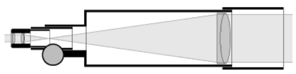
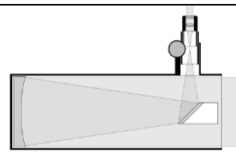
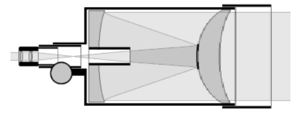
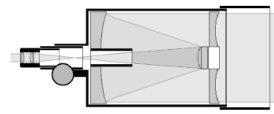
Selecting a telescope

Telescope Type: Telescopes are put into three major categories, Refractors that use lens (what most people think as a telescope), Reflectors that use a concave mirror to form an image, and Catadioptrics which use both a mirror and a lens.

			
Refractors use a lens to focus light to the eyepiece. Because there isn't a second mirror the images are usually better in a good quality refractor of the same size as a reflector.	Reflectors use a concave mirror to focus light. Newtonian reflectors use a second flat mirror to reflect the light to the side of the tube	Cassigrain reflectors use a convex mirror to reflect the light to the back of the telescope. This can shorten the length of the tube needed.	Catadioptric telescopes (like this Schmidt Cassigrain) use both a lens and mirror to focus the light to the back of the telescope.

Each telescope type has advantages and disadvantages. Refractors are much easier to build and to keep aligned, however, the cost of the lens increases drastically for sizes over 3 inches. Reflectors are by far the most cost effective for larger instruments but suffer from poor images at the edges of the field of view. This is solved in the Catadioptric telescopes by putting a corrector lens in front of the mirror, but that adds more cost. For beginning telescope users the Newtonian reflector has the best cost to size ratio.

Objective size: The size of the mirror or lens usually given in inches (larger scopes) or millimeters (smaller scopes and binoculars). This is probably the most important thing to look for. The bigger the objective the more light it gathers and the brighter the objects will appear. The bigger the objective the more useful magnification you can use on an object, so it is always better to get the biggest telescope you can afford. One thing to watch out for is Objective size versus effective aperture size. Some of the cheap refractors sold by department stores may say they have a 60mm or 90mm lens, but they use a very inferior lens and put a piece of cardboard around the lens that makes the "effective aperture" size much smaller, sometimes as small as 25mm (1 inch).

Focal Length (FL): This is a measure of how far from the objective (mirror or lens) the light reaches the best focus. This is usually given in inches (larger scopes) or millimeters. This will effect the magnification (see below) as well as the field of view.

f/ratio: This is simply the focal length divided by the diameter. For instance, a 200mm diameter objective with a 1600mm focal length has an f/ratio of f/8. This is of primary importance when using the telescope for photography. A small number is also referred to as "fast" while a large number is "slow". Small f/ratio (fast) systems tend to have a larger field of view, but also can suffer from image defects near the edge.

Field of view (FOV): Measured in degrees, is dependent on eyepiece so isn't listed on most telescopes. For comparison, the full moon is about ½ degree in diameter so if the field of view is ½ degree the full moon would just fit. The FOV is determined by the focal length of the telescope and the eyepiece used. Short focal length telescopes will usually give a larger field of view and are sometimes referred to as a "Rich Field Telescope (RFT)".

Usually the FOV is not given except for binoculars where eyepiece is integral and cannot be changed. In binoculars it is often given as Linear Field of View which gives the number of feet at 1000 yes., for instance 300ft at 1000 yes.

Power / Magnification: This is the least important of the parameters and defines the magnification of the telescope. The magnification (Power) is given by the focal length of the objective (mirror or lens) divided by the focal length of the eyepiece (Focal length objective / focal length of eyepiece). Since eyepiece focal lengths are usually given in millimeters and objective focal lengths are in inches you will usually need to convert one or the other so that both are in the same system. So, if your telescope has a 64 inch focal length and you are using a 12.5mm eyepiece the power is (64in*25.4mm/in)/12.5mm = 128. Even though eyepieces are measured in millimeters, they often come in focal lengths that convert easily to the English system. So 25mm eyepiece is a 1 inch eyepiece, 12.5mm is ½ inch, 6mm is ¼ inch, etc. This can make it easier to convert the eyepiece to inches. In theory you can get almost any magnification from a telescope you want. For example, if you have one of the 2.5" (60mm) telescopes common at discount stores they typically have a 900mm focal length. If you use a 10mm eyepiece it would give you 90 power, a 6mm eyepiece would give 150 power and a 4mm eyepiece would give 225 power. There is an accessory called a Barlow lens that will effectively double the focal length of the telescope. Using this with the above eyepieces would yield 180 power, 300 power and 450 power for this telescope. So, these telescopes are often advertized as 450 power.

The truth: In reality power is not what you want. Many things in the sky are quite large, but very dim so what you really need is light collecting power which means a bigger objective. One problem with small focal length eyepieces is that the resulting beam of light becomes harder for the eye to see as the focal length of the eyepiece becomes smaller. So at higher power the telescope becomes harder to focus. In addition when you magnify the image you magnify the imperfections in the telescope as well as the optical effects that come with any lens/mirror. So, at high magnifications the image becomes blurrier, dimmer and harder to see so you usually end up looking at a dim, fuzzy blob.

The rule of thumb is that the most magnification from a perfect telescope on a perfect night is 50 times the objective size in inches so the 3 inch telescope in our example has an absolute maximum power of 150. However, these telescopes are far from perfect and most people don't live above 14,000 ft in perfect conditions, so a better rule of thumb is 30 times the objective or 90 power for the 3 inch in our example. In general, the main need for power for beginners is for planets and the moon.

The Mount: In addition, the telescope will also magnify any movement or vibration of the telescope. This includes the rotation of the earth, any movement due to wind and any vibration picked up by the telescope from the observer and or floor that it is setting on. So another major requirement for a telescope is a solid mount. There are two basic categories of mounting, Altitude – Azimuth (Alt-Az) (figures a and b below) and Equatorial (figures c and d below). The Alt-Az is the most common form on small telescopes and has two axis, one that allows for horizontal movement and the other for vertical movement. The Equatorial mount has on axis called the polar axis that is aligned with the earth's axis of rotation (and therefore pointed at the north pole star or Polaris) and the other at 90 degrees from this axis called declination. The Equatorial mount allows for better guiding of the telescope and counteraction of the rotation of the earth and is usually found on higher end telescopes. There are several types of alt-az found on telescopes, a simple "camera tripod" type of mount, a heavier duty version now on most Go-To scopes and the Dobson. The Dobson is characterized by a large

platform or cradle the telescope which rides in with large bearings for the altitude axis and a large disk on the bottom that forms the azimuth axis. Dobson mounts tend to be very stable and are relatively inexpensive to build and are found on the better low end telescopes. However, in general they cannot be motorized so cannot follow the stars as they move across the sky. This is OK at low power, but can be quite troublesome when using high power on the moon and planets as the image moves through the field of view very quickly.
Equatorial mounts come in two main types, German Equatorial Mount (GEM) and

			
a) Catadioptric Scope (Celestron Schmidt-Cassigrain) on an Alt-Azimuth Mount	b) Orion 10” Newtonian Reflector on a Dobson Mount (a form of Alt-Az)	c) Meade 12” Catadioptric Scope with Starlock (small scope on right) on a German Equatorial Mount (GEM)	d) Same Meade Scope with Starlock (small scope on above main scope) on a Equatorial Fork Mount

Finder Scope: Finder scopes are small telescopes that aid in locating objects in the sky. Finder scopes need to be aligned with the telescope to be effective. On inexpensive scopes these are often very cheap and tend to make it more difficult to find an object than easier. However, there are multiple aiming aids (similar to gun sights) that are used to help you aim the telescope and these can be easier to use on smaller scopes. More expensive Go-To scopes not have an extra set of optics that replace the finder and will set up the mount and locate objects automatically (i.e. the Starlock system seen on the right side of the Meade 12” in the image above). Although it is very nice to have it does add a considerable cost ($1000+) to the cost of the telescope.

Eyepieces: Eyepieces come in three physical sizes based on the diameter of the barrel: .926 inch, 1.25 inch and 2 inches. The .962” eyepieces typically come with the cheaper refractors sold by department stores (and on line) and are normally not that good. 1.25 inch eyepieces are the standard for most scopes with the larger scopes having 2” eyepiece holders. The 2” holders typically come with an adapter for the 1.25” eyepieces. You can get adapters for the .962, but there isn’t a good reason to.

There are all different kinds of eyepieces in all different focal lengths, far too many to go into detail here. The eyepieces that come standard with quite a few scopes are usually not that good, but can be used at the beginning until you get familiar with the hobby. You would be advised to replace them with good eyepieces at some future time.

(Digital) Setting Circles/Computerized (GoTo) Telescopes: In the old days better telescopes came with dials on each axis that told you where the telescope was pointing. On equatorial mounts this would be in Right Ascension for the polar axis and degrees for the declination axis. It would be in degrees for both axis on a Alt-Az mount. Most of these have been replaced by digital encoders that connect to a small hand-held computer to tell you where the telescope is pointing. These are referred to as Digital Setting Circles, GoTo telescopes, IntelleScope, etc. Many reasonably priced scopes now come with this standard and can make the process of finding objects to observe much easier. However, it usually adds $200 or more to the price of the scope. Many telescopes are sold without this, but with the option to upgrade later so it is worth checking to see if the telescope you are looking to buy can be upgraded.

What should I buy?:
For a beginner (particularly a child) who wants to become more familiar with the sky I would recommend a Celestron 70mm Travelscope. I would also get a good photographic tripod to mount it on as the one that comes with it is nearly unusable. Buy from a place that is easy to return as I have heard that there are quality concerns with these and you might need to return for another one until you find a good one. Beyond that there is the Newtonian reflector in the 6-10 inch range on a Dobson mount or a 90mm Catadioptric scope (Meade or Celestron) on a simple tripod. This gives the best combination of objective size to cost. There are several vendors selling them including Orion (Oriontelescopes.com, astronomics.com and Amazon). Definitely avoid the cheap refractors and small reflectors sold at department stores. The poor image quality of these scopes turns more people off to the hobby of astronomy than anything else.

For someone with a more than passing interest and more resources (money) it is hard to beat the Schmidt-Cassigrain Catadioptrics sold by Celestron and Meade (also available from Orion, astronomics.com and even Amazon). They offer a great mix of objective size with small size and weight and are easy to use. They are also great for photography (if you get the equatorial mount). The Starlock scopes offered by Meade offer a great mix of features for the advanced user but come at a hefty cost ($5000 and up).

I know several people who have been able to get good deals on used equipment on Craigs list, ebay and other sites. However, with used equipment it is always buyer beware, but if you are careful you might find a good bargain.

Other accessories: There are several other accessories you will see, filters, light pollution filters, Barlow lenses, camera adapters, auto-guiders, etc. I would recommend you put off buying these until you use the scope for a while and understand the basics.