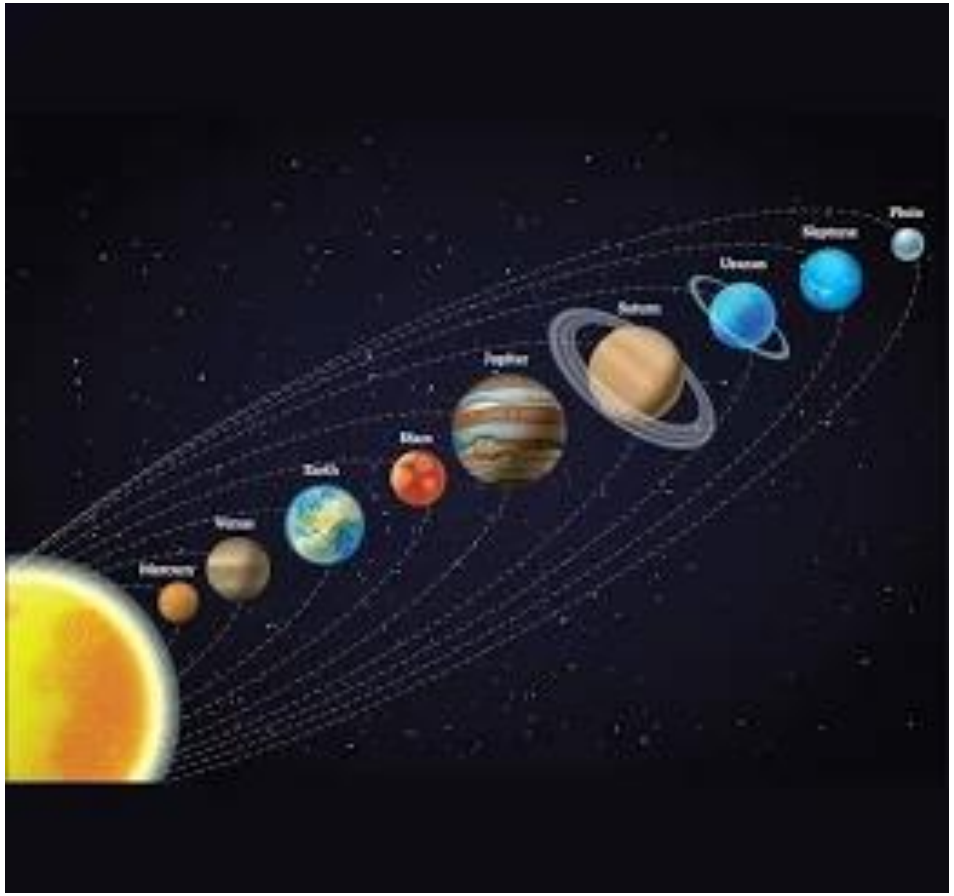
Topic 11: Exploring the solar system

Objects in the solar system

- Planets
- Dwarf planets
- Small solar system objects (SSSOs)
  - Comets
  - Meteors
  - Asteroids



Q: What is the difference between a planet and a dwarf plant?

Planets

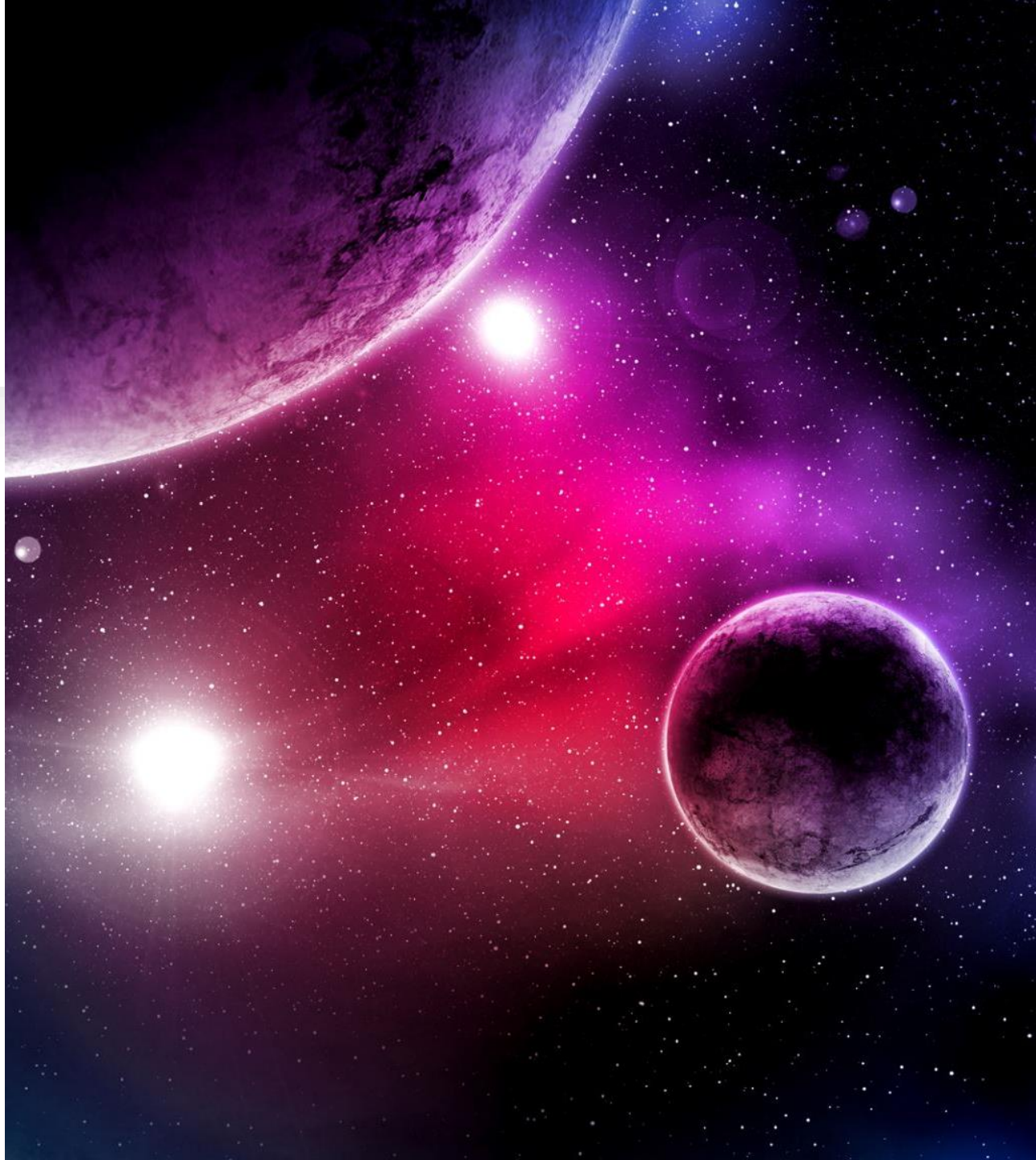
8 planets in the solar system split into 2 groups

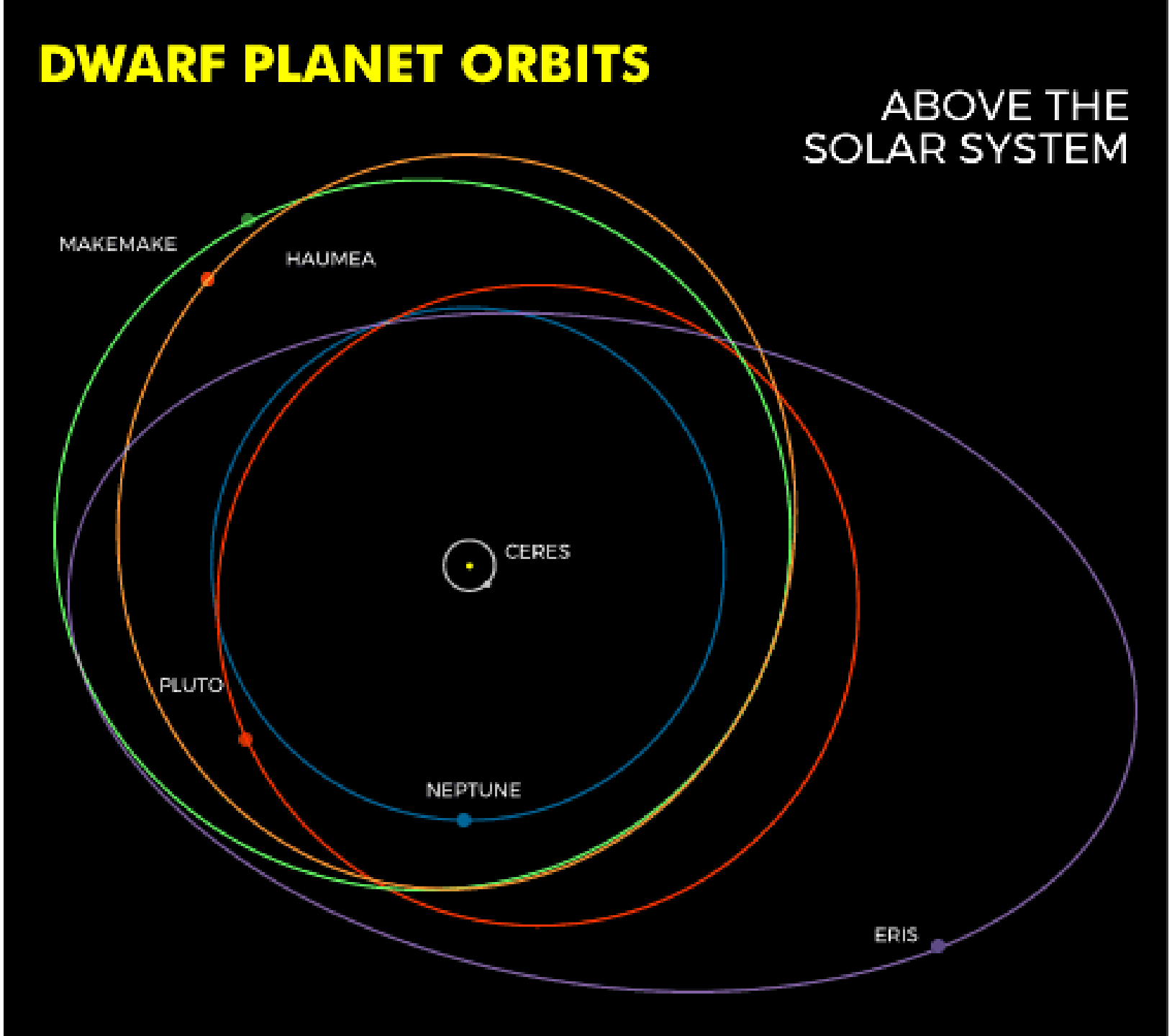
1. Terrestrial planets – relatively small worlds of rock with iron cores
    1. Mercury
    2. Venus
    3. Earth
    4. Mars
2. Gas giants – liquid interiors with atmospheres of H_2, He with trace amounts of CH_4. They have ring systems and moons.
    1. Jupiter
    2. Saturn
    3. Uranus
    4. Neptune

Dwarf Planets

Dwarf planets have

- Enough mass to be spherical
- Lack the gravitational force to clear their orbits of debris
- Except for Ceres (found in the Asteroid belt) most dwarf plants are found in the outer solar system (Kuiper belt)




DWARF PLANET ORBITS
ABOVE THE SOLAR SYSTEM
MAKEMAKE
HAUMEA
CERES
PLUTO
NEPTUNE
ERIS

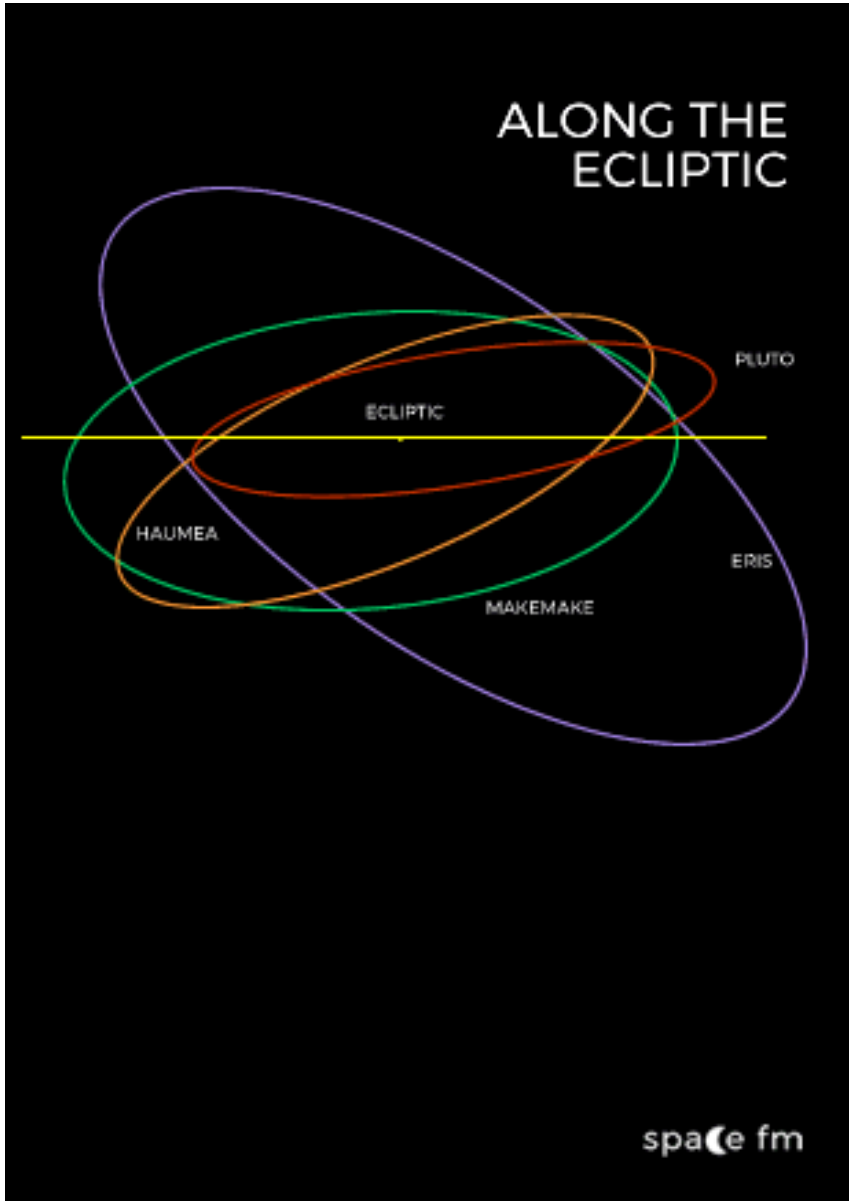
Characteristics of planets and dwarf plants

You need to understand and be able to use the following characteristics of planets and dwarf planets.

- **Relative size**
- **Relative mass**
- **Surface temperature**
- **Atmospheric composition**
- **Presence of satellites**
- **Presence of ring systems**

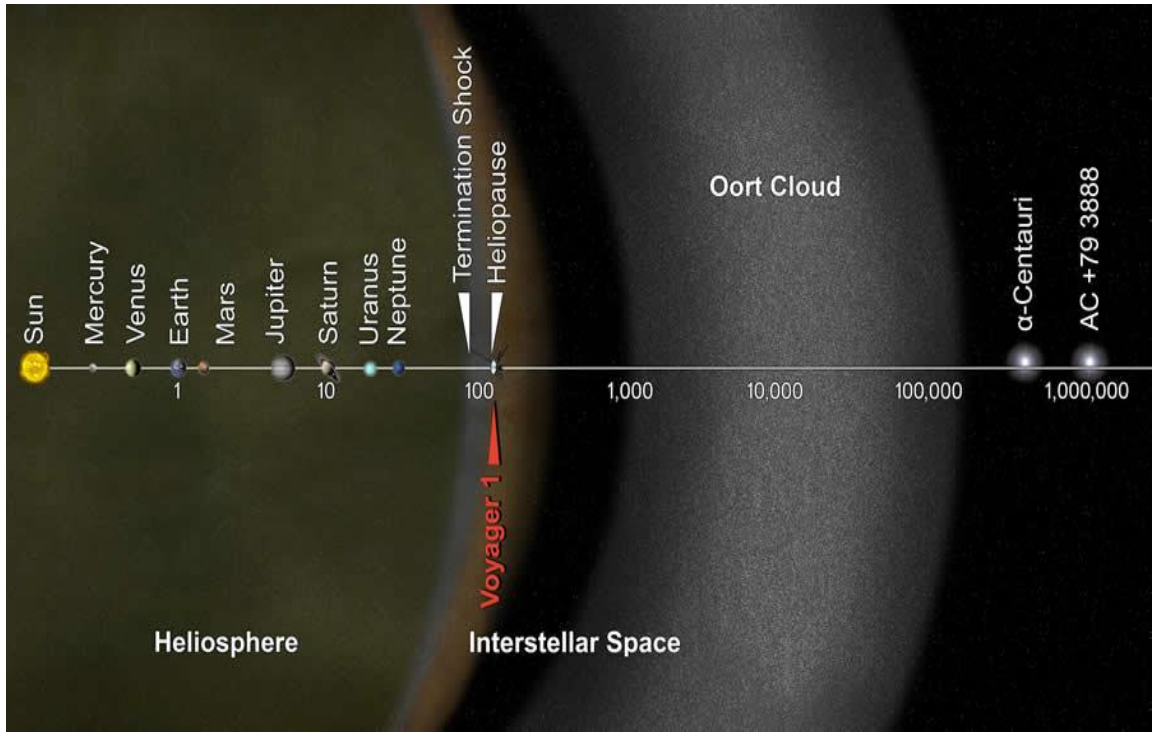
Name	Type of body	Mean distance from Sun/AU	Sidereal period/ Earth year	Mean temperature /°C	Diameter /1000 km	Mass/ Earth mass	Ring systems	Moons
Mercury	planet	0.38	0.24	170	4.9	0.055	no	none
Venus	planet	0.72	0.62	470	12.1	0.82	no	none
Earth	planet	1.0	1.0	15	12.8	1.00	no	1: the Moon
Mars	planet	1.5	1.9	−50	6.9	0.11	no	2 small moons: Deimos and Phobos
Ceres	dwarf planet	2.8	4.6	−105	0.95	1.5×10^{-4}	no	none
Jupiter	planet	5.2	11.9	−150	143	318	yes	4 major moons: Ganymede, Callisto, Europa, Io >60 others
Saturn	planet	9.5	29.5	−180	121	95	yes	5 major moons: including Titan, Iapetus >55 others
Uranus	planet	19.1	84.0	−210	51	15	yes	5 major moons: including Titania, Oberon >20 others
Neptune	planet	30.0	165	−220	50	17	yes	1 major: Triton >12 others
Pluto	dwarf planet	39.5	248	−230	2.4	2.2×10^{-3}	no	1 major: Charon >4 other moons
Haumea	dwarf planet	43.1	283	−241	1.4	6.7×10^{-4}	no	2
Eris	dwarf planet	67.8	557	−230	2.3	2.8×10^{-3}	no	at least 1

The Ecliptic



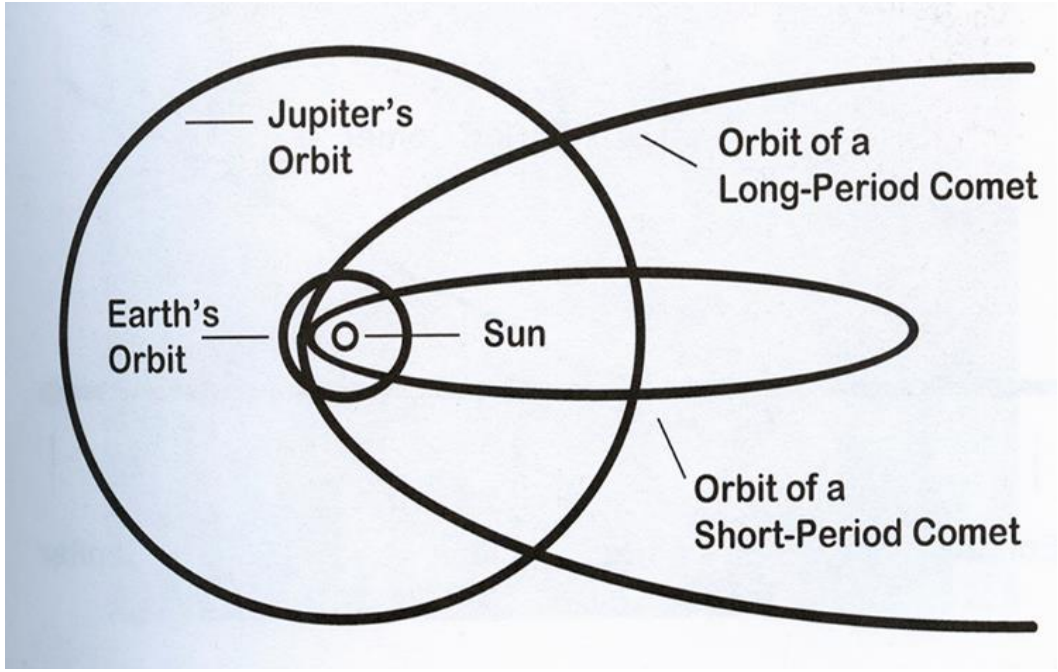
Belts and Heliosphere

- Asteroid belt - Most asteroids orbit within the orbits of Mars and Jupiter in an area called the Asteroid Belt.
- Kuiper Belt - region of the Solar System outside the orbit of Neptune. It is thought to extend several times the orbit of Pluto, possibly between 100 to 1000 AU.
- Oort cloud - spherical region at between 10,000 to 20,000 AU
- Heliosphere - It is a 'bubble' surrounding the solar system, created by the solar wind. It is thought to be 'cigar-shaped' as it is shaped by the Sun's movement.



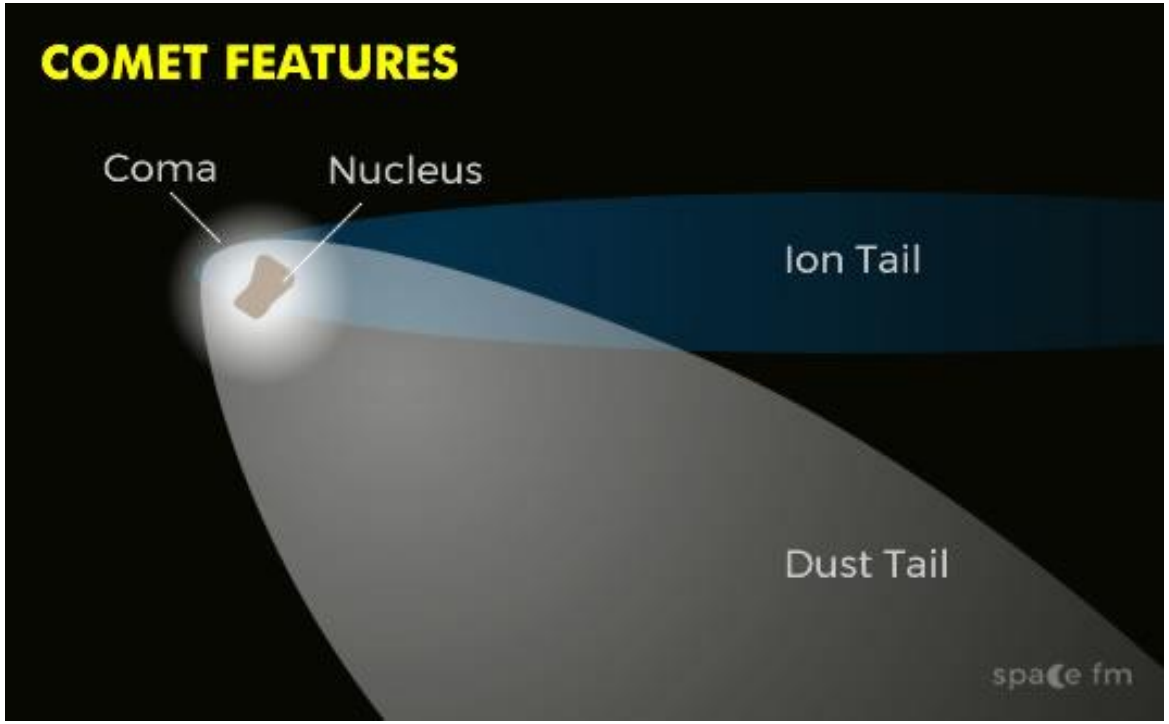
Comets

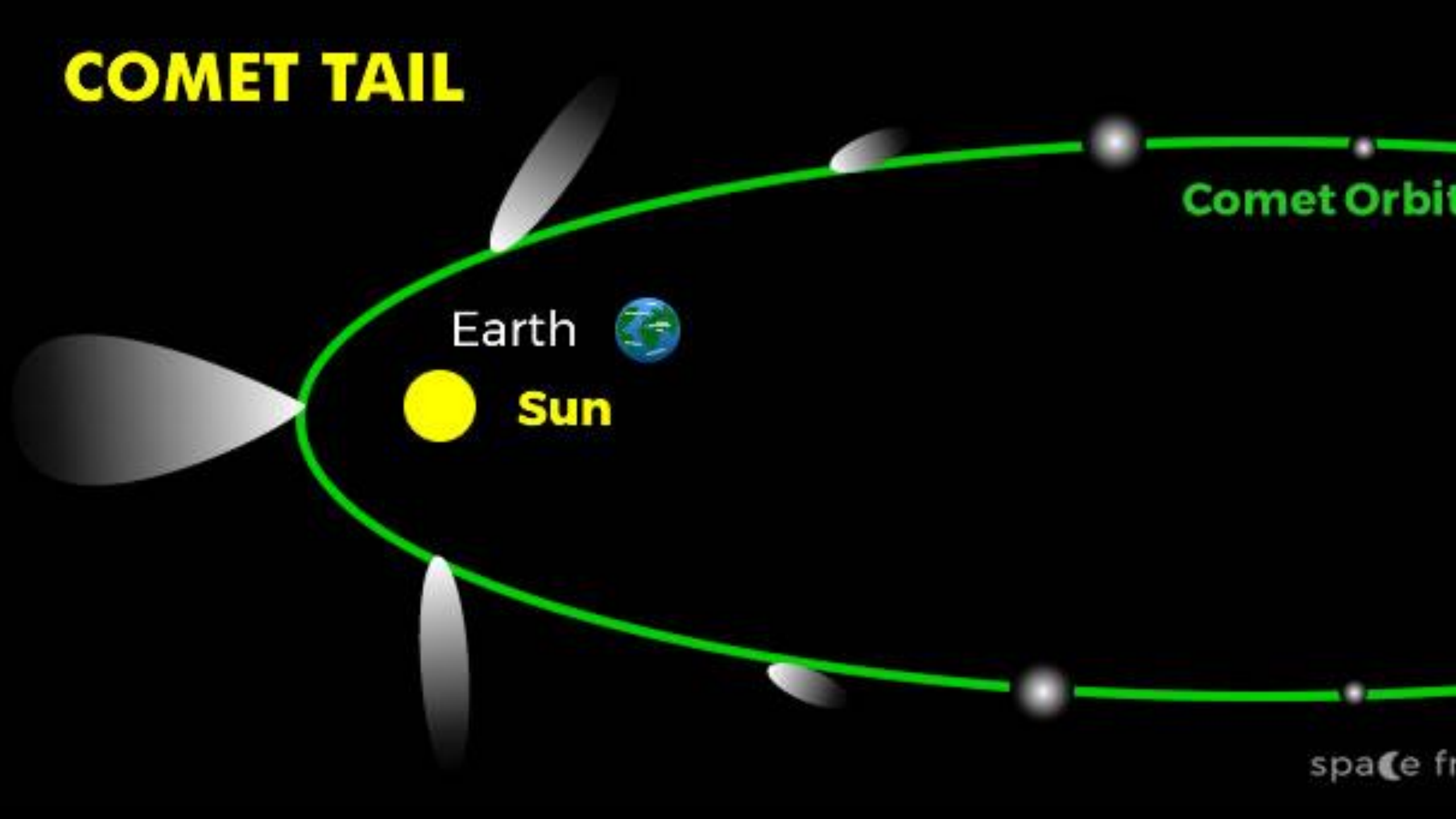
- **Comets -** are ice and rock bodies. Comets have a highly elliptical inclined orbit, can have retrograde motion. Some comets have open orbits.
- **Short-period comets** – Originate in the **Kuiper Belt**, taking less than 200 years to orbit.
- **Long-period comets** – Originate in the **Oort Cloud**, taking thousands of years to orbit.



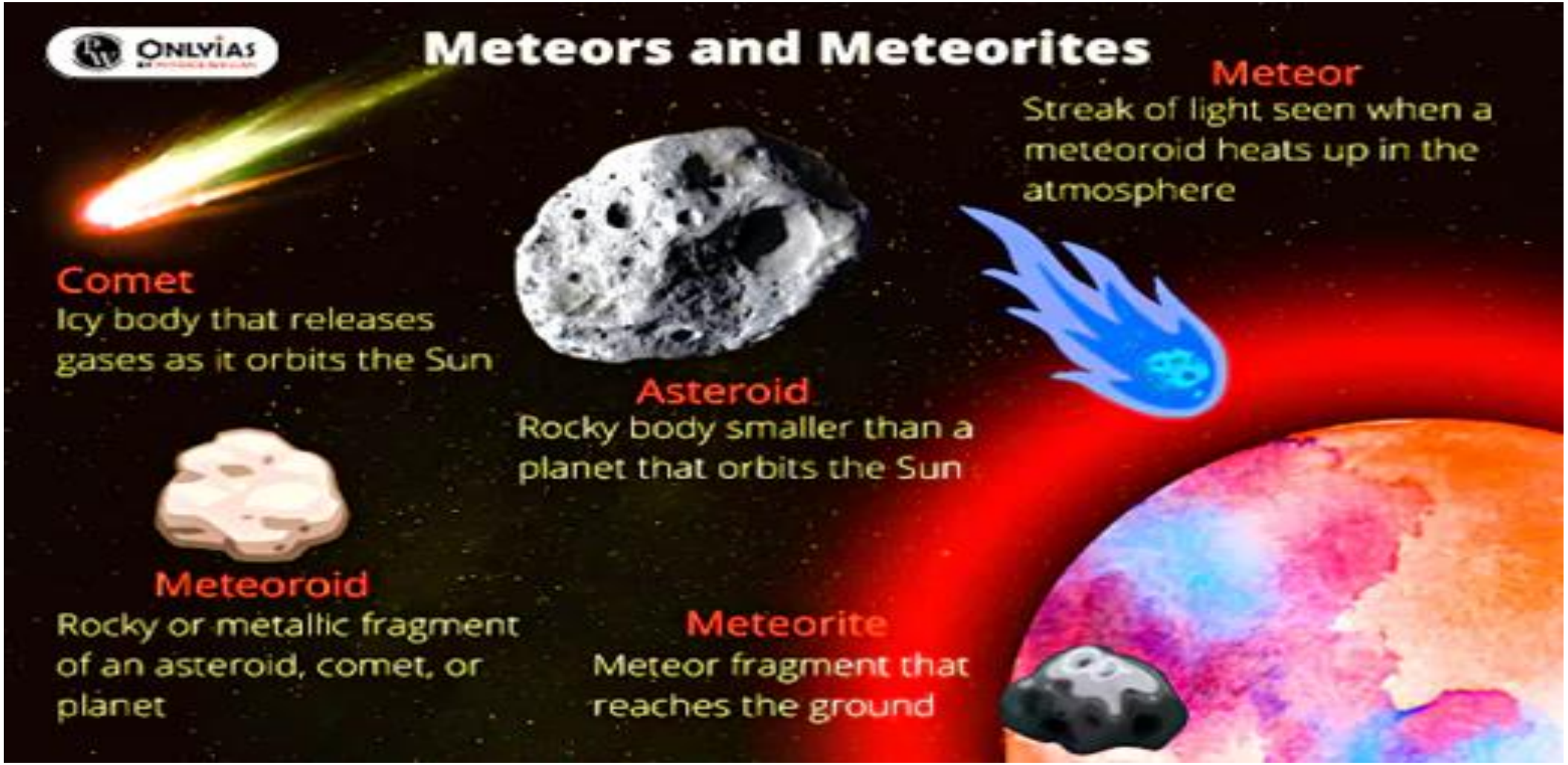
Structure of comets

- **Nucleus –** Solid ice and rock, typically no larger than an average asteroid.
- **Coma –** Spherical region around the nucleus formed by evaporation of ice as the comet approaches the sun
- **Dust tail** - A curved dust tail forms and can be up to several millions of kilometres long. This tail forms because of radiation pressure from the Sun.
- **Ion tail -** Particles from the solar wind hit the comet and an ion tail is produced which is more coloured but straighter than the dust tail.

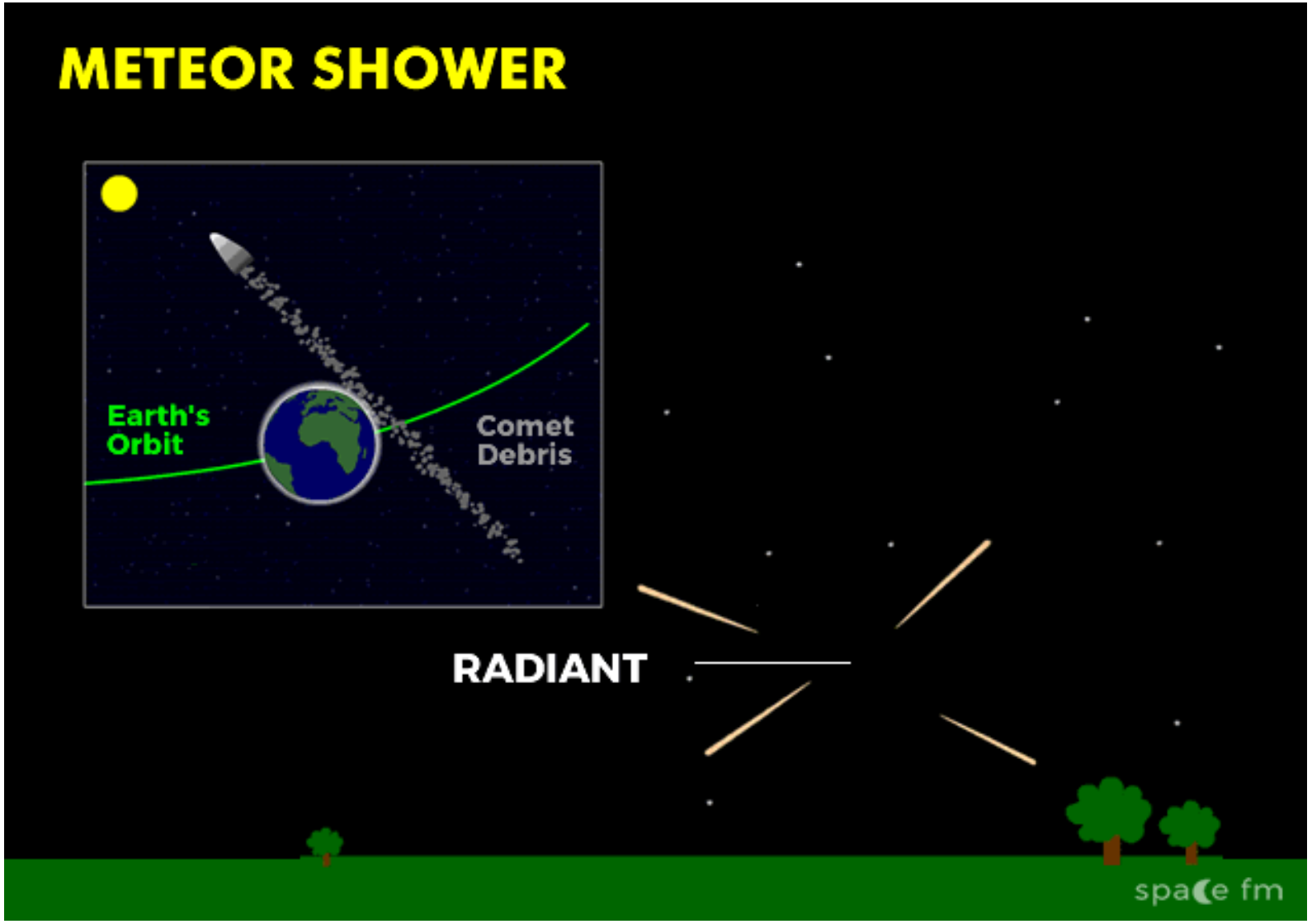



COMET TAIL
Comet Orbit
Earth
Sun

Meteor, Meteoroid or Meteorite?

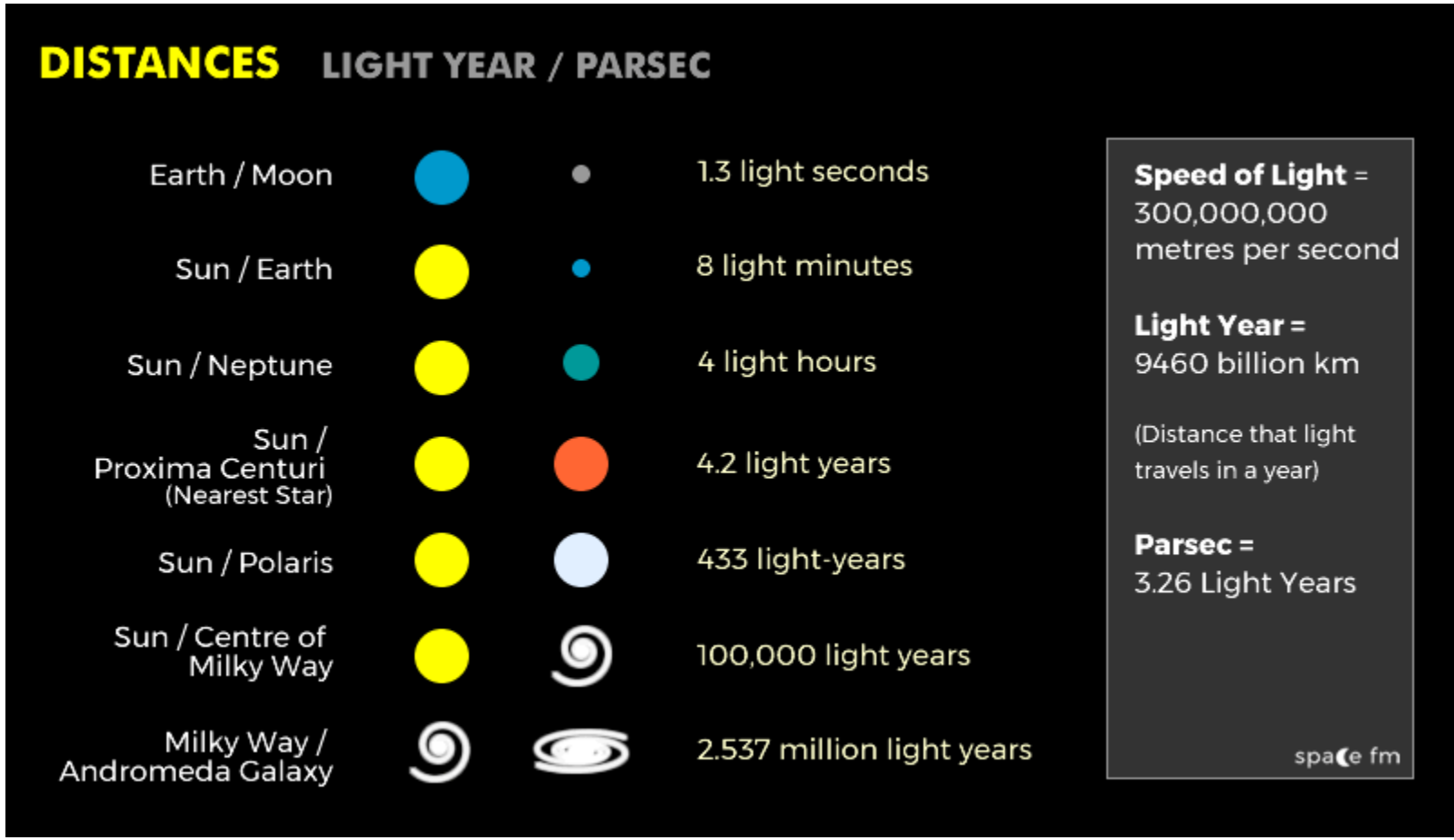


Meteor showers

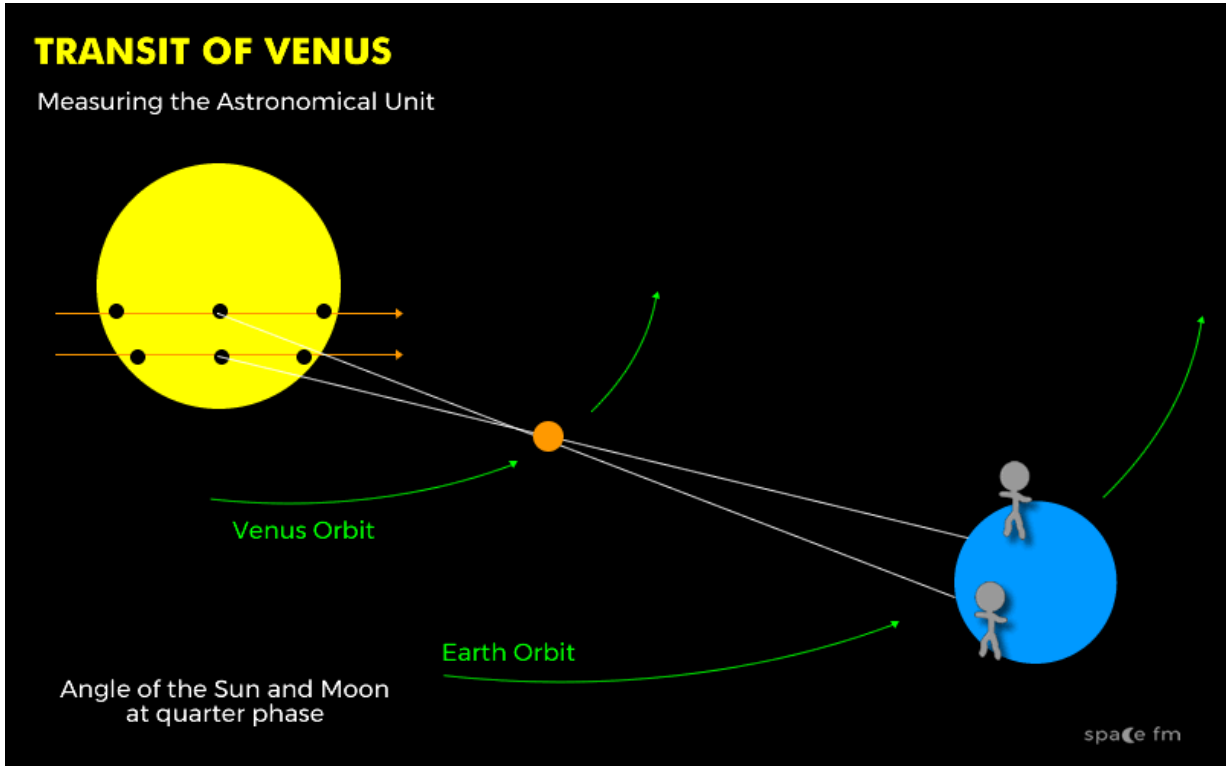


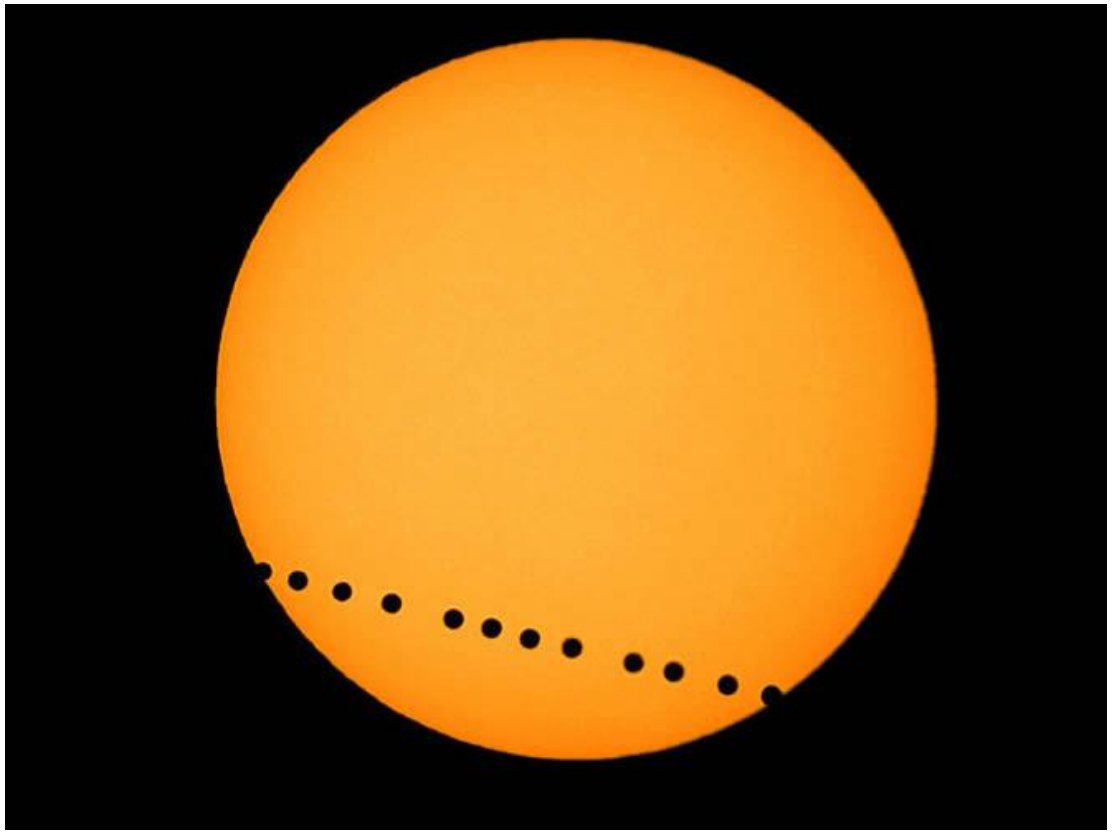
The size of the solar system

- **Astronomical Unit (AU)** – Mean distance from Earth to the Sun (1 AU = 1.5×10^8 km).
- **Light Year (l.y.)** – Distance light travels in one year.
- **Parsec (pc)** – Equal to 3.26 light-years, used for measuring greater distances.



Finding AU


TRANSIT OF VENUS
Measuring the Astronomical Unit
Venus Orbit
Earth Orbit
Angle of the Sun and Moon
at quarter phase
space fm



Water on Earth

- **Cometary Theory** – It is thought that Earth was heavily bombarded by comets and other bodies early in its evolution and the Moon bears evidence of this. Comets contain large amounts of ice and this would have fed our oceans on impact.
- **Outgassing Theory** – This theory says that water was part of Earth's body when it formed. As the Earth cooled, water leaked from rocks and the atmosphere condensed the water into liquid form.

Topic 11: Exploring the solar system P2

Observations

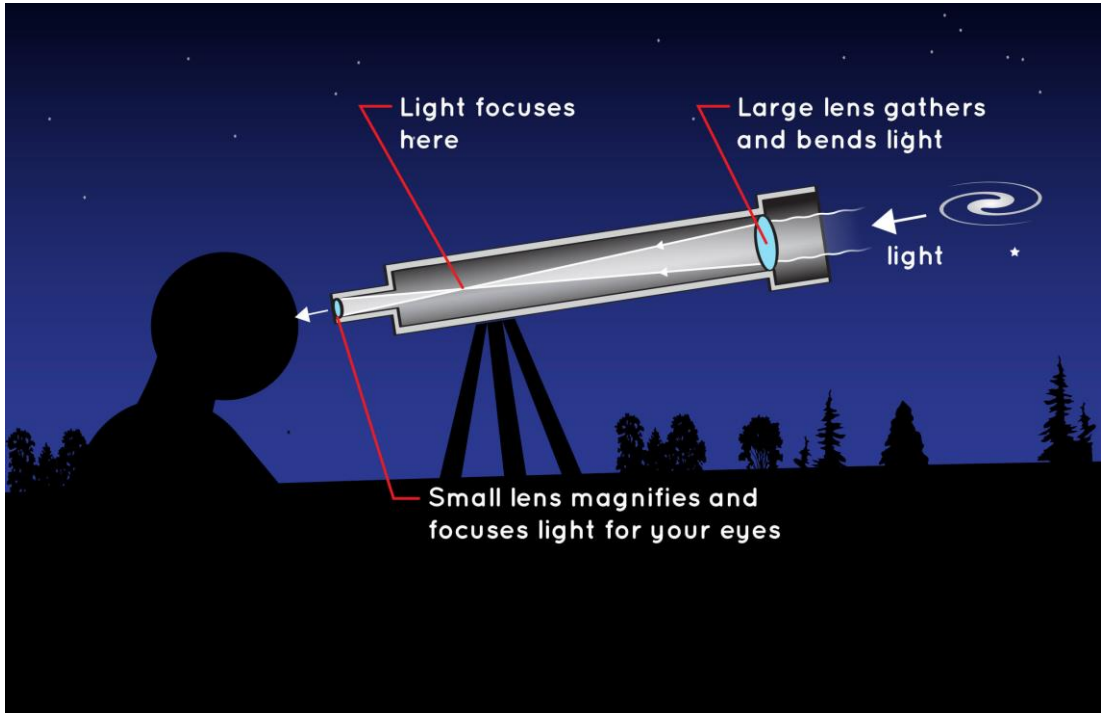
- Most common observations are with the eye.

- The eye has its limitations;
  - Low light sensitivity
  - Small aperture

- Telescopes and binoculars can be used to see further.
- There are 2 main types of telescopes
  - Refracting
  - Reflecting

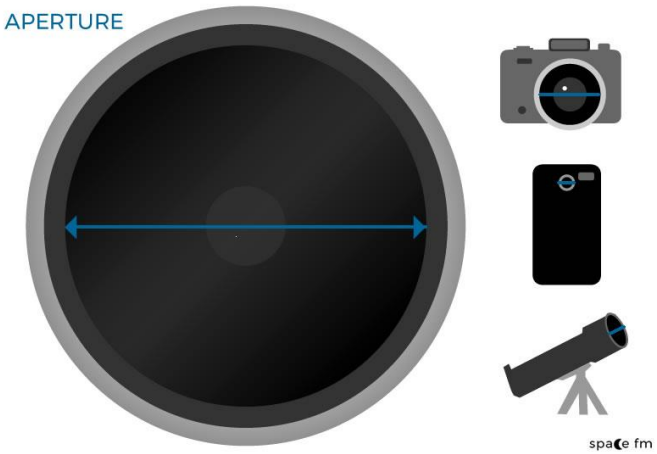
Telescope Basics

- Objective element collects as much light as possible and focuses the light to a small bright image.
- Telescopes have a lens, mirror or both to enlarge images by collecting light.
- The image is then magnified with the using the eyepiece lens.
- This allows us to view the objects in much more detail (higher resolution) and much bigger than with the naked eye.



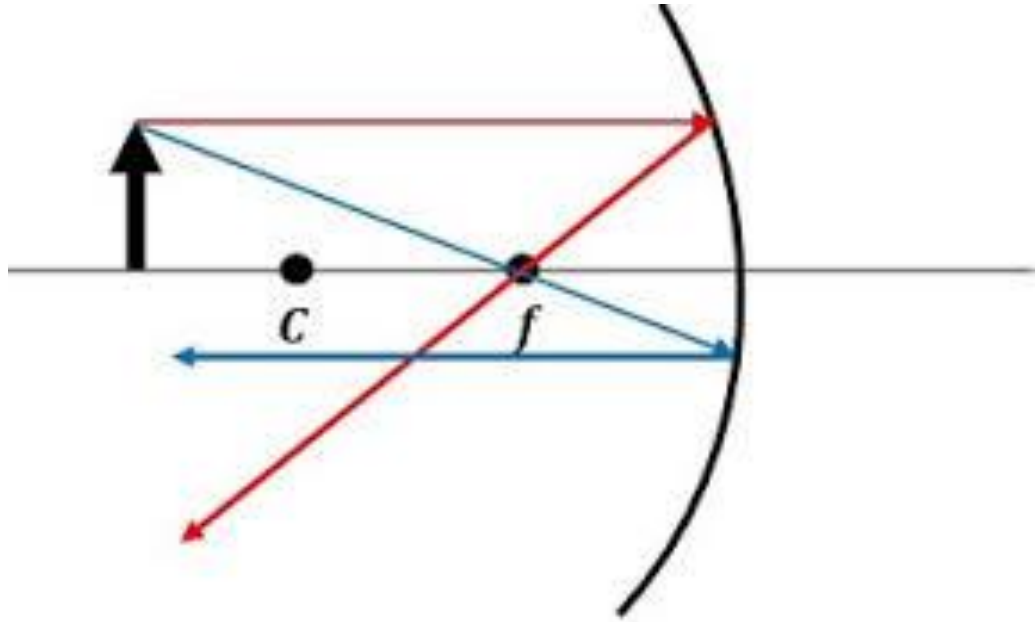
Telescope Terms

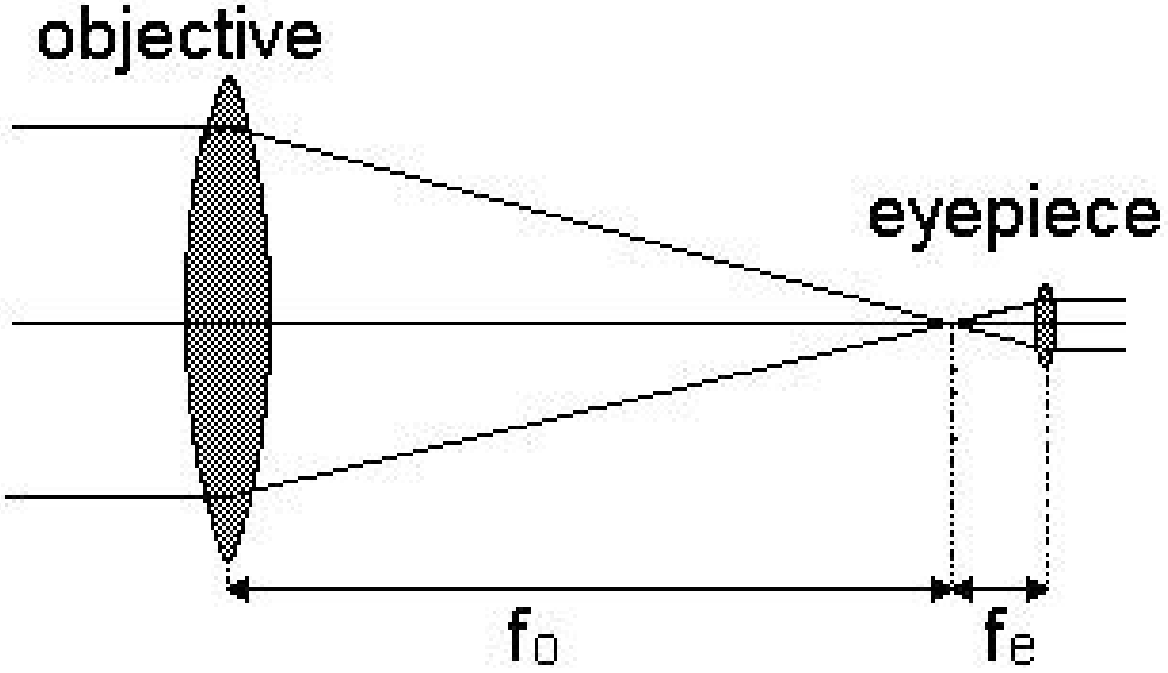
- The aperture is the diameter of the objective lens or mirror. The bigger the aperture:
  - The more light, brighter image
  - The shaper the image
- Light Grasp - is a measure of a telescope's ability to capture light; it depends on its cross-sectional area. (Square of the diameter).
- Resolution is how a telescope will show the detail of an object being observed. Resolution is dependent on:
  - Aperture of the objective element
  - Wavelength of light – the longer the wavelength the poorer the resolution



Lenses and mirrors

- Telescopes can be made from a combination of convex lenses and concave mirrors.
- Typically, a lens or mirror is placed at the end of a tube. The light is magnified or reflected to an eyepiece which shows an enlarged image of what is being viewed.
- A convex lens will enlarge an image and viewed in focus by another convex lens. A larger concave mirror can capture light and focus it to a point where it is viewed by a convex lens.





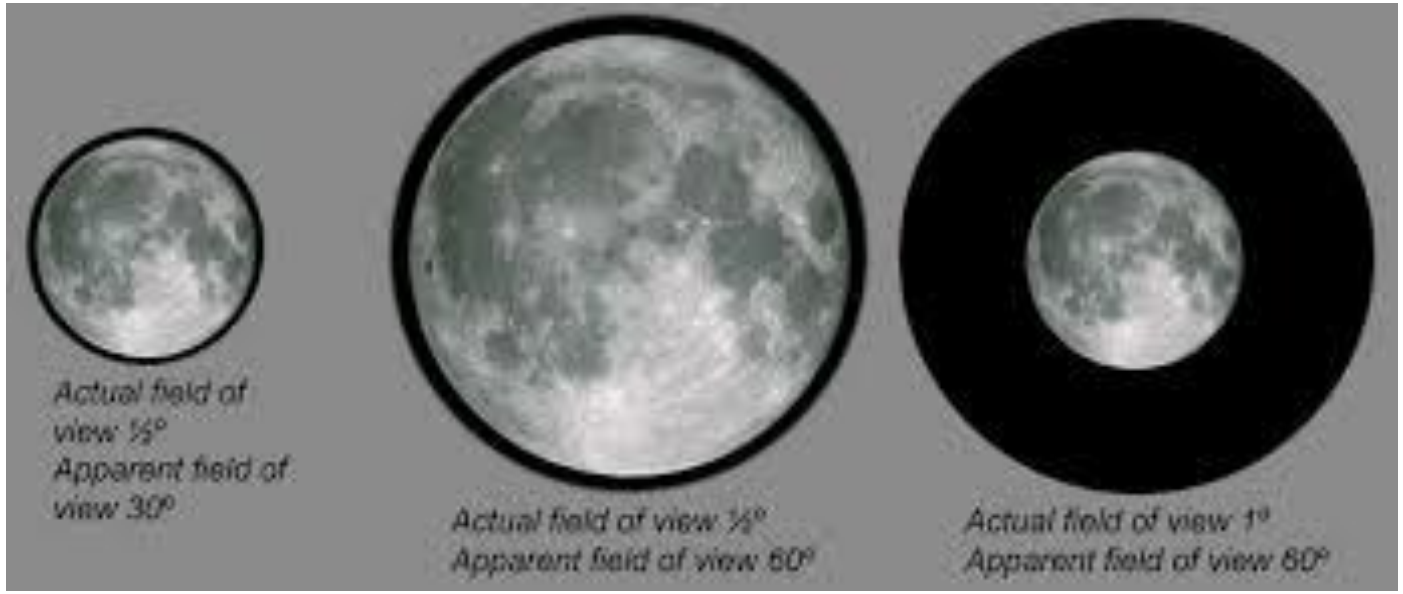
Magnification

- Magnification is the ratio of focal lengths of the objective lens and the eyepiece lens:
- $magnification = \frac{focal\ length\ of\ obective}{focal\ length\ of\ eyepiece} = \frac{f_o}{f_e}$

- Both units must be the same.
- Eyepiece lens can be changed to increase magnification.
- The shorter the focal length of the eyepiece the greater the magnification.

Field of view FOV

- Circle of the sky that is visible through the eyepiece.
- Measured in degrees or minutes of arc
- The greater the magnification the smaller the FOV

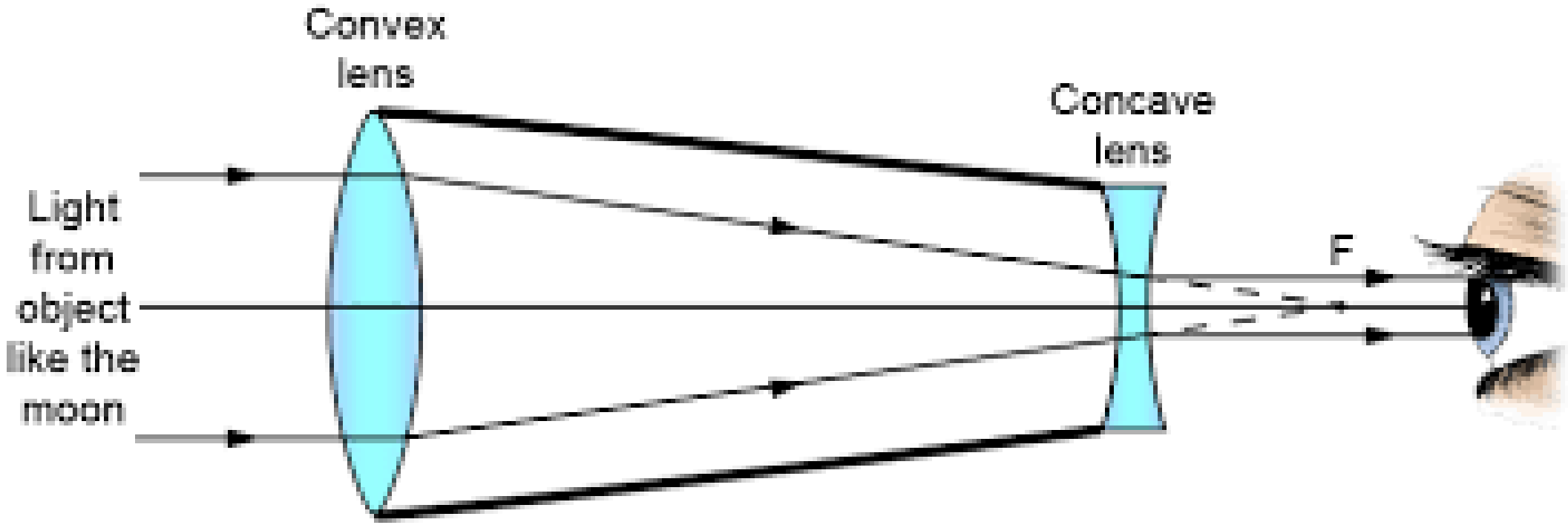


Reflecting telescopes

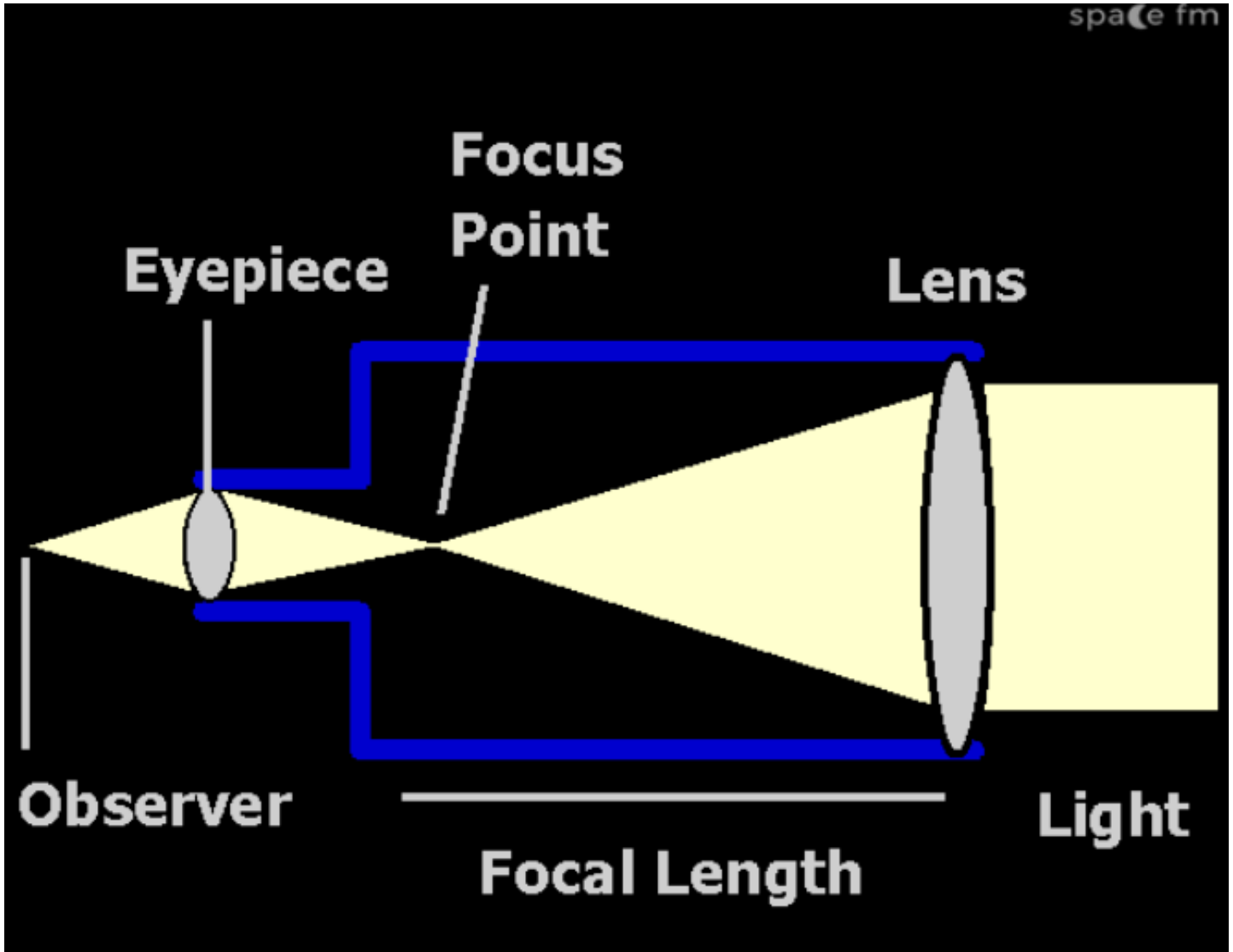
- A convex lens is used at the end of a tube to bring an image into focus at a point. Another lens called an eyepiece is used at the opposite end of the tube to magnify the image.

- The lens is typically made of glass coated in a film to allow less light to be reflected and more to pass through the lens.

Galilean Telescope

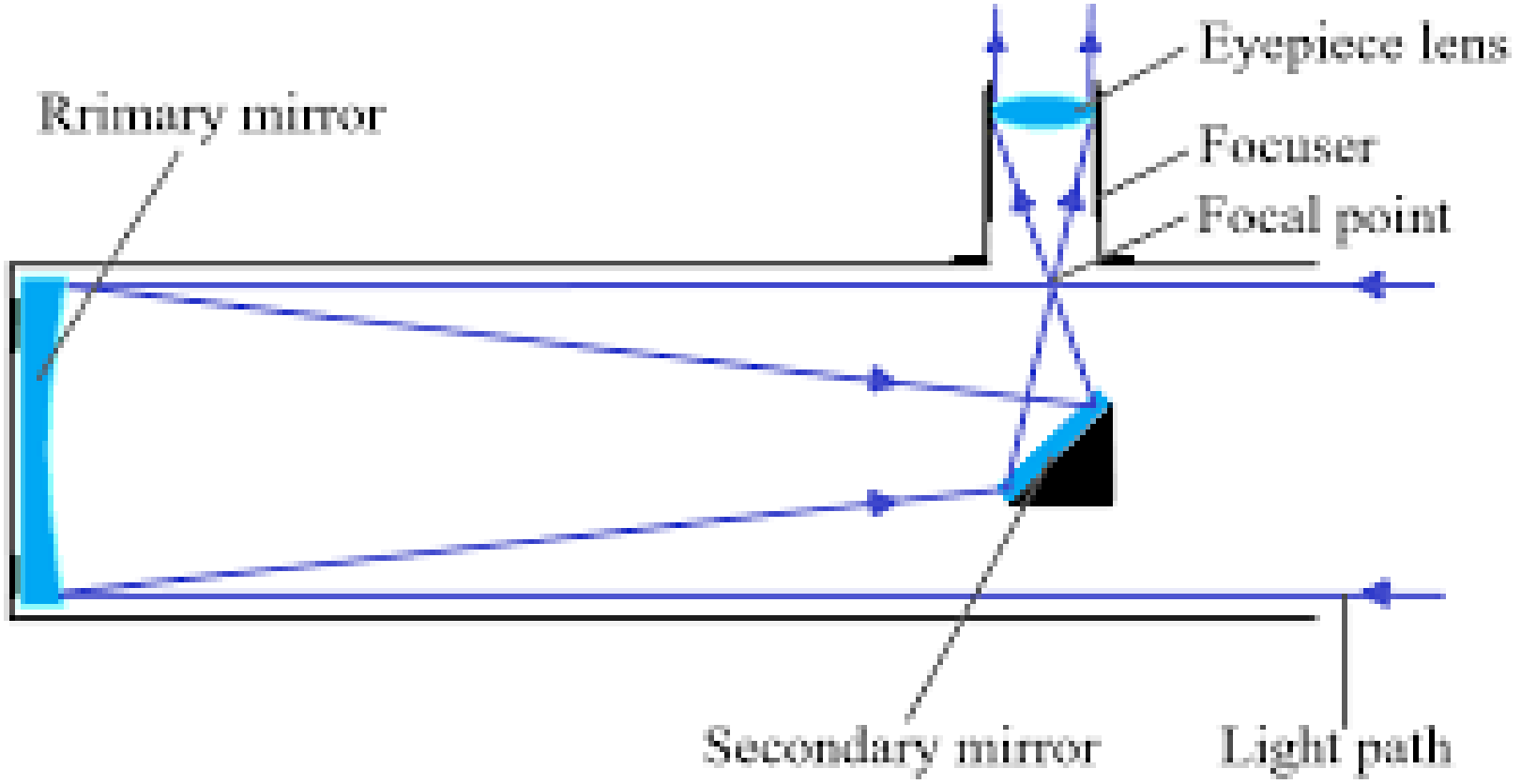


Keplerian Telescope

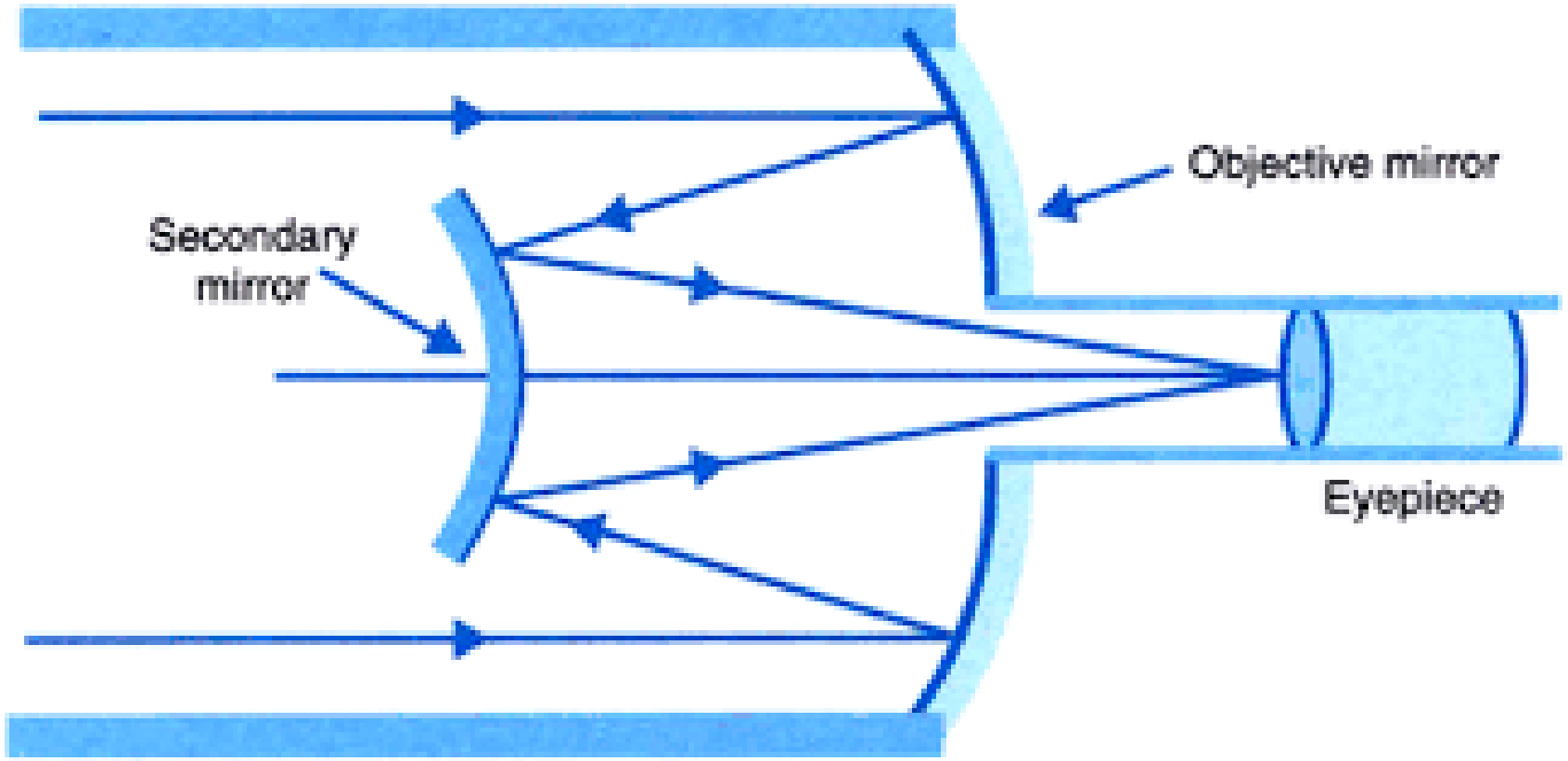


Reflecting Telescopes

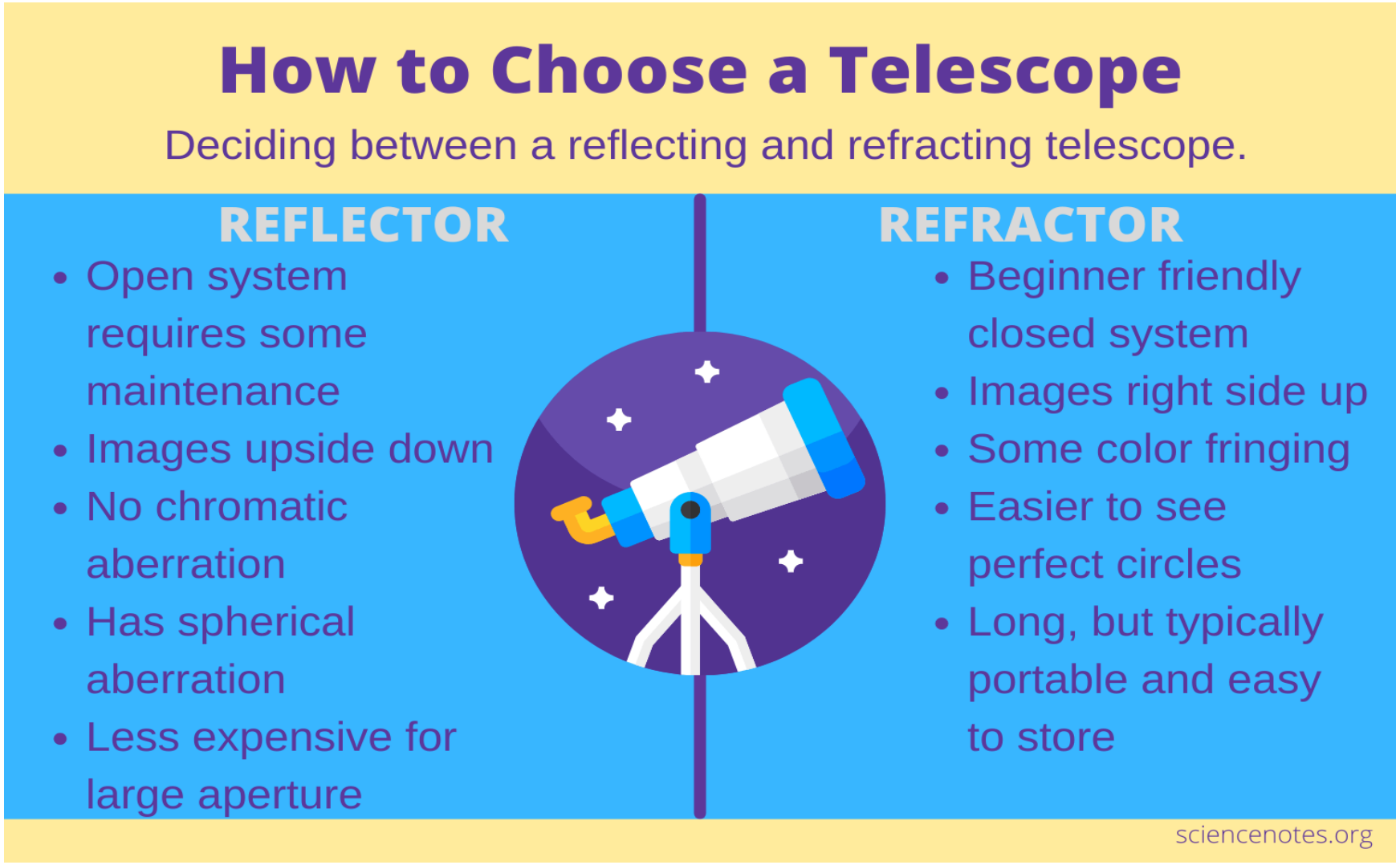
Newtonian Telescope



Cassegrain Telescope

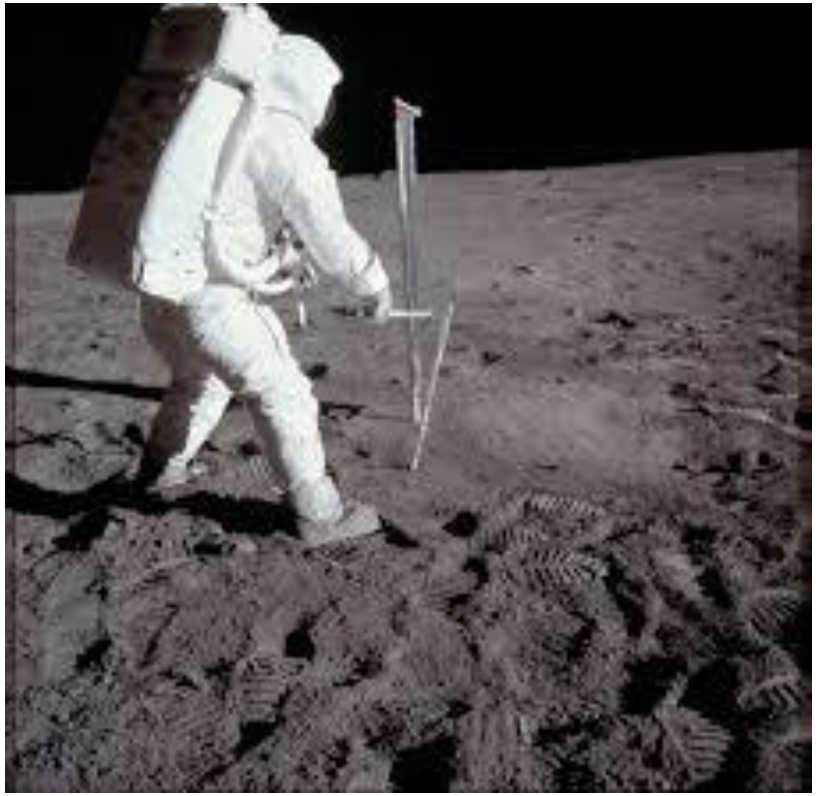


Advantages/Disadvantages

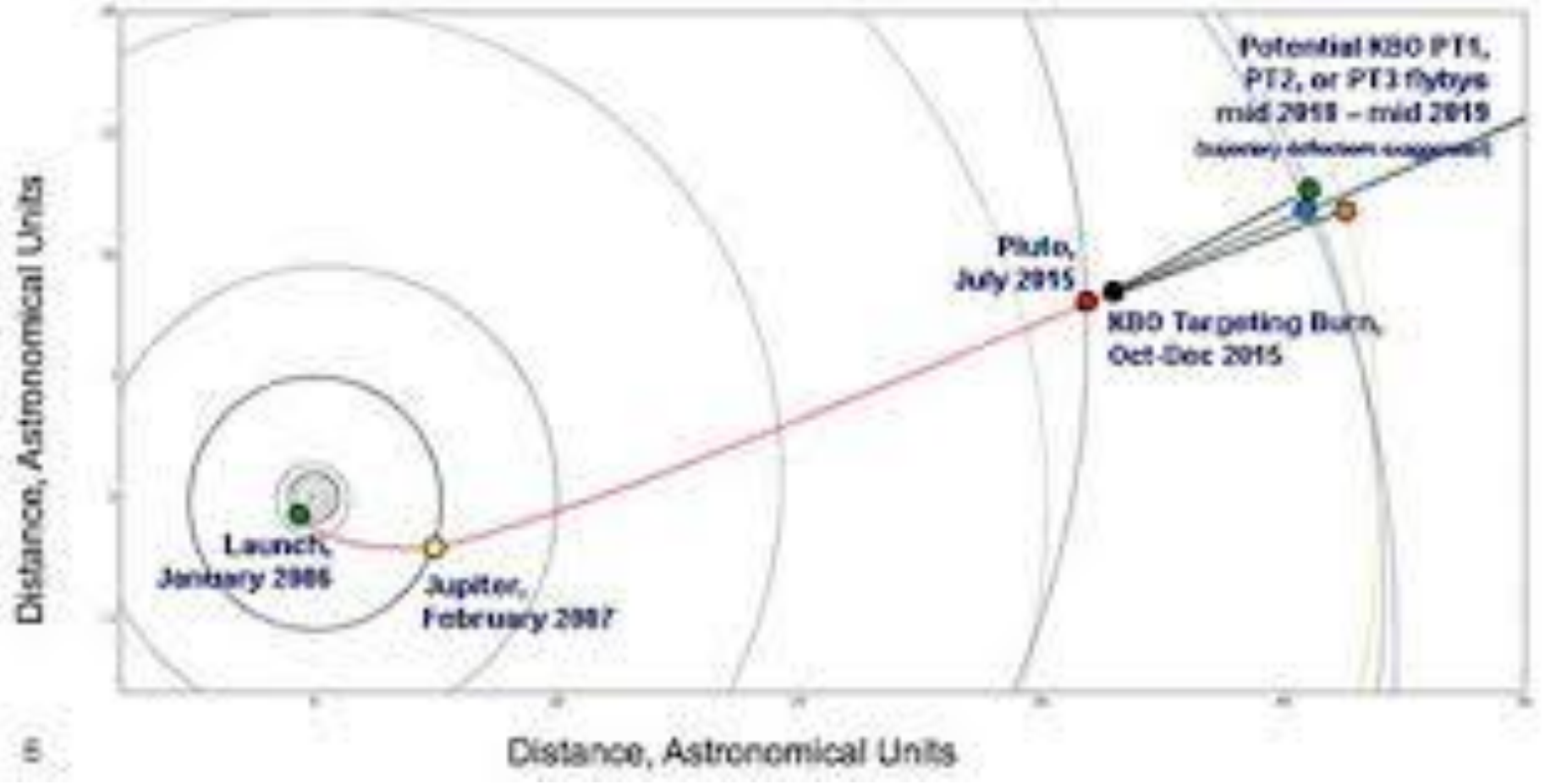


Other ways to explore space

- Manned Missons
  - Apollo
- Space probes
  - Fly-by
  - Impactors
  - Orbiters
  - Landers

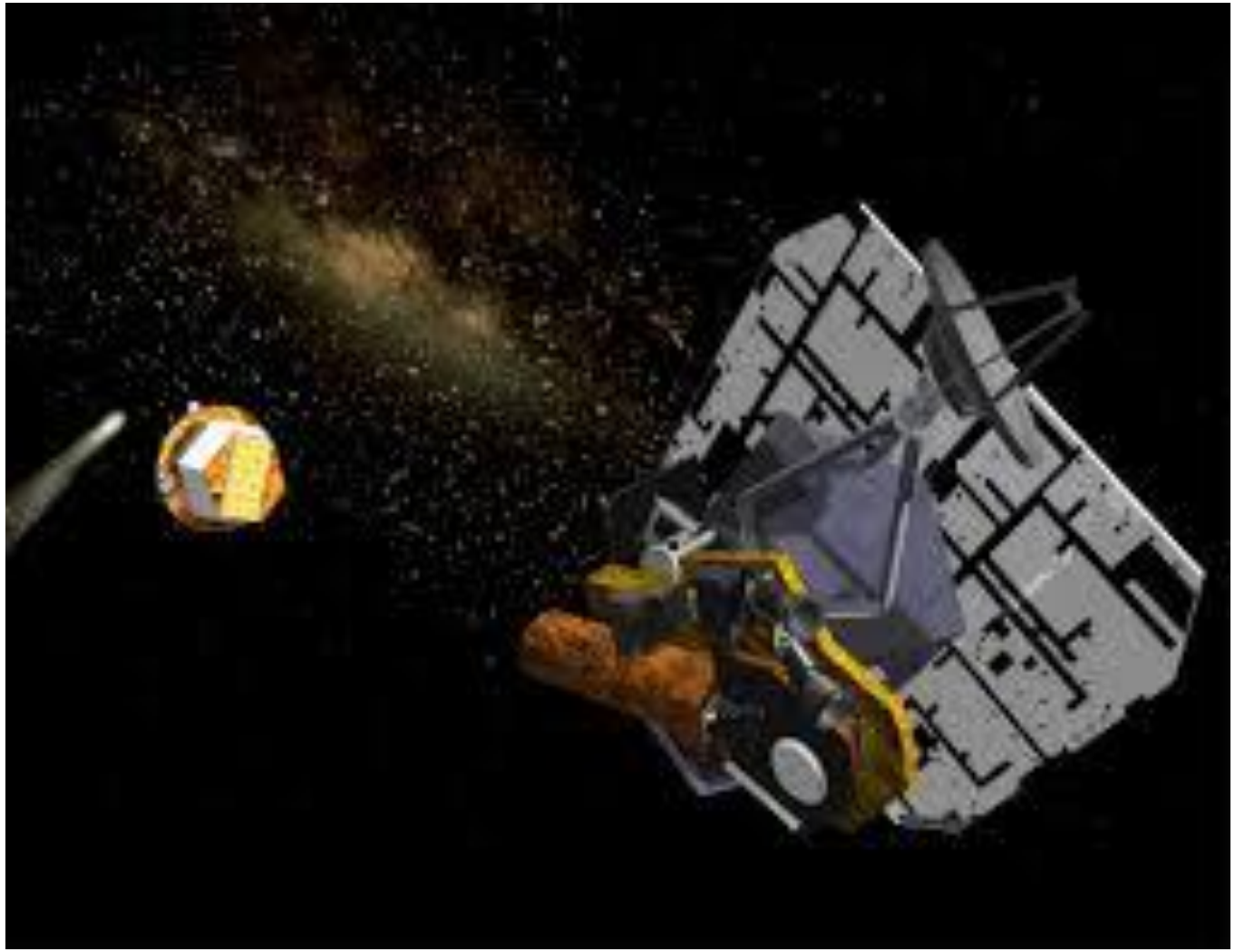


Fly-by – New Horizons



Orbiter – Juno & Dawn

Impactor – Deep Impact



Apollo