Buying a Telescope

Originally by Carl Wenning (ISU Planetarium), adapted by Dave Leake

Many people are faced with the same dilemma – what do I look for when buying a telescope? We preach to stay away from a high-power (magnification) telescope. But let's face it . . . .if you're faced with two telescopes, side-by-side, same size but one goes to 80x and the other goes to 500x, how many will take the 500x telescope? Probably quite a few! High magnification makes an object appear larger but it also takes the feeble light from a distant object in space and spreads it out, thus making the object appear dimmer. It is possible to use so much magnification that you won't find the nebula or galaxy at all! High magnification also brings with it a narrow field of view, like you're looking through a long cardboard tube used for wrapping paper. I've seen kids using 500x not be able to find a full Moon! So how do you account for losses in light from magnification? *You collect more light!* Collecting light makes an image brighter. This is done by using a lens or mirror to bring more light to your eye. More light means a brighter image and then you can get away from magnifying it more. A larger "light collector," of course, means a larger chunk missing from your wallet, too.

Here's a little diddy about Jack & Diane . .. two American kids living in the heartland. Jack & Diane live next door to each other. Diane purchases a modest instrument that has an aperture (diameter of the lens or mirror) of 2 inches and magnifies only 7 times. The magnification makes the object you're looking at 7 times higher and 7 times wider, so you're really spreading out the image by a factor of 7 x 7 or 49 times. The object would appear 49 times dimmer. However, we're collecting a lot of light. When fully dilated, your eye is about ¼ inch in diameter. A 2 inch aperture is 8 times larger than your eye (8 x ¼ = 2 inches) but your eye and the lens are circles. We must consider the area of a circle (πr^2) so, if we leave off π and just take 8 x 8, we're collecting 64 times more light than our eye alone. This is good! Let's do a ratio now. We're collecting 64 times more light than our eye (making our object 64 times brighter) but we're spreading out the light by a factor of 49. 64/49 = 1.3 . . . or we can say the object we're looking at through the telescope will appear 30% brighter.

Now let us consider Jack's choice. Jack goes to a local department store where, on sale, there is a telescope with a 3 inch lens and it magnifies 500x. There are also photos on the box taken by the Hubble Space Telescope. We do the same calculations. A 3 inch lens is 12 times larger (diameter-wise) than our ¼ inch eye (1/4 x 12 = 3). But we have to consider areas so we're collecting 12 x 12 or 144 times more light than our eye can do alone. But Jack is impatient and wants to use the telescope immediately at 500x. The target will have its light spread out by a factor of 500 x 500 (remember, we deal with areas) or 250,000 times! So we're collecting 144 times more light but we're spreading it out by a factor of 250,000!! Lets do the same ratio: 144/250,000 = 0.000576. The image will appear 1736 times dimmer!!!

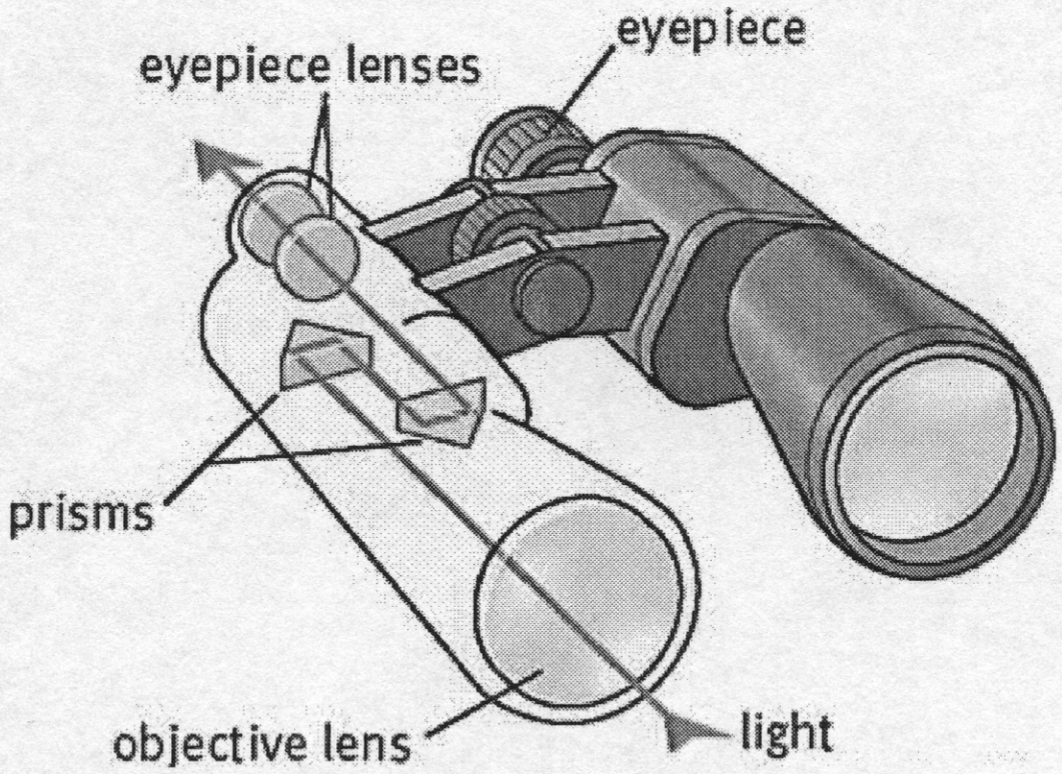
What is sad is that Jack's telescope is typical of many on the market these days, especially in department stores. <u>The most important thing a telescope can do is collect light!</u> Sure, they do magnify objects but *ONLY* after the light is collected. You can have too much magnification. A suggested maximum high magnification is 60 power per inch of aperture. So, for a 3 inch telescope (3 inch lens), you can go to

180x and no more. Jack's telescope used at low magnification would be fine but you're paying for the high magnification eyepieces.

Diane's "telescope" is actually a pair of 7 x 50 binoculars. "7" is the magnification and the "50" is the diameter of the lenses (aperture) in millimeters. 50mm = 2 inches. When beginners want a telescope, binoculars are often suggested as a first step, but few see the advantage of buying binoculars (which are two telescopes mounted side-by-side . . .see the diagram below).

Binoculars also have a wide field-of-view. A typical binocular FOV is 6-8 degrees where a high power telescope may yield a ¼ degree FOV. Again, the area of the sky observed increases with the square of the radius, so a 7° field will show you about 784 times more area of the sky than the telescope. You can see more! Binoculars area also usually less expensive, light-weight, easier to maintain, and you can take them to a football game.

Which would you buy? A toy telescope or binoculars?



"WHAT KIND OF TELESCOPE SHOULD I BUY?"

Buying a telescope requires much time, thought, and (yes, you guessed it!) money. A telescope should be thought of as an investment and there are many things to consider before you get out your wallet. First and foremost, we must clear up a common misnomer, the concept of "power." A telescope's primary function is to *collect* more light than your tiny eyeball. This is done by means of a mirror (a reflecting telescope) or a lens (a refracting telescope). When you magnify an object you spread out the light you are receiving and the object actually appears dimmer. High magnification yields a narrow field of view, making it more difficult to locate things in the sky. Therefore, useful magnification is related to "aperture," or the diameter of the light collector. A useful magnification is 30 times per inch of aperture. A telescope that advertises a 3" lens and 454x is ripping you off!! Use it at, say, 60x and it might be a good telescope.

Are you ready for a telescope? They require more know-how than you may think. A basic knowledge of the sky is essential. Learn a few of the major constellations and what phases of the Moon to expect. It is important to know the orientation of the sky; how the stars rise and set. A recommended first step that is usually bypassed is the purchase of a pair of binoculars. Many star clusters, nebulae, comets, and the Milky Way are within the range of these relatively inexpensive instruments. If interest wanes, they can always be taken to the football game!

If you want to purchase a larger instrument, consider a few points:

1) *How much can you spend?* Count on roughly $200 minimum for a good first instrument. And though it's unfortunate, count on going mail order, too.

2) *Where are you going to observe?* Will portability be a factor? Don't buy a large scope and then expect to take it out in the country in a compact car!

3) *What will I be doing with the scope?* Casual Observing? Photography? Mostly seeing faint galaxies or bright planets?

4) *How serious am I?* A good pair of binoculars is a good place to start. 7x50 (7 power magnification and 50mm lenses) are recommended. And invest in some simple star charts, too.

Consider buying a telescope like buying a car. If possible, try to "test-drive" it in the field. Buy a *Sky & Telescope* or a *Astronomy* magazine at a bookstore and look through the ads. When you think you have found what you want, give the CU Astronomical Society a call (http://www.cuas.org). If one of their members owns this type, they are usually happy to allow you a look. Attend a "star party." The quality of the optics, sturdiness of the mounting, and portability will be evident.

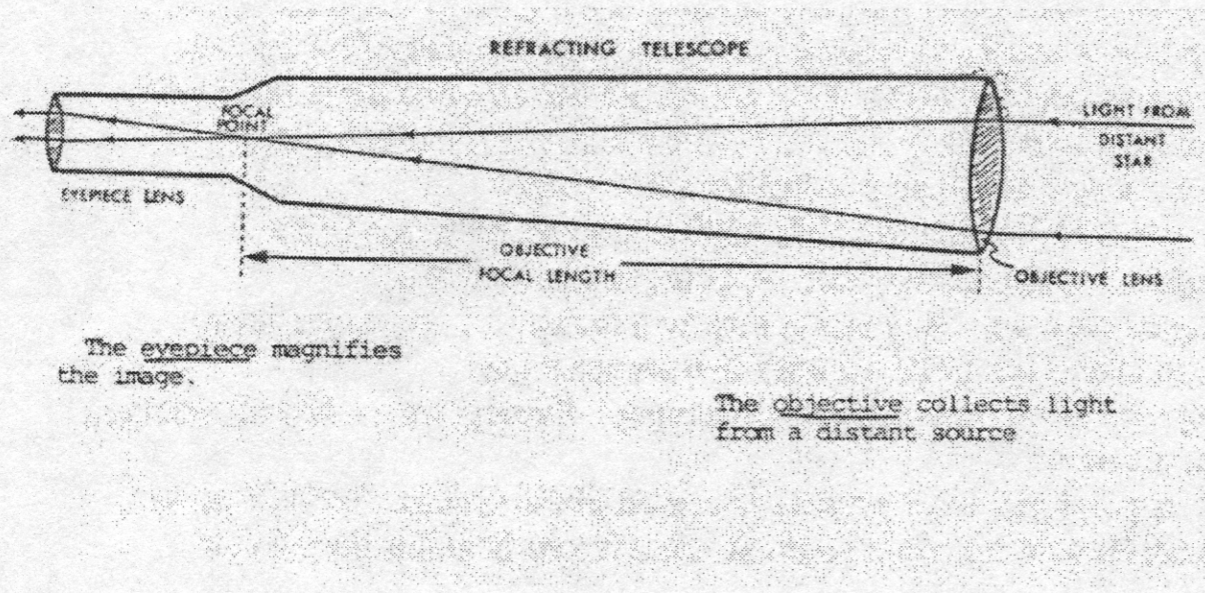
You will undoubtedly be introduced to the three basic telescope designs: the refractor, the reflector, and the catadioptric or compound telescope, of which the Schmidt-Cassegrain is the most popular. The **Refractor** uses an "objective lens" to focus starlight to the eyepiece. The refractor will give you the best definition and sharpest images *if* it is of good quality, but large collecting lenses mean "big bucks!" Shy away from the department store varieties due to their poor workmanship and inflated claims of high-power. These will end up collecting dust in a closet.

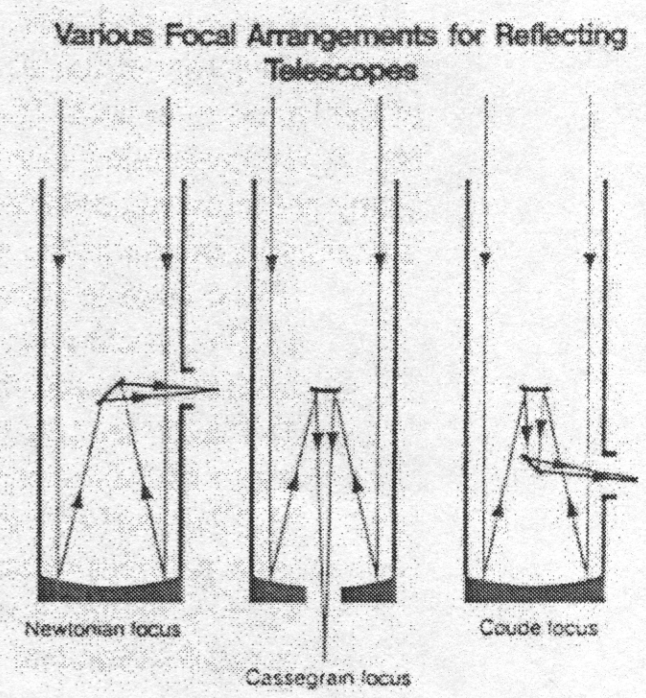
The **reflector** uses a parabolic mirror to collect light and provides the most collecting area for the dollar. Large mirrors are relatively easy to construct. Most reflectors have open

tubes which must reach ambient temperature before they will operate efficiently. A simple design is called the "Dobsonian Reflector," which combines a thin (but large) mirror with an inexpensive mounting to provide large aperture at a low cost. More “bang for the buck” here!

The **Schmidt-Cassegrain** is the design that you often see advertised. It combines a reflecting system, in which the secondary mirror reflects the image back through a hole in the primary mirror, with a lens to increase the quality. These telescopes are very portable and easy to use but cost more than the more conventional reflectors.

Another decision to be made is the type of telescope mount that is desired. There are two basic designs. The **altazimuth** mount is a very simple up/down/left/right design. If you want to track objects across the sky you will want to spend a little bit extra on an **equatorial** mount. Once aligned to the North Star, this design will follow any star as it appears to move across the sky because of the Earth's rotation. It is a must for any astrophotography as these mounts can be motorized to match the Earth’s spin rate.





In summary, you can see that there is much more to purchasing a telescope than "meets the eye." Don't let this discourage you, though. You will soon find that operating a telescope is easy, entertaining, as well as educational. It is important to research your purchase before you get out your wallet to insure a lifetime of having the universe at your fingertips!

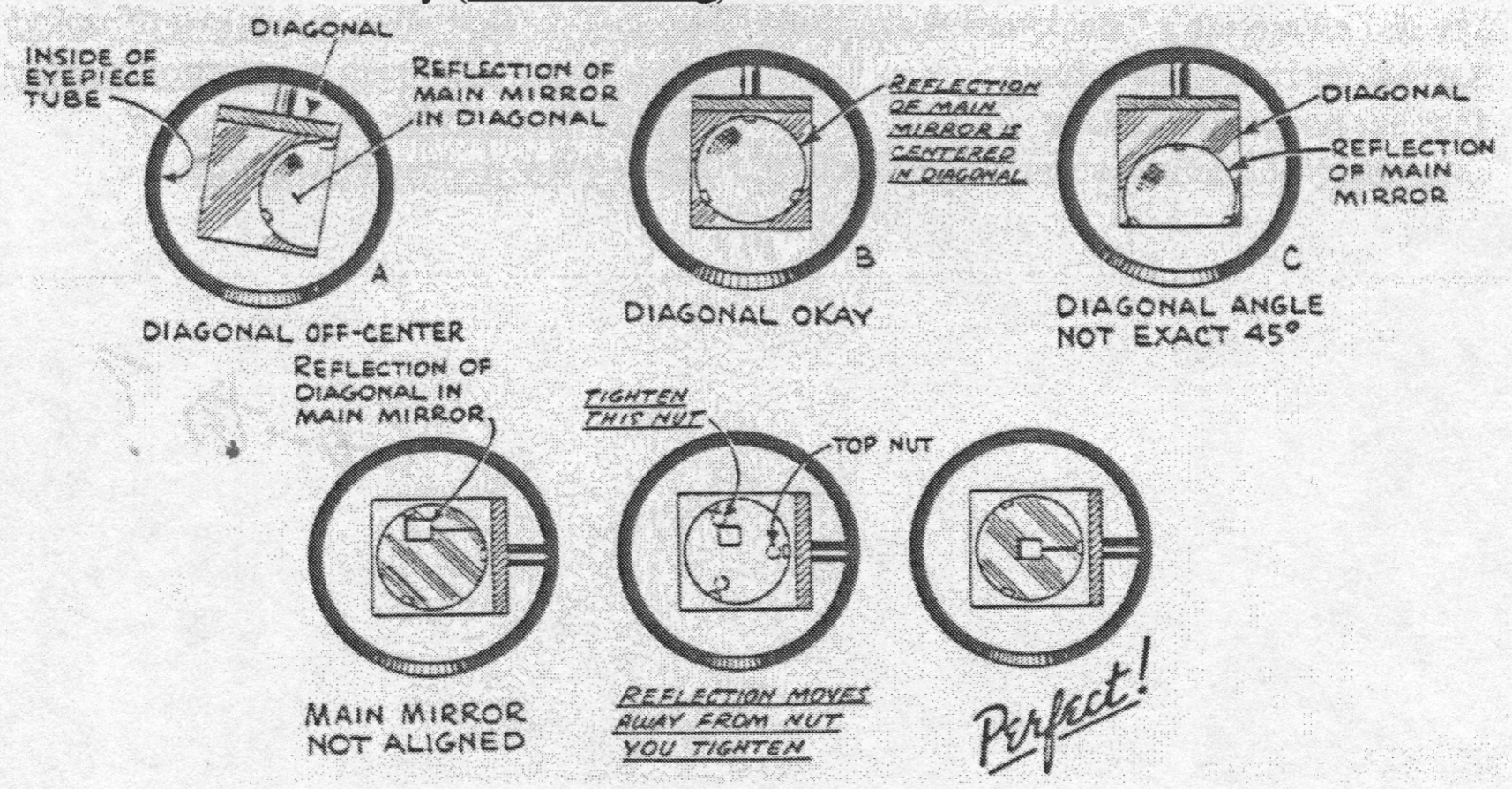
Some web sites of interest:

Staerkel Planetarium: www.parkland.edu/planetarium
Sky & Telescopes’s Buyers guide: www.skyandtelescope.com/astronomy-equipment/choosing-astronomy-equipment/telescopes/
Abrams “Sky Calendar,” a good first chart: www.abramsplanetarium.org/skycalendar/
Astronomy magazine’s hints: www.astronomy.com/observing/get-to-know-the-night-sky
Orion Telescope hints: www.telescope.com/Getting-Started/com/460.uts
Good used equipment: www.cloudynights.com
Space.com’s buying guide: www.space.com/15693-telescopes-beginners-telescope-reviews-buying-guide.html

"I CAN'T SEE ANYTHING . . . WHAT'S WRONG WITH MY TELESCOPE?"

OK, so you've purchased a telescope and you can't get it to work. What do you do? There are several things you can do to test your telescope and improve the views you're getting . . . or hope to get.

- *Use low power!* Many telescope manufacturers promote high magnification, which is very misleading! High powers mean narrow fields of view and you might have trouble finding a full Moon! Start with your lowest power eyepiece (the one with the highest number on it) and stick with it for a while. Don't use an eyepiece that has a number (its focal length) less than 10 mm until you're very familiar with what your telescope can do.
- *Set aside your barlow.* Barlow lenses double or triple the magnification and, on cheaper model telescopes, aren't worth much.
- *Look at your telescope's alignment.* Your telescope either collects light by a lens or mirror and then an removable eyepiece magnifies that light. IF your telescope uses a lens (refractor) don't touch it! Your best bet is to leave the optics alone. IF you have a mirror (reflector), the optical components can become easily misaligned. Look into the eyepiece holder without an eyepiece. You should see the main mirror and the image of the secondary mirror. They should all be aligned as seen in the diagram. If not, you can experiment by adjusting the set screws on the main mirror end of the telescope – there are usually three. The secondary mirror may need adjusted as well. If in doubt give someone at the planetarium or the CU Astronomical Society (www.cuas.org) a call.



- *Correct your wobbly mount.* Many telescopes come on tripods that are top-heavy and hence wobbly. You can tap the telescope and easily loose the image. To combat this, attach a cord or rope to the top of the tripod and let it hang down through the tripod. Attach a gallon milk jug filled with sand to the lower end so that it hangs just above the ground. This will greatly decrease your vibration problem.

- *Align your finder.* Most scopes come with a smaller telescope attached to the main tube. This is a telescope with a wider field of view to allow you to find things. Sight the Moon in your main scope by sighting along the tube. Once you have it centered, adjust the set screws on the finder and center the Moon. This will make finding other objects much easier.
- *Buy a star chart.* You've found the Moon and don't know what else to look at? You'd be surprised by what else is out there! But you need a road map. The local libraries have some star charts and you can purchase a good one for under $20. Recall that the planets will slowly move through the sky so don't expect to find them on a chart. Also, get a flashlight that is covered with red plastic so that the light won't hurt your night vision.
- *Cleaning your optics.* One word . . "don't." Unless you have a lot of experience, the best way to clean your telescope is by not letting it get dirty! When not in use, cover the entire telescope. Don't try taking it apart – you may be in for more than you bargained for!
- *Loose the ego!* Books are filled with many pretty colored pictures of nebulae and galaxies. Don't expect to see that! Our eyes operate differently than your digital camera; we have trouble seeing color. Galaxies will appear as fuzzy spots and only a few nebula will show detail unless you're in some pretty dark skies. The sky has many beautiful things to offer though you can't expect to see things like the Hubble Telescope sees them.
- *Lose your "solar filter."* Some department store instruments come with solar filters that thread into the eyepiece. This is where the sunlight is most concentrated and the filter can crack, thus relieving you of your eyesight. DON'T take a chance!
- *Make sure you are dark adapted.* Being in the dark, your pupils dilate and allow more light in. Even being outside 10-15 minutes, you'll notice how much more you can see. Allow time for dark adaptation.
- *Be careful with go-to telescopes*. Telescopes with electronics are nice . . . when you get them set-up. And that's not always easy. If they don't come with GPS, you may have to enter your latitude and longitude, date and time. Then you usually have to site several stars so the telescope "knows" where it is pointing. Go-to's are wonderful but allow for set-up time.

Some web resources:

Staerkel Planetarium: www.parkland.edu/planetarium
Collimating a reflector: www.garyseronik.com/?q=node/169 or
www.telescope.com/How-To-Collimate-an-Orion-Reflector-Telescope/p/99861.uts or
www.loptics.com/articles/starshape/starshape.html or
www.youtube.com/watch?v=YAVGcGEBmCE
Cleaning a mirror: www.loptics.com/articles/mirrorcare/mirrorcare.html
"Go-to" telescopes: www.universetoday.com/83208/choosing-a-new-telescope-goto-or-not-goto/
Performance tips: www.bbastrodesigns.com/TipsToImproveTelescopePerformance.html