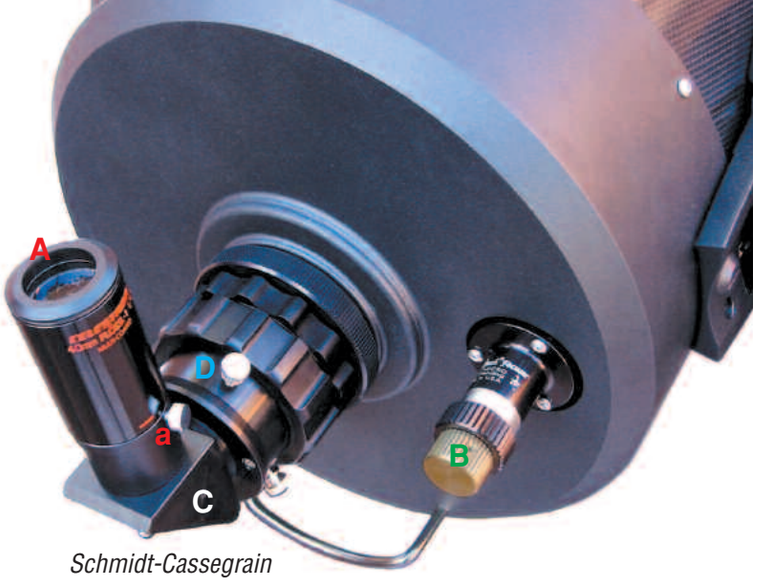
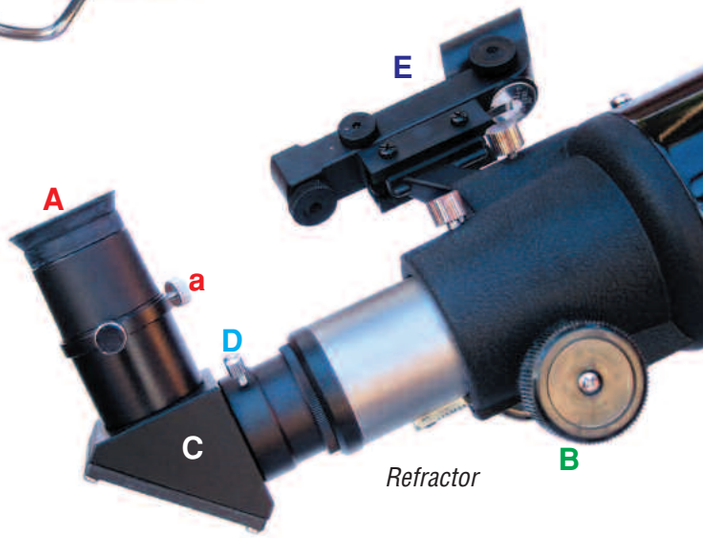
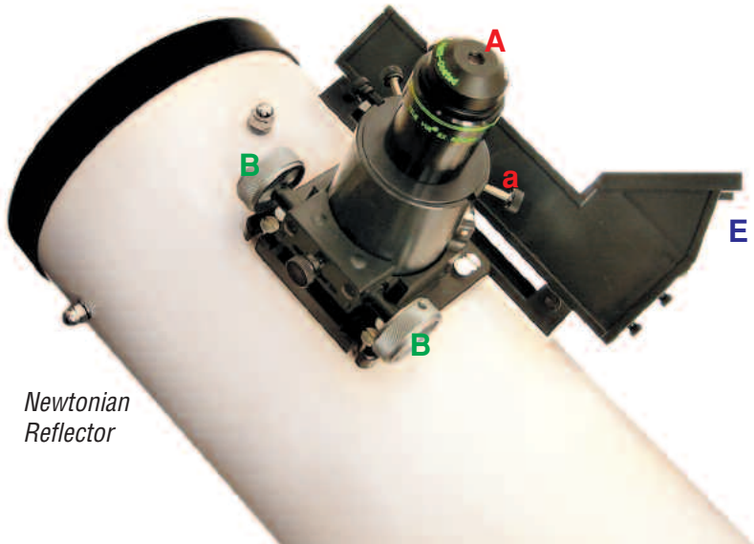


Schmidt-Cassegrain Telescope (SCT)



Refractor



Newtonian Reflector

Telescopes & Binoculars

Anyone can participate in and enjoy astronomy without the aid of binoculars or a telescope. However, their use will heighten the experience of exploring the heavens, opening vistas unobtainable in any other manner, revealing a hidden Universe out of reach of the eye alone.

TELESCOPE OVERVIEW

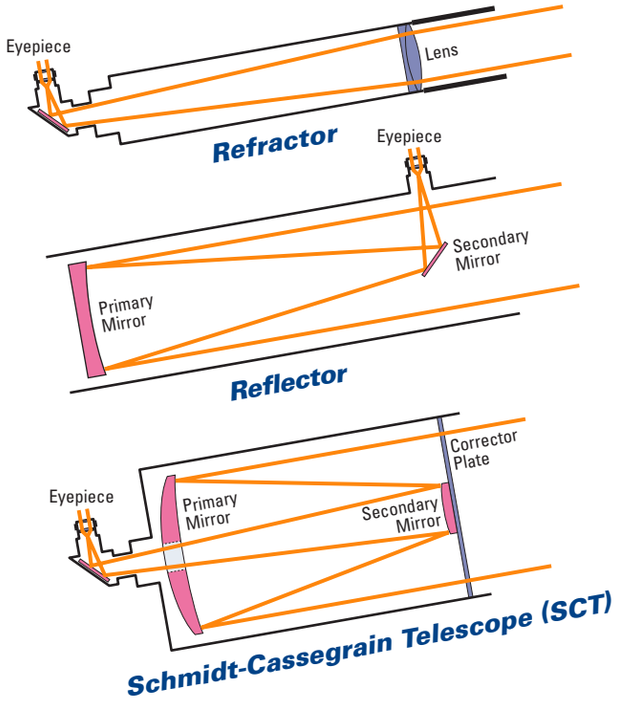
Refractors and reflectors are the two basic types of telescopes; although today, a hybrid of the two has become popular. Refractor telescopes utilize clear optical lenses for focusing light while reflector telescopes use mirrors. The hybrid telescopes use mirrors for focusing light, but also employ a front "correcting lens."

Refractors. Refractors represent the most common notion of a telescope. The front lens used for focusing light is called the objective lens. Common objective diameters range from 2.4 inches (60mm) to 6 inches (150mm). Most are 4 inches (101mm) or less. Refractors are more expensive per inch of aperture than other telescopes. However, small, inexpensive refractors are often purchased for children and since these telescopes do not perform well, they very often taint first impressions of observational astronomy.

Tele Vue 101 Refractor

Facing page. *Telescope basics. From top to bottom: SCT or Schmidt-Cassegrain Telescope, Refractor and a Reflector.* **A • Eyepieces**. *Telescopes use eyepieces that allow changing the magnification. Eyepieces are secured "lightly" with a thumbscrew,* **a**, *so they do not fall out when the telescope is moved.* **B • Focusing**. *Telescopes are focused by turning a knob. Each observer must focus for his or her eyes.* **C • Diagonal**. *A 90° diagonal is used with SCTs and Refractors to make viewing more comfortable. Diagonals are unnecessary for reflectors.* **D • Swivel**. *Diagonals can be rotated or swiveled to make viewing comfortable by loosening a thumbscrew and rotating. Don't forget to "snugly" retighten the thumbscrew after repositioning.* **E • Reflex-sight Finder**. *It is very difficult to aim a telescope at an object in the sky without some type of "Finder." In the past, these were commonly small-diameter, low-powered telescopes. Today, the Finder of choice is a Reflex-sight that optically projects a red dot or concentric circles onto the night sky.*

Three Popular Telescopes



*The **Refractor** was the first type of telescope invented, around 1609. And, Galileo was one of the first to make and use this instrument to explore the heavens for a better understanding of our world. Although Galileo's telescopes had apertures averaging about an inch in diameter, most amateur refractors today have diameters of 4 inches or less with the largest around 6 inches.*

*In 1668, just 60 years after the telescope was introduced to the world, Isaac Newton made the first reflector telescope, utilizing a concave mirror to focus light. His original design is still extensively used today and appropriately called the **Newtonian Reflector**. Although Newton's original mirror measured just 1⅓ inches in diameter, today, common sizes range from 4½ to 12 inches. Many Newtonian reflectors, especially those called "Dobsonians," which are characterized by their simple altazimuth mounts, are manual scopes, that is, designed to be moved by hand. Although this makes them the least expensive per aperture inch of any telescope, they require a greater knowledge of the sky in order to locate objects.*

*The **Schmidt-Cassegrain Telescope or SCT** uses two mirrors and a front correcting plate to focus light. Although this optical design was introduced in the 1950s, it became popular when Celestron made them for amateurs in the early 1970s.*

Telescopes

Reflectors. The Newtonian reflector, patterned after Newton's original design, is the most common reflector telescope. These telescopes use a concave parabolic primary mirror to focus light. Today, the most popular form of the Newtonian telescope is nicknamed a "Dobsonian" (see Glossary). The Dobsonian telescope features a Newtonian telescope on an inexpensive and simple altazimuth mount that allows easy vertical and horizontal movement. These simple mounts have enabled amateurs to purchase larger telescopes for the lowest cost ever. Common diameters of Newtonians reflectors range from 4½ inches to 12 inches, but they max out around 36 inches. The 6 and 8-inch diameters are affordable to own and convenient to use.

Newtonian Reflector, "Dobsonian" Style

SCT

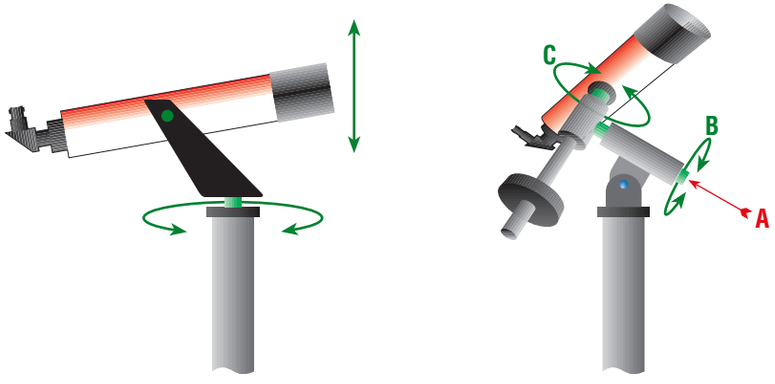
Hybrids. Although there are several types of hybrid telescopes, the Schmidt-Cassegrain Telescope (SCT) is the most popular. The 8-inch diameter is the best-selling size and provides an extremely portable observing system because of its compact "folded" optical system. SCTs have primary mirrors for focusing light, but incorporate a front correcting plate or lens, which also helps seal the optics from the environment. Per aperture inch, SCT telescopes cost less than refractors but more than "Dobsonian" reflectors.

TELESCOPE MOUNTS

Although there are just two basic types of telescope mounts, the **altazimuth** and **equatorial**, there are many variations.

The simplest and most prevalent mount is the **altazimuth**. Everyone is familiar with this type because it is the same mount used with giant binoculars at tourist attractions. Altazimuth mounts allow quick and easy, up-and-down and side-to-side movement. Newtonian reflectors mounted on altazimuth mounts are often referred to as "Dobsonians." I use telescopes on altaz-

Telescope Mounts



ALTAZIMUTH MOUNT

Simple, easy vertical and horizontal movement.

*For amateurs, a form of the Equatorial mount is required to take photographs of celestial objects requiring **extended** exposures. Altazimuth mounts can be tilted to perform just like Equatorial mounts. The largest professional telescopes are on computer-controlled Altazimuth mounts.*

EQUATORIAL MOUNT

Shown is a traditional German Equatorial Mount. To set up, the Polar Axis, **A**, must be pointed to a Celestial Pole. The telescope is positioned and rotates around the Polar Axis, **B** and the Declination Axis, **C**. A slow moving motor attached to the Polar Axis allows the scope to "follow" celestial objects.

imuth mounts for much of my visual observing. See pictures on pages 81, 83 and 92 of telescopes on this type of mount.

The **equatorial** mount was the traditional astronomical mount before the age of computers because it was the only mount that could be motorized to automatically follow a celestial object across the sky. Equatorial mounts have two axes. One points directly at a celestial pole (close to the star Polaris in the northern hemisphere) and is called the Polar Axis. The other axis, the Declination Axis, is perpendicular to the Polar Axis. A popular design of the equatorial mount is called the German Equatorial (illustrated above), which is recognizable by a counterweight shaft on one end of the Declination Axis.

The New Mounts — Compliments of the Computer

Computer-controlled telescope mounts have revolutionized astronomy for both the amateur and professional.

Professional astronomers started building and using computer-controlled altazimuth mounts in the early 1970s. They quickly caught on because they were considerably less expensive (and less massive) than equatorial mounts. This technology was eventually adopted to amateur mounts when computer components became affordable in the early 1990s.

Motorized Mounts & GO TO Computerized Telescopes

Slow-moving motors are or can be attached to the axes of many altazimuth and equatorial mounts, allowing telescopes to follow celestial objects. So, instead of nudging the telescope every minute or so to keep a celestial object in view, the motorized mounts do it for you. Many SCTs come with motorized mounts; however, for many telescopes, it is an option or accessory.

One of the greatest technological breakthroughs for amateurs was the introduction of the GO TO computerized/motorized telescopes in the 1990s (it is actually the mount and not the telescope that is motorized and controlled by a computer even though it is often referred to as the telescope having this capability). For the first time, amateurs had telescopes like their professional counterparts — telescopes that could automatically find and follow celestial objects. GO TO telescopes are controlled through handcontrollers that look and work similar to cellular phones. They have a small display screen, where celestial objects, including the Planets, can be chosen from scrollable lists.

The handcontroller on a SCT telescope with GO TO technology. Databases of objects are accessed through the keypad — similar to phone number lists on cellphones.

All altazimuth GO TO telescopes are easy to set up and use, however, like with any new electronic piece of equipment (VCR or DVD players, etc), they require a short learning curve for their operation to become second nature.

How do you get a GO TO mount going? After the mount or "telescope" is turned on, it must first be aligned to two bright stars before it will automatically find, move to, and follow objects. This two-star alignment takes about five minutes and the hand controller displays information that walks you through the process. The telescope will even choose the two bright stars to be used for alignment and it will also move and roughly point the telescope close to them. All you have to do is center the stars in the eyepiece and press a button on the keypad to indicate that you have accomplished each of the alignments. After this has been completed, the telescope will automatically move to any object in the sky (except for objects like new comets) selected from scrollable lists.

MORE ABOUT TELESCOPES

The Myth about Telescope Magnification

Magnification is the least important factor in choosing a telescope! But, unfortunately, the selling and marketing of many telescopes, especially those sold in department, chain or toy stores, has often been based on magnification.

Technically, it is possible to get any magnification out of any optical system, but there are practical limits. *Useful magnification for most observing, independent of objective lens or primary mirror size, is from 30x to 250x. Magnifications higher than 250x often do not provide more detail because the usually turbulent atmosphere limits image quality and resolution.*

The practice of selling "high magnification" does not seem to go away despite the repeated efforts of professional and amateur astronomers to stamp out this idea. The reason for its persistence is simple. Marketers realize that high magnification is a selling point — something that consumers understand, especially when purchasing telescopes for children. Even the largest telescope manufacturers, who should know better, are guilty of using this hyperbole to sell their lower-end telescope line.

What are all those f/numbers about?

The f/numbers (e.g. f/4, f/5.4, f/8) associated with telescopes indicate the ratio of the telescope focal length to its aperture. In other words, the focal length of a telescope, divided by the

Computing Telescope Magnification

***Focal Length* of TELESCOPE ÷ *Focal Length* of EYEPIECE = Magnification**

NOTE: All focal lengths must be expressed in the same units — usually millimeters.

EXAMPLE 1

What magnifications are achieved using 8mm, 15mm & 20mm eyepieces with an 8-inch SCT having a focal length of 2032mm?

2032mm ÷ 8mm = 254x
2032mm ÷ 15mm = 135.5x
2032mm ÷ 20mm = 101.6x

EXAMPLE 2

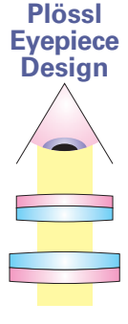
What magnification is achieved with a 4-inch f/6 telescope and 20mm eyepiece?

1. Compute focal length of the telescope. 4-inch x 6 (f/6) = 24-inch focal length
2. Change 24-inch focal length into millimeters. 24 x 25.4 (conversion factor) = 610mm focal length
3. Compute Magnification. 610mm ÷ 20mm = 30.5x

diameter of the objective lens or primary mirror, gives you the f/number. For example, if your telescope has a focal length of 21.5 inches (540mm) and an objective lens diameter of 4 inches (100mm), then your f/number is f/5.4 (21.5 inches ÷ 4 inches = 5.4 *or* 540mm ÷ 100mm = 5.4). Telescopes with f/numbers of 5 or lower are considered rich-field telescopes (RFT) because they provide lower magnifications and wider fields of view (that is, you can see more of the sky through an eyepiece). Most telescopes have f/numbers that range from f/4 to f/15. The f/number is also referred to as the focal ratio and it is the same number used with camera lenses.

Eyepieces, the Barlow Lens, Eyeglasses & Focusing

Quality eyepieces are just as important as a quality objective lens or primary mirror. Low quality eyepieces will render poor quality images. The standard eyepiece is the Plössl eyepiece (Plössl is the name of a specific lens design). Plössls are excellent eyepieces because they provide good imagery across a wide field of view and are reasonably priced.



Eyepieces are identified by their focal length, which is always expressed in millimeters (mm). Focal lengths range from about 2mm to 55mm (0.08 inches to 2.16 inches). Shorter focal length eyepieces (those with smaller numbers) provide higher magnifications.
See the top of this page for computing magnifications.

Computing Magnification

The standard eyepiece barrel diameter is 1¼ inches. There is also a 2-inch size. Some inexpensive telescopes use eyepieces that have barrel diameters of 0.965 inches, but very few eyepieces are available for this smaller barrel diameter.

A **barlow lens** can be used in conjunction with an eyepiece to double (triple or even quadruple) its magnification. A quality barlow will not degrade the performance of an eyepiece. Most barlows look like long eyepieces that fit into the eyepiece holder (focuser) of a telescope. Regular eyepieces are then inserted into the barlow (see photo below).

There are many "specialty" eyepieces that provide different viewing experiences. Mostly, these eyepieces provide a greater field of view, that is, they allow you can see more of the sky, similar to the difference between looking out a small and large window. Unfortunately, these eyepieces are considerably more expensive than the Plössl design, so if possible, try them out before you buy.

Most telescopes come with at least one eyepiece, so be prepared to purchase more. To start, I recommend two Plössls and a 2x barlow. If you start with this combination, the focal length of your "shorter" eyepiece should be ⅔ to ¾ that of your longer focal length eyepiece in order to avoid duplicate magnifications when using the barlow.

If possible, observe without eyeglasses. If you are unsure as to whether or not you can, give it a try. Observing is more pleasant and comfortable without them. If you must wear your glasses, remember that some eyepieces have a rubber guard

The eyepiece on the far left has a barrel diameter of 0.965 inches. The 20mm Plössl eyepiece to its right has the standard barrel diameter of 1¼ inches. The very large eyepiece in the "center," a 55mm Plössl, has the largest commercially made barrel diameter of 2 inches. The 2x Barlow lens at the far right accepts eyepieces with 1¼-inch barrel diameters (they are inserted at the top and secured with a thumbscrew (not visible).

that can be folded back to get you closer to the lens for a better view. Better yet, there are specialty eyepieces designed with "long eye relief" that allow eyeglass users to comfortably look through eyepieces. These designs enable eyeglass wearers to easily see to the edge of the field of view instead of just seeing the middle portion of the image.

Focusing. Everyone needs to focus a telescope to his or her individual eyes. I am always amazed at the difference in focus from one person to another. What may be completely out of focus for one is perfectly focused to another. Although it is a common courtesy to ask the owner or operator of a telescope if you can use the focuser, please do not hesitate to ask for there is nothing worse than viewing an image that is not focused.

iFdnrecspose& R feel xiShgstH

Above. The view through a Telrad, one of the most popular reflex-sight finders. To use, position an eye 6-inches or so behind the slanted glass plate to see the bulls-eye for aiming the scope. These finders are natural and fun to use — kids really like them.

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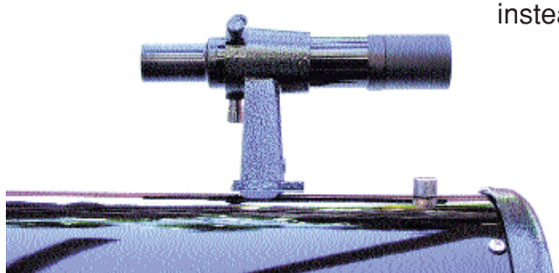
tsin toe sa yiwhtuo t aifdnrecspo.e
Aifdnrecspo esia s amll ,ol-wopewer detelcspo etatached to the main telescope. It usually has cross reticles and is used to steer or target the telescope. Even economically priced finderscopes will help you enormously to guide your telescope.

However, today, there are finders, known as "reflex sights," that project a red dot or concentric circles onto the night sky for guiding the telescope. Reflex sights are wonderful because you can quickly point a telescope to a specific spot in the night sky without having to look through the "narrow" confines of a finderscope. Most amateurs now use reflex sights instead of traditional finderscopes.



Left. A traditional finderscope is nothing more than a small, low-powered telescope with a "generous" field of view.

Upside-Down and Inside-Out Images

Most astronomical telescopes and traditional finderscopes do not provide upright, true-to-life views. For instance, refractors without the 90° diagonal, provide upside down views. With the 90° diagonal, the image is upright but it is a "mirror image" where left and right are reversed. SCTs with a 90° diagonal provide the same view as a refractor with a 90° diagonal. The biggest problem with reversed "mirror-image" views is matching stars in the eyepiece to those printed correctly in star atlases. Newtonian reflectors provide a true-to-life image but its orientation changes depending on your position to the eyepiece, so these telescopes are not the most practical for terrestrial viewing if you require an upright image.

There has always been a toleration for mirrored and upside down images in astronomy because image orientation is generally immaterial when studying the stars.

Modern Optical Quality

At the beginning of this twenty-first century, middle-of-the-line telescopes and other optical instruments perform better than the very high-end telescopes of the 1970s. Modern computer technology, sophisticated production techniques and new materials give us the highest mechanical and optical quality ever.

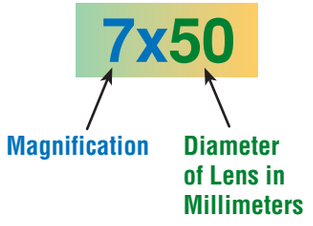
Unfortunately, not all optics are excellent. Most telescopes sold in department and discount stores, as well as the lower-end line of telescopes sold by the major telescope manufacturers, almost always exhibit lower optical quality. Don't disappoint yourself — if you are in the market to purchase binoculars or a telescope, buy at least middle-of-the-line.

BINOCULARS

Binoculars are an excellent instrument for observing the heavens. They offer the comfort of two-eye viewing and capture greater vistas than can be obtained with telescopes.

Almost all middle-of-the-line binoculars offer good optical performance. The standard configuration, 7x50, is ideal for gazing at the heavens and for daytime use. I do not recommend binoculars smaller than 40mm for astronomical use. My 10x40s provide excellent views of the brighter nebulae and star clusters, however, my 8x20 pair is not adequate for these fainter objects. There are speciality binoculars with magnification above 10x, but I don't recommend them because you can't use them easily, for terrestrial viewing, without a tripod.

Binocular Nomenclature



Since most binoculars are limited to magnification from 7x to 10x, they cannot provide the detail possible with telescopes. On the other hand, the wide vistas obtainable with binoculars are impossible to capture with telescopes. In my opinion, the most beautiful views of the Pleiades (M45, page 273) and the Praesepe (M44, page 279) are through binoculars. These clusters fill the binoculars' field of view and give the impression that the stars are floating in front of you. Many deep sky objects *are* visible with binoculars, however, they just appear smaller and fainter than through telescopes. About 80 of the Messier Objects (pages 248–251) can be seen through binoculars. For the most part, binoculars serve as observing adjuncts for amateur astronomers.

A tripod is very useful when using binoculars to view the heavens. It steadies your view and gives you the opportunity to study the heavens without making your arms tired. I also lean on the tripod, which makes it more comfortable for me to stand in place for a period of time. Most binoculars sold today have a tripod socket that allows easy attachment to the tripod head. You may

Porro-Prism *binoculars (left) represent a proven design and are identified by the offset of the eyepieces from the front lenses. Although this design is bigger and thus bulkier than* ***Roof-Prism*** *binoculars (right), they can edge out the performance of roof-prism binoculars for a much lower cost.*

have to get creative to attach older binoculars without tripod sockets to tripod heads. In lieu of a tripod, I often sit or lay on lawn furniture to not only steady my view but to also make my observing more comfortable.

Tripod adapters are used to attach binoculars to tripods.

TELESCOPE RECOMMENDATIONS & CONSIDERATIONS

The best telescope is the one that gets used. Often, this may be the easiest one to set up. Although I have several telescopes ranging in diameters from 4 to 8 inches, I tend to use a lightweight 6-inch Newtonian Reflector on a simple altazimuth mount because it *is* easy to set up and take down.

For casual observing, that is, when I want to go outside for a quick look around, I want it to be simple and fun, so I shy away from my larger and heavier scopes.

On the next page, I have provided summaries on telescopes, binoculars and eyepieces as well as some suggestions about purchasing these optics.

A favorite scope of mine is this 6-inch diameter Newtonian Reflector mounted on a simple altazimuth pipe mount that I made a few years ago. It is quick and easy to set up and fun to use. This is a "manual" scope so I have to move it around by hand.

Summary & Recommendations

Telescopes

REFRACTORS

- Highest cost per inch of aperture.
- Practically maintenance-free.
- Diameters are small, most from 2⅜ to 4 inches. (60 to 100mm). Largest diameters are around 6 inches.
- Easy set up and take down for 4-inch and smaller sizes.
- Various mounts available.
- Smaller "entry level" refractors are inexpensive but are not a good choice for astronomical use.
- Most expensive refractors (called apochromatic) provide the highest image quality of all telescopes.

NEWTONIAN REFLECTORS — DOBSONIAN STYLE

- Lowest cost per inch of aperture.
- Optics need to be realigned frequently and cleaned occasionally.
- Diameters range from 4½ to 12 and on up to 36 inches.
- Easy set up and take down for 10-inch and smaller sizes.
- Mount limited to simple altazimuth.
- Low-quality components in some commercially produced units.
- These are mostly manual telescopes that are moved around by hand, so some knowledge of navigating the sky is necessary.
- Larger diameter provide the brightest and most detailed images of deep sky objects (DSOs). See pages 239 to 253.

HYBRIDS ★ SCHMIDT-CASSEGRAIN TELESCOPES (SCT)

- Per inch of aperture, SCTs are more expensive than Newtonian Reflectors but less expensive than refractors.
- Maintenance required occasionally.
- Common diameters range from 5 to 16 inches.
- Easy set up and take down for 8-inch and smaller sizes. Those larger than 8-inches get heavy fast.
- Front correcting plate susceptible to dew.
- Often have computerized and motorized mounts that find and follow the stars (GO TO).
- 8-inch is telescope of choice for many amateurs.

BINOCULARS

- Purchase at least middle-of-the-line binoculars. These should provide good image quality.
- 7x40, 10x40, 7x50 or 10x50 or similar are good choices for astronomical and terrestrial use.
- A tripod or lawn chair is helpful to steady your view when looking at astronomical objects.
- Older binoculars may not have a tripod socket, so you may have to get creative in latching them to a tripod's head.

EYEPIECES

- Telescopes are only half of the equation for viewing the heavens. Good quality eyepieces are the other half.
- Be prepared to purchase a few with your telescope since most telescopes come with only one eyepiece.
- Plössl is the standard eyepiece of choice.
- A barlow lens can economically double or triple the magnification range of your set of eyepieces.

Here are some of my suggestions for exploring the heavens with and without your own optical instrument.

Interloper. Do not buy a telescope or binoculars, but instead attend public astronomy events that feature telescope viewing. If you "hang around" at these events, you will see more celestial objects than you ever would by yourself, and see them through larger telescopes than you would have purchased. And you won't have to do any of the work. At such gatherings, I have looked through 2 to 36-inch telescopes and have seen objects that I can't see with my own scopes.

Gathering Dust. Borrow a friend's telescope that is sitting in the garage or basement. They may not want to sell it, but they may let you use it.

Really Want a Telescope. Please take some time to become informed so you can choose the best telescope for your budget and interests. Read about astronomy, subscribe to one of the popular monthly astronomy magazines, visit telescope shops, attend astronomy events, join a club and ask lots of questions

Summary & Recommendations

Telescopes

before you decide to buy. And remember, most amateurs go through several telescopes during their lifetime.

Used Telescopes. Some telescope stores sell used telescopes but they usually go quickly because they are less expensive than new. So, visit www.astromart.com and sign up for their email alerts on used telescopes sold by amateurs across America.

Bottom Line Recommendation. My first recommendation would be a 6 or 8-inch Newtonian Reflector (Dobsonian style) with several quality eyepieces. This will cost around $500 to $600. For around $2,000, you can get an 8-inch GO TO SCT. The 8-inch SCT is the most versatile product for the price. Either of these telescopes can easily be sold or traded if you outgrow them.