

# Astronomical Tools

September, 2002

*The Antelope Valley Astronomy Club, Inc. is a California Non-Profit Organization to further the local interest in the night sky. The Club meets the second Friday of every month at the SAGE Planetarium in Palmdale at 7:00 pm. (On the North-East corner of 20<sup>th</sup> East and Avenue R) A short business meeting is followed by a guest speaker and a brief planetarium show. Free admission.*

## **Sources:**

1. "The Dobsonian Telescope, A Practical Manual For Building Large Aperture Telescopes." By David Kriege and Richard Berry, Willmann-Bell, Inc., 1<sup>st</sup> Edition, 1997.
2. "Horizons, Exploring the Universe," Chapter 5, "Astronomical Tools, By Michael A. Seeds, By Wadsworth Publishing Company, Inc.
3. Amateur astronomy website [www.astro-tom.com](http://www.astro-tom.com)

# Types of Telescopes

There are two basic types of telescopes: refractors and reflectors. Both have their advantages. Properly outfitted, either will show distant galaxies, the rings of Saturn, and the craters of the Moon.

- **Refractor Telescope**

- Refracting telescopes gather light with a lens, directing it to the eyepiece.

- **Reflecting Telescopes**

- Reflecting telescopes gather light with a concave mirror, reflecting it before directing it to the eyepiece.

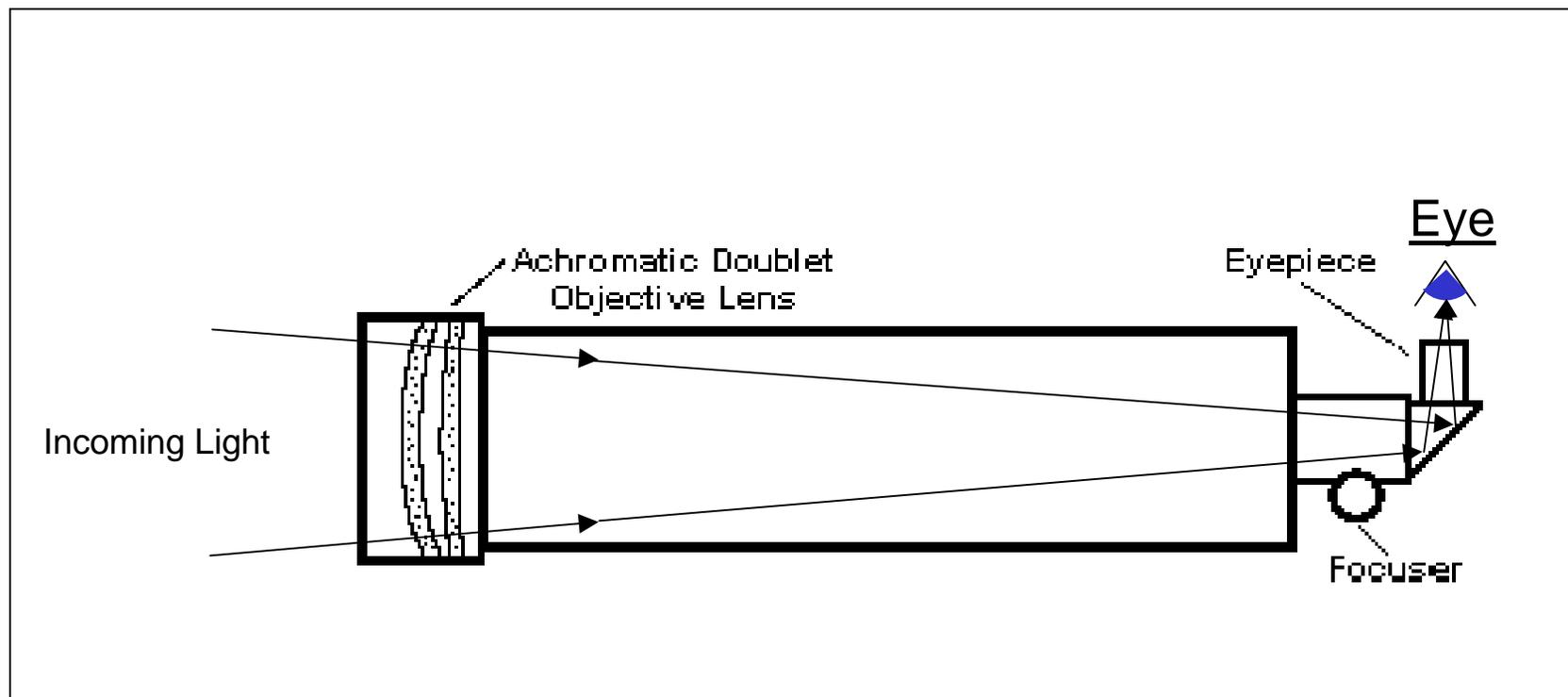
# Types of Telescopes

## Hybrid Telescopes

- **Schmidt-Cassegrain Telescope**  
It is a reflector telescope that also uses a corrector plate to eliminate chromatic aberration (false color).
- **Maksutov-Cassegrain Telescope**  
Renowned for the views they offer. They employ both mirrors and a lens, resulting in optical configurations that achieve remarkable image quality and resolution.

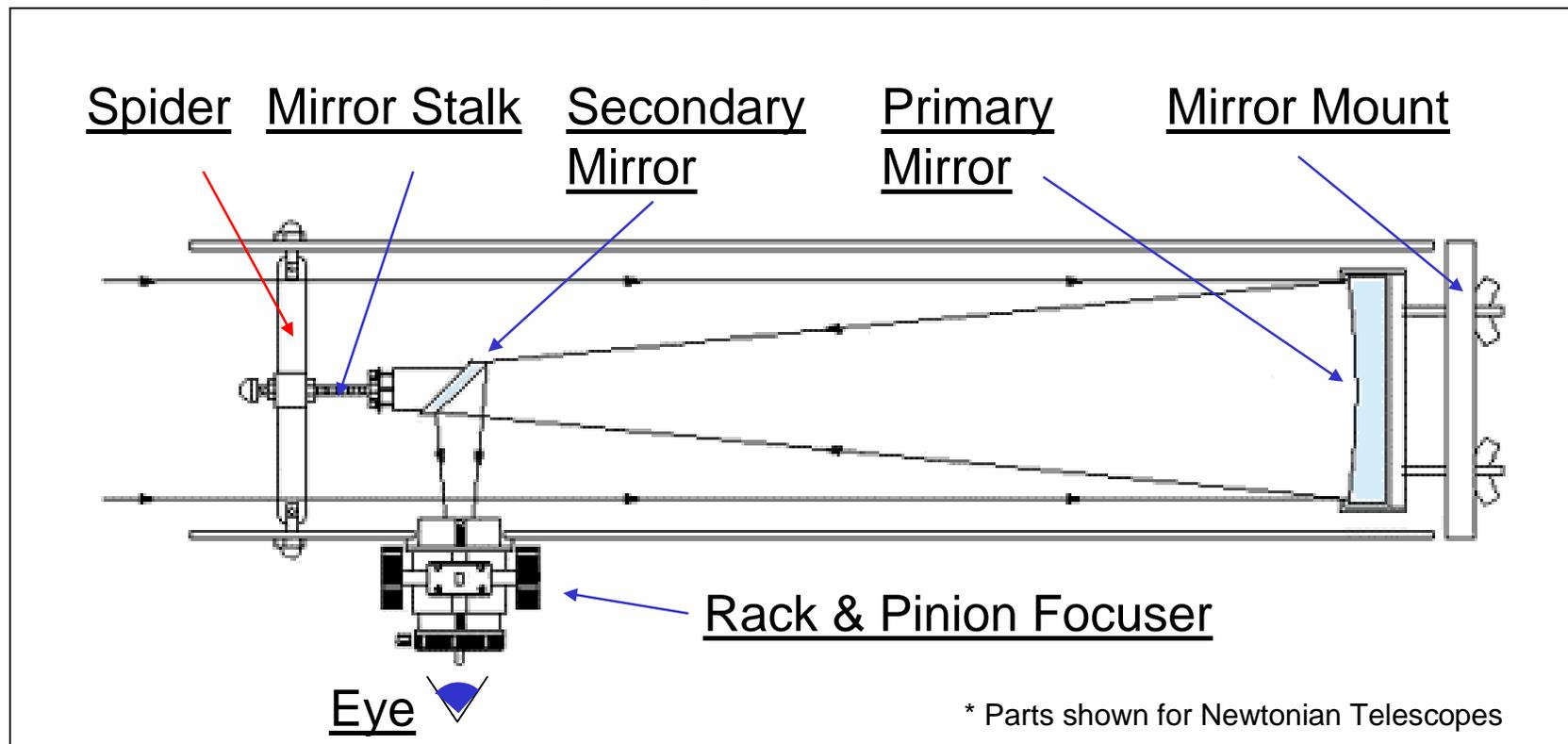
# Refractor Telescope

- Refractors consist of lenses at the front and an eyepiece at the back of the telescope tube to bring light to a focus at your eye.



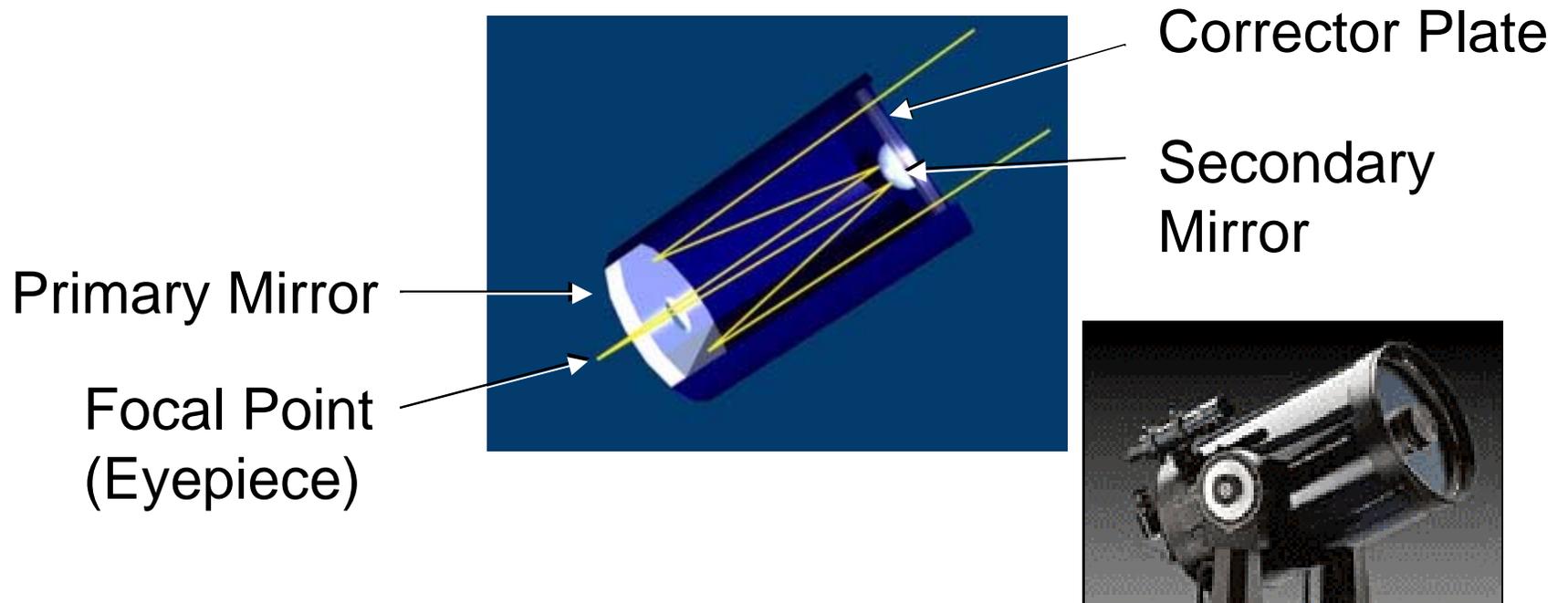
# Reflector Telescope

- Reflector Telescopes use mirrors to collect light and bring it to a focus at the eyepiece. Mirrors can be made very economically compared with lenses.

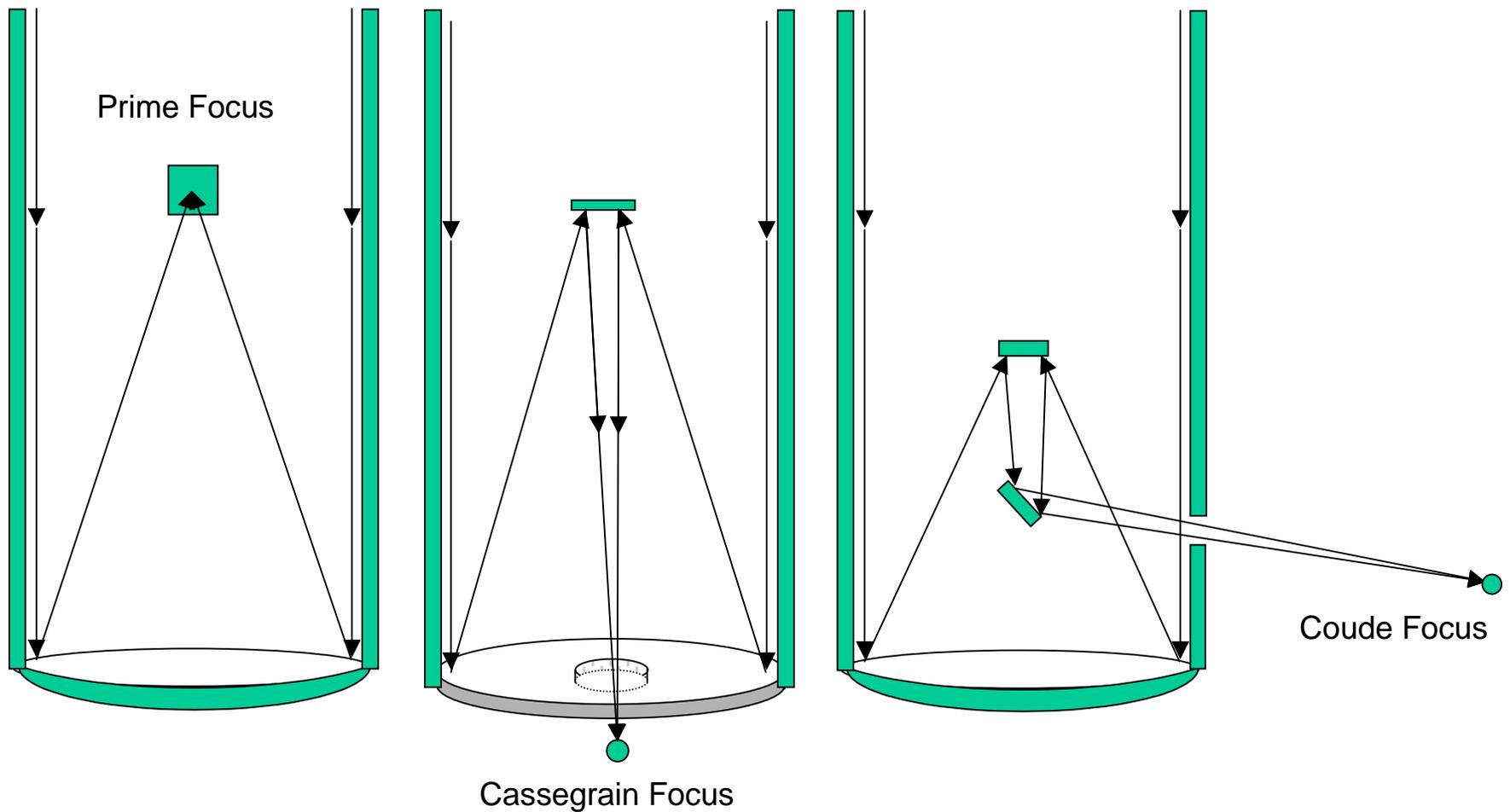


# Schmidt-Cassegrain

- A Schmidt-Cassegrain Telescope uses a combination of mirrors with a “corrector plate” lens to fold the light’s path into a very convenient length.

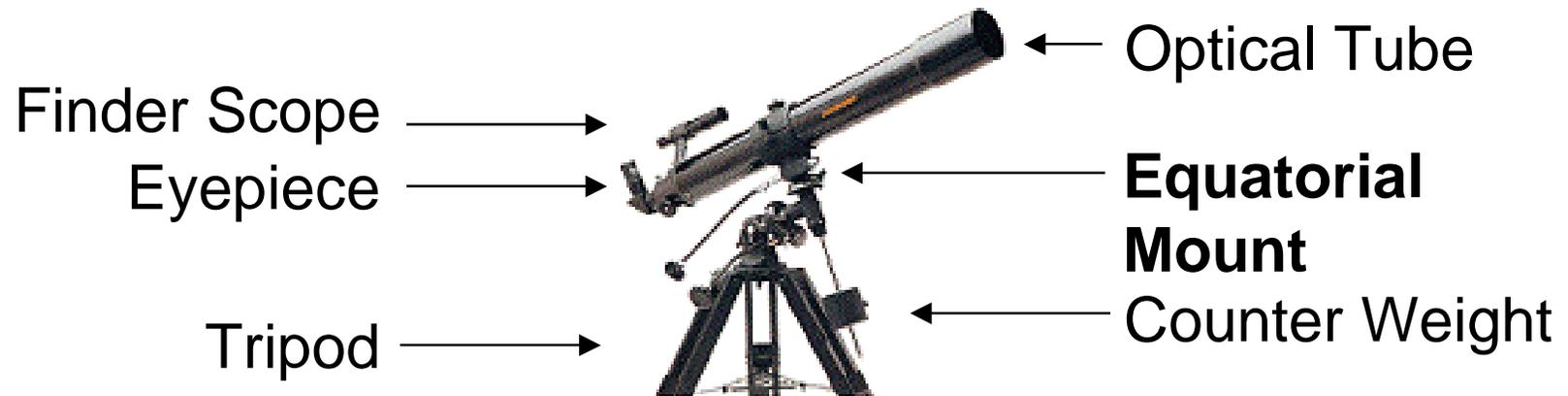


# Other Types of Telescopes



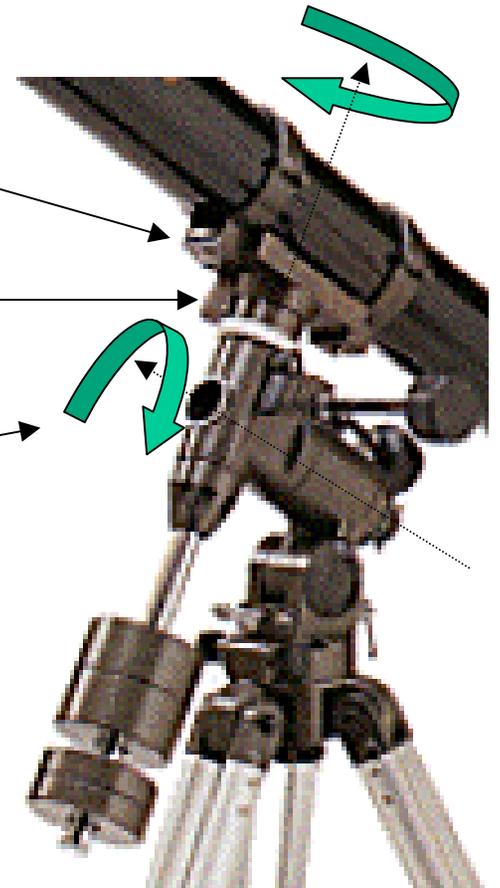
# Typical Telescope Parts

- Equatorially Mounted Refractor



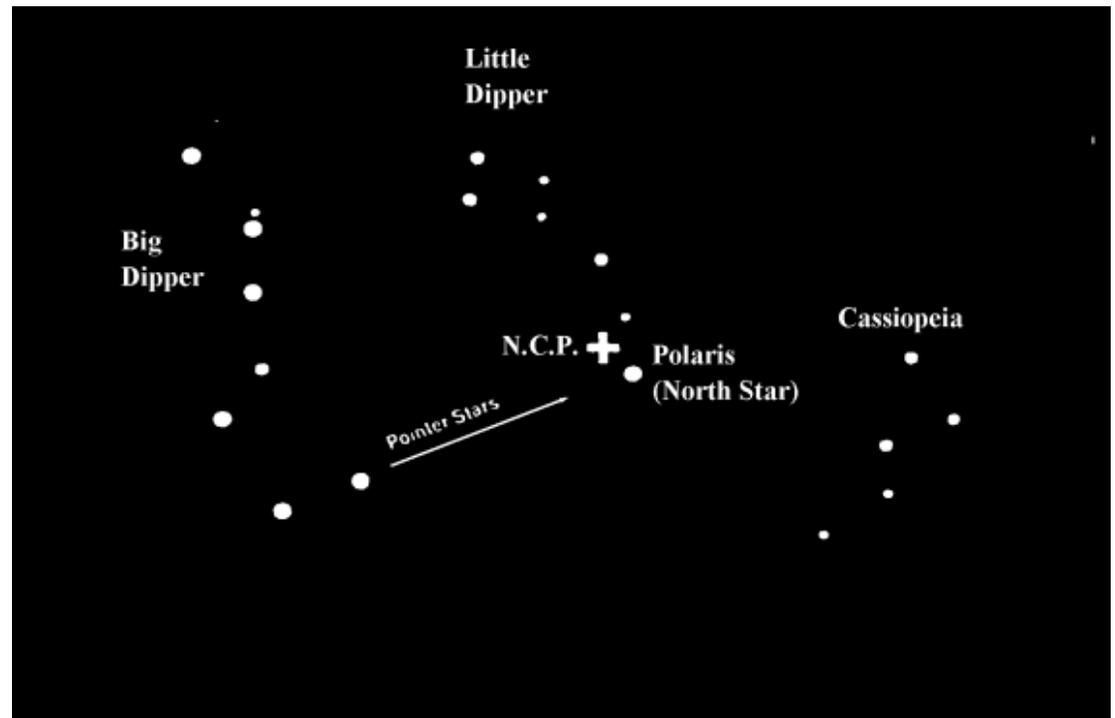
# Typical Telescope Parts

- The Equatorial Mount
  - Some kind of attachment to the telescope itself
  - The Declination (north-south movement) mechanical axis
  - The Right Ascension (east-west movement) mechanical axis



# Polar Alignment for Equatorially Mounted Telescopes

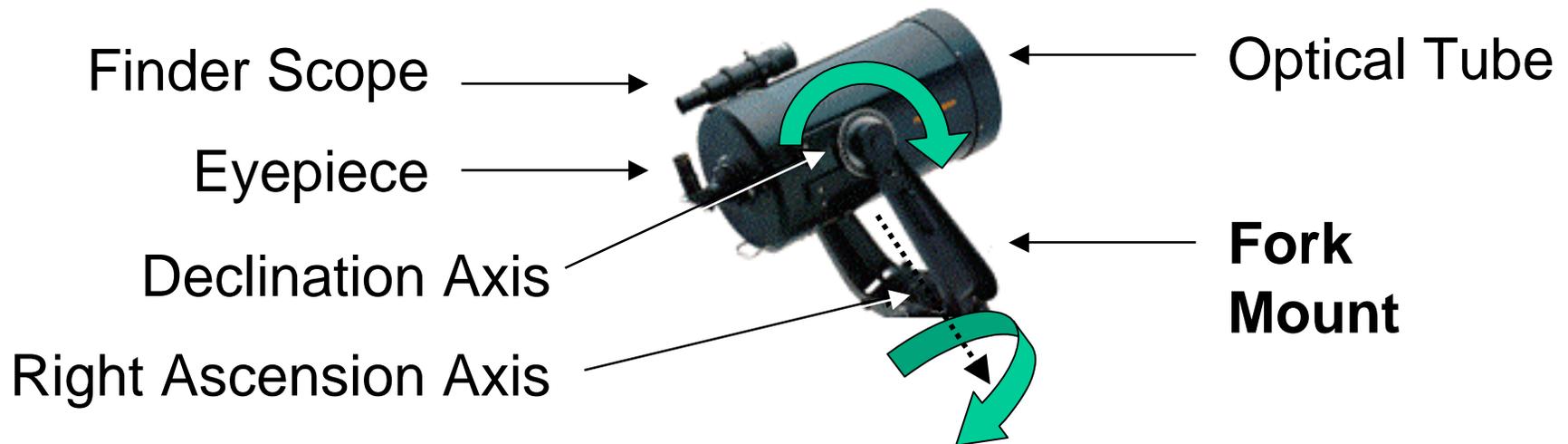
- Simple Method
  - Sight along the telescope's Right Ascension axis towards Polaris.
  - Offset the axis from Polaris about a degree opposite of Cassiopeia.
  - This is good enough for an evening of casual visual observing.



# Typical Telescope Parts

- The Fork Mount

- Fork Mounts can be equatorially or Alt-azimuth.
- Inclined at the Earth's axis = Equatorial Mount
- No inclination = Alt-Azimuth Mount

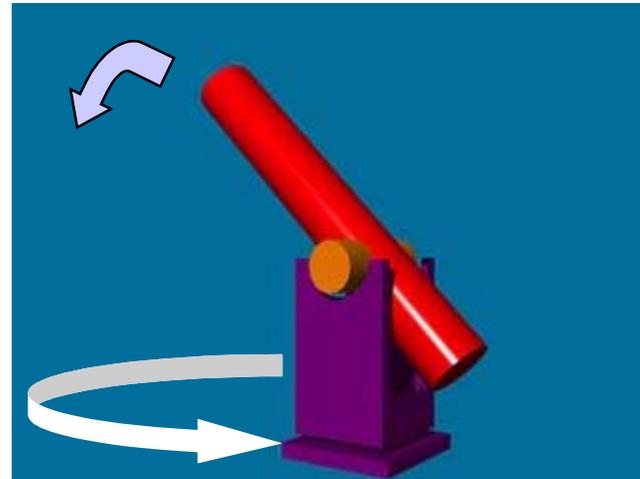


# Dobsonian Design

- The simplest amateur astronomy mount: The Dobsonian Mounting. This mount is usually used with a Newtonian telescope.

*“Three hundred years of telescope designs... but it took John Dobson, to figure out that we could aim telescopes simply, like a cannon!”*

Rotation about the side pivot is “Elevation”



Rotation about the base is “Azimuth”

# What can be seen...



*Veil Nebula in Cygnus*

*Dumbbell  
Nebula  
(M27) in  
Vulpecula*



*Andromeda Galaxy (M31, M32, and M110) in  
Andromeda*

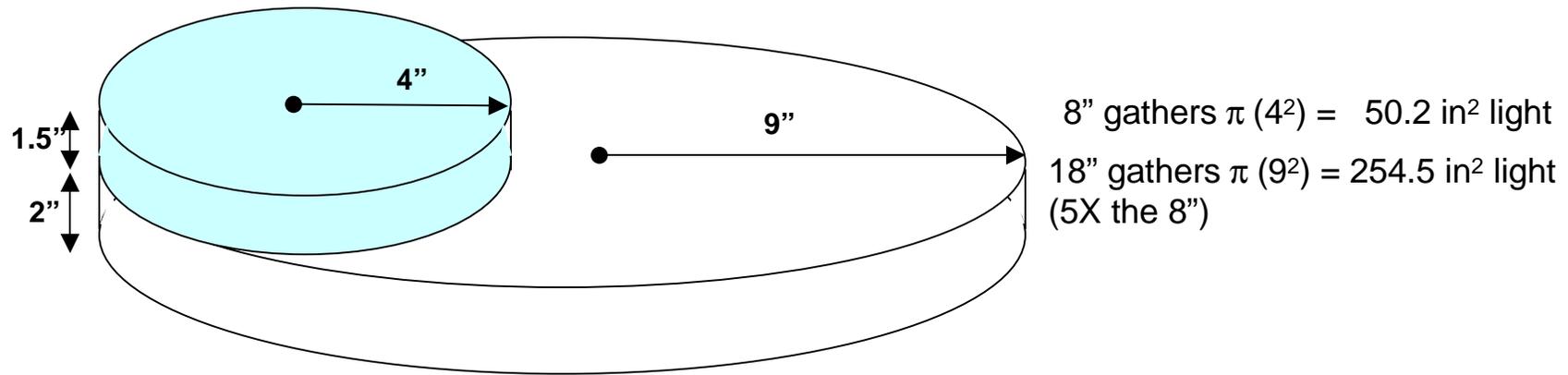
# Telescope Scaling

- Building small telescopes is easy. Building large aperture telescopes is not.
- You can't just scale up the dimensions. Telescope designs don't scale in a simple way.
- Stiffness, weight, and dimensional relationships all change at different rates.



*Whirlpool Galaxy (M51)*

# 8" to 18" Comparison



8" Pyrex mirror weighs  $\pi(4^2) \times (1.5) \times (0.081 \text{ lb/in}^3) = 4.1 \text{ lb}$

18" Pyrex mirror weighs  $\pi(9^2) \times (2) \times (0.081 \text{ lb/in}^3) = 41.2 \text{ lb}$  (10X the 8")

	Resolution (arc seconds)	Galaxies Seen	Weight of Telescope (lb)	Height (Ft)	Cost of Optics (\$)	Light Gathering (in <sup>2</sup> )
8"	0.68	1000	40	4	300	50.2
18"	0.31	12,000	120	6.5	2000	254.5



*Ring Nebula (M57)*

# Weight and Friction

A very good large amateur telescope is a precisely engineered combination of Balance and Friction.

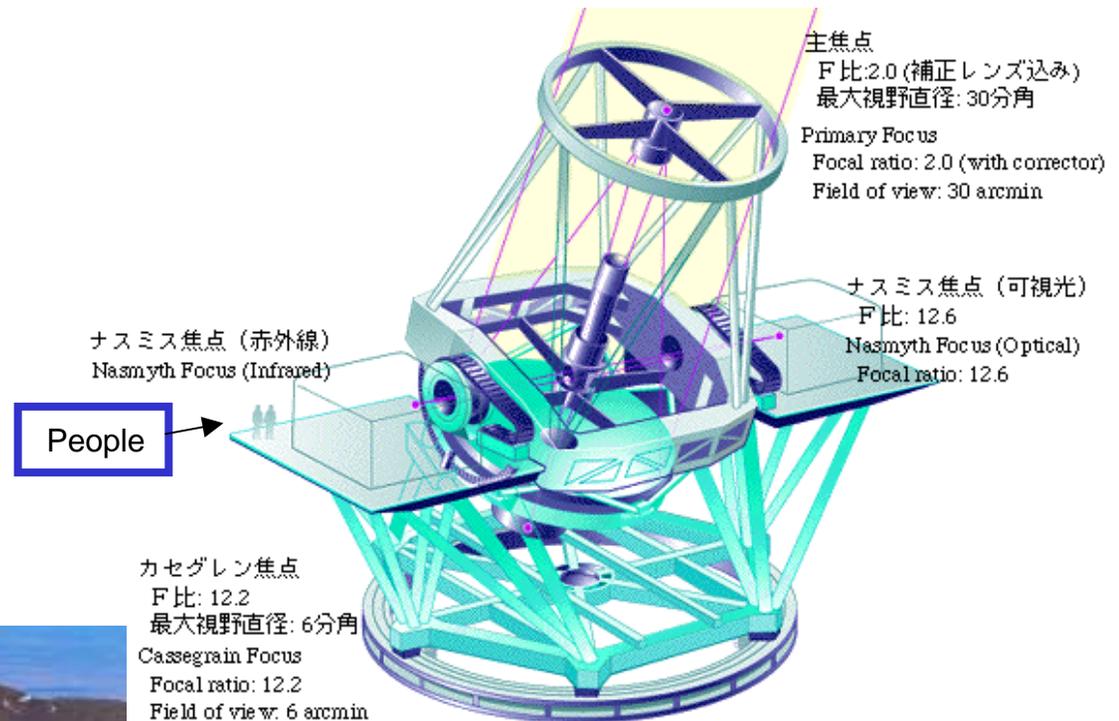
It should be very easy to move around the night sky...

...Just enough friction to hold it still against the pressure of the wind, but little enough that a light touch near the eyepiece will allow the user to follow a star.



# Really Big Telescopes

Many new professional telescopes use segmented mirrors (easy to make) that are supported by individually controlled actuators. Their light is combined digitally to produce the final image.



Subaru Telescope, National  
Astronomical Observatory of Japan,  
Mauna Kea, HI

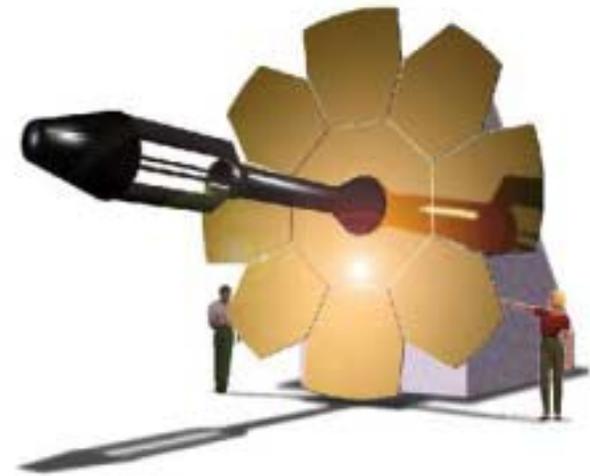
# World's Biggest Telescopes

Rank	Aperture (meters)	Name	Location	Comments
1	10	Keck	Mauna Kea, Hawaii	Mirror composed of 36 segments
2	10	Keck II	Mauna Kea, Hawaii	
3	9.2	Hobby-Eberly	Mt. Fowkes, Texas	Very inexpensive: spherical segmented mirror; fixed elevation; spectroscopy only
4	8.3	Subaru	Mauna Kea, Hawaii	National Astronomical Observatory of Japan
5	8.2	Antu	Cerro Paranal, Chile	All four will be elements of The Very Large Telescope
6	8.2	Kueyen	Cerro Paranal, Chile	
7	8.2	Melipal	Cerro Paranal, Chile	
8	8.2	Yepun	Cerro Paranal, Chile	

# Space-Based Telescopes

Extremely large, lightweight telescopes are being developed for space-based operation.

The Next Generation Space Telescope Observatory includes a large segmented primary mirror that will unfold, or deploy, to approximately 6 meters (20 ft) in diameter and a sunshield that will also deploy to about the size of a tennis court. .

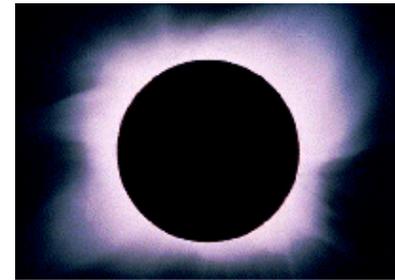


# The Big Rules of Observing

- Don't look directly at the Sun.
  - A special Solar Filter can be used over the FRONT of your telescope, or “eyepiece projection” with an eyepiece that is not cemented together.
  - Without a Solar Filter, if you glimpse the sun with your telescope, you will instantly burn your retina, perhaps go blind... and besides you'll ruin a perfectly good eyepiece from the intense heat.
  - This is “**Bad.**”

# The Big Rules of Observing

- Don't look directly at a Solar Eclipse with out a Solar Filter.
  - A Solar Eclipse happens during the day when the Moon passes in front of the Sun.



- You may use your telescope to look at a Lunar Eclipse – No Filter Required!
  - A Lunar Eclipse happens at night when the Moon passes into the Earth's shadow.



# Amateur Telescope Size

- The bigger the telescope mirror, the more light it can gather, and the fainter the objects that can be seen.
- Galaxies and gaseous nebula are usually extremely dim, diffuse objects, so a large aperture telescope is needed to see these. Larger aperture also increases resolution.
- Weight and ease of use are major considerations in larger amateur telescopes.



Globular star cluster  
M13 with an 8" mirror



Globular star cluster  
M13 with an 18" mirror



*"The best telescope for you is the one you'll use all of the time"*

# Astronomy Observing Tips

- Line up the finder scope during the day.
- Don't look through a window (even an open one).
- Learn what magnification each eyepiece provides.
- Always start with the lowest power eyepiece you have.
- Keep the magnification under 50x the aperture of your telescope in inches.
- Don't expect to see...
  - ...Stars looking like disks. They're too far away to look like anything but points of light.
  - ...Colors in nebulae and galaxies. The colors only show up in long photographic exposures. They will look mostly gray.
  - ...Planets filling the eyepiece view like the Voyager photos. They will appear as small disks.
  - ...The Apollo spacecraft on the moon. No telescope on earth can see these.



8"



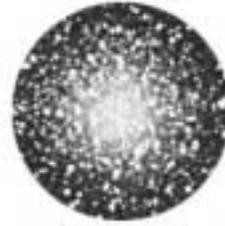
15"



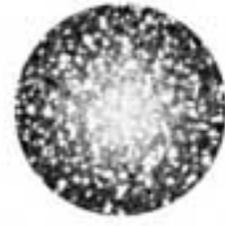
18"



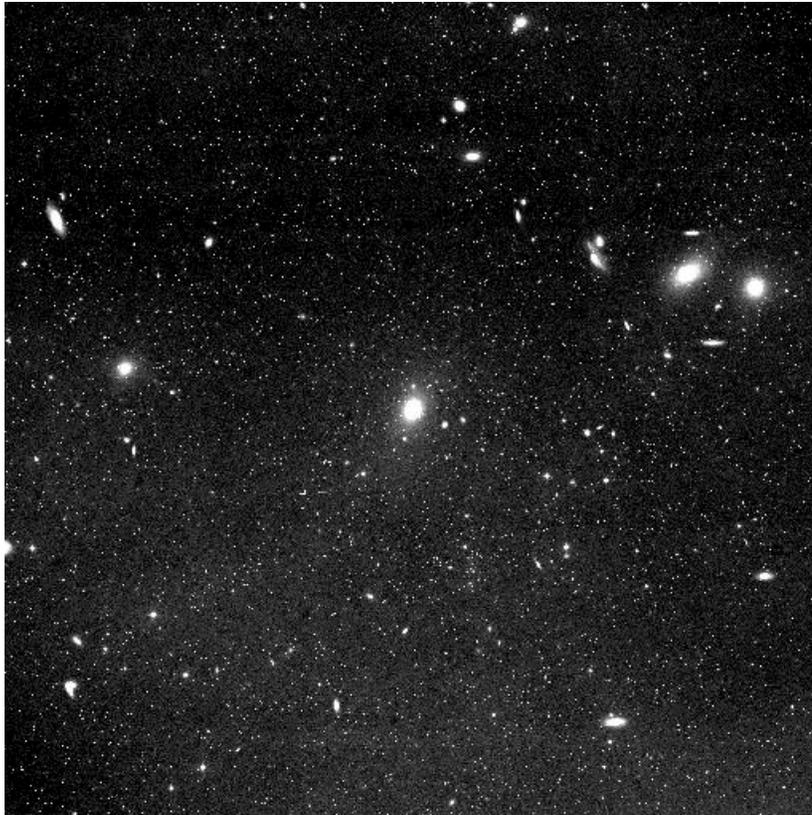
20"



25"



30"



*Virgo  
Galaxy  
Cluster*



*Sunflower  
Galaxy*