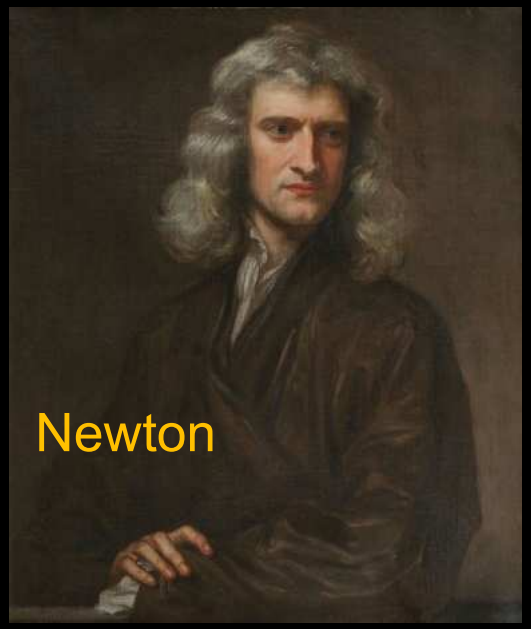

Telescopes

Short History

1. The first telescope, a **REFRACTOR**, invented in 1609, was based on eyeglass technology, which got its start in Italy during the 1200s.
2. In 1609, Galileo heard about the invention, immediately made several scopes and increased the magnification. He published his observations of the planets/stars in early 1610 and that was the beginning of his troubles.
3. The first *design/proposal for* a **REFLECTOR** telescope was a complicated design by Scottish James Gregory in 1663 BUT the first built was a simple design by Newton in 1668 that is the most popular reflector used today by amateurs—the Newtonian Reflector. All the early reflectors, through 1864 used metal for their mirrors.


Galileo


Newton

Magnification Myth

1. Magnification is not of supreme importance. Most of the time, one uses magnification from 40x to 400x.
2. 400x is about the maximum for *any* telescope. **40x to 150x are used most.**
3. Larger diameter scopes support higher magnifications better. **A rule of thumb is 50x to 60x per optical inch**, so the maximum magnification for a 3-inch diameter objective is around 180x.
4. Higher magnification of 250x and up are usually used for the planets but only if the atmosphere is steady.
5. **Our atmosphere, often turbulent, is the biggest limiting factor for magnification.** When very turbulent, magnifications over 100x or so may be "useless."
6. Bigger diameter telescopes are better for fainter objects, and a little more detail. They can support higher magnifications better but only if the atmospheric turbulence is low.

875x, Really!

Roll over image to zoom in

HSL Reflector Telescope,76mm Aperture 700mm Focal Length Astronomy Reflector Telescopes (35X-875X) for Adults and Kids-with 3 Eyepieces,5X Barlow Lens,Solar Filter,Moon Filter and Smartphone Adapter

Brand: HSL

3 answered questions

-20% $111.99

Was: $139.99

prime

& FREE Returns

Prime Day Deal Includes $28.00 Prime savings

Thank you for being a Prime member. Get a $200 Gift Card: Pay $0.00 upon approval for the Amazon Prime Rewards Visa Card. No annual fee.

Brand	HSL
Objective Lens Diameter	76 Millimeters
Focus Type	Manual Focus
Finderscope	Straight-Through
Item Weight	11.02 Pounds
Focal Length Description	700 millimeters

About this item

- 【Powerful Beginners Telescope】The HSL76700 is a powerful and entry-level newtonian reflector telescopio(Max Magnification=875X).This

Calculating Magnification

Telescope Focal Length ÷ Eyepiece Focal Length

If, your telescope has a focal length of 780mm and your eyepieces have focal lengths of 6, 15 and 20mm, what are your magnifications?

6mm	➡	780 ÷ 6 = 130x
15mm	➡	780 ÷ 15 = 52x
20mm	➡	780 ÷ 20 = 39x

Some Terms

- **Objective**, is the lens or mirror that is used in a telescope to bring distant images to a focus. The Primary Objective or Primary is the lens or mirror that collects and focuses the incoming light.
- **Aperture** is the diameter of the objective.
- **Focal Length**, is the "distance," often measured in millimeters, from the objective to the point that an image comes to focus. This can vary from about 3 to 15 times the diameter of the objective.
- **Metric Measurement** is increasingly being used for the objective diameter and focal length, but many of us in the US still use inches. The focal length of eyepieces is *always* in millimeters.

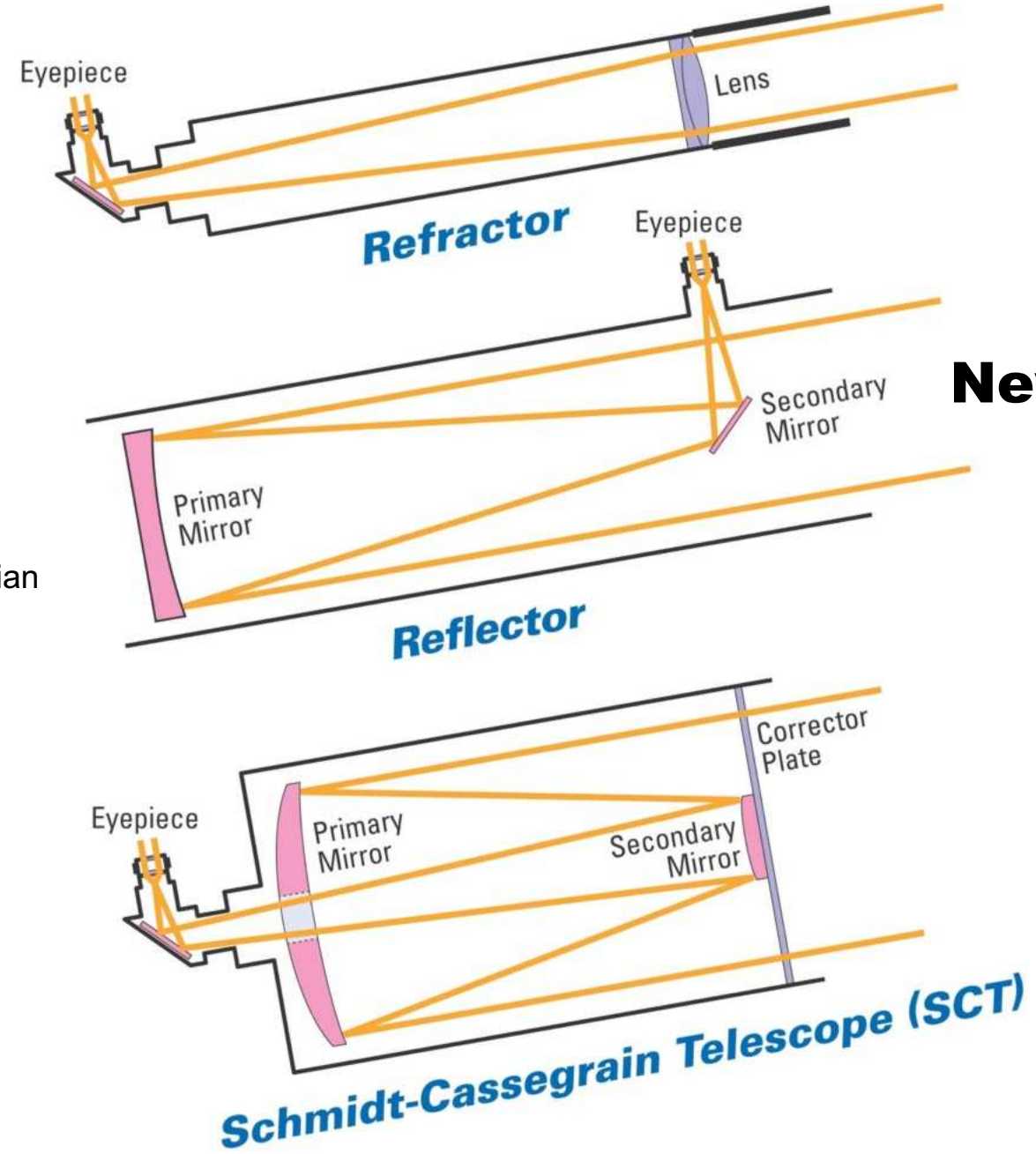
3 Types of Telescopes

Optical instruments that magnify to make distant objects larger.

- **Refractors**, using lenses, invented around 1609, first used by Galileo for astronomical observations.
- **Reflectors**, using mirrors, first invented/made around 1668 by Newton. His reflector telescope design is the most popular design used today and is called a Newtonian reflector. The “Dob” or “Dobsonian” is a Newtonian reflector.
- **Catadioptrics**, combo of lenses/mirrors came about in early 1900s. All use a mirror for their Primary. The **SCT** or **Schmidt-Cassegrain Telescope** became popular for amateurs around 1970. There is a catadioptric called a Maksutov with common sizes of 3 or 4-inches.

Newtonian

Dobs or
Dobsonians
ARE Newtonian
reflectors

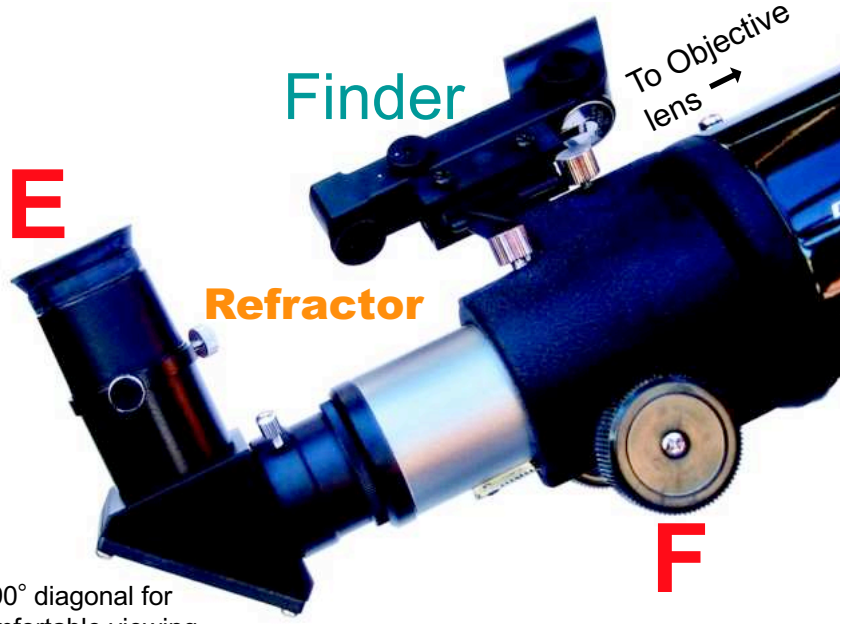


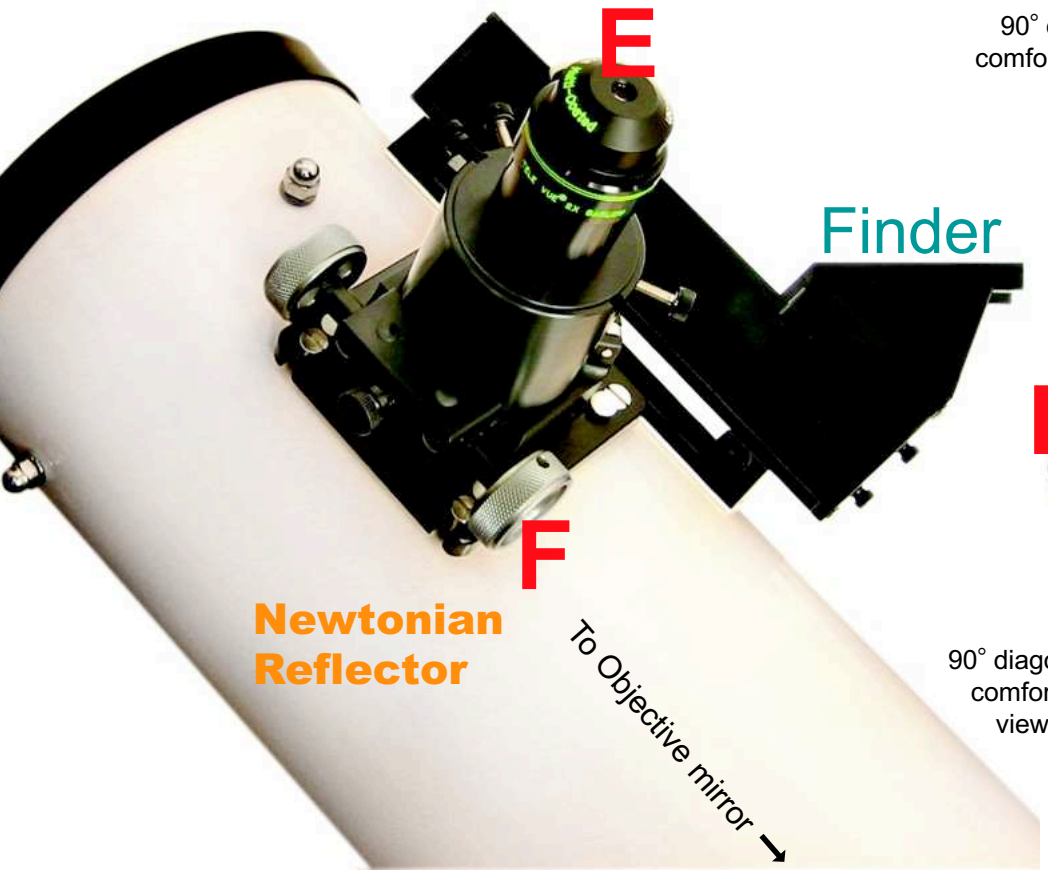
The 3 Major Parts of all Telescopes

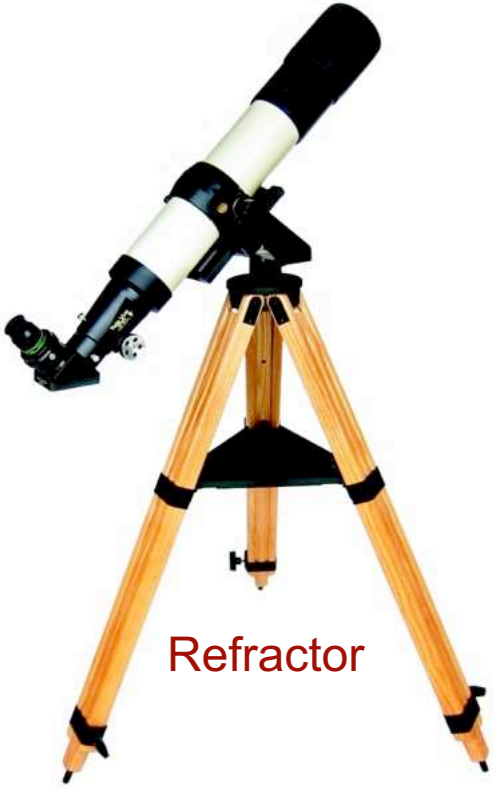
1. **Objective. Lens or Mirror to focus light.**
2. **Focuser. Either standalone or a knob.**
   a. Eyepieces, which are separate from the telescope need to be moved in order to focus images so stars are pinpoint.
   b. For Newtonian Reflectors and Refractors, the Focuser is a standalone unit that holds an eyepiece and has knobs to turn for focusing (moving the eyepiece).
   c. The SCTs have a separate knob for focusing and is next to the place where eyepieces are inserted—usually in a 90° diagonal.
3. **Finder. A "pointer" to aim the telescope.**
   a. It is very difficult to point a telescope at a point in the sky without a Finder – try it.
   b. Traditionally, the finder is a small, low magnification refractor that is used to aim the scope and even though they are still used, they are not the easiest to use. Often, the imagery is upsidedown or reversed like in a mirror.
   c. Today, most people, including myself, use reflex-sight finders that project a dot/crosshairs/circles onto the night sky. These are natural and are easy to use with just a minimum of practice.

All telescopes have the same basic 3 parts

E = Eyepiece
F = Focusing knob







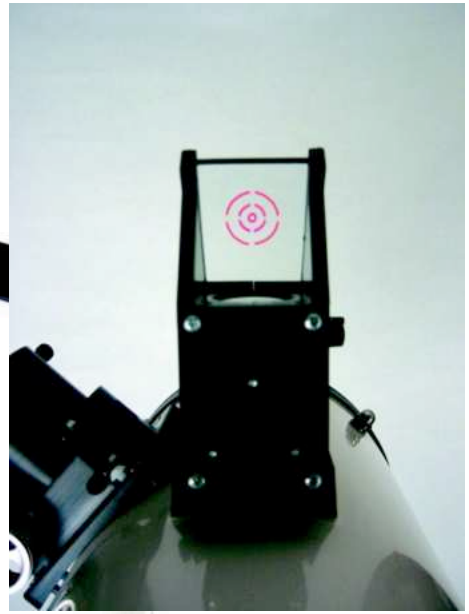
Refractor

Newtonian
Reflector

Newtonian
Reflector,
“Dobsonian”
Style

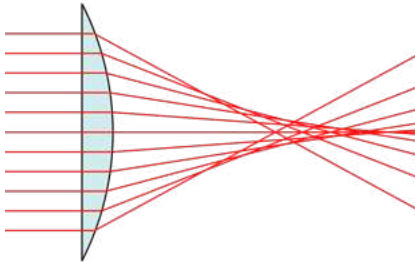
SCT

Finder // Reflex-sight // Telrad

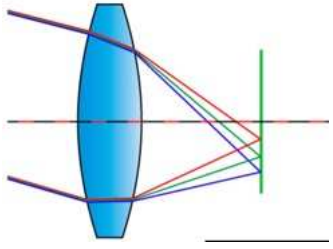


Lenses vs Mirrors

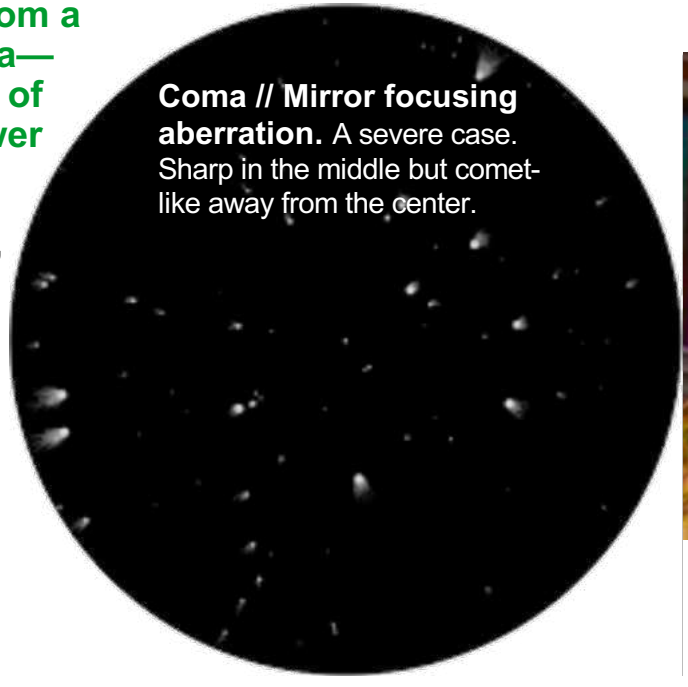
1. LENSES can suffer from focusing and color "problems" or aberrations.
2. The two main optical aberrations for lenses are chromatic and spherical aberration.
3. MIRRORS have problems with focusing to the same spot but have perfect color correction.
4. All colors of the spectrum reflect off any mirror in exactly the same manner—they reflect together.
5. Newtonian reflectors suffer from a focusing problem called Coma—more pronounced at the edge of the field-of-view and f/5 or lower focal ratios.
6. Ironically, almost all focusing, and color problems are alleviated using lenses.
7. All of these aberrations are more noticeable when looking at stars.



Spherical Aberration
Not all rays come to the same focus because of the shape of the lens.



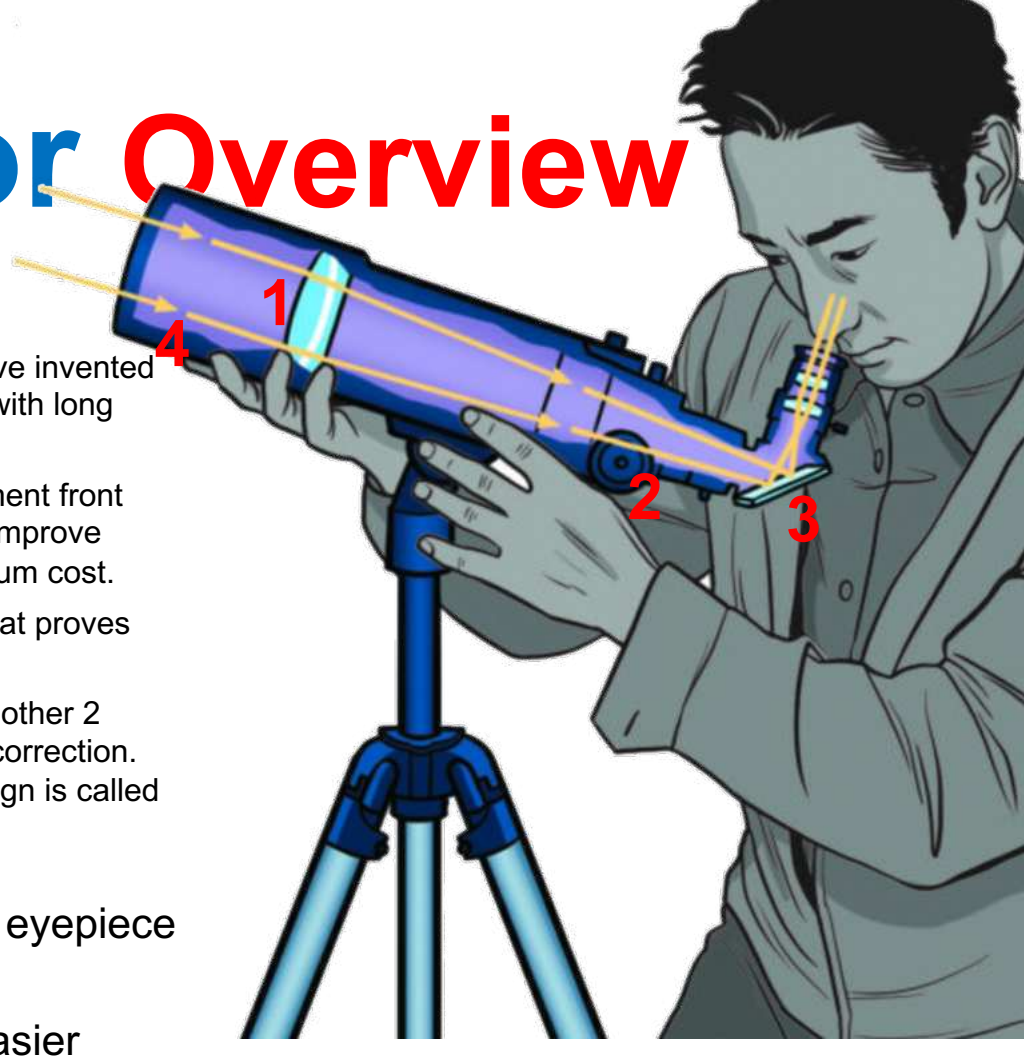
Chromatic Aberration
Different colors of light are refracted at different angles.



Coma // Mirror focusing aberration. A severe case. Sharp in the middle but comet-like away from the center.

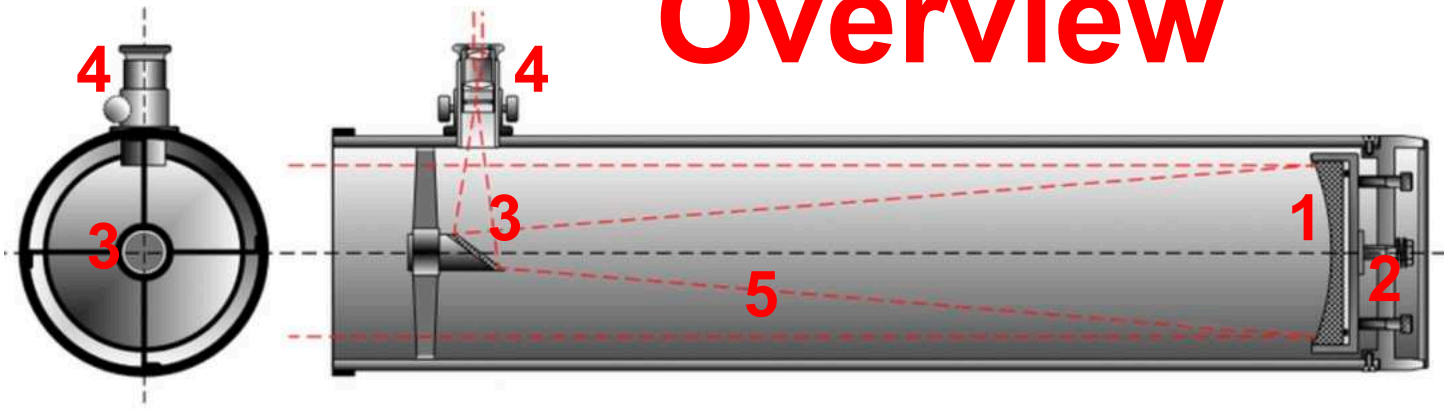
Chromatic Aberration
Usually seen as color fringing in photos—problem with lenses

Refractor Overview

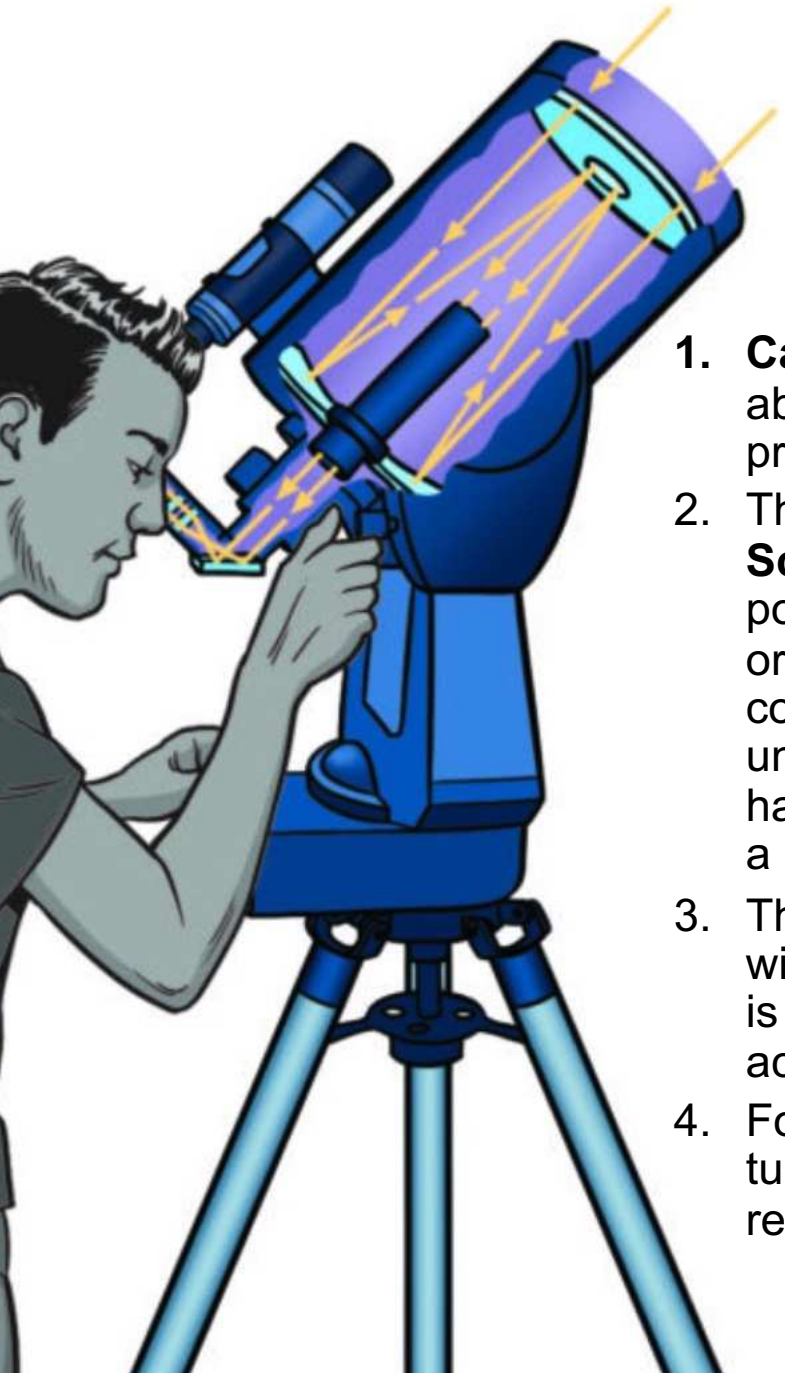


1. **Objective**
   a. **Achromat**. Two element flint/crown front objective invented in the 1700s and still used today. Good images with long focal lengths.
   b. **Achromat ED** (Extra Low Dispersion). Two element front objective but one or both using special glass to improve color correction. Can make tubes shorter. Premium cost.
   c. **Apochromatic**. Three element front objective that proves excellent color correction. Expensive.
   d. **Quadruplet**. Two element front objective and another 2 elements farther back. Provides excellent color correction. Many 3-inch versions available. One optical design is called a Petzval. Expensive.
2. **Focuser** has knobs with tube to insert eyepiece or diagonal.
3. **90° Diagonal** inserted in focuser for easier viewing. Most refractors and SCTs utilize these to make viewing more comfortable. Image is reversed like in a mirror.
4. **Dew/Light Shield** over front objective. Some are permanently placed/attached where others slide back or come off.
   A cap/cover is usually provided to protect the objective from dust, etc.

Newtonian Reflector Overview



1. **The Primary Mirror** is always at the rear of the tube and held by a Mirror Cell.
2. **The Mirror Cell** often has three clips to hold the mirror in place and at the very back, three thumb type screws that can be turned to allow tilting of the mirror slightly for alignment.
3. **There is a Secondary Mirror** placed in the middle of the tube at a 45 degree angle under the focuser to ”bend” the light to the focuser. The secondary mirror is held in place by a single metal stalk or 3 or 4 thin vanes (often called a spider). This mirror is held in a holder that has 3 adjustment screws for alignment.
4. **The Focuser** is on the opposite end of the tube from the primary mirror. It is outside the tube and usually has knobs to move the inserted eyepiece. Some focusers are turned to move the eyepiece up and down.
5. **Collimation**, is the process of aligning the two mirrors so the Primary’s mirror focus comes to the middle of the focusing tube (4).



Catadioptric Overview

1. **Catadioptrics**, a combo of lenses/mirrors came about in the early 1900s. All catadioptrics have primary objectives that are mirrors.
2. The most popular catadioptric is the **SCT** or **Schmidt-Cassegrain Telescope which** became popular for amateurs around 1970. The **SCT** was originally popularized by Celestron and then copied by Meade. Celestron came up with a unique technique to make the front “lens,” which had been difficult to make, is usually referred to as a corrector plate and it is very thick.
3. There is a catadioptric called a **Maksutov** (Mak) with common sizes of 3 or 4-inches. The Maksutov is very similar to a SCT but the front lens is actually a lens.
4. Focal length of these units are longer than the tube length because the optics get folded by reflection.

Dew/Light Shields

Dew in Tucson and Southern Arizona is almost nonexistent. I don't know anyone in southern Arizona who has to worry about dew forming on a refractor objective or the front "lens" of the SCT. This is an issue for other parts of the country. Solutions are shields and/or slightly warming up the optics exposed to the air (often with an electric warming band that wraps around the tube of the telescope).

Refractors almost always come with a dew/light shield while SCTs don't.

A dew/light shield can be helpful to keep nearby glaring lights out of your optical system—interfering with your image quality.

Refractor Overview

The Original Telescope

1. Restricted to 6-inches or less. Usually 4-inches or less.
2. Highest cost per inch but optically, can be the best.
3. Smaller, thus more portable—easier to set up and take down.
4. Sometimes sold separately without a mount—usually the better units. These are often referred to as OTA, that is, Optical Tube Assembly
5. Low maintenance but optics can get out of alignment.
6. $200 to $10,000 plus. Optical/Mechanical quality varies
7. Avoid lower cost units, especially those sold in department stores or at Costco at Christmas time!
8. Many astrophotographers use 3- to 4-inch refractors.

a. There are no single lens objective telescopes produced anymore (like Galileo's).
b. The **ACHROMAT** refractor, having two lens elements for the objective consisting of Flint and Crown glasses was invented in 1758 and is still used in telescopes today. It corrects for a lot of color aberration, especially with longer focal lengths.
c. Some Achromats use special glasses (called **ED** for Extra-low Dispersion) for the objective lenses which provide good color correction for shorter focal lengths. Some manufactures call these APOs but they are not APOs.
d. **APO** refractors (APO stands for **APOCHROMATIC**) have 3 lens elements for the objective that provide exceptional color correction. These are expensive.
e. **QUINTUPLET** refractors employing some ED glass have an objective with 2 lens elemets and a second 2 element group farther down the tube. These are like APOs but at a lower cost.

1

3.1-inch
Achromat
Alt-Az
$750

2

3.5-inch
Achromat
Equatorial
$330

4-inch
Quad
OTA
$2,500

3

4

3-inch
ED
OTA
$1,750

1. Vixen Astronomical Telescope PORTA II A80mf From Japan, $750
2. Orion Observer 90mm Equatorial Refractor Telescope, $330
3. Askar 4.2" 107mm f/7 Quadruplet Flat-Field Astrograph # 107PHQ, $2,500
4. Tele Vue TV76, $1750

Newtonian Reflector Overview

The Light Buckets

1. Newtonian reflectors on simple alt-az mounts are often called Dobsonians.
2. Apertures range from 4 to 30 or more inches. Average 6 to 8-inches or so.
3. Lowest cost per optical inch. Optics are usually good. Mechanical quality varies.
4. Often alt-az mounts with no motors.
5. Usually 10-inch or smaller are in tubes while those larger are open using “truss tubes.”
6. Higher “maintenance”—optical alignment required frequently. It is not difficult to align.

a. Remember, reflectors have NO color aberration, but shorter focal lengths are plagued by coma, an elongation of the stars which is especially pronounces near the edge of the field of view. Shorter f-rations, like f/4 and lower have pronounced coma.
b. Traditionally, focal lengths around f/8 to reduce coma.
c. Today, many of the larger diameters, like 12-inches plus are f/4 or even lower to keep the “tube” short for easier access to the focuser. These light buckets exhibit a tremendous amount of coma that can be alleviated by a coma corrector that is inserted into the focuser.

1

8-inch
Dob
$850

6-inch
Dob
$460

2

3

16-inch
Dob
$3,600

5-inch
Newt
$280

4

6-inch
Newt
GOTO
$1,110

5

1. Orion SkyLine 8" Dobsonian Reflector Telescope, $850
2. Sky-Watcher 6" Classic Dobsonian Telescope - S11600, $460
3. Explore Scientific 16" Truss Tube Dobsonian - Generation II - DOB1645-00, $3,600
4. Orion Observer 134mm Equatorial Reflector Telescope, $280
5. Meade 6" Reflector on LX85 GoTo Equatorial Mount – 217003, $1,110

SCT

Biggest bang for the buck.

1. 8-inch most popular size. Diameters Available: 5, 6, 8, 9.25, 11, 14
2. Often all-inclusive — usually has integrated motorized/computerized mount and tripod. Will automatically “GO TO” any object selected with a hand controller and track across the sky.
3. Quality good.
4. Low maintenance.
5. Long focal lengths — excludes low powers.

a. Takes time for the optics to reach outside temperature. Images not the best until this is achieved.

b. Most popular is 8-inch which is a reasonable size/weight. 11 & 14-inch are very heavy.

c. Celestron and Meade are the two major manufacturers.

d. Celestron invented the manufacturing process to produce SCTs. Celestron’s scopes are generally preferred over Meade’s.

1

8-inch
GOTO
1-arm Fork
$1,600

2

11-inch
GOTO
2-arm
Fork
Alt-Az
$5,100

3

9.25-inch
GOTO
Equatorial
$2,950

4

5-inch Mak
Manual
Equatorial
$530

1. Celestron - NexStar 8SE Telescope, $1600 (Amazon)
2. Celestron CPC Deluxe 1100 HD Computerized Telescope, $5,100 (Amazon)
3. Celestron Advanced VX 9.25" SCT GoTo EQ Telescope, $2,950
4. Explore FirstLight 127mm Mak-Cassegrain Telescope with EQ3 Mount - FL-MC1271900EQ3, $530

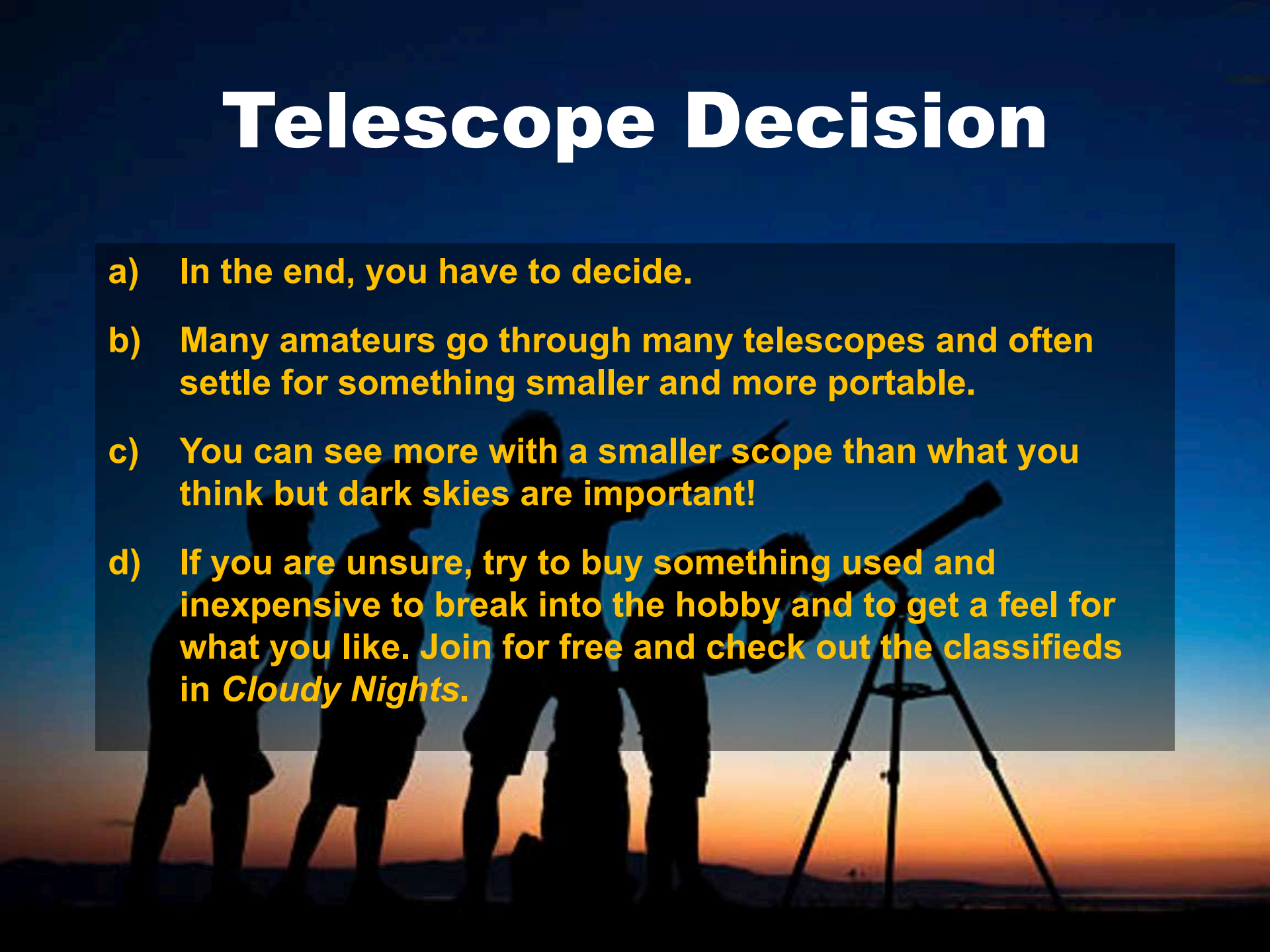
Telescope Decision

a) In the end, you have to decide.

b) Many amateurs go through many telescopes and often settle for something smaller and more portable.

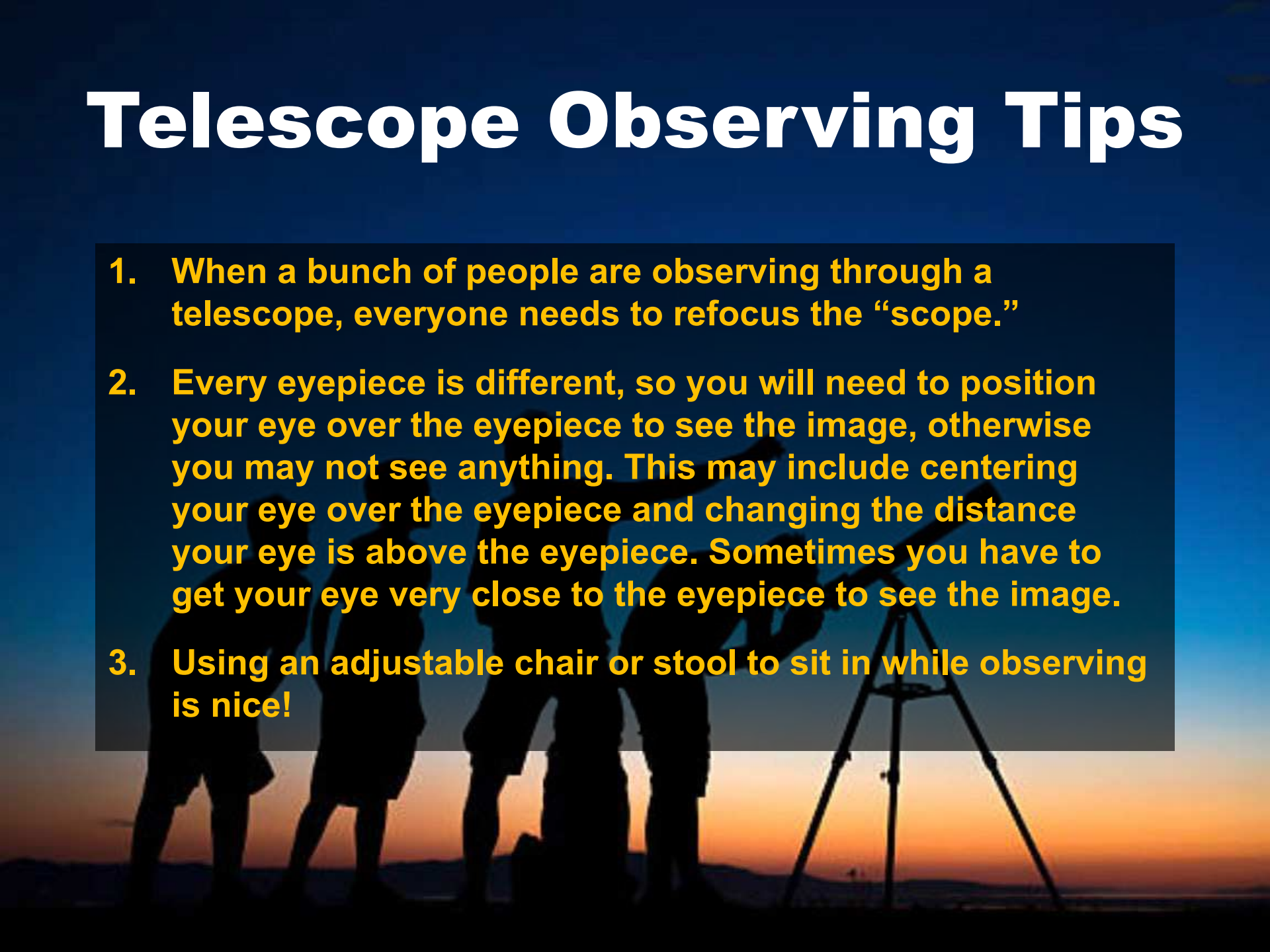
c) You can see more with a smaller scope than what you think but dark skies are important!

d) If you are unsure, try to buy something used and inexpensive to break into the hobby and to get a feel for what you like. Join for free and check out the classifieds in *Cloudy Nights*.



Telescope Observing Tips

1. When a bunch of people are observing through a telescope, everyone needs to refocus the "scope."
2. Every eyepiece is different, so you will need to position your eye over the eyepiece to see the image, otherwise you may not see anything. This may include centering your eye over the eyepiece and changing the distance your eye is above the eyepiece. Sometimes you have to get your eye very close to the eyepiece to see the image.
3. Using an adjustable chair or stool to sit in while observing is nice!



Orion Telescopes

Sky-Watchers

Celestron

Meade

Vixen

Tele Vue

Takahashi

Explore Scientific

Starizona store in Tucson

Classified in *Cloudy Nights*

Telescope Summary

The larger the objective, the greater the light gathering capability allowing one to see fainter stars and DSOs. There is also an increase in the ability to see more detail as aperture increases but this has limits.

Newtonian Reflector

1. Least expensive per aperture inch
2. Diameters range from 3 to 20 inches or more
3. Popular sizes are 6, 8 & 10 inches
4. Will require tweaks to alignment

Refractor

1. Generally, most expensive per aperture inch, especially for quality optics
2. Diameters range from 2.4 to 6 inches. 6-inch size is rare and expensive and needs sturdy stand/mount.
3. Popular sizes are 3 and 4 inches.
4. Easy to setup/takedown.

SCT +

1. Biggest bang for the buck.
2. Diameters range from 3 to 14 inches
3. Popular size is 8 inches
4. Made by Celestron/Meade. **Many models are fully computerized and motorized.** Relatively compact.

f-ratios

You might be familiar with f-ratio from using cameras. An f-ratio is nothing more than expressing the focal length of a lens/mirror/objective in terms of its diameter.

For example: A 6-inch mirror having a focal length of 30 inches would have an f-ratio of f/5 (6-inches x 5 = 30)

Newtonian Reflectors

1. f/4 is very short and often called a RFT or rich-field-telescope. Usually used on large Dobsonians of around 15+ inches to keep scope length reasonable. Need coma corrector for good images!
2. f/6 to f/8 or greater provides good imagery, better as f-ratio increases, like with f/8.

Refractors

1. Achromats—traditionally around f10+ give good performance.
2. Achromats around f/6 or so show a lot of color plus other problems—*not good!*
3. Achromats with ED glass, Apochromats plus Quadruplets are *good* at f/5+ (expensive)

SCT +

1. All around f/10 or so—no problem with coma or anything.

Examples

f/3.8
f/4
f/5
f/6
f/8
f/10
f/15

Reflectors around f/4 or so need an optical coma corrector! No achromat should be less than f/10!