# *Telescopes: The Astronomer's Primary Tool*

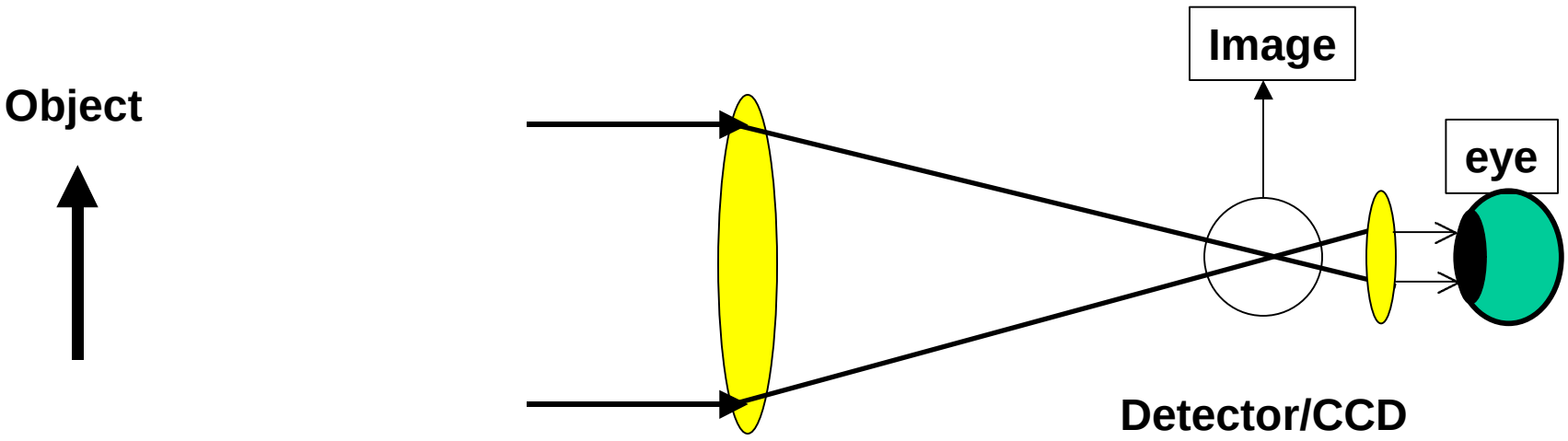
**Chapter 2**

# *Our Objective*

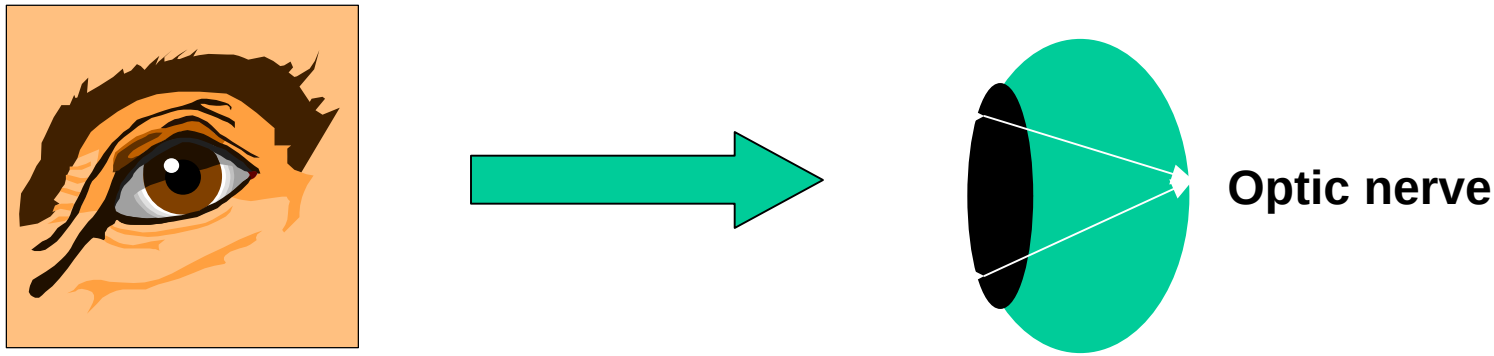
- **Treat the telescope as an instrument:**
  - **Learn telescope parameters**
  - **What makes a telescope useful?**
  - **Telescope operation**
  - **Different telescope types**
- **Two telescope labs:**
  - **Field of view lab**
  - **Construction of a refracting telescope**

# *What is a Telescope?*

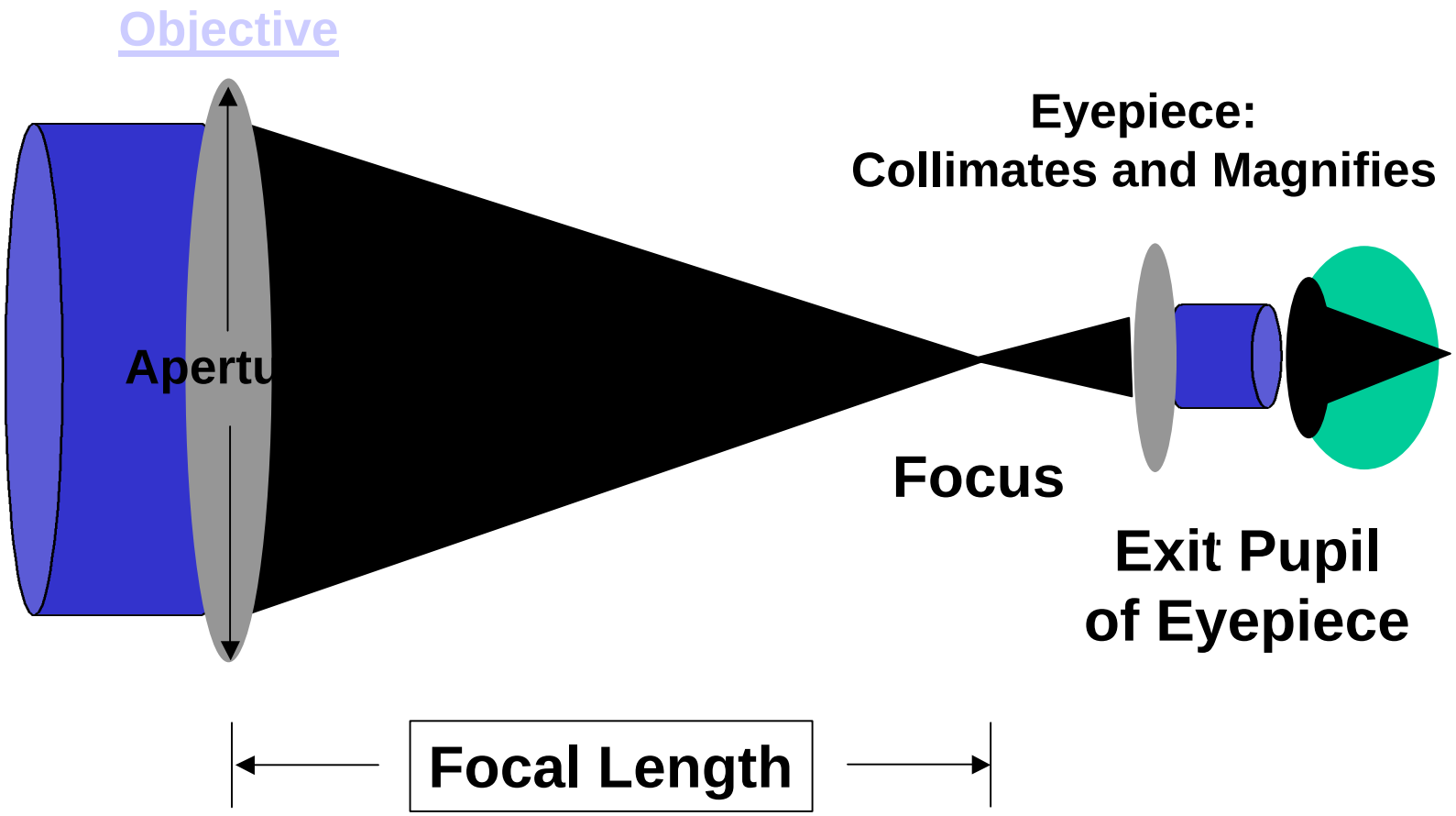
- **An instrument that gathers light**
- **It brings the light down to a focus and**
- **Forms a magnified image of the object**



# *Primary Optical Instrument*



# *Telescope Parameters*

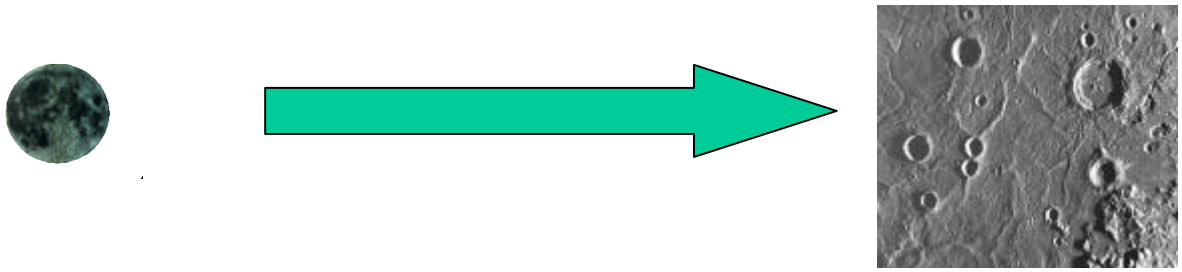



**F-Number (f/#) = Focal Length/Aperture**

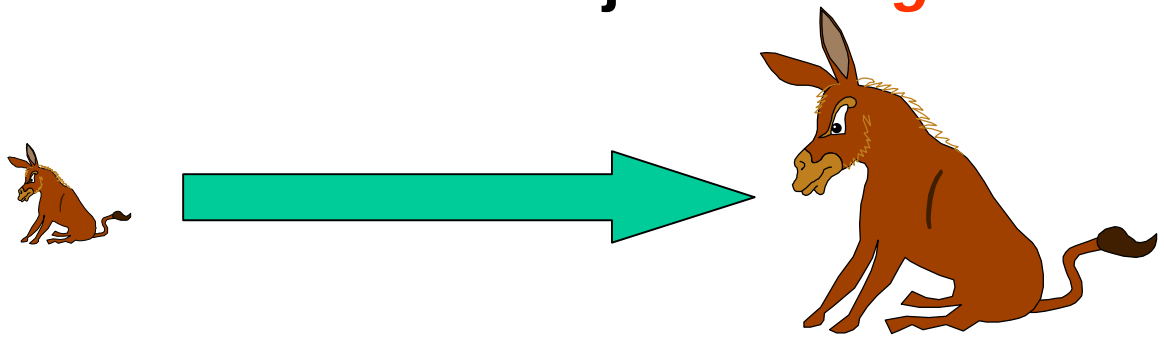
# *The Job of a Telescope*

**See faint objects – *Has light gathering power***

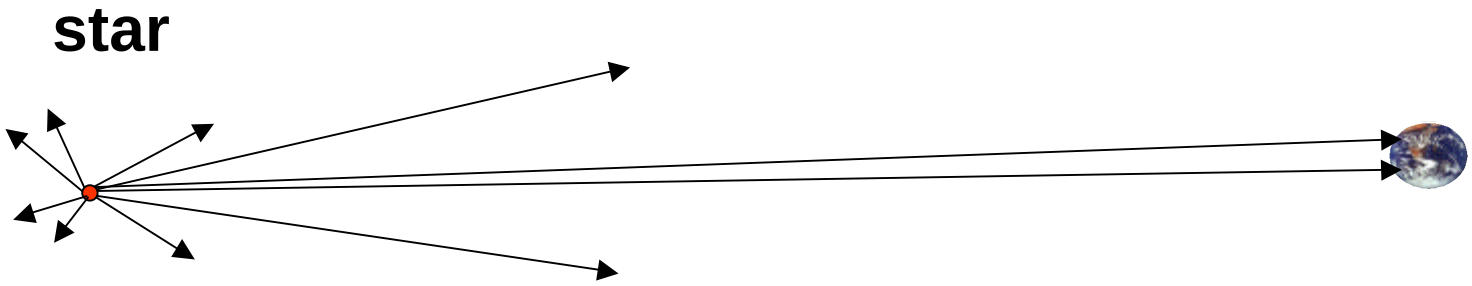
**See detail on objects - *Resolving power***



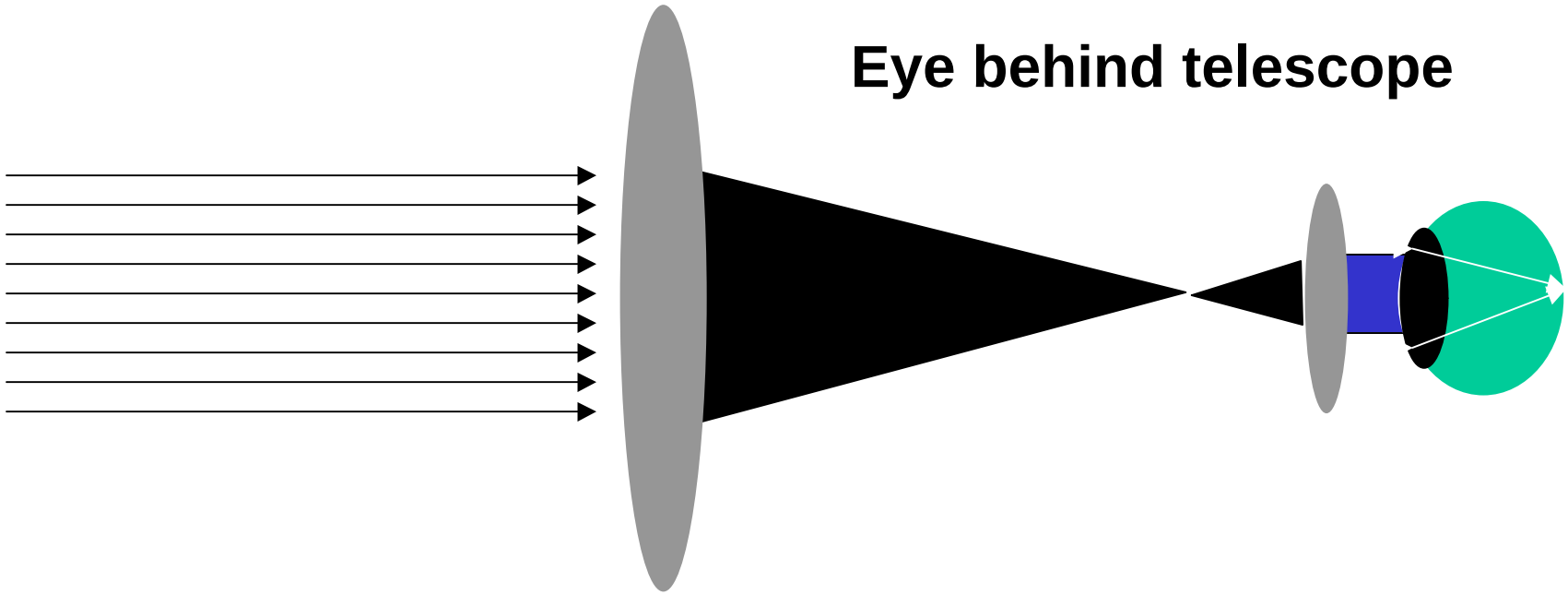
**Magnify otherwise small objects - *Magnification***



# *Light Gathering Power: Starlight Floods the Earth*




# *Light Gathering Power*
# *The Power of a Telescope*

# *Quantifying Light Gathering Power: The Magnitude Scale*

**Magnitude scale is a relative logarithmic scale**

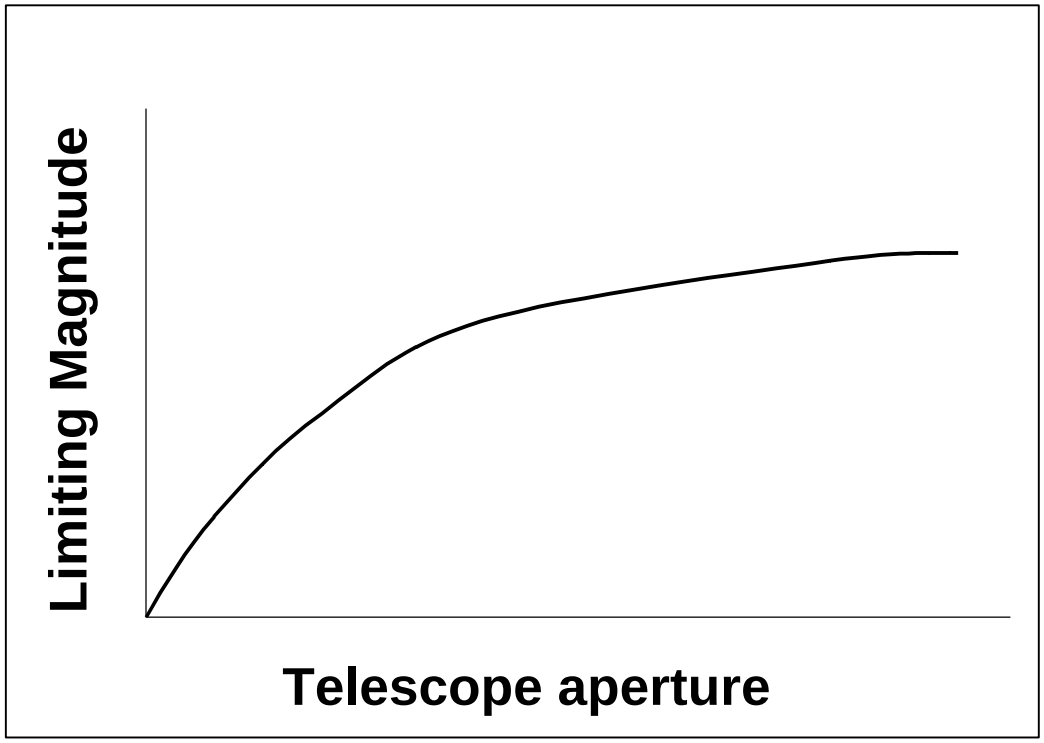
| | |
|---|---|
| **Sun** | **-27** |
| **Moon** | **-12** |
| **Sirius** | **0** |
| **Vega** | **1** |
| **Polaris** | **2** |
| **Eye's limit** | **6** |

**Brightness Difference= $2.5^{\text{magnitude difference}}$**

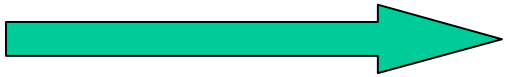
***Mag 1 star is 100 X brighter than a Mag 6 star***

# *Example of Telescope Limiting Magnitudes*

| | |
|---|---|
| **Eye** | **6** |
| **1” Telescope** | **9** |
| **8”** | **13.6** |
| **16”** | **16** |



# *Telescope Resolving Power*



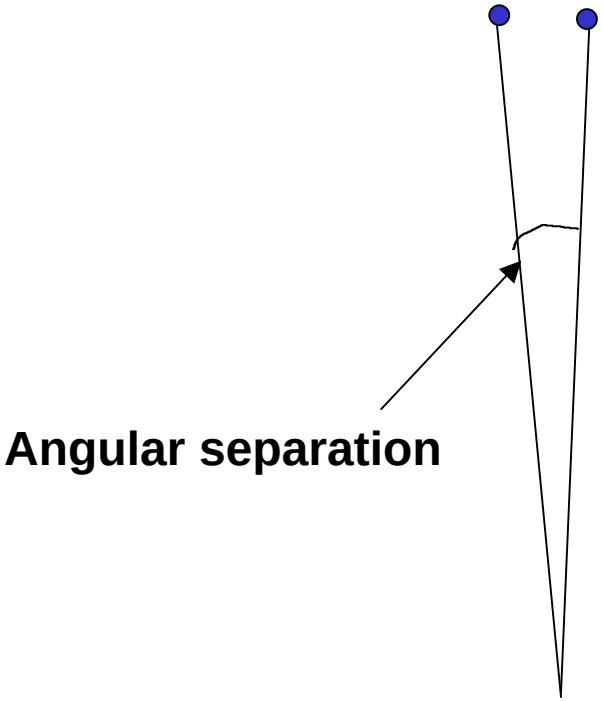
**Star**

**Double Star**

# *Resolving Power Depends on Aperture*

**Angular Resolution (sec. of arc) = 4.56/Aperture”**

**Separation of 2 stars**




**Theoretical Resolving Power**

| | |
|---|---|
| **Eye** | **16.5”** |
| **2”** | **2.28”** |
| **8”** | **0.56”** |
| **10”** | **0.45”** |
| **16”** | **0.29”** |

***Practical resolving power depends on the atmosphere***

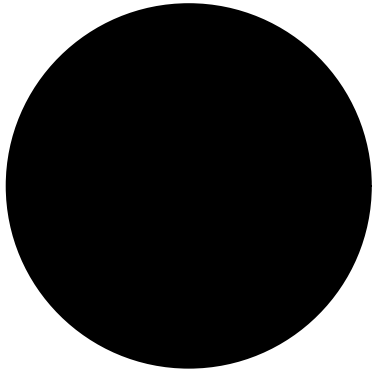
# *Magnification*

**Magnification = Telescope focal length ÷ eyepiece focal length**

**2000 mm ÷ 76 mm = 78 X**

**2000 mm ÷ 10 mm = 200 X**

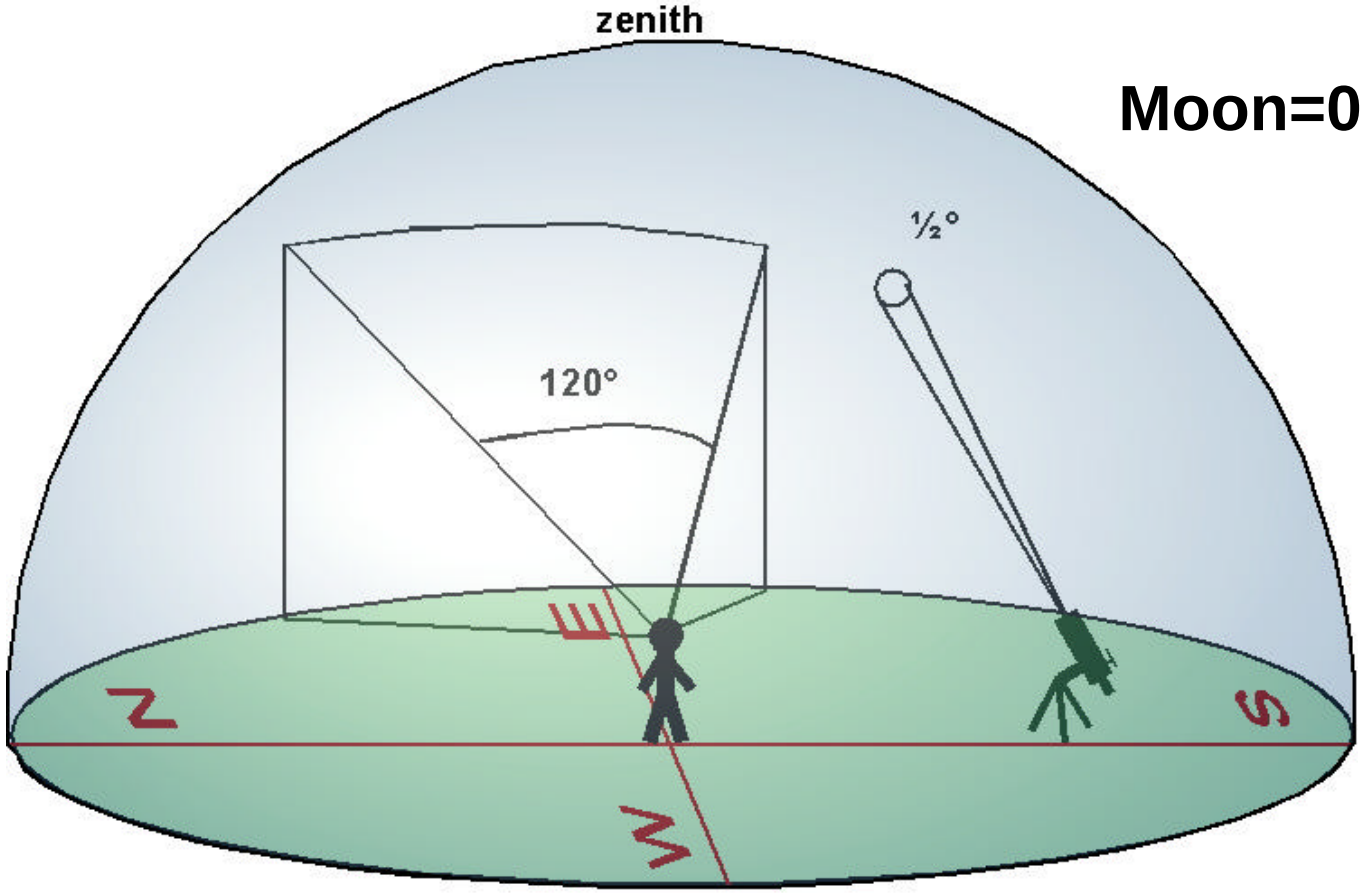
**2000 mm ÷ 1 mm = 2000X**



**Maximum useful magnification:**
- **60X per 1 inch of aperture**

**Practical magnification depends on**
- **optics and seeing**

# *Telescope Field of View*




**Moon=0.5 deg.**

**Field of View = Eyepiece apparent FOV ÷ Magnification**

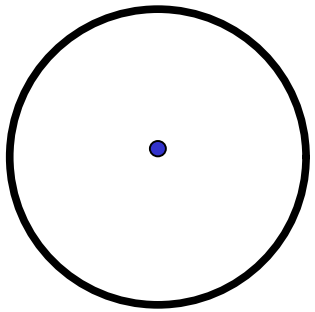
**Large Magnification = Small field of view**

**Small Magnification = Large Field of view**

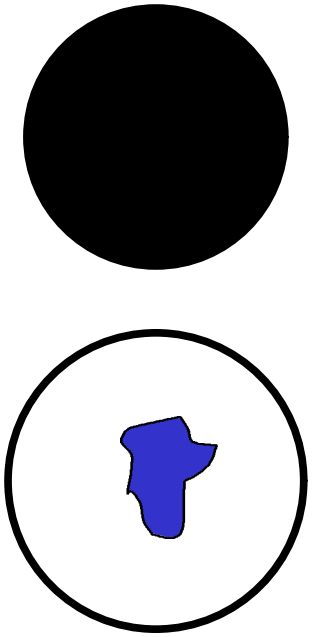
# *Aberrations*

- **A defect inherent in the optical design or caused by the atmosphere.**

***Diffraction limited image***



***Aberrated image***

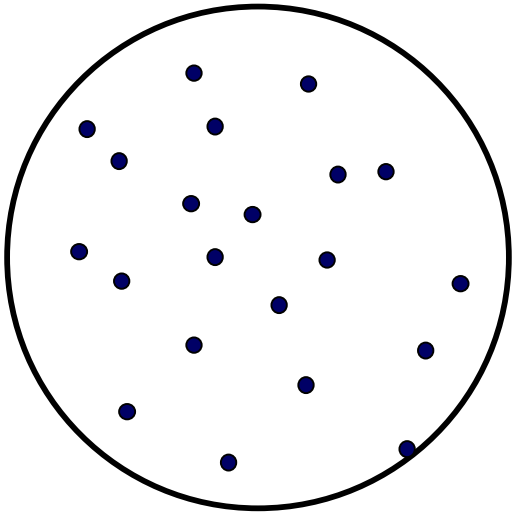


# *Common Aberrations*

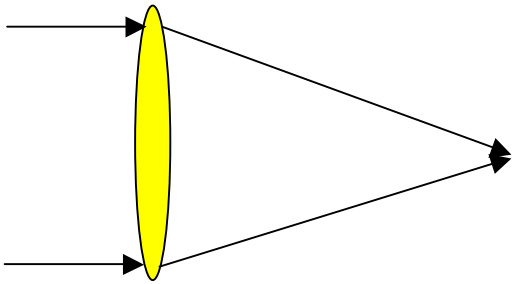
- **Poor seeing**
  - **Aberration caused by atmosphere**
- **Spherical aberration**
- **Chromatic aberration**
- **Coma**
- **Astigmatism**
- **Distortion**

# *Coma*

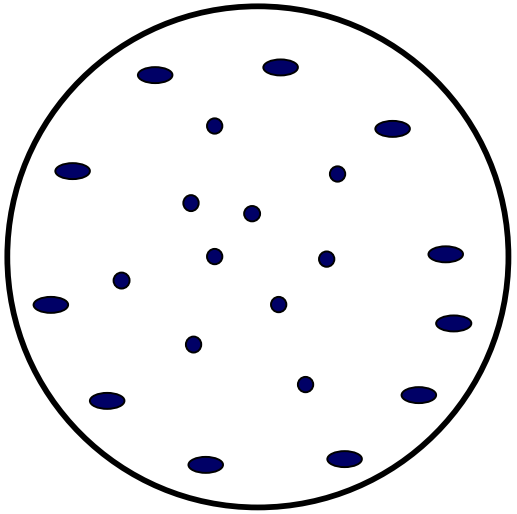
**Diffraction Limited Across the FOV**



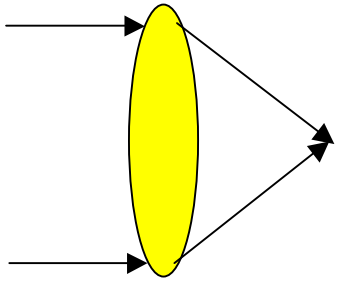
**>f/7 telescopes**



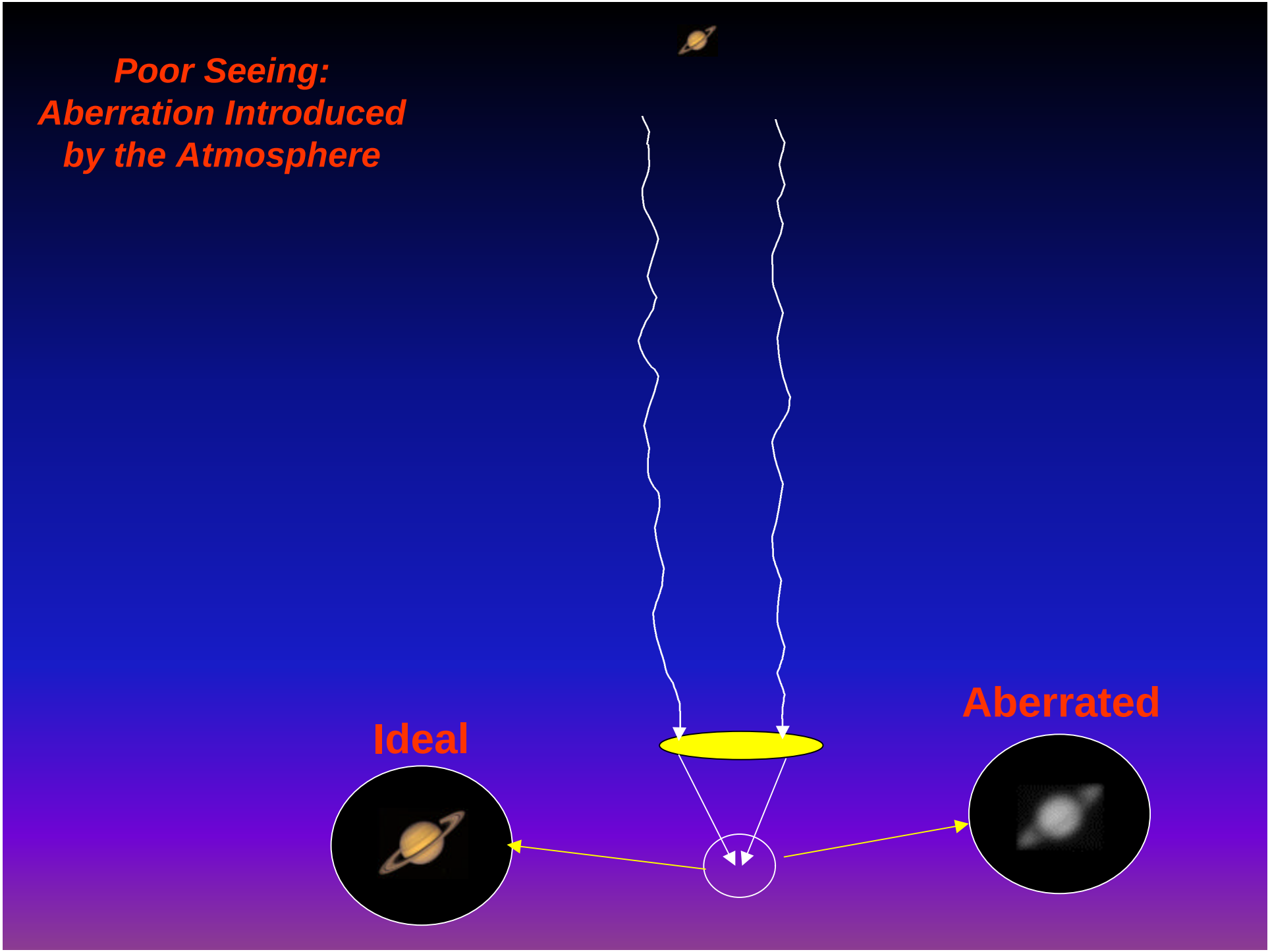
**Appearance of Coma**



**<f/6 telescopes**

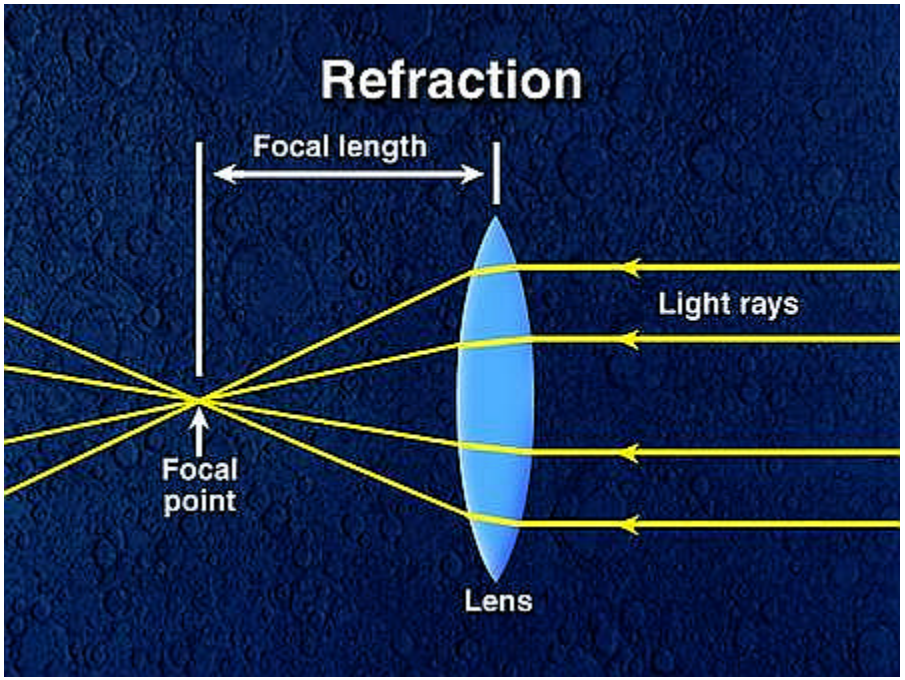


***Poor Seeing:***
***Aberration Introduced***
***by the Atmosphere***

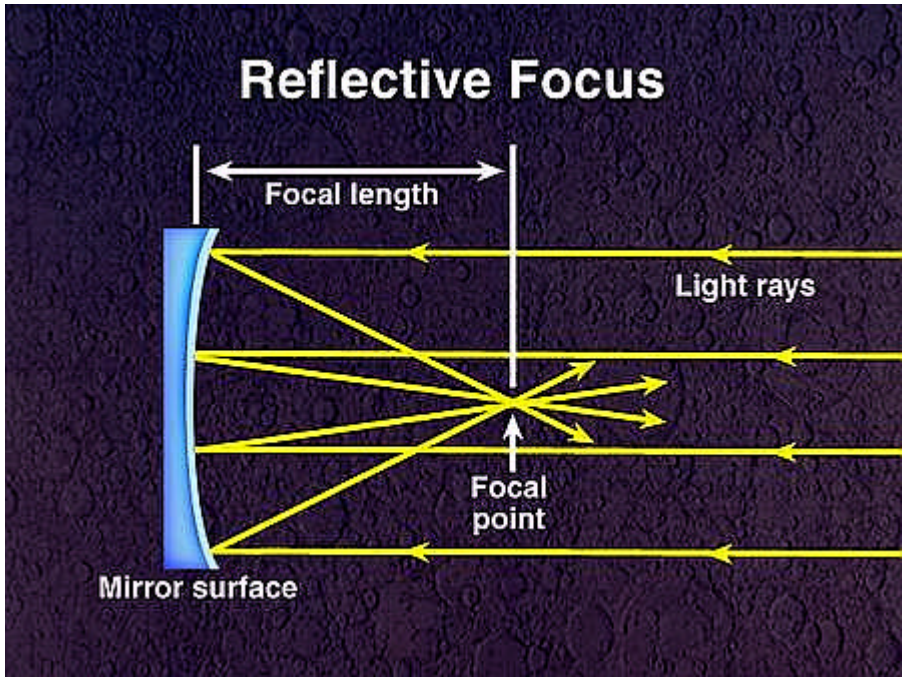


# *Refractor and Reflector*

## Lens

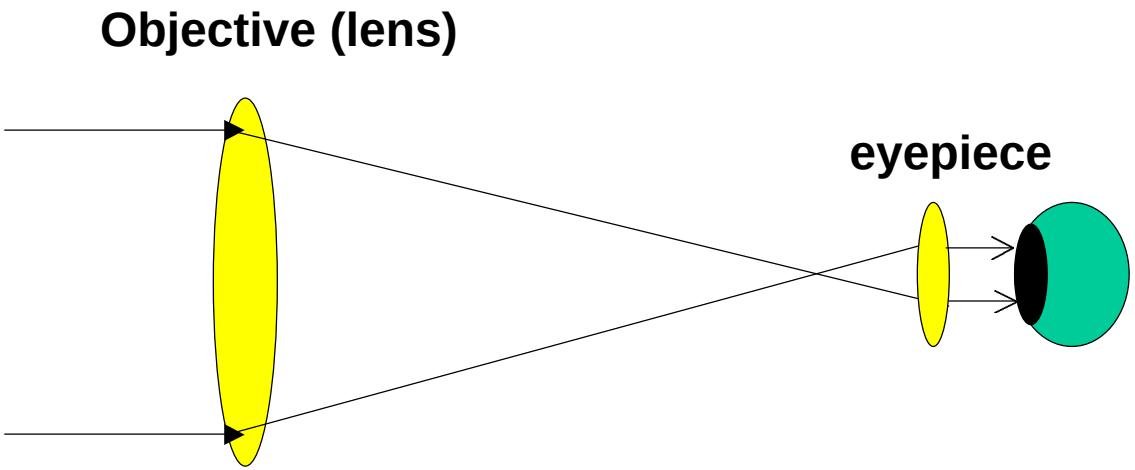



## Mirror



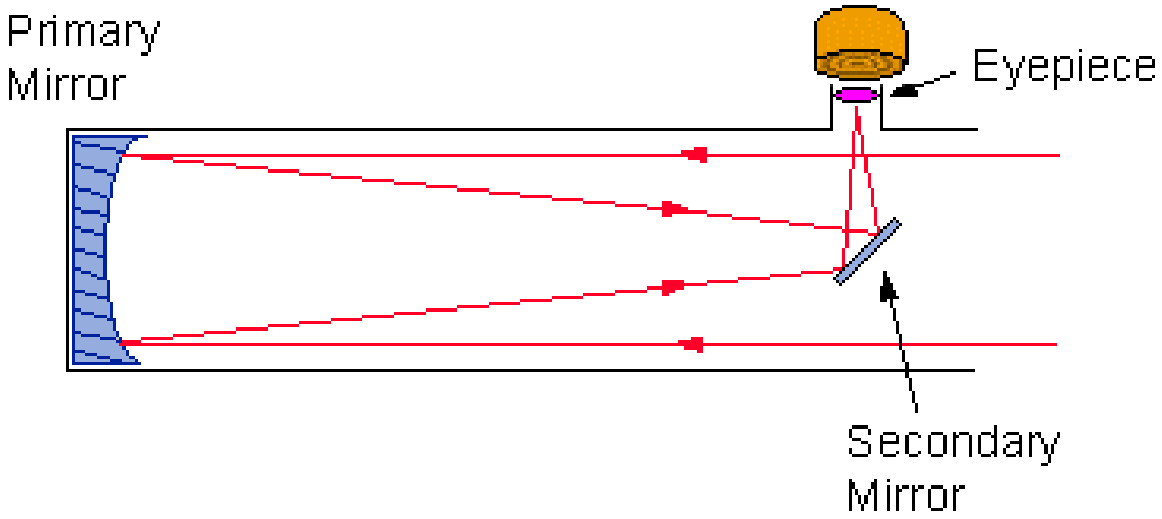

Telescope Parameters

# *The Refractor*




- **Common in small telescopes**
- **$$$ for large apertures**
- **Superb image quality**

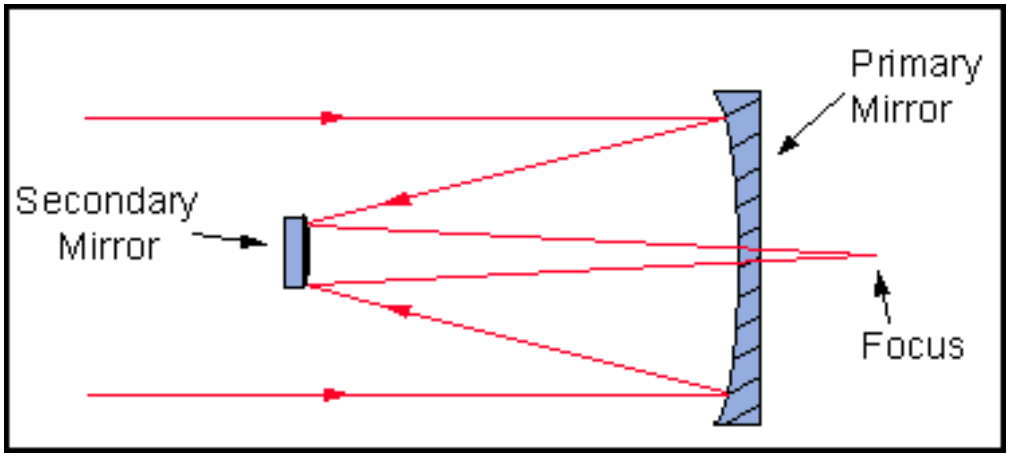
# *The Newtonian Reflector*




**6” Amateur Newtonian**

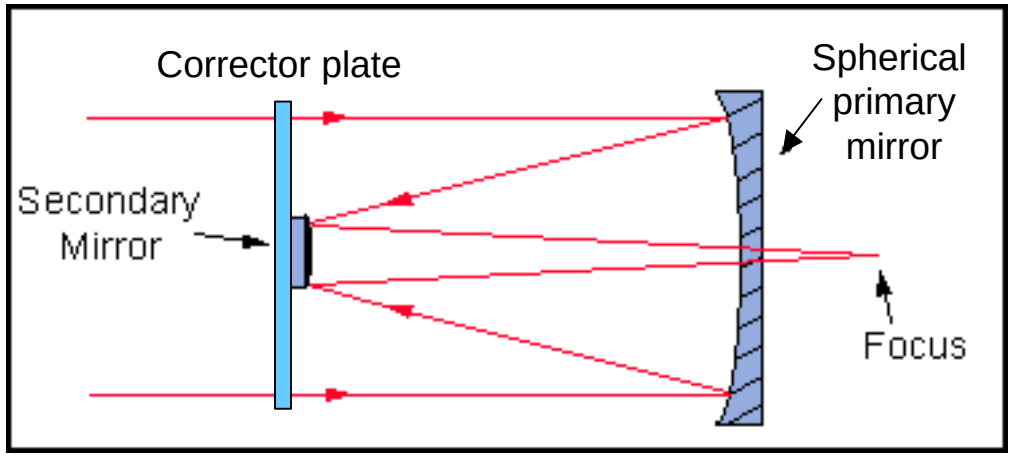
- **Common in amateur telescopes**
- **Lower cost**
- **Simple optical design**
- **Good image quality**
- **Central obstruction**

# The Cassegrain Reflector




- **Large f-number in small package**
- **F/10 in a 24” long tube**
- **Good imagery for large f/#**
- **Design used in large telescopes**

# *The Schmidt-Cassegrain*




**8” Schmidt-Cassegrain**

- **Large f-number in small package**
- **F/10 in a 24” long tube**
- **Good imagery for large f/#**
- **Better spherical aberration control**

# *Eyepiece Designs*

- **Ramsden**
- **Kellner**
- **Erfle**
- **Othoscopic**
- **Plössl**
- **Nagler**

# *Telescope Summary*

- **Telescope parameters**
  - **Focal Length**
  - **Light gathering power**
  - **Field of view**
  - **Magnification**
  - **Resolving power**
  - **Eyepiece**
  - **Objective**
  - **Focus**
- **Aberrations - Atmosphere, spherical, chromatic, coma**
- **Telescope designs**
  - **Refractor**
  - **Reflector**
    - **Newtonian**
    - **Cassegrain**
    - **Schmidt-Cassegrain**