 3-inch telescope. You can even do the marathon with high-quality 7x50 binoculars.

Besides planets, you will also want to look at the constellations in the night sky. The sky is divided up into 88 areas, known as constellations, which serve as a convenient way of locating the position of objects in the sky. The stars of a constellation usually have no physical connection between one another: although they appear in the same direction in the sky, they are actually at vastly differing distances from us.

Constellations come in many different shapes and sizes. The largest constellation, Hydra, the water snake, is a long and rambling figure that covers an area of sky 19 times greater than that of the smallest constellation. Crux, the Southern Cross. Some constellations consist of easily recognizable patterns of bright stars, such as Orion, while others are faint and difficult to identify.

Constellations really exist only in the minds of human beings although they are tangible layouts in the sky. They are projected onto random groups of stars to create a picture story. These pictures have appeared in the sky every year at the same time for thousands of years.

From very early in recorded history, the stars were important to people in their daily lives. The stars assisted the ancients in planning for the planting of their crops, guiding navigators on their many adventures, and as a way of telling time. Much wonder and mystery was associated with the stars, and the people of ancient times began to place a grander, often divine, meaning on the majestic heavenly bodies.

We’ll begin with the zodiacal constellations. The twelve signs of the zodiac have beautiful myths associated with them and they can be very interesting. While some people use the zodiac to guide their lives and decisions, many people dismiss it as voodoo science. Nonetheless, the zodiacal constellations are fun to study and learn about.

According to astrology, the period of the year which each sign of the zodiac dominates is determined by the time in which the Sun is "in" its corresponding constellation. For that reason, it is not actually possible to observe a zodiacal constellation in the night sky during the time its sign is dominant.

Instead, look for your constellation in the exact opposite time of the year. For example, Sagittarius is designated as from November 22 to December 21. However, if you want to observe Sagittarius, you will have to wait until summer to see it. Instead, spend your observing time viewing Taurus.

## Zodiac Constellations
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### Aries

Aries the Ram is an autumn constellation, and can be best viewed in the night sky during the month of November. Aries marks the beginning of spring or the Vernal Equinox.

This constellation dates from Greek and Roman times, and depicts the Golden Ram that was sacrificed by Phrixus to bring fertility to his homeland in Thessaly. The Golden Fleece of the sacrificed ram was given to Jason and the Argonauts to return it home. It is visible between latitudes 90 and -60 degrees.


### Taurus

Taurus the Bull is an autumn constellation, and can be best viewed in the night sky during the month of December. The constellation of Taurus lies along the winter Milky Way, and therefore contains many objects (primarily open clusters) of interest to the amateur astronomer. Some are large enough to be seen easily with the naked eye, while others need moderate telescopic apertures to appreciate.

As for the myth behind Taurus, it goes like this. The delightful daughter of Agenor, Europa, was so beautiful that Zeus immediately fell in love with her. Determined to win Europa's heart, Zeus assumed the form of a milky white bull, whose horns were crowned with flowers, and mingled with the herds of Agenor.

Europa was enchanted with the sight of this splendid creature, and climbed upon its back. Taking advantage of his good fortune, Zeus carried the fair maiden away from her homeland, across the seas to the island of Crete.

Here, Europa gave birth to Minos, father of the creature Minotaur, who was half bull and half man. Zeus celebrated his love for Europa by having the continent Europe named after her, and created the constellation Taurus, to be seen in the sky for eternity, the symbol of fertility and power.

Taurus is visible between latitudes 90 and -65 degrees


## Gemini

Gemini the Twins is a winter constellation, and can be best viewed in the night sky during the month of January. Gemini lies right along the Milky Way, and the ecliptic (the region in which the Sun and planets are constrained) passes through it.

Mythology tells the story like this. After Zeus, disguised as a graceful swan, visited Queen Leda of Sparta, she gave birth to twin sons, Castor and Pollux. The two were devoted and loving brothers who later became as different in nature as they appeared alike as twins.

The mortal Castor developed into a master horseman, while the immortal Pollux became a famous boxer. Together, The Twins grew to become skillful warriors.

When Castor was killed in battle, Pollux, who was so very attached to his brother, could not bear to continue on without him. Stricken with great sorrow, Pollux asked of their father, Zeus, to bring Castor back to life. Zeus, touched by this display of devoted brotherly love, arranged for The Twins to stay endlessly side by side among the stars as the brilliant constellation Gemini.

This constellation is visible between latitudes 90 and -60 degrees.


## Cancer

Cancer the Crab is a winter constellation, and can be best viewed in the night sky during the month of February. Cancer is a small but important zodiacal constellation. It was the fourth constellation of the ancient zodiac, east of Aries, Taurus and Gemini, but is now fifth, since the first point of Aries, the point of the astrological Spring Equinox, has moved west into Pisces.

The story of cancer begins with Zeus having an affair with Alcmene, the queen of Tiryns. The result of this union was the Heracles (the Romans named him our familiar Hercules), the most famous Greek Hero.

Of course, this union and offspring did not go over too well with Hera, the wife of Zeus. Hera, in her jealous state, swore to kill Hercules. Hera attempted to have Hercules killed many times but his imposing strength allowed him to overcome.

Cancer comes into this ‘beloved’ scene when Hercules is fighting the terrible water-serpent, Hydra. During the battle between Heracles and Hydra, Hera sent Cancer, the giant crab, to aid the serpent.

As the violent fight took place, Cancer was nipping at Hercules feet. But Heracles, being so mighty in strength, killed the crab by smashing its shell with his foot. Hera then placed the crab's image in the night sky as a reward for its service.

Cancer may be found between the constellations of Leo and Gemini and is visible between latitudes 90 and -60 degrees.

## Leo

Leo the Lion is a winter constellation, and can be best viewed in the night during the month of March. Leo lays far enough away from the Milky Way to let us peer into extragalactic space. As such, we are no longer looking at objects that are "merely" a few hundred or thousand light years away.

Instead, the distance to the galaxies of Leo is on the order of twenty to thirty MILLION light years. Thus, these objects in general are not flashy and splashy, but rather yield their detail in subtle ways.

Besides adequate dark adaptation of one's eyes, the most useful technique for coaxing details out of galaxies is averted vision. By looking slightly away from your target while keeping your attention on it, features such as spiral arms and subtle mottling can become apparent where none was seen before.

As for the myth, the first labor imposed on The Hero, Hercules, by mighty Zeus was to slay Leo, the frightful lion which roamed the forest of Nemaea. Hercules accomplished this task with the utmost of ease, simply strangling the fierce beast with his bare hands.

From this point on, the courageous hero wore the lion's skin over his shoulders, assuring him eternal protection from harm. In memory of this dreadful battle, Zeus placed the proud and passionate lion in the heavens to eternally symbolize the challenges of kingship.

The constellation of Leo contains the enormously bright star, Regulus, known as "the star of the king," perhaps referring to Alexander the Great, King of Macedonia, who, during his lifetime, ruled the entire known world, and who was born during the Lion month.

Leo is visible between latitudes 90 and -65 degrees.


## Virgo

Virgo the Virgin is a spring constellation, and can be best viewed during the month of April. The constellation of Virgo is the center of the closest large cluster of galaxies, and can easily take up several evenings of observing time.

While the galaxies in Ursa Major are 10-40 million light years away, the galaxies of Virgo are, at about 70 million light years, almost twice as distant. As such, these galaxies show a lot less detail.

But what they lack in quality, they make up in quantity. In some areas, it is difficult to move a whole telescopic field of view without seeing one or more galaxies. A good star atlas is a must in this region for identifying all the galaxies visible in a telescope of moderate aperture.

Legend goes that Astraea was the daughter of Zeus and Themis (Themis is usually identified with Libra). Long ago Astrea mixed with mortals; she was their Goddess of Justice and administered just law in the Golden Age (which was ruled by Saturn), but after wickedness took possession of the world, Astraea returned to the heavens, where she became the constellation Virgo.

This constellation is visible between latitudes 80 and -80 degrees.


## Libra

Libra the Scales is a spring constellation. It can be best viewed in the night sky during the month of May.

During the Golden Age, the legendary first period of human existence, Astraea, the Roman Goddess of justice, lived on the earth, mingling among the many mortal beings. In the pans of her great golden scales, she heavily weighed the good and evil deeds of men and women, thereby deciding their many different fates.

As Astraea became increasingly offended by the wickedness of her citizens, she decided to flee from the corrupt civilization, and returned to the heavens, joining Demeter as the constellation of the Virgin Goddess. Astraea abandoned civilization so hurriedly that she left behind her golden scales of justice.

The Romans, in fear of her judgment, created the constellation of Libra from the ancient Scorpion's claws so that The Scales would always be nearby in the sky.

Libra is visible between latitudes 65 and -90 degrees.


## Scorpio

Scorpio the Scorpion is a spring constellation with an astronomical name of Scorpius, and can be best viewed in the night sky during the month of June. Scorpius is a large and sprawling constellation which lies near the Milky Way, and thus holds many bright open and globular star clusters.

As the giant hunter, Orion, sets each spring in the west, his mortal enemy, The Scorpion, rises in the eastern sky. Scorpius gained eternal fame when, upon command of the gods, he spring from the earth to surprise Orion, and sent the able hunter to his final resting place. Even the God of Healing, Asclepius, was unable to reverse the fatal effects of The Scorpion’s sharp sting.

Scorpius is also remembered for his disastrous intervention when the mortal man, Phaeton, attempted to drive the chariot of Apollo, God of the Sun. Here, Scorpius but pricked Apollo's horses with his lethal sting, causing the creatures to bolt and driving the sun-bearing chariot recklessly through the heavens, drying up many rivers and scorching the earth below.

It is visiblebetween latitudes 40 and -90 degrees.


## Sagittarius

Sagittarius the Archer is a summer constellation, and can be best viewed in the night sky during the month of July.  An easy way to find Sagittarius would be to find the Milky Way overhead in summer. Follow it to the southern horizon, and you should find Sagittarius.

As with all constellations, Sagittarius is best seen in a dark sky outside the city. However, because its stars are relatively bright, you should be able to make out the basic shape even when the moon is up.

While Cronus, father of Zeus, was courting the mortal woman Philyra, he assumed the form of a stallion to avoid the fury of his jealous wife, Rhea. From this union was born Chiron, the most famous of centaurs and a skillful archer.

Although centaurs, creatures that are part man and part horse, were generally savage and cruel, Chiron was wise, gentle and good. As the teacher of several famous heroes, he educated the boys about the mysteries of life.

One fated day, Chiron was mistakenly slain by his student, Hercules. Realizing the wound was incurable, Chiron begged Zeus not to deprive him of immortality.

Pitying his half-brother's predicament, Zeus granted the request and located Chiron in the sky as the constellation Sagittarius, where The Archer stands with bow and arrow for all time.

Aries is visible between latitudes 55 and -90 degrees.


## Capricorn

Capricorn the Sea Goat is a summer constellation with an astronomical name of Capricornus, and can be best viewed in the night sky during the month of August. Aquarius and Capricornus lie away from the main body of the Milky Way, and mostly contain faint galaxies with only a few star clusters and nebulae.

This zodiacal constellation, like Pisces, depicts the result of the sudden appearance of the earthborn giant Typhoeus. Bacchus was feasting on the banks of the Nile at the time, and jumped into the river. The part of him that was below water was transformed into a fish, while his upper body became that of a goat.

From this point of view, he saw that Typhoeus was attempting to tear Jupiter into pieces; he blew a shrill note on his pipes, and Typhoeus fled. Jupiter then placed the new shape of Bacchus in the heavens out of thanks for the rescue.

Capricornus has therefore from antiquity been represented by a figure with the head and body of a goat and the tail of a fish.

It is visible between latitudes 60 and -90 degrees.


## Aquarius

Aquarius the Water Bearer is a summer constellation, and can be best viewed in the night sky during the month of September.  Like Capricorn, Aquarius lies away from the main body of the Milky Way, and mostly contains faint galaxies with only a few star clusters and nebulae.

Greek legend tells of Ganymede, an exceptionally handsome, young prince of Troy. He was spotted by Zeus, who immediately decided that he would make a perfect cup-bearer.

The story then differs - one version telling how Zeus sent his pet eagle, Aquila, to carry Ganymede to Olympus, another that it was Zeus, himself, disguised as an eagle, who swept up the youth and carried him to the home of the gods. In either case, once Ganymede arrived, he had to contend with the wrath of Hera, wife of Zeus.

She was annoyed on two counts - firstly, that her husband should have such strong feelings for a mere boy and, secondly, that Ganymede was to occupy the favored position previously held by her own daughter Hebe, goddess of youth. But Zeus was not to be thwarted and Ganymede, often riding on Aquila and always carrying the golden cup, accompanied the great god on his travels, impressing him with his kindness.

This was made manifest when, realizing how in need of water the people on earth were, he pleaded with Zeus to be allowed to help them and was given permission to send down rain. Eventually he was glorified as Aquarius, god of rain, and placed amongst the stars.

It is visible between latitudes 65 and -90 degrees.


## Pisces

Pisces the Fishes is an autumn constellation, and can be best viewed in the night sky during the month of October. Pisces contains few bright stars, and only one important object, the face on spiral galaxy M74.

However, even though somewhat indistinct, this constellation can be easily made out with a bit of practice, as it is located to the south west of Andromeda and directly below the Great Square of Pegasus.

First locate the "Circlet" on the western end of the constellation. From there, follow the line of stars marking the Western Fish to Alpha Piscium. Then move up and to the right along the line of stars marking the Eastern Fish.

In Greek mythology, the horrible earthborn giant Typhoeus suddenly appeared one day, startling all the gods into taking on different forms to flee. Jupiter, for instance, transformed himself into a ram; Mercury became an ibis; Apollo took on the shape of a crow; Diana hid herself as a cat; and Bacchus disguised himself as a goat.

Venus and her son Cupid were bathing on the banks of the Euphrates River that day, and took on the shapes of a pair of fish to escape danger. Minerva later immortalized the event by placing the figures of two fish amongst the stars. The zodiacal constellation Pisces represents two fish, tied together with a cord. The constellation is neither particularly bright nor easy to locate, but it lies near Pegasus and Aquarius.

Pisces is visible between latitudes 90 and -65 degrees.

Here are a few of the other more popular constellations for you to look for in the night sky.

## Andromeda

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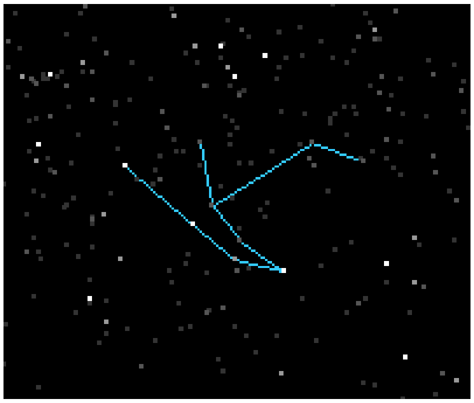
The constellation of Andromeda contains many galaxies, most of which are relatively faint. They challenge the observer not only to find them, but to detect detail in them. Andromeda lies away from our galaxy's plane, and lets us see the inhabitants of intergalactic space. Some of the finest objects of their respective classes reside in these constellations, and it is well worth braving cold weather to observe them.

In mythology, the story is as follows. As the frightful sea monster, Cetus, ravaged the Ethiopian coast, Cassiopeia pleaded with Zeus, the all-powerful King of Gods, for his help in driving Cetus from her shores. Zeus ruled that Queen Cassiopeia and King Cepheus must sacrifice their only daughter, Princess Andromeda, to soothe the anger of Poseidon.

After much hesitation a tearful Cassiopeia gave up Andromeda, who was chained to a rocky ridge at the edge of the sea so that Cetus might come and devour her. As Andromeda awaited her sorrowful fate, the brave champion Perseus miraculously appeared and disposed of the sea monster for all time. Perseus then released Andromeda, and the princess sailed away with the hero to become his bride. The two went on to live a long and happy life together.



## Pegasus

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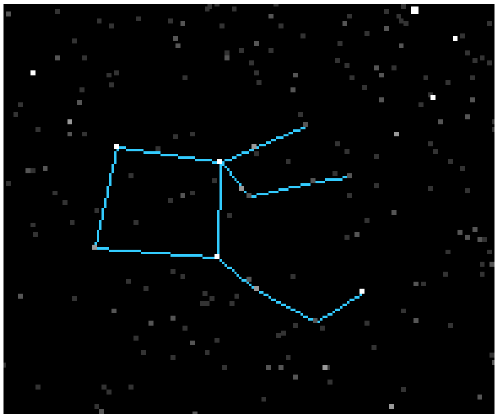
A snow white, winged horse with a mane of glittering gold, Pegasus was the son of Poseidon and the Gorgon Medusa. As Perseus beheaded Medusa, Pegasus was born from its blood which fell into the sea, creating frothing foam.

One fated day, Athena gave Pegasus to the warrior Bellerophon to aid him in defeating the Chimaera, a dreadful monster which was part lion, part serpent and part goat. Bellerophon was so proud after his successful conquest that he boldly attempted to ride Pegasus to Mount Olympus, home of the Gods, where mortals do not dwell.

Zeus became infuriated at Bellerophon's self importance and caused the flying horse to throw his rider. Alone, Pegasus soared to the heavens where he became the Thundering Horse of Zeus and carrier of the divine lightning.



## Ursa Major
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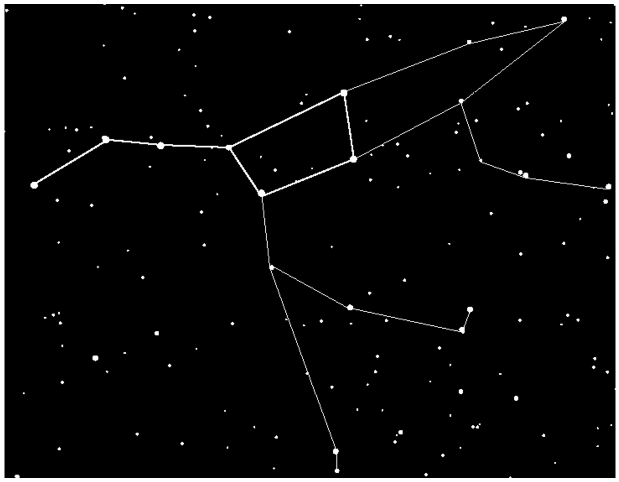
Ursa Major is one of the most well known constellations in the heavens. It contains the famous grouping of stars known as the Big Dipper, which is often the first group of stars learned by people in the northern hemisphere.

Ursa Major lies away from the obscuring dust of the Milky Way, many galaxies are visible in its confines, and several of these are large and bright in amateur instruments due to their relative closeness. A whole night's observing can easily be spent in this large constellation.

Callisto was the splendid Princess of Arcadia who captured Zeus' heart, and gave birth to his son, Arcas. Seething with jealousy, the Queen of Gods, Hera, unleashed her mighty wrath and transformed Callisto into a bear, doomed to prowl the forests forever.

Years later, while Arcas was out hunting, the vengeful Hera brought Callisto before the young man as prey. While Arcas unknowingly prepared to kill his mother, Zeus swiftly stepped between them and sent Callisto soaring into the heavens to become Ursa Major, The Greater Bear.

Later, the King of the Gods placed Arcas in the sky to be forever known as Ursa Minor, The Lesser Bear, reuniting mother and son for all time. Ursa Major, also called the Big Dipper, is the best known constellation in the northern sky.



## Cassiopeia

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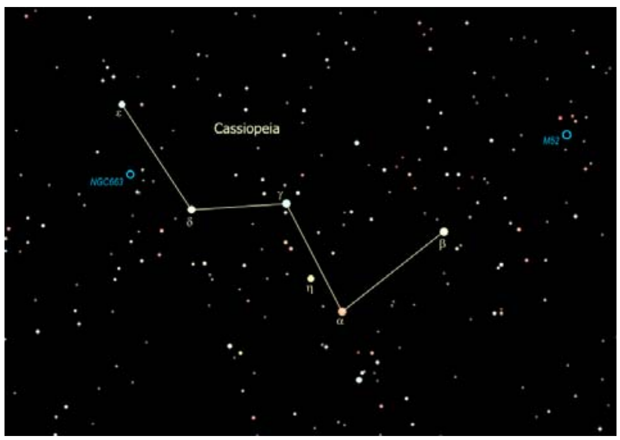
The constellation of Cassiopeia is a circumpolar constellation which lies on or near to the Milky Way. As such, many open clusters are in this region, including some of the finest in the whole sky.

There are also large regions of nebulosity in this area. Some of these nebulous regions are accessible with amateur instruments, but most of them are best seen in long exposure photographs. Planetary nebulae and even some galaxies are even found in this interesting and rich region.

Cassiopeia was the legendary queen of Ethiopia, known throughout the land for her elegant beauty. Becoming increasingly vain, Cassiopeia boasted that she was even lovelier than the Sea Nymphs, goddesses of unmatched beauty who ruled over nature.

Enraged by Cassiopeia's false bragging, the Sea Nymph's begged the God of the Sea, Poseidon, to punish the queen for her insults and conceit. Poseidon became so angry with Cassiopeia that he unleashed the horrible sea monster, Cetus the Whale, and sent him to destroy the coast of Cassiopeia's homeland.

The Sea Nymphs also sought eternal punishment for Cassiopeia, arranging for her to be placed in the heavens tied to a chair. In the northern sky, Cassiopeia sits, forever circling the celestial pole.




## Canis Major

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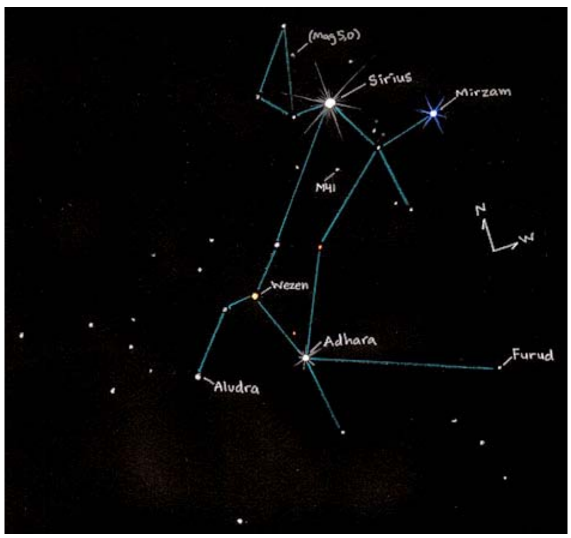
Containing Sirius, the brightest star visible on earth, the constellation of Canis Major is one of the few constellations in the heavens which resemble what it is supposed to be: a large dog.

Canis Major lies along the winter Milky Way. Several interesting planetary nebulae and double stars are also found in this region.

The greater & lesser dogs always followed the legendary Orion on his exciting adventures, Canis Major and Canis Minor were two of the giant's loyal hunting dogs. The Greater Dog, Canis Major, stands in the sky on his hind feet watching his master, or springing after The Hare, Lepus, which closely hides under Orion's feet.

The wide stretched jaws of Canis Major sparkle with the brightest of all fixed stars, Sirius, which signifies brightness and heat. Canis Minor, The Lesser Dog, a well trained house or watch dog which accompanied Orion on his hunting trips, owes its fame in the heavens to the first magnitude star, Procyon.

The expression "Dog Days of Summer" came into being because the rising of the stars Procyon and Sirius often corresponded with periods of extreme heat.



# The Milky Way

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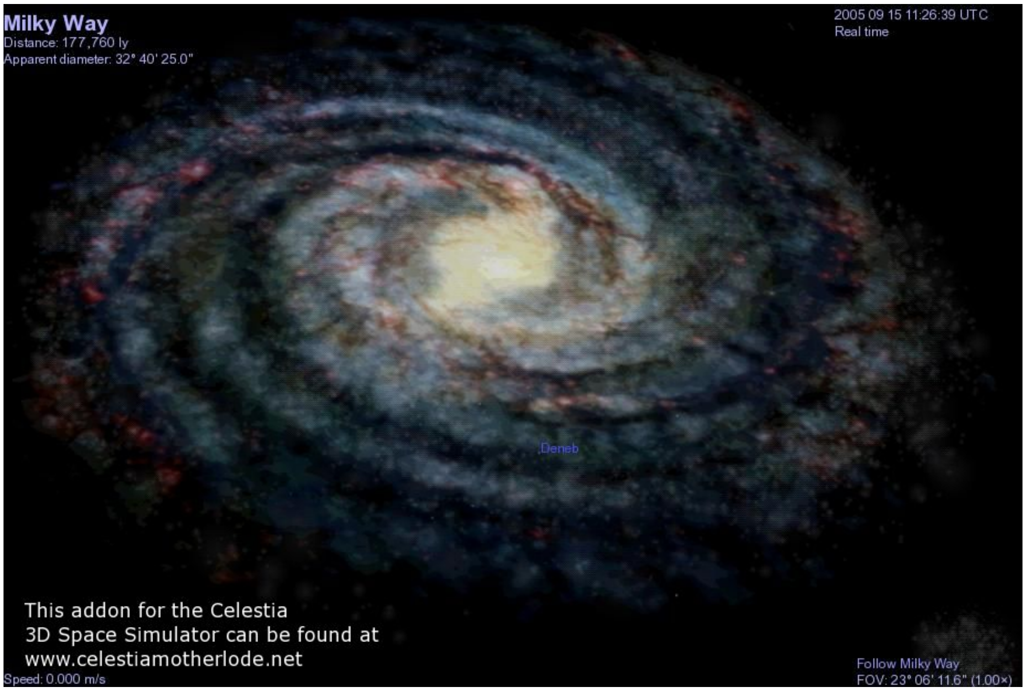
The Milky Way is a barred spiral galaxy which is but one of billions of galaxies in the observable universe. The galaxy has special significance to the human race as it is the home of our solar system. The Greek philosopher Democritus was the first known person to claim that the Milky Way consists of distant stars.

To see the Milky Way, look for the constellation Sagittarius. The center of the Milky Way galaxy is located beyond it. To look up one of the galaxy's arms, the one the Sun is located in, look towards the constellation Cygnus. To look back down this arm, look towards Orion. Sagittarius is overhead during the summer months in the Northern Hemisphere.




According to star watcher manuals, to see it you need a clear night on the darkest time of the month when the Moon is near to New. During the dark summer evenings, the Milky Way is oriented in a more or less north-south direction. During autumn it lies more nearly in an east-west direction.

## Deep Sky Gazing

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When you start to look at the night sky, you may want to start looking at tough objects such as nebulae, galaxies, or star clusters. However, you might be worried that they will be faint and fuzzy and you just don't know where to begin. Fear not!

The things you seek are called deep-sky objects. Simply put, the term refers to all celestial objects outside the solar system. In essence, though, we're talking about star clusters and nebulae within the Milky Way, plus the myriad galaxies beyond.

Individual stars, double stars, and constellations, while also outside of the solar system, are a different kettle of fish. In the lexicon of amateur astronomy, star clusters, nebulae, and galaxies aren't just far — they're "deep."

Yes, most deep-sky objects are a challenge to observe, especially if you're working with modest equipment under a suburban sky. So what makes the little fuzzies so special? In a word, it's their exclusivity. When a faint cluster or nebula materializes in the eyepiece of your telescope, you're scrutinizing a part of the

Milky Way that might be several thousand light-years from Earth. Gaze upon a galaxy, and the light-years number in the millions.

Picture our galaxy as a stellar metropolis containing billions of stars. The central hub, or bulge, is congested with mostly older suns. Away from the hub, the galaxy thins into a disk of gas, dust, and stars of all ages.

Rippling through the disk like ocean waves, a pinwheel pattern of glowing spiral arms hosts the youngest stars and the nebulae associated with their births. Our middle-aged Sun and its family of planets reside in a suburban neighborhood called the Orion Arm, which is located roughly two-thirds of the distance from the downtown core to the city limits. Finally, in the galactic outskirts, a vast halo dotted with clusters of ancient stars surrounds the whole galaxy.

Viewed from Earth, portions of several spiral arms blend together in our night sky to form the arching band of the Milky Way. Deep-sky treasures abound in and around that glittering band.

Your best bet when it comes to in-depth star gazing is to obtain a map of the heavens through a book that point out exact locations of various constellations. We've given you a good start, but the best teacher is experimentation and experience.

Look around and see what you can find.  You may be pleasantly surprised at what you see!  Don't forget to sketch what you see and take notes.  If you're lucky enough to have a telescope equipped with a camera, take lots of pictures, but don't expect them to look like the ones you see from professionals.  You will want to document what you find, so take copious notes and then enjoy them later!

Although we've already covered how to buy a telescope, believe it or not, you can actually make your own telescope!

# Chapter 6 - Make Your Own Telescope

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A telescope really isn't a very involved piece of equipment. You can make your own telescope with just a few items and little bit of know-how. In this section, we'll show you how to illustrate the concept of a telescope.

## Basic

This device shows the basic concept behind a telescope and would be great to use in a classroom as it can show the children just how a telescope can be used. It is only for the concept of telescopes, and probably not for looking at the stars. Although I guess you could try it if you wanted!

The materials you will need include:

- A pair of "drugstore" reading glasses ("Weak" glasses—those with low numbers—will work the best)
- A magnifying glass
- A flashlight
- Masking tape
- A piece of waxed paper or thin typing paper
- A friend

The reading glasses serve as your objective lens and you will want to keep them steady. Use the tape to secure it someplace where one of the lenses is taped down and the other is sticking out. This could be a chair leg, a coat rack, or anyplace else you can think of, but one of the lenses must be sticking out into space.
Set the flashlight on a table four meters (thirteen feet) or more from the glasses. Turn the flashlight on and shine it at the lens.

Hold the paper in front of the lens on the side opposite from the flashlight. Then walk away from the lens, perhaps as far as a meter, until you see a small image of the flashlight on the paper. Normally, this image is formed inside the tube of the telescope and can't be seen directly. This is the focal point of the objective lens.

Have your friend hold the paper at the focal point. Face the back side of the paper and look at the image through your magnifying glass. Adjust the position of the magnifying glass until the flashlight image is magnified.

Have your friend take the paper away, but continue looking through the eyepiece of your telescope. The image should be a lot brighter since the paper won't be diffusing the light.

Try looking at other objects that are near the flashlight by slightly moving the eyepiece up, down, and from side to side.

And that's it!

You can make your own fully functional working telescope and there are places on the Internet as well as in books that can teach you how to do this. It can be very complicated if you choose to do it on your own, so you might want to consider buying a kit that comes with everything you need.

Of course, if you're lazy like me, I'd much prefer to shop around for one already made professionally so I don't spend a lot of money for something I might mess up! However, you can get a lot of personal satisfaction by showing people you are savvy enough to actually make your own working telescope!

I say more power to ya!

# Conclusion

The sky can really tell us so much about our little lives down here on Earth. It can reveal new mysteries, a glimpse of that which is so much bigger than us, and a new appreciation for the vastness of the universe. When you have a telescope to view the heavens, you will be amazed at what is out there to see.

When you gaze at the moon through the lens of your telescope, you'll see a landscape filled with new mysteries and revelations. Finding a planet like Jupiter or Mars in the telescope can show you a new world beyond that which we know here on Earth.

Look through the eyepiece of your telescope and marvel at what is out there in the galaxies. Don't be surprised to see a shooting star. Study the cycle of comets and see if you can catch one of them. They really are stunning. Meteors shoot through the sky at a quick rate – write it down when one comes into eyesight.

But most of all, when you are taking up astronomy as a hobby, share your passion. Share what you've seen, talk to other people about how wonderful it is. Show them what you enjoy and watch the excitement grow.

Pretty soon, there will be a whole community of you eager to share your findings and talk about what you've been able to find. Whether it's on the Internet or in your hometown, there are plenty of places where people who share a love of amateur astronomy can gather and share and even grow.

Go through your astronomy diary faithfully and see where you are lacking in what you want to see and find. Study the art as much as you possibly can, and you will be introduced to a world beyond anything we could every truly and completely imagine.

It's easy to get caught up in a hobby – especially the hobby of astronomy. The best part is that the hobby is full of never-ending discoveries and can be passed from generation to generation for years and years to come. As long as the world exists, the heavens have much to reveal when you look for it.

Think about how it makes you feel as you realize just how big the sky is and how small you are. There's a lot to be learned not only about our world but about ourselves as well.

I well remember a scene from the movie "Animal House" where three people were in a bathtub after consuming an illegal substance and marveling at the possibility that there could be a universe underneath their own thumbnails or that we could be a universe underneath a giant's thumbnail. It can be mind-boggling!

Hundreds of years ago, Galileo had a little idea. He got an itch in his mind of how he could see the sky closer. He took that idea and gave birth to the telescope. Since then astronomers have discovered many new things – from water on Mars to new planets and moons that we never knew about.

You might be the next person to make an exciting discovery. So study up, get out that telescope, and see what you can see. Then sit back and be amazed at how vast and wonderful the universe we dwell in actually is!

## Recommended Resources

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**Free HTML Editor** – NVU allow you to create your own web pages the simple and easy way without any HTML or PHP programming knowledge.

**Free FTP Program** – FileZilla is FTP (File Transfer Protocol) software that allows you to upload files to your website and also it is built-in and strong and easy to use web interface, besides using for uploading of files to your website, you can also use this software to perform files downloading from your website for backup purpose.

**Domain Names –** NameCheap.com domain Names for your new website are a bargain here.

**Web Hosting -** HostGator.com offers unlimited domain hosted in one account with reasonable monthly hosting fee of less than $10 per month.

**Merchant Account –** Paypal.com offers you to accept credit card payment from your customers all around the world with various currency options.

**Autoresponder Choice 1 -** Aweber offers the most reliable autoresponders on the net! If email deliverability is important to you signup today!

**Autoresponder Choice 2 –** Emailaces offers the reliable autoresponders on the net with a reasonable monthly fee! If email deliverability is important to you signup today!

**Niche Contents PLR & MRR Membership** – Niche4Wealth is a membership site that delivers 4 brand new niche private labels resell rights products on monthly basis and also offers more than hundreds resell rights products in the libraries. If you are looking for a way to make more income profits on each day selling info products, why not pay a visit to this site to see how you can make money with the products and contents in the membership.

# ADDITIONAL BONUS

## Congratulations!

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Your Gold member benefits entitle you to:

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