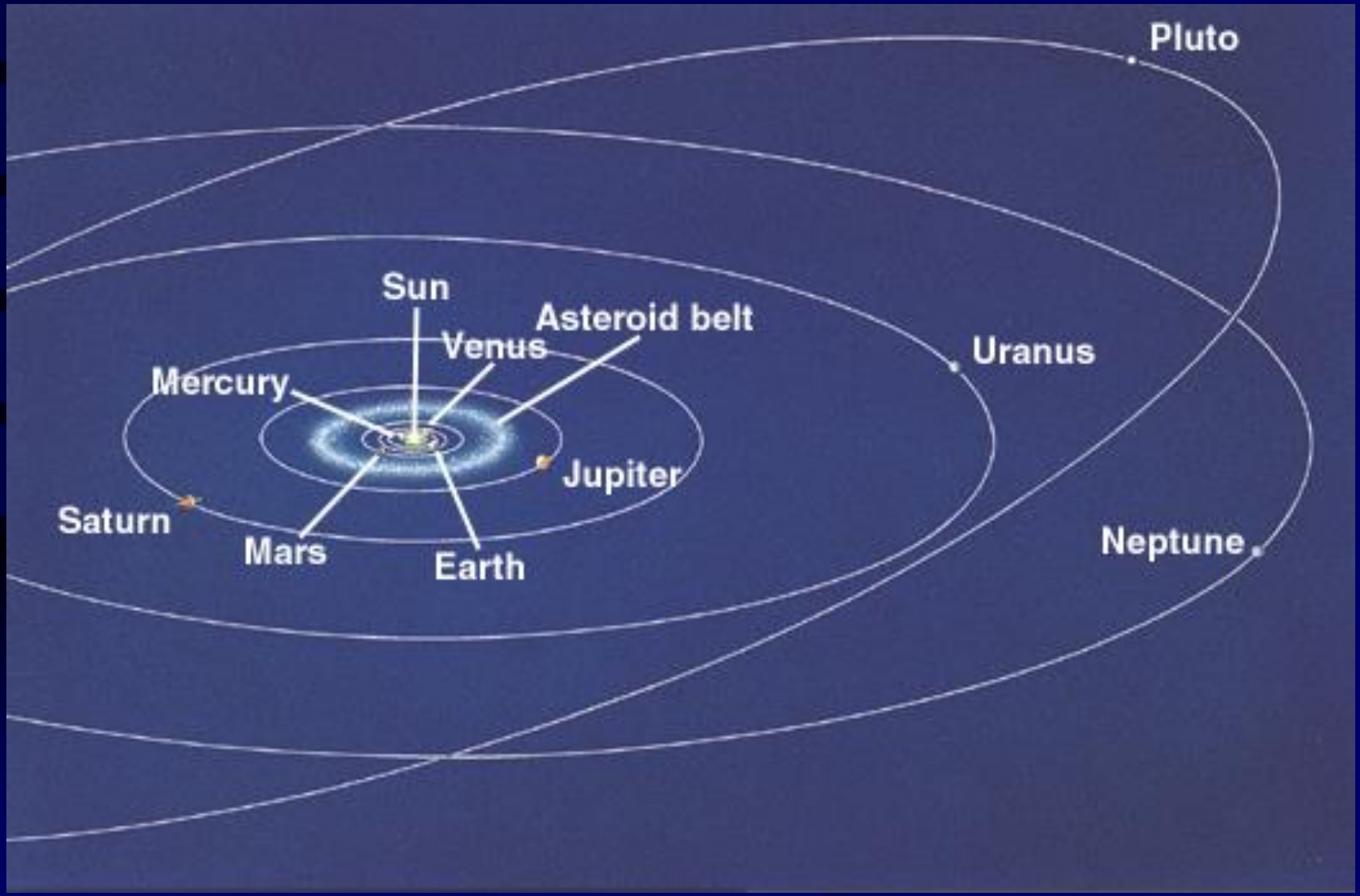
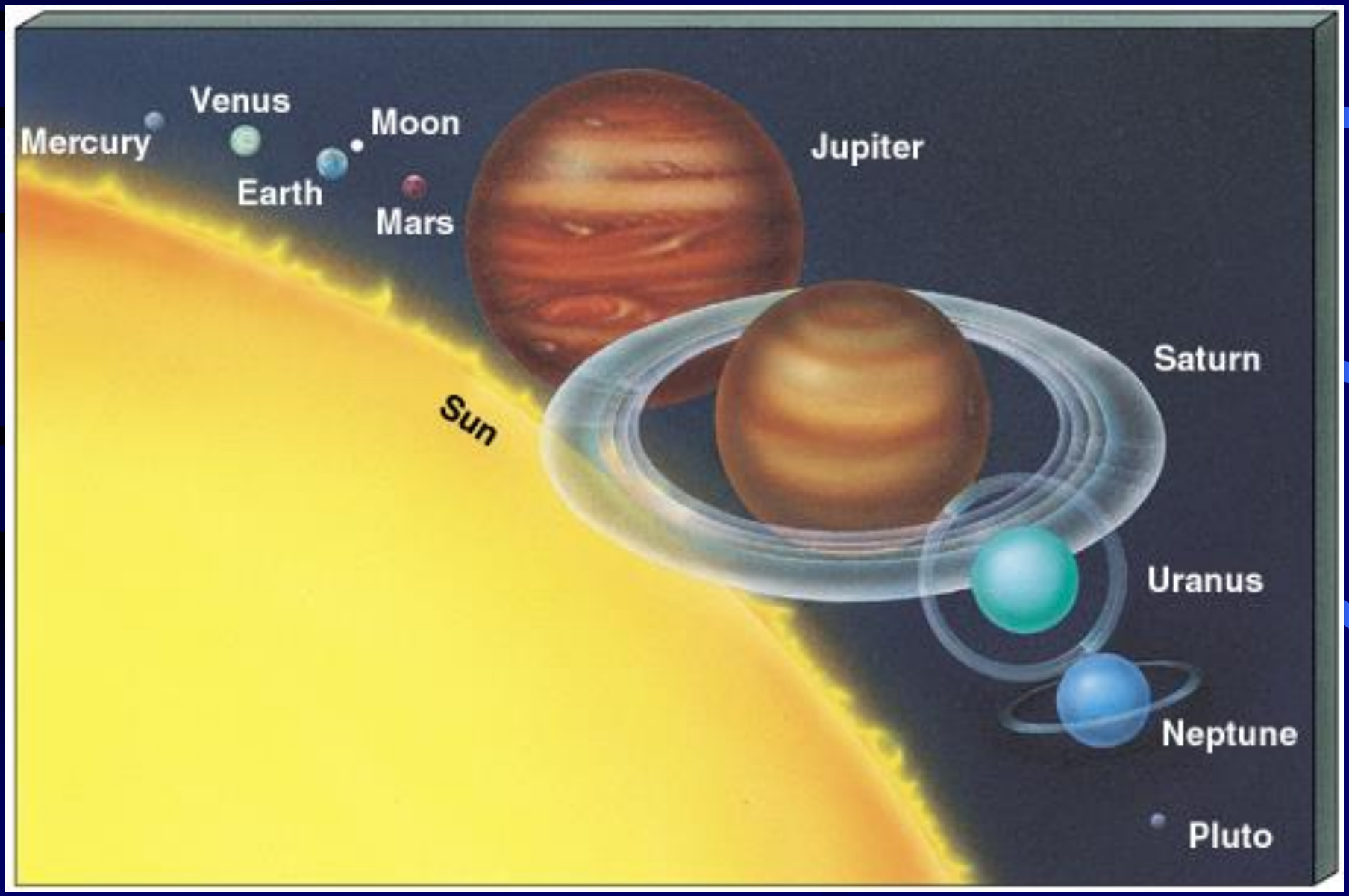
The Solar System



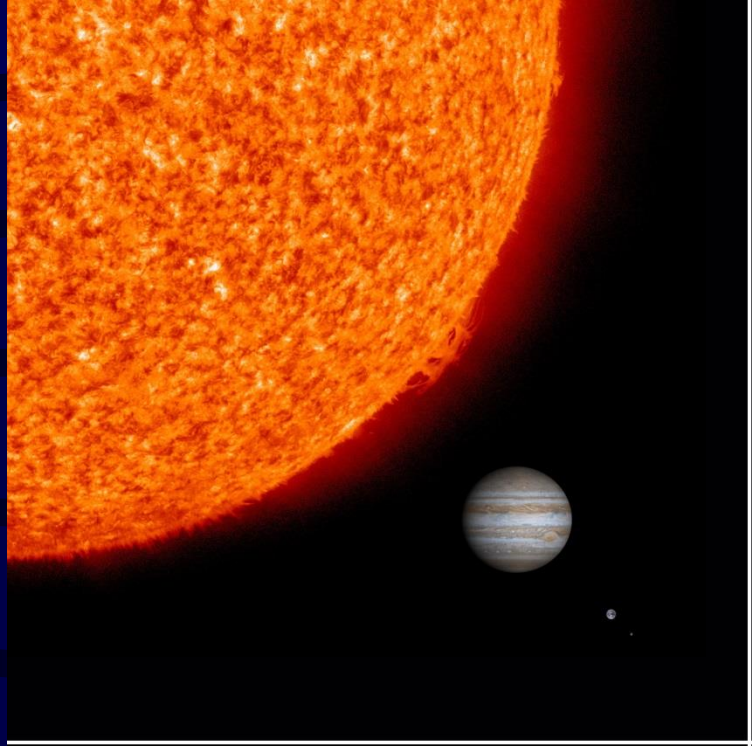
Contents of the Solar System

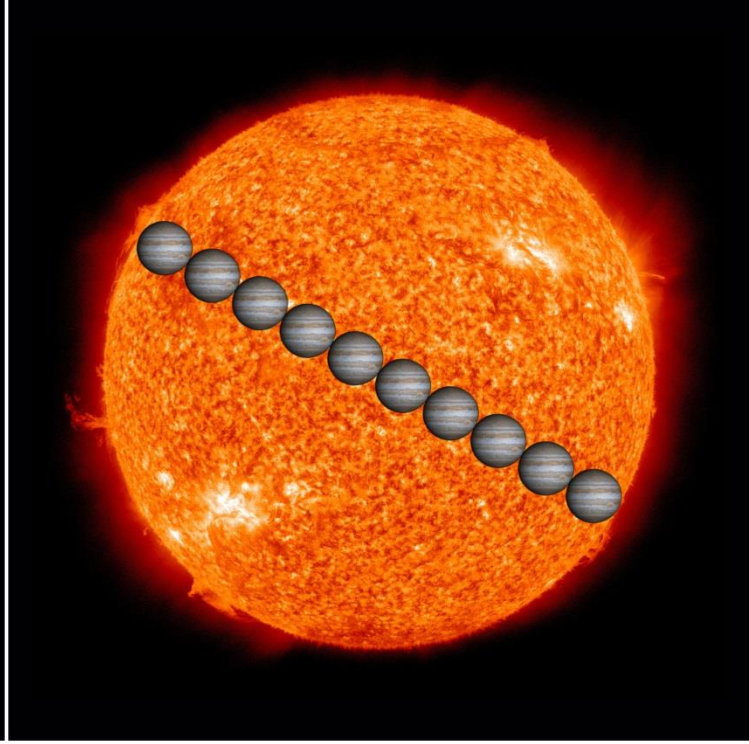
- Sun
- Planets – 9 known (now: 8)
  - Mercury, Venus, Earth, Mars (“Terrestrials”)
  - Jupiter, Saturn, Uranus, Neptune (“Jovians”)
  - Pluto (a Kuiper Belt object?)
- Natural satellites (moons) – over a hundred
- Asteroids and Meteoroids
  - 6 known that are larger than 300 km across
  - Largest, Ceres, is about 940 km in diameter
- Comets
- Rings
- Dust

Size matters: radii of the Planets



Sun: Jupiter: Earth: Moon = 110:11:1:1/4

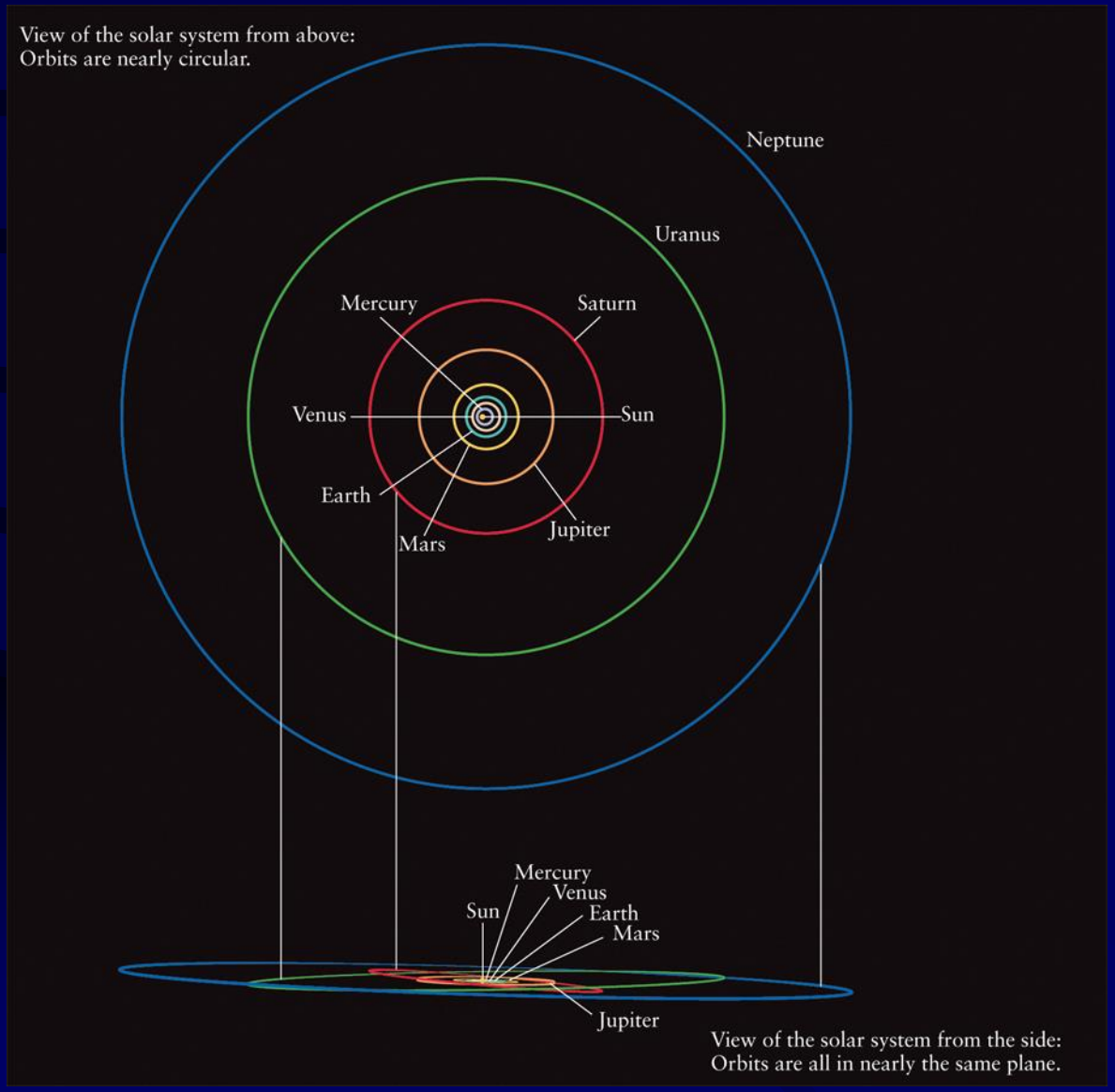




The Astronomical Unit

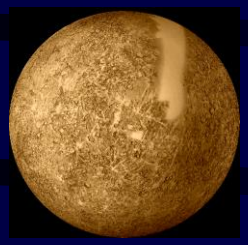
- A convenient unit of length for discussing the solar system is the Astronomical Unit (A.U.)
- One A.U. is the average distance between the Earth and Sun
  - About 1.5×10^8 km or 8 light-minutes
- Entire solar system is about 80 A.U. across

The solar system is a disk, not a sphere

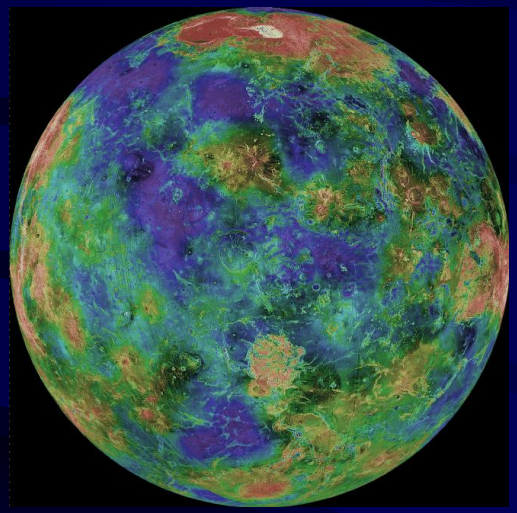


The Terrestrial Planets

- Small, dense and rocky



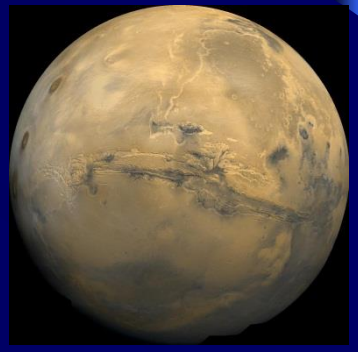
Mercury



Venus

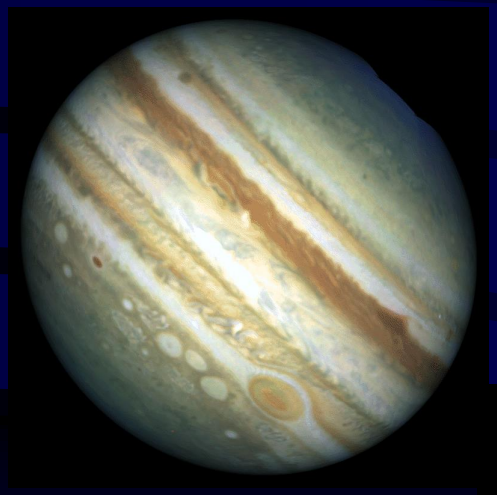
Earth

Mars



The Jovian Planets

- Large, made out of gas, and low density

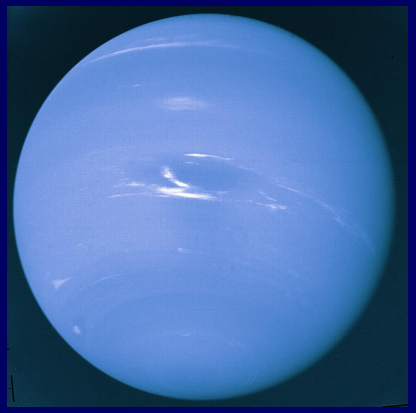


Jupiter

Saturn

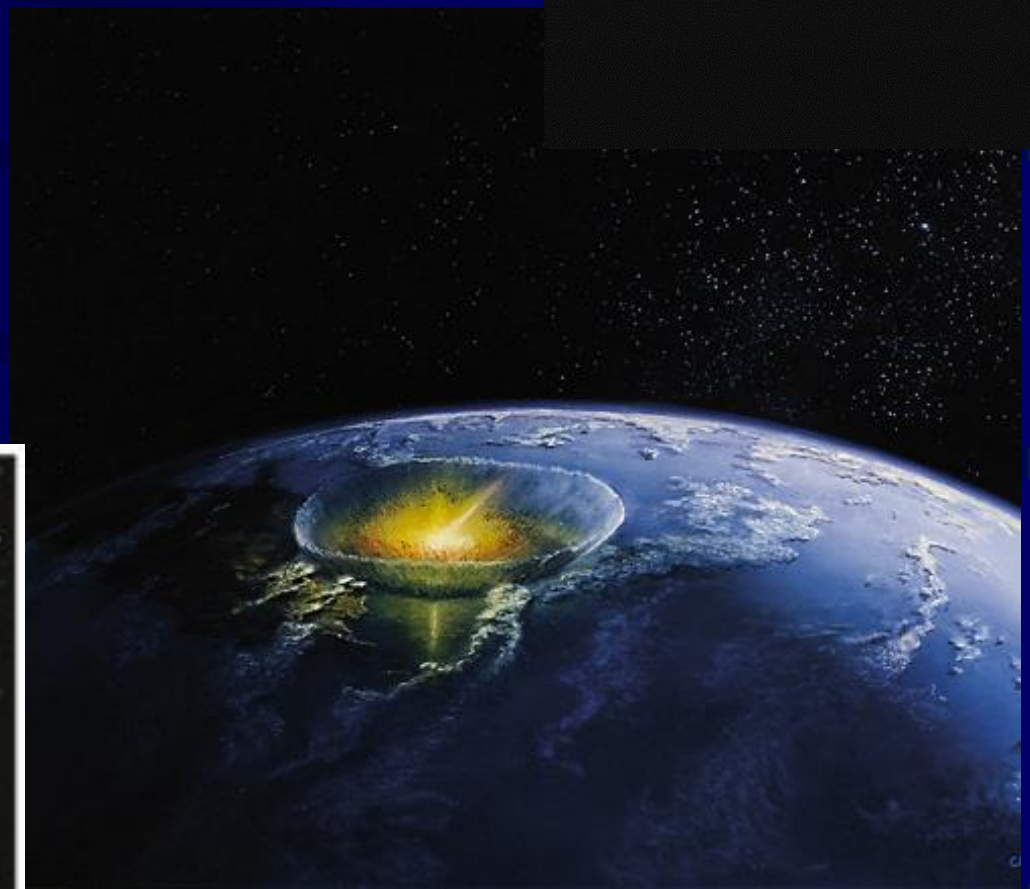
Uranus

Neptune



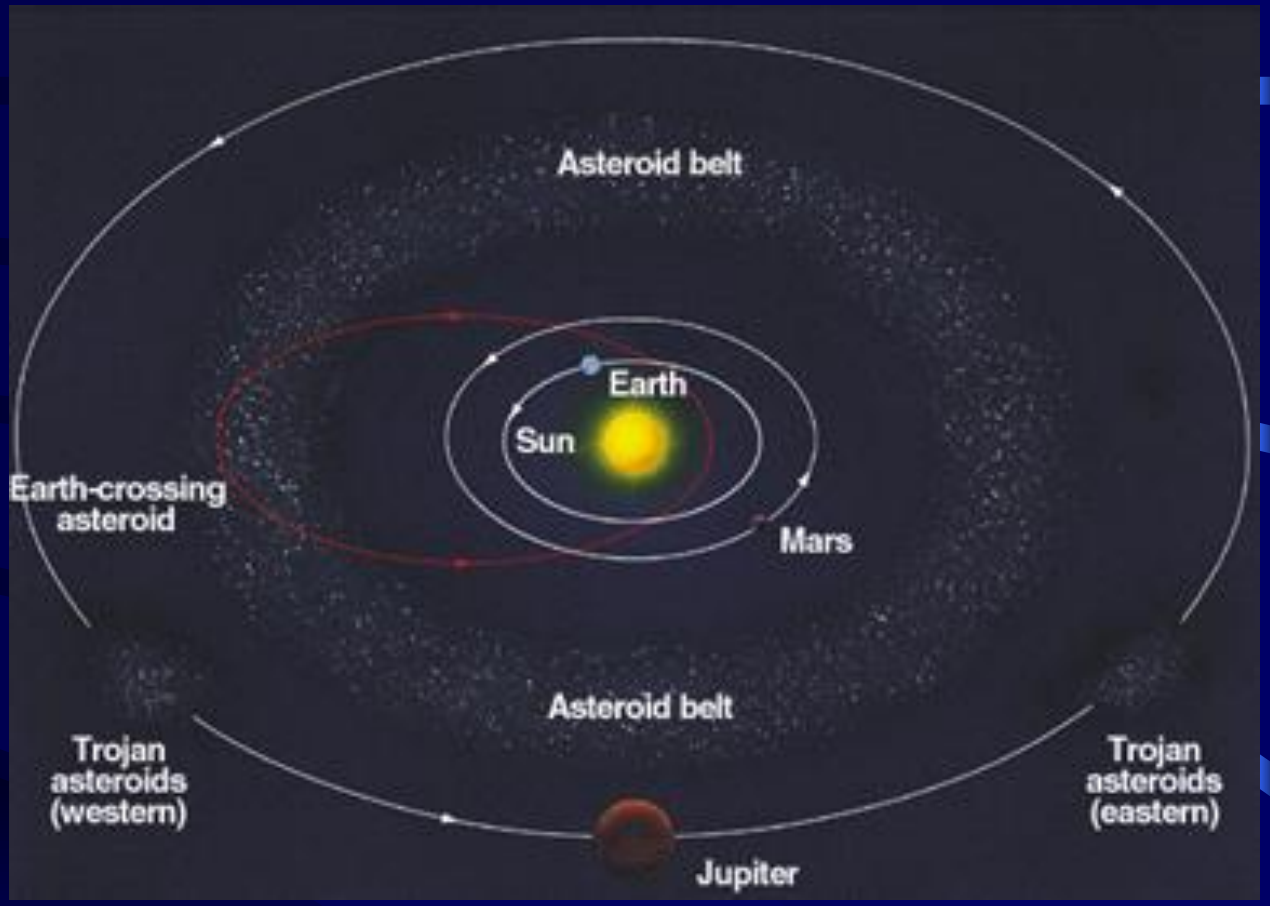
Asteroids, Comets and Meteors

Debris in the Solar System



Asteroids

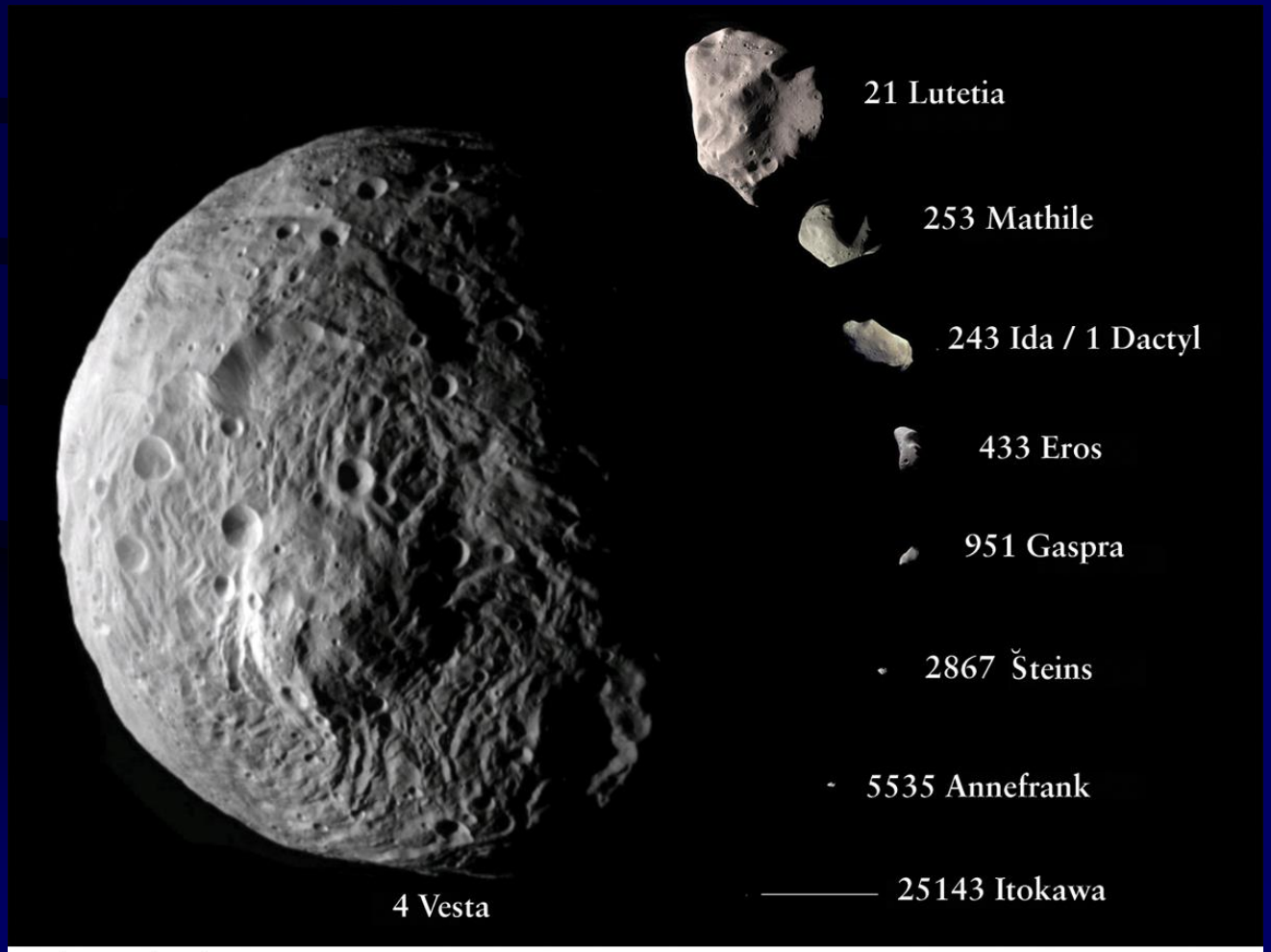
- Most asteroid orbits are situated between Mars and Jupiter



Asteroid Discovery

- First (and largest) Asteroid Ceres discovered New Year's 1801 by G. Piazzi, fitting exactly into Bode's law: a=2.8 A.U.
- Today more than 100,000 asteroids known
- Largest diameter 960 km, smallest: few km
- Most of them are named
- about 20 of them are visible with binoculars

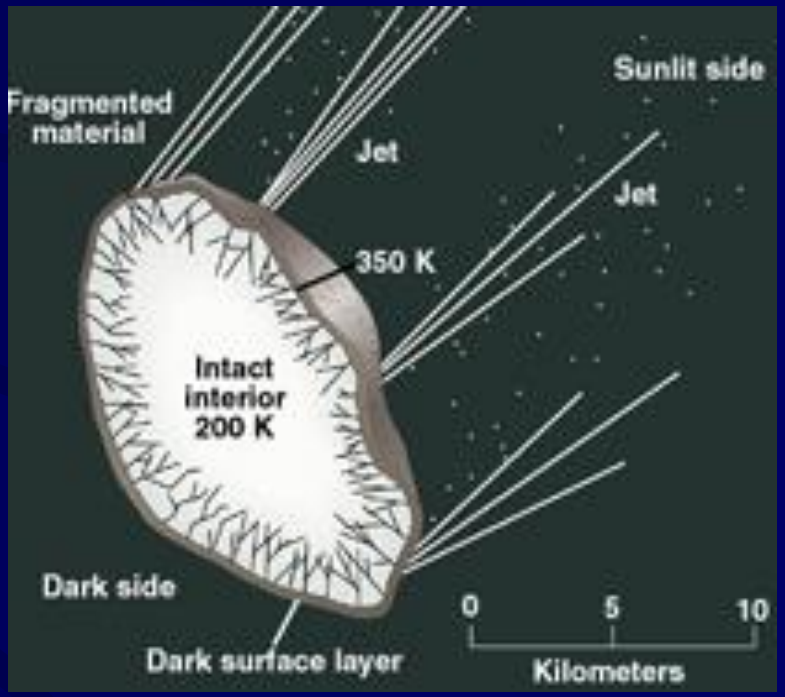
Most asteroids are very small



NASA/JPL-Caltech/JAXA/ESA

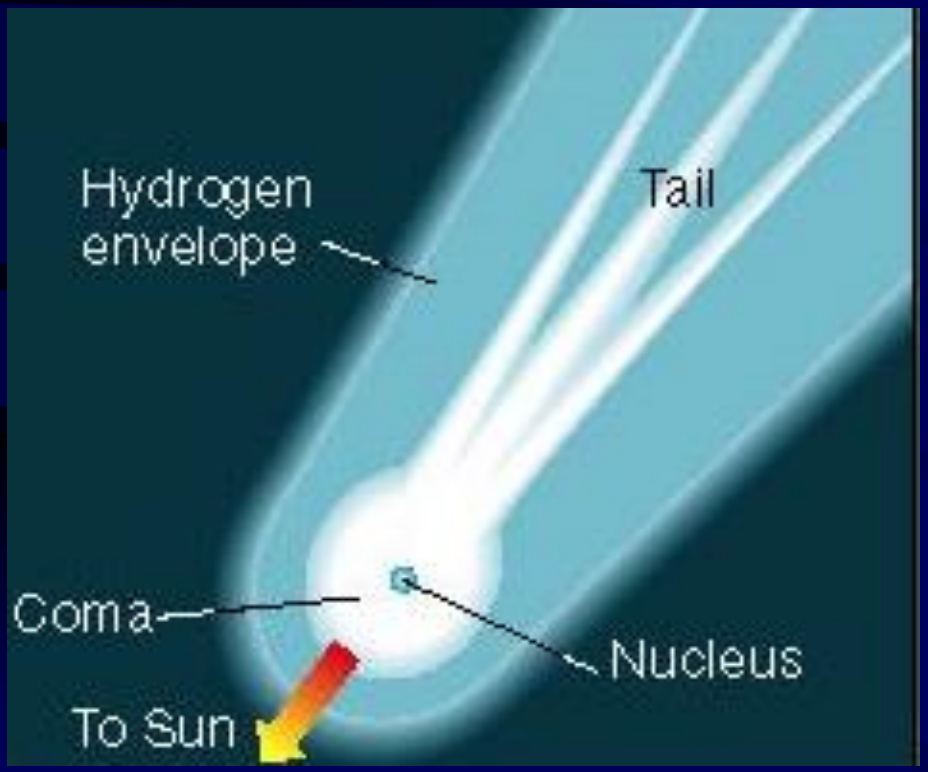
Comets - Traveling Dirty Snowballs

- Small icy bodies, “dirty snowballs”
- Develops a “tail” as it approaches the Sun



Comet Anatomy

- Tail may be up to 1 A.U. long
- Ion tail points away from sun



Shapes

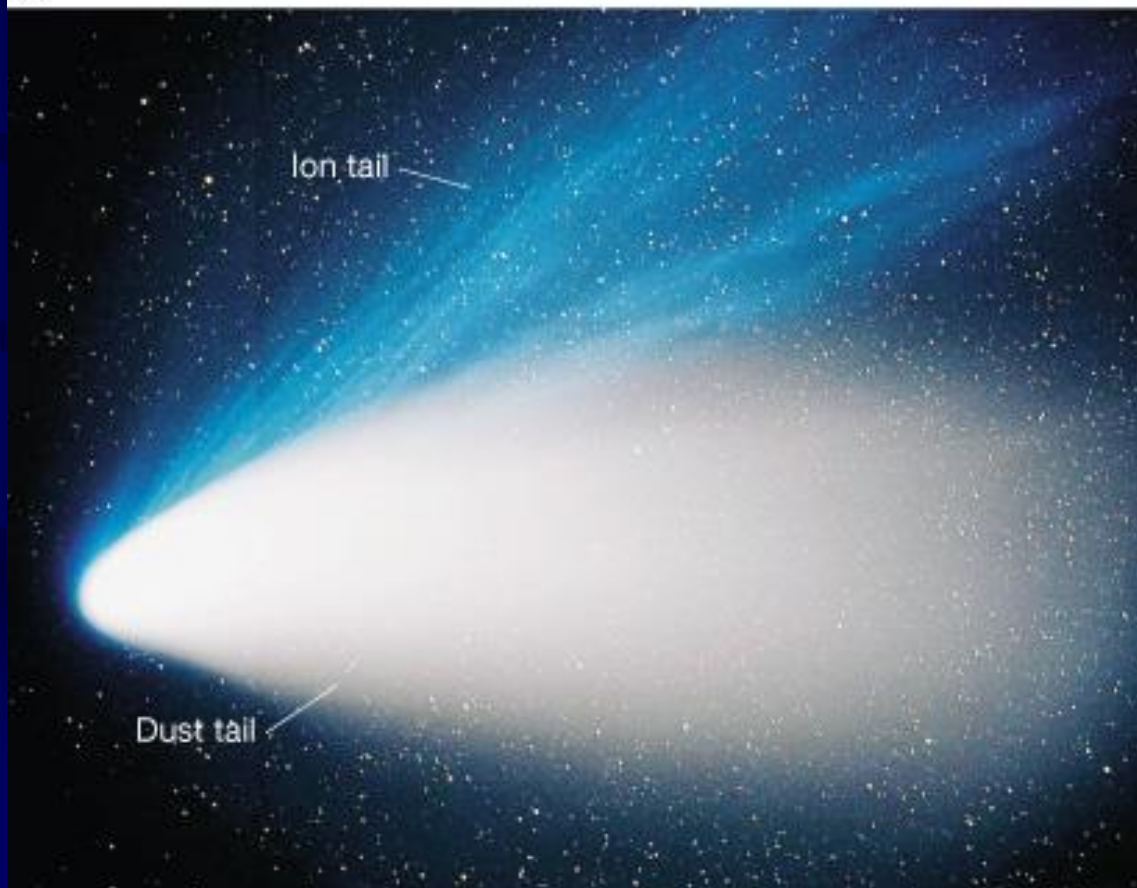
Comet **Giacobini-Zinner** (1959)

- Ion tail 500,000 km long
- Coma: 70,000 km across

(a)

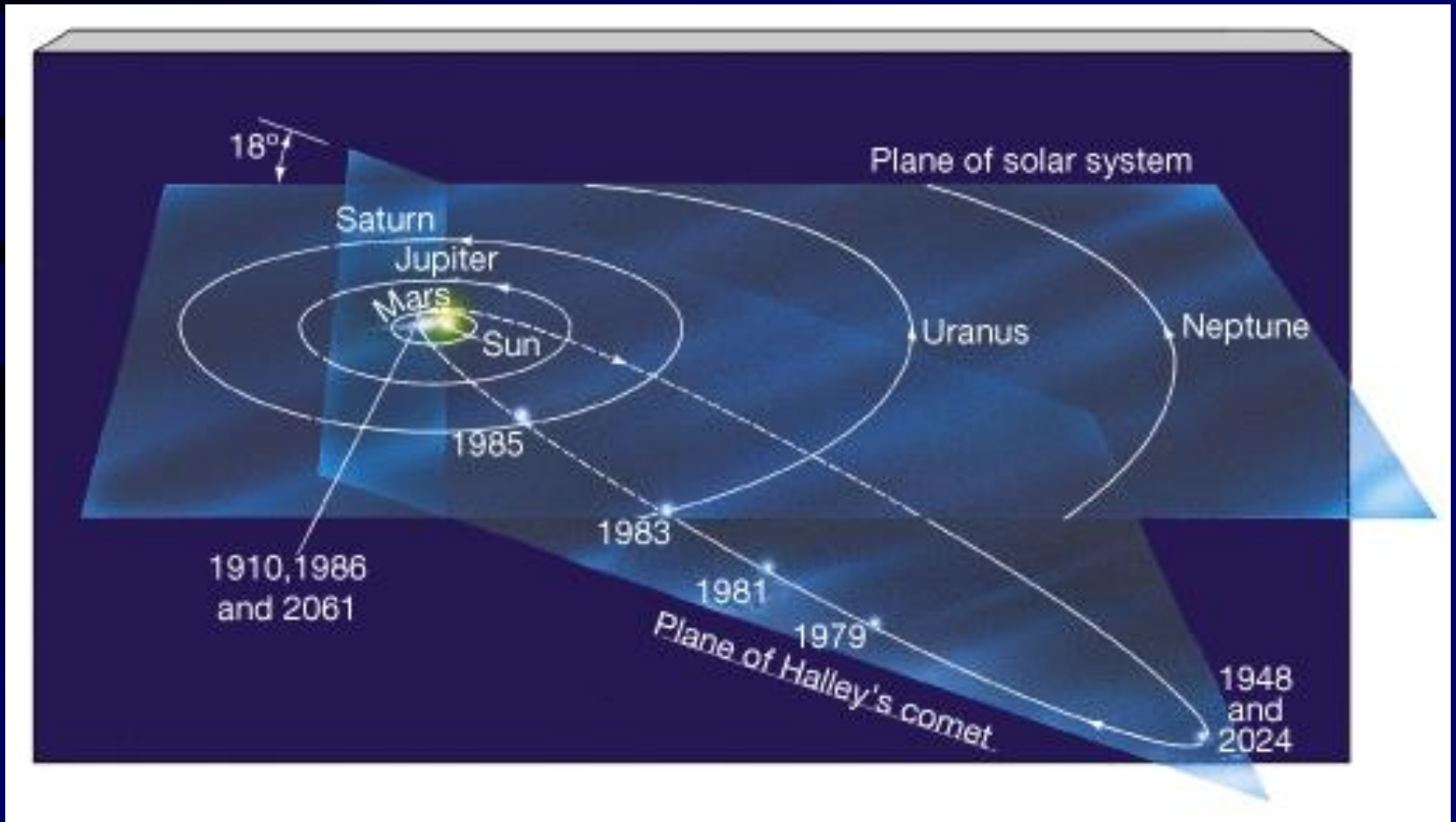
Comet **Hale-Bopp** (1997)

- Tail 40° long as seen from earth



Halley's Comet – a typical Comet

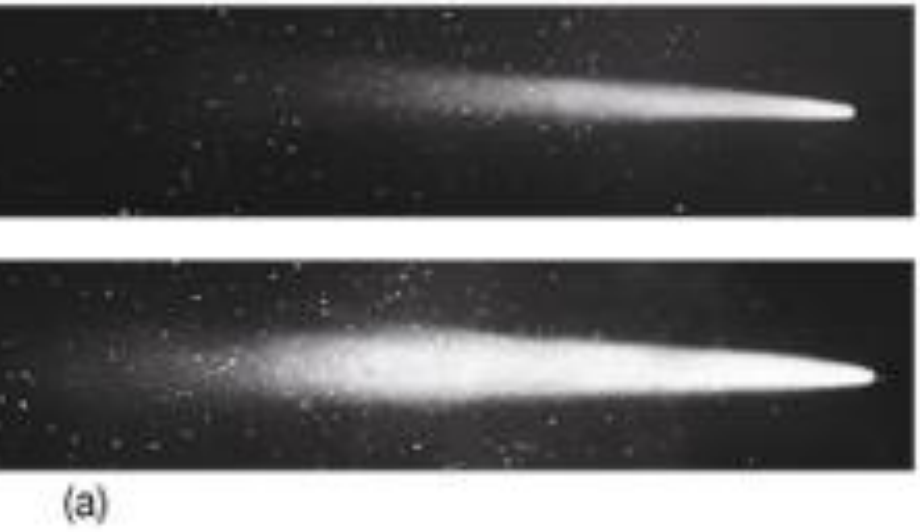
- Highly eccentric orbit, inclined substantially



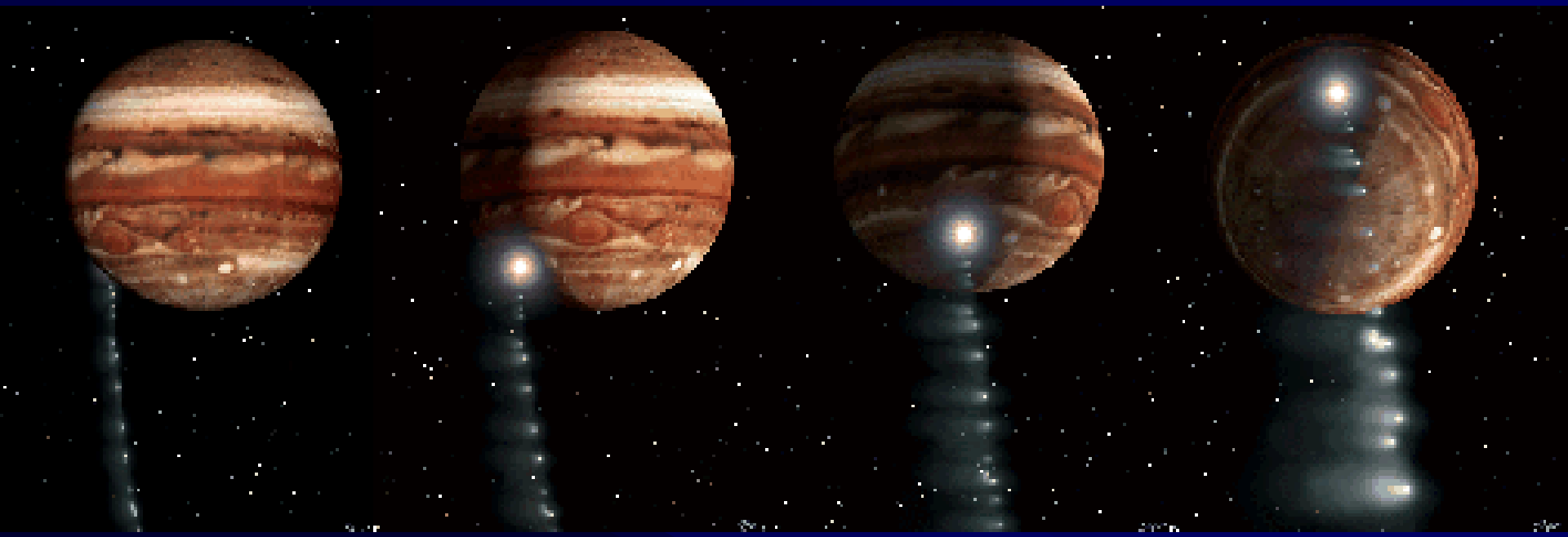
Halley's Comet – Now and then

- Halley's Comet in **1910**
- Top: May 10, 30° tail
- Bottom May 12, 40° tail

- Halley's Comet in **1986**
  - March 14, 1986

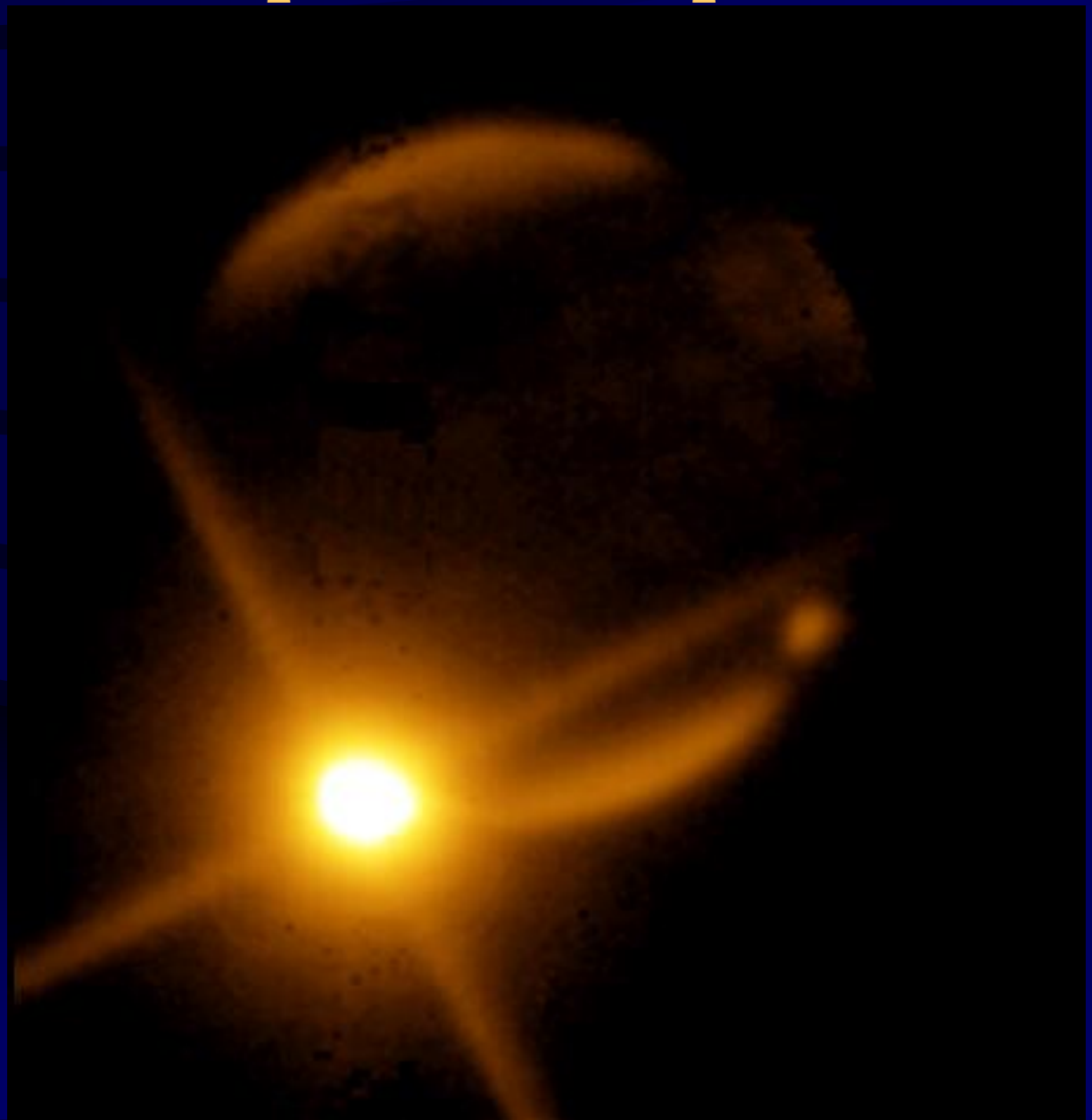


Comet Shoemaker-Levy 9



Headed for Jupiter…

Impact on Jupiter

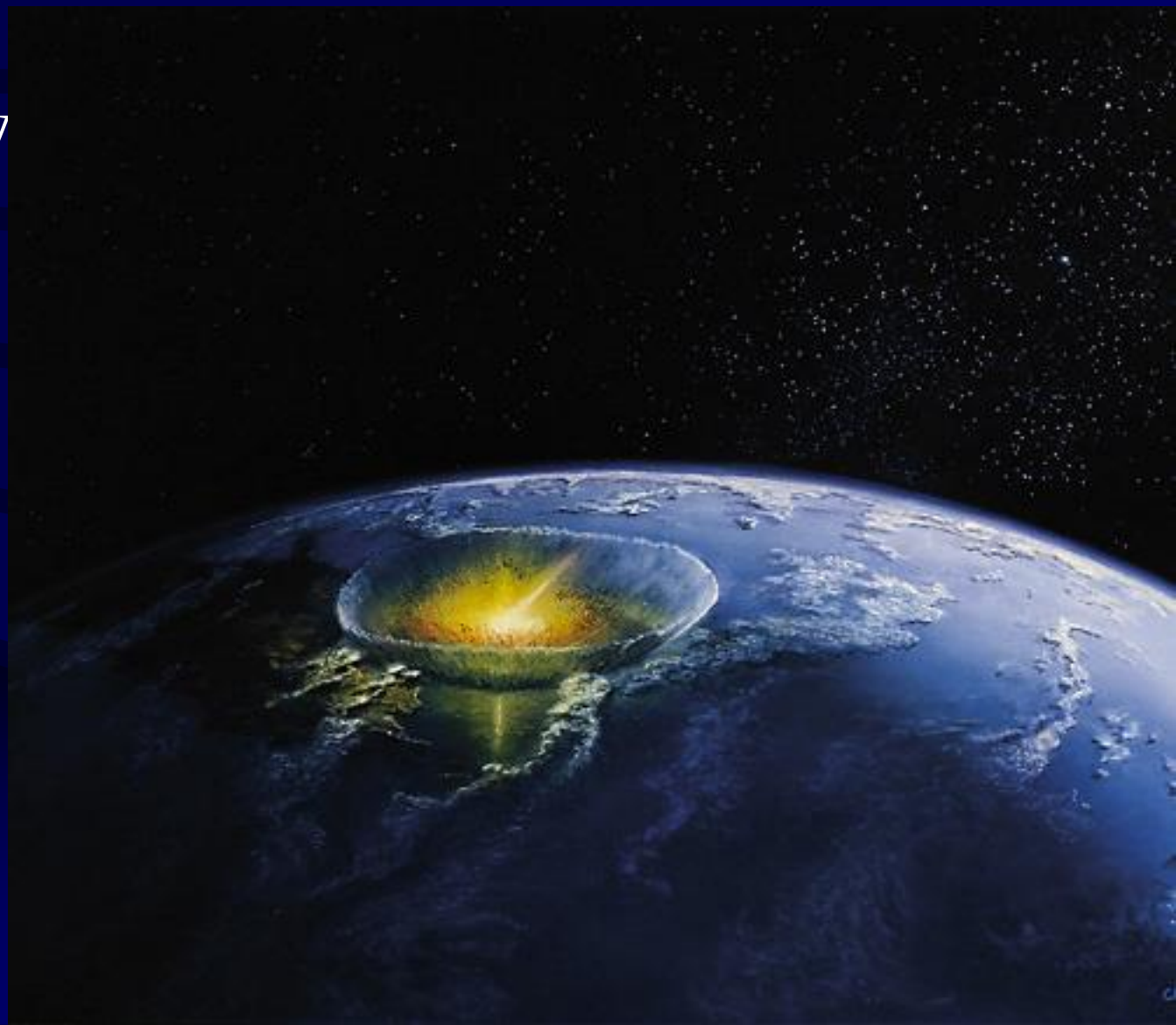


Meteor Showers – caused by comets

Radiant	Duration
Quadrantids (QUA)	Dec. 28-Jan. 7
Lyrids (LYR)	Apr. 16-25
Eta Aquarids	Apr. 21-May 12
Beta Taurids	June 30
Delta Aquarids	July 25-31
Perseids (PER)	Aug. 10-14
Draconids	Oct. 6-10
Orionids (ORI)	Oct. 15-29
Taurids	Oct.12- Dec 2
Leonids (LEO)	Nov. 14-20
Geminids (GEM)	Dec. 6-19

Impact on Earth

- Most probably caused the extinction of the dinosaurs



Impact Craters

- Barringer Crater, AZ 0.8 mi diameter, 200 yd deep; produced by impact about 25,000 years ago

- Quebec's Manicouagan Reservoir. Large meteorite landed about 200 million years ago. The lake, 45 miles in diameter, now fills the ring.

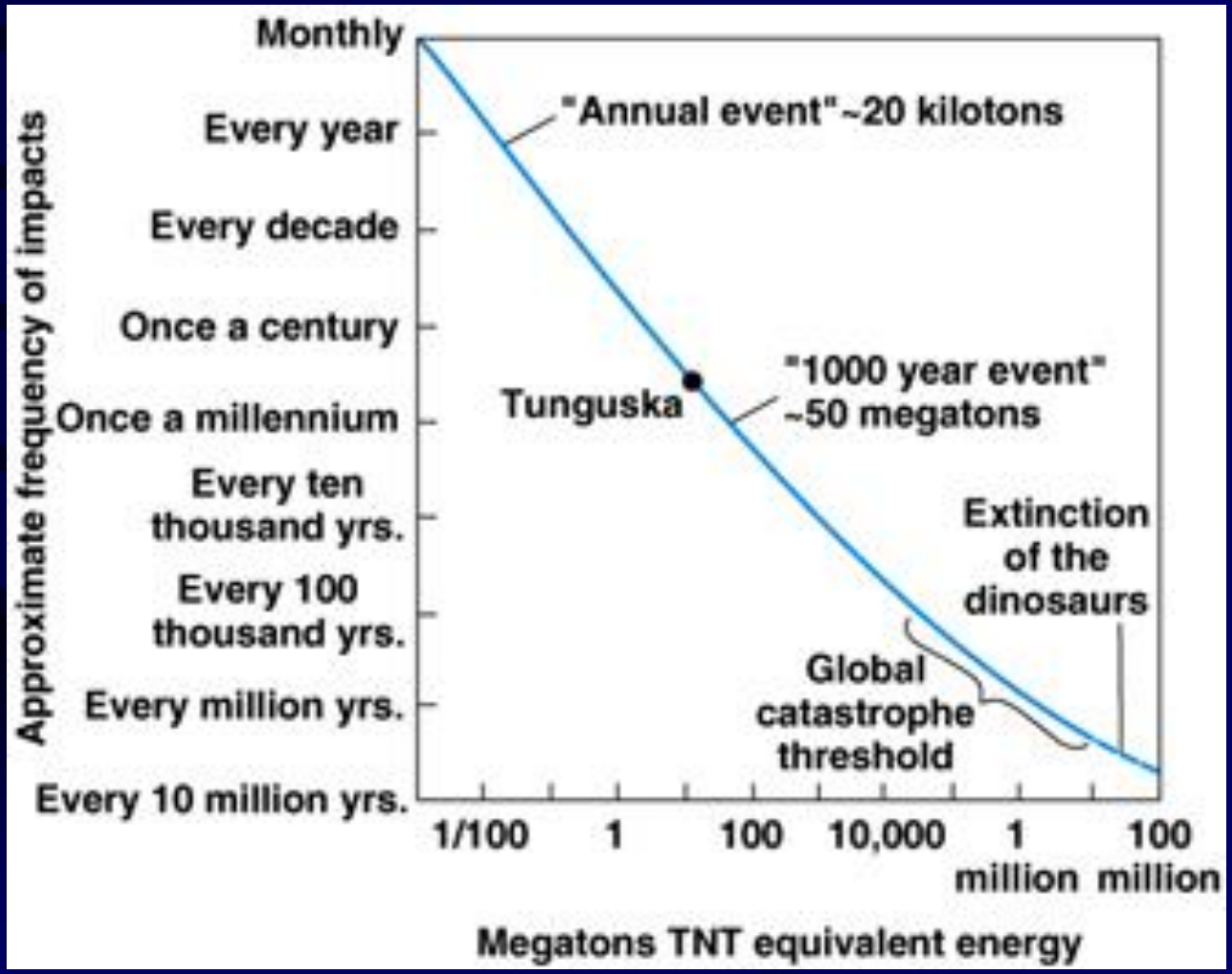
Tunguska

- ~30 m body struck Siberia in 1908
- Energy equal to that of a 10 Megaton bomb!
- Detonation above ground; several craters

2013: Siberia Again!

- 1000 people injured as 20m rock strikes
- Explodes about 20km overhead
- 16 hours before known non-fatal asteroid encounter

Frequency of Impact Events



The Earth-Moon System

Earth/Moon radius: **¼**

Earth/Moon mass: **1/81**

Earth-Moon distance:

384,000 km

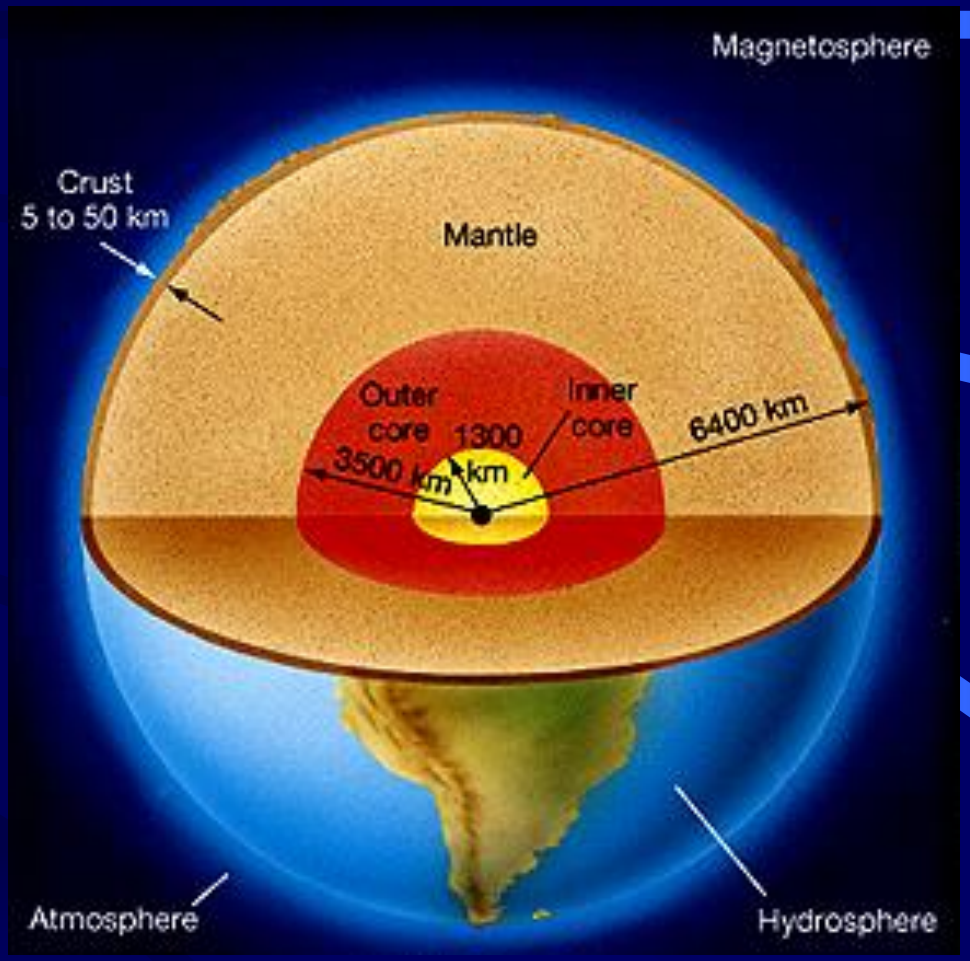
Features of the Earth & Moon

- Mass: Earth: 6×10^{24} kg — Moon: 1/81 Earth's
- Radius: Earth: 6400 km — Moon: 1/4 Earth's ra
- Density: Earth: 5500 kg/m^3 — Moon: 3300 kg/m^3
  - 5.5 times that of water
  - About 2 times that of a rock
- Gravity: Earth: 9.8 m/s^2 — Moon: 1/6 Earth's gravity

(about the same as in water)

Structure of the Earth

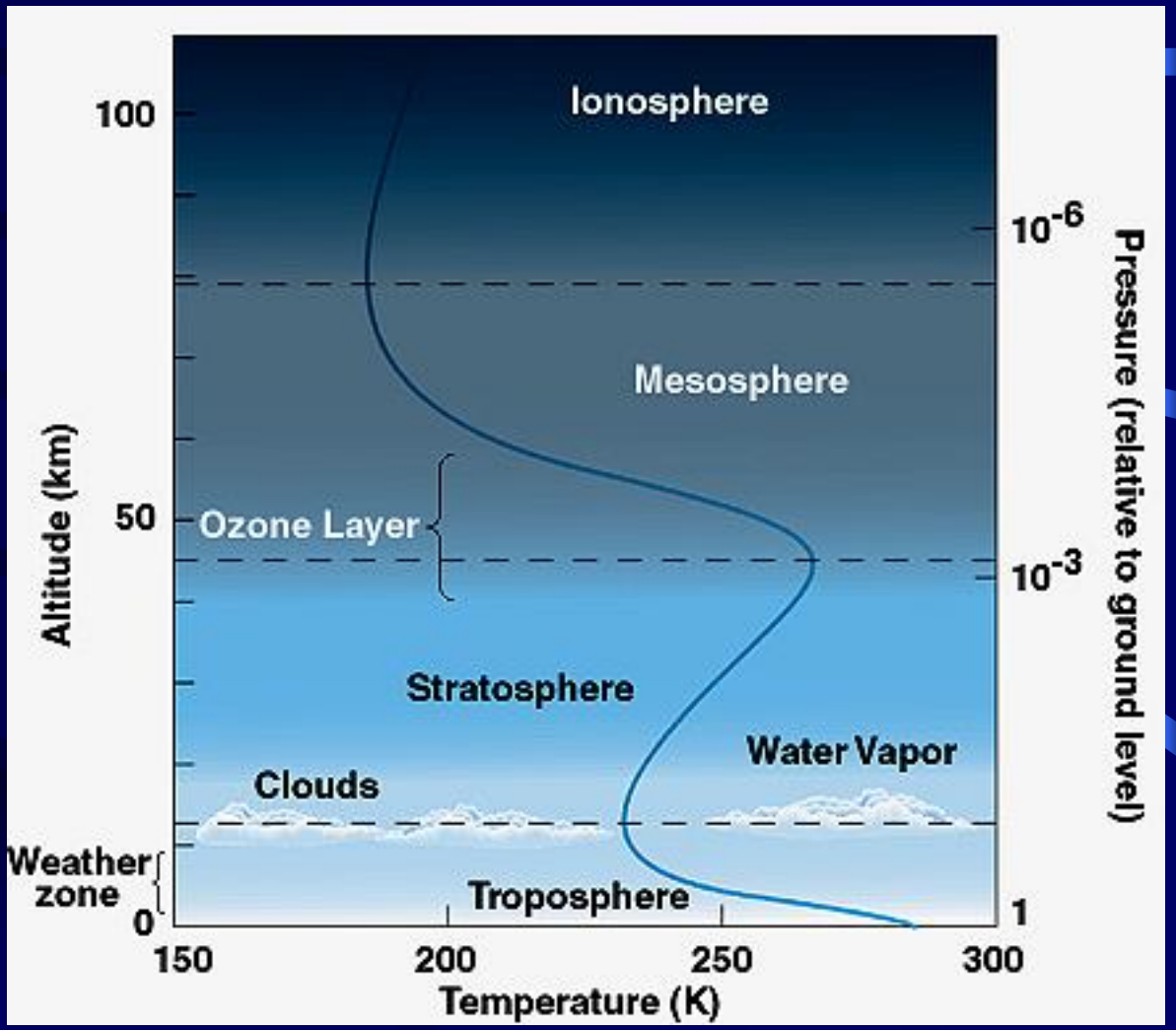
- Core
  - Mostly iron and nickel
  - Inner core solid, outer core liquid
- Mantle
  - Mostly basalt, a heavy mineral containing iron and magnesium
  - Soft; can flow even though it is solid rock
- Crust
  - Solid surface layer; “floats” on the mantle



- Density and temperature both increase with depth

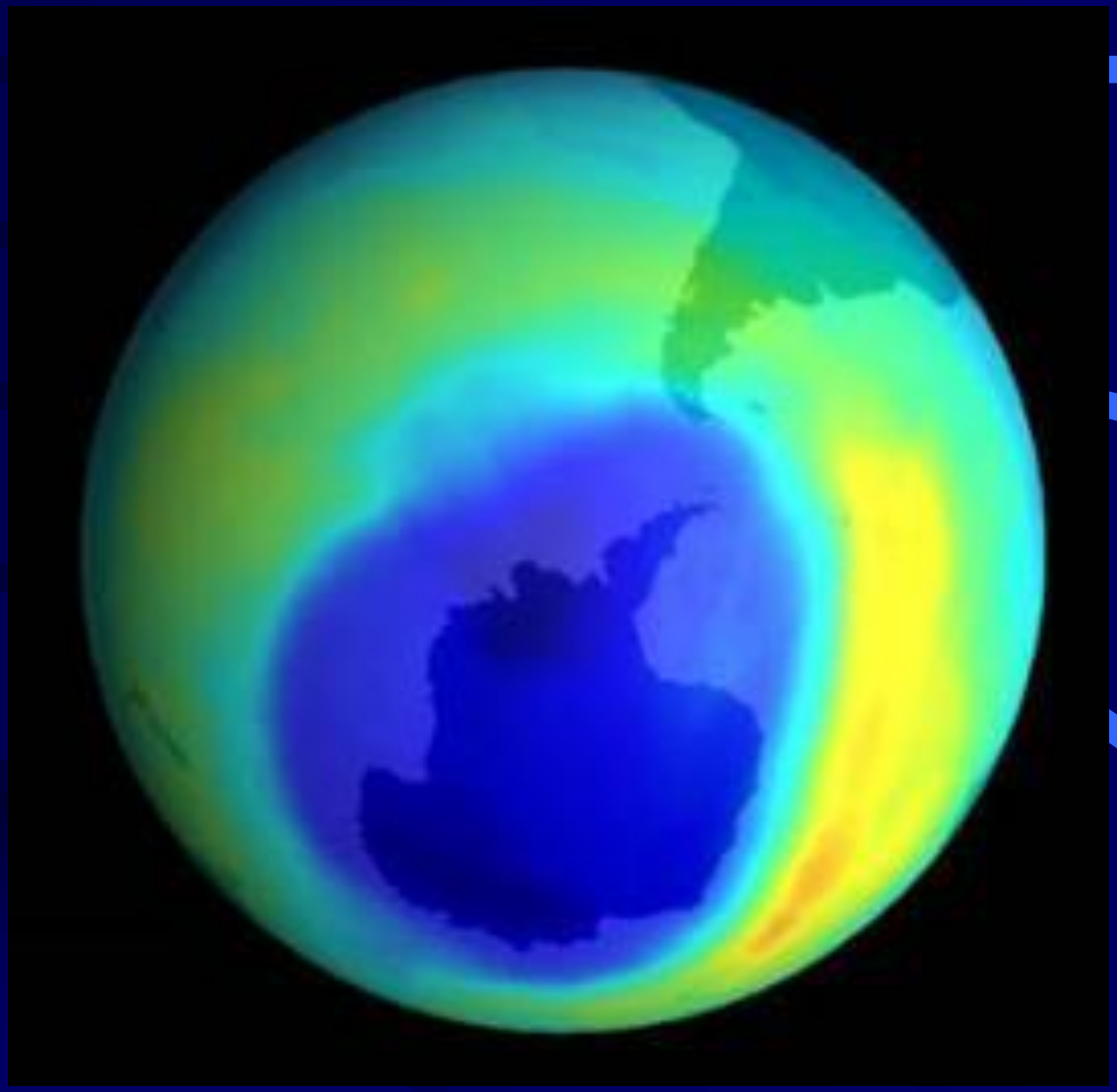
Earth's Atmosphere

- 78% Nitrogen, 21% Oxygen, 1% Other
- Troposphere – region of weather
- Stratosphere – stable and calm
- Ionosphere – gases charged by interaction with radiation from space



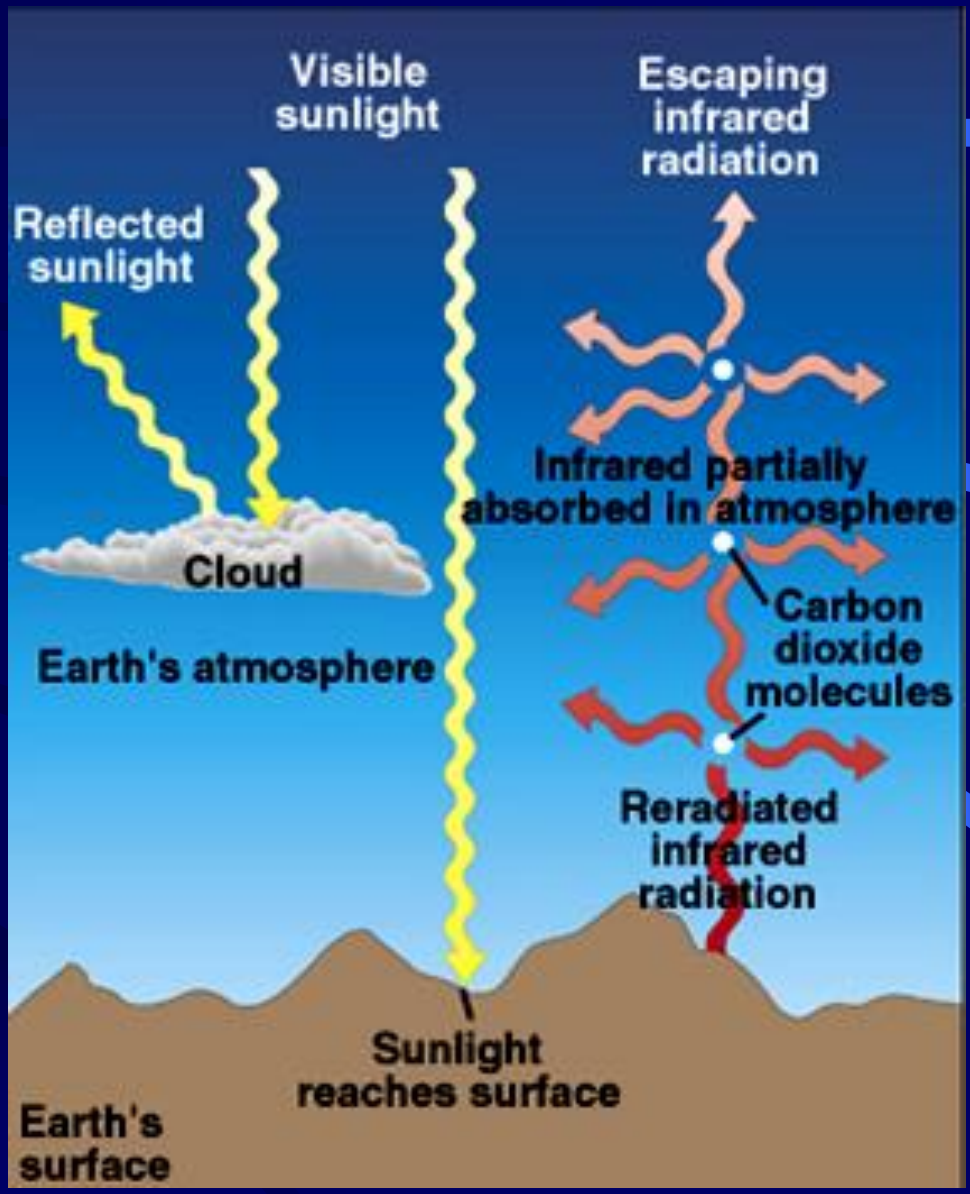
Ozone Layer (O_3)

- Absorbs most UV radiation from the Sun
- Hole over Antarctic
  - *Chlorofluorocarbons* (CFC's) – released by spray cans, refrigerators



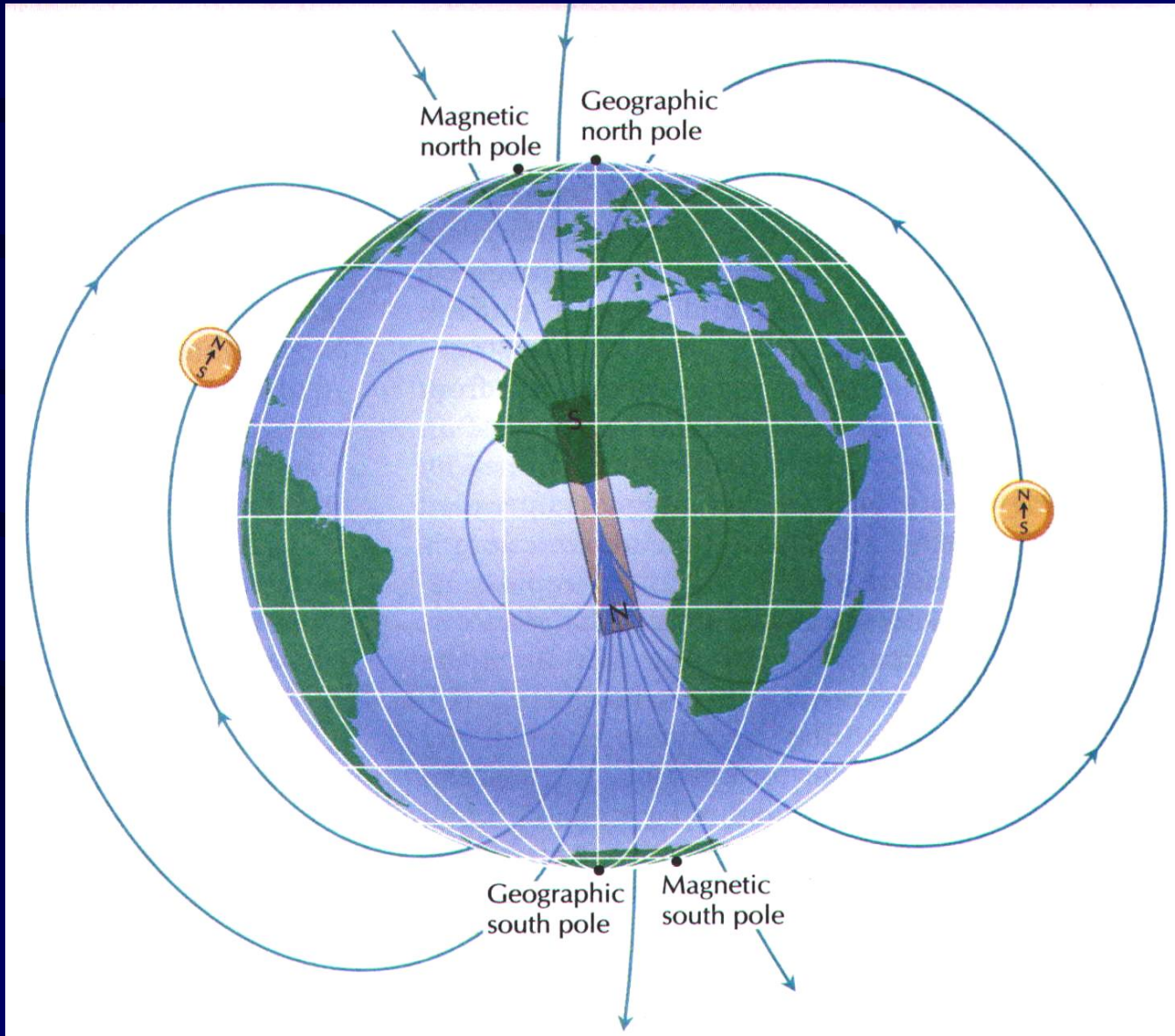
Greenhouse Effect

- Earth absorbs energy from the Sun and heats up
- Earth re-radiates the absorbed energy in the form of infrared radiation
- The infrared radiation is absorbed by carbon dioxide and water vapor in the atmosphere



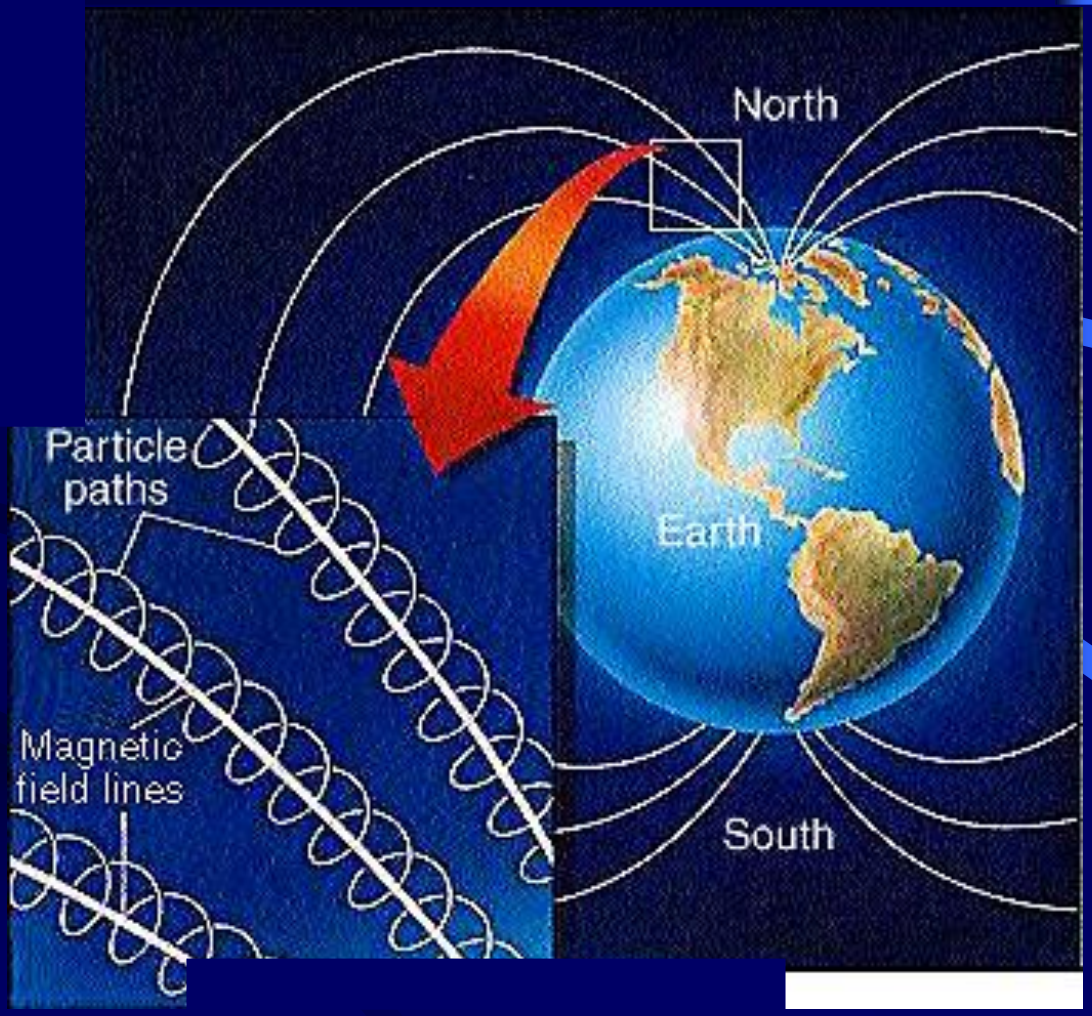
Magnetosphere

- Magnetic north pole about 7° west of geographic north pole
- Driven by motion of molten metals in core



Magnetic field/shield: Motion of Charged Particles

- Charged particles "trapped" by magnetic fields
- Origin of the Van Allen radiation belts
- Protects us!



Aurora Borealis from Space