

# Plan

- Questions?
- Syllabus; administrative details
- Some Definitions
- An Idea of Scale

# The Sun and its Planets

## ASTR 101 - Spring 2019

### Prof. Stacy McGaugh

stacy.mcgaugh [at] case.edu  
Sears 573  
368-1808

TA Ray Garner  
crg56 [at] case.edu  
Sears 561  
368-3896

TA Tiffany Visgaitis  
txv64 [at] case.edu  
Sears 572  
368-3537

Time: Tu Th 11:30 AM - 12:45 PM  
Room: TBA

### Textbook

*The Cosmic Perspective*  
*The Solar System*  
Eighth edition

Bennett, Donahue, Schneider, & Voit



Jupiter up close, as seen by Juno

---

## Syllabus

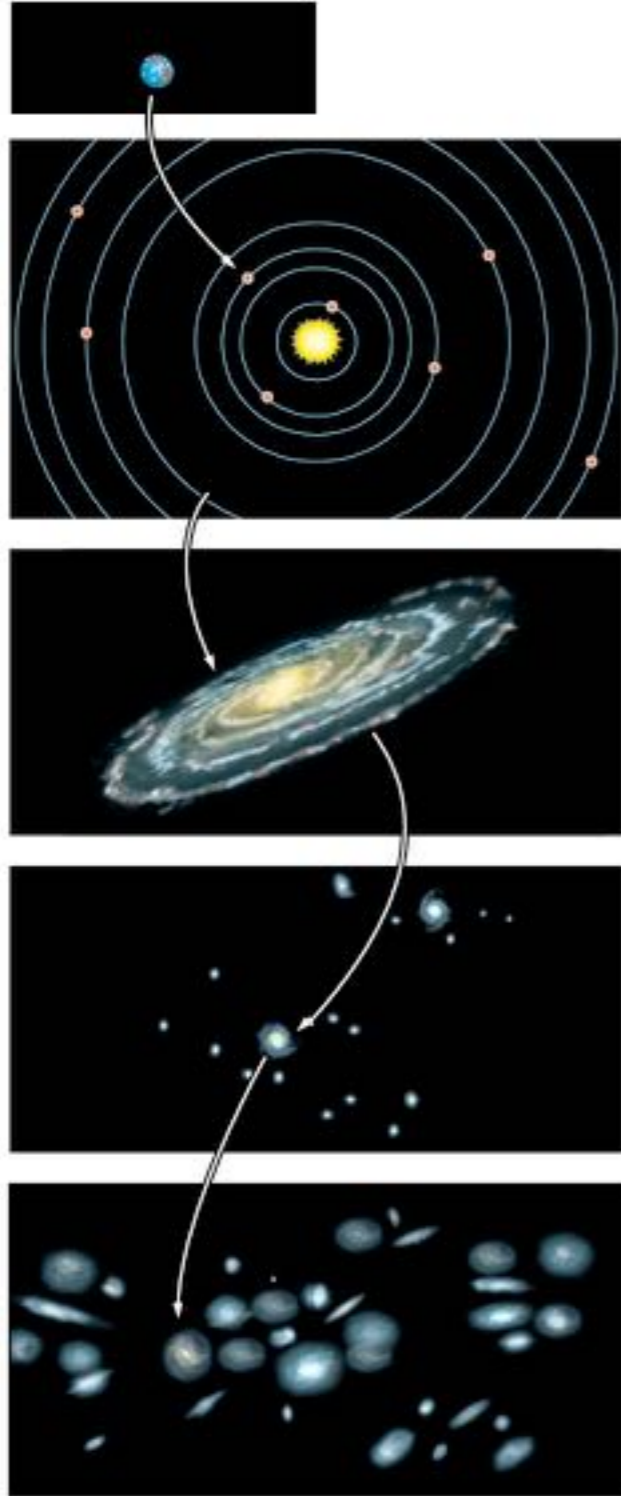
- Course Description
- Lecture Schedule including links to pdf files of lecture slides
- Learning Outcomes
- Grades
- Assignemnts and Exams
- Homework
  
- PDF syllabus

All material available from

<http://astroweb.case.edu/ssm/astr101/>

which is the primary document for the course (not Canvas).

# Our Place in the Universe



Earth is a small planet,

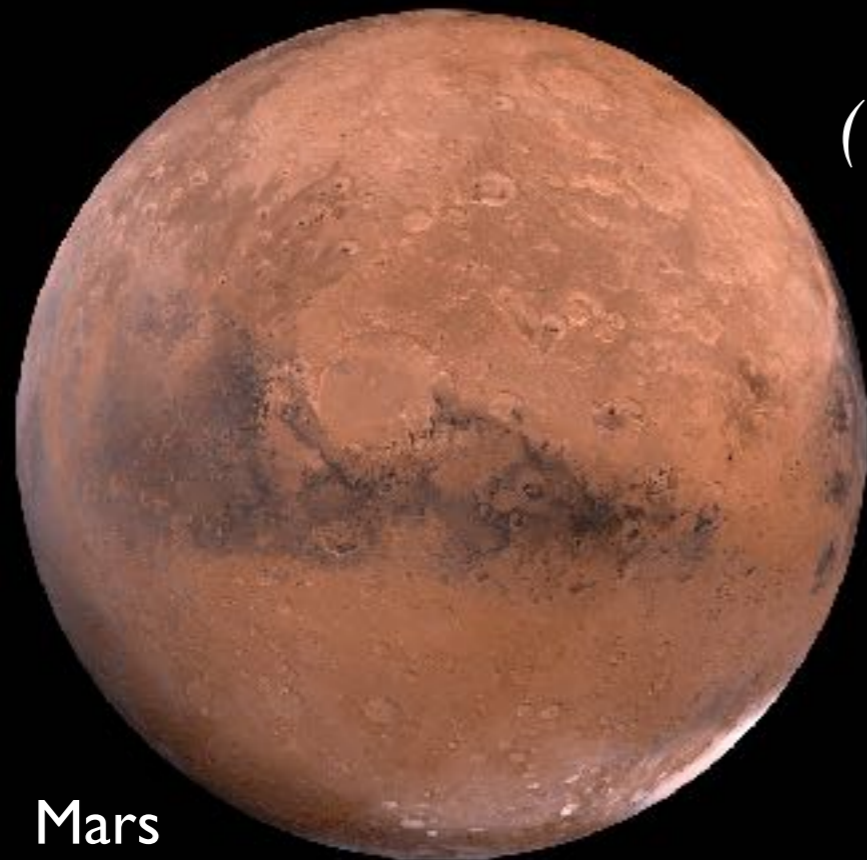
orbiting a medium-sized star,

in a galaxy of 100 billion stars,

which is just one of billions of galaxies,

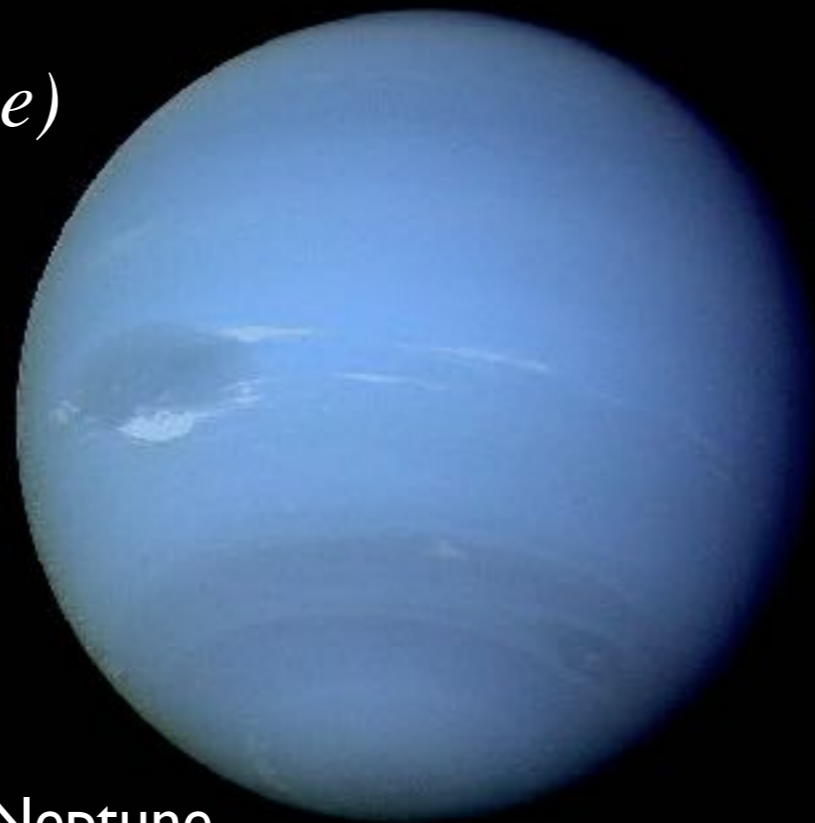
in a universe that is ~14 billion years old.

# Planet



Mars

*(not to scale)*



Neptune

A moderately large object that orbits a star that has cleared its orbit of similar objects.

It shines by reflected light. Planets may be rocky, icy, or gaseous in composition.

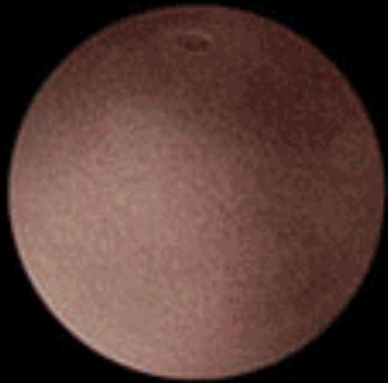
# Dwarf Planet



A moderately small object that orbits a star.  
It has not cleared similar objects out its orbit.

# A few dwarf planets to scale

Makemake



Dysnomia



Eris



Luna



Charon



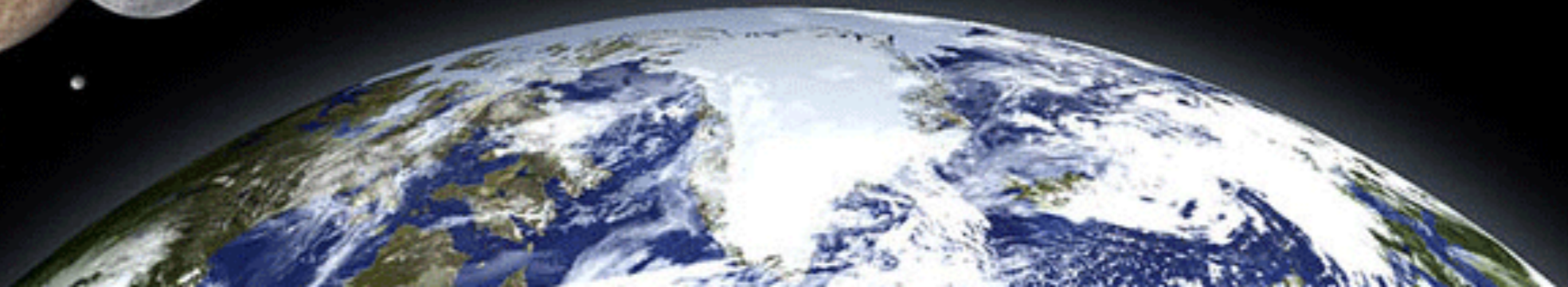
Ceres



Earth



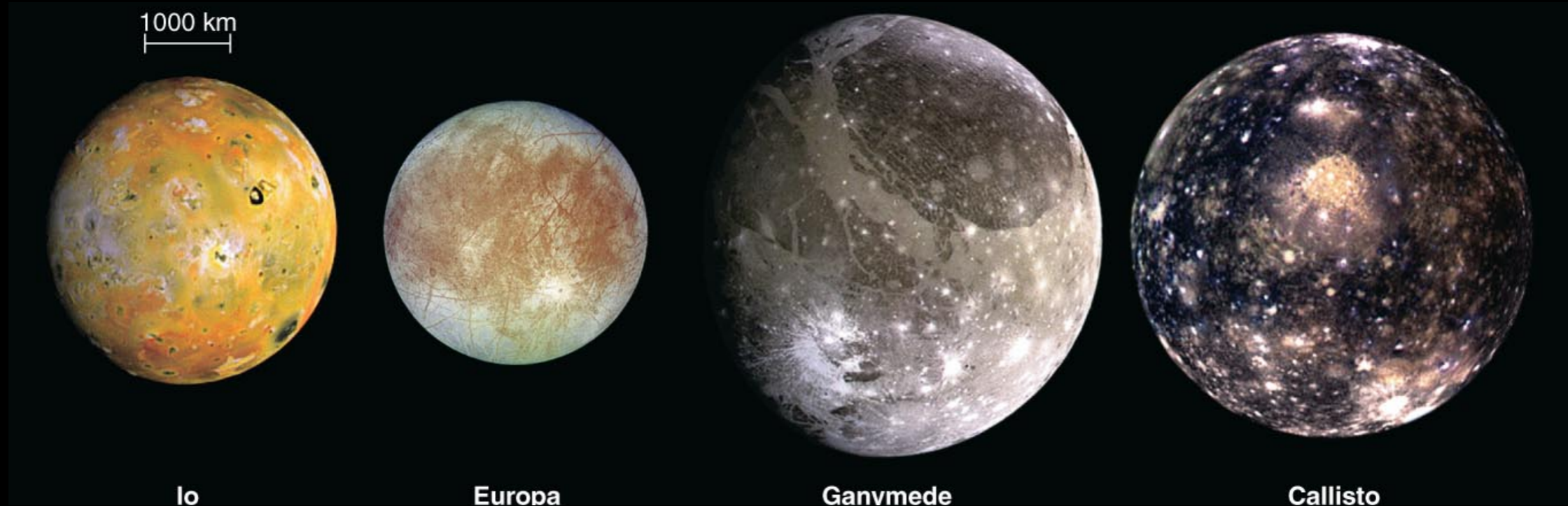
Pluto



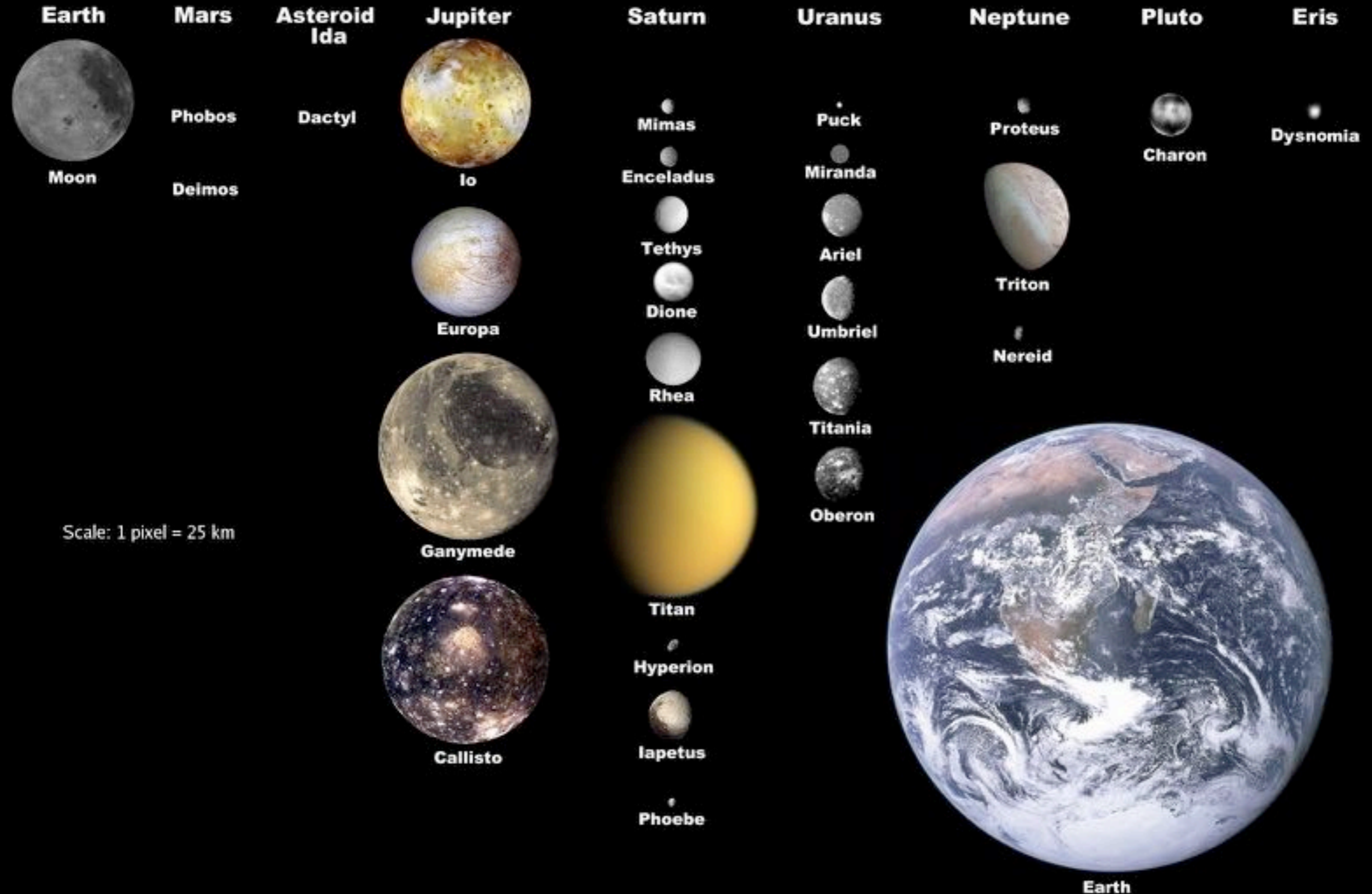
# Moon (or satellite)

An object that orbits a planet.

## Moons of Jupiter



# Selected Moons of the Solar System, with Earth for Scale





# Asteroid

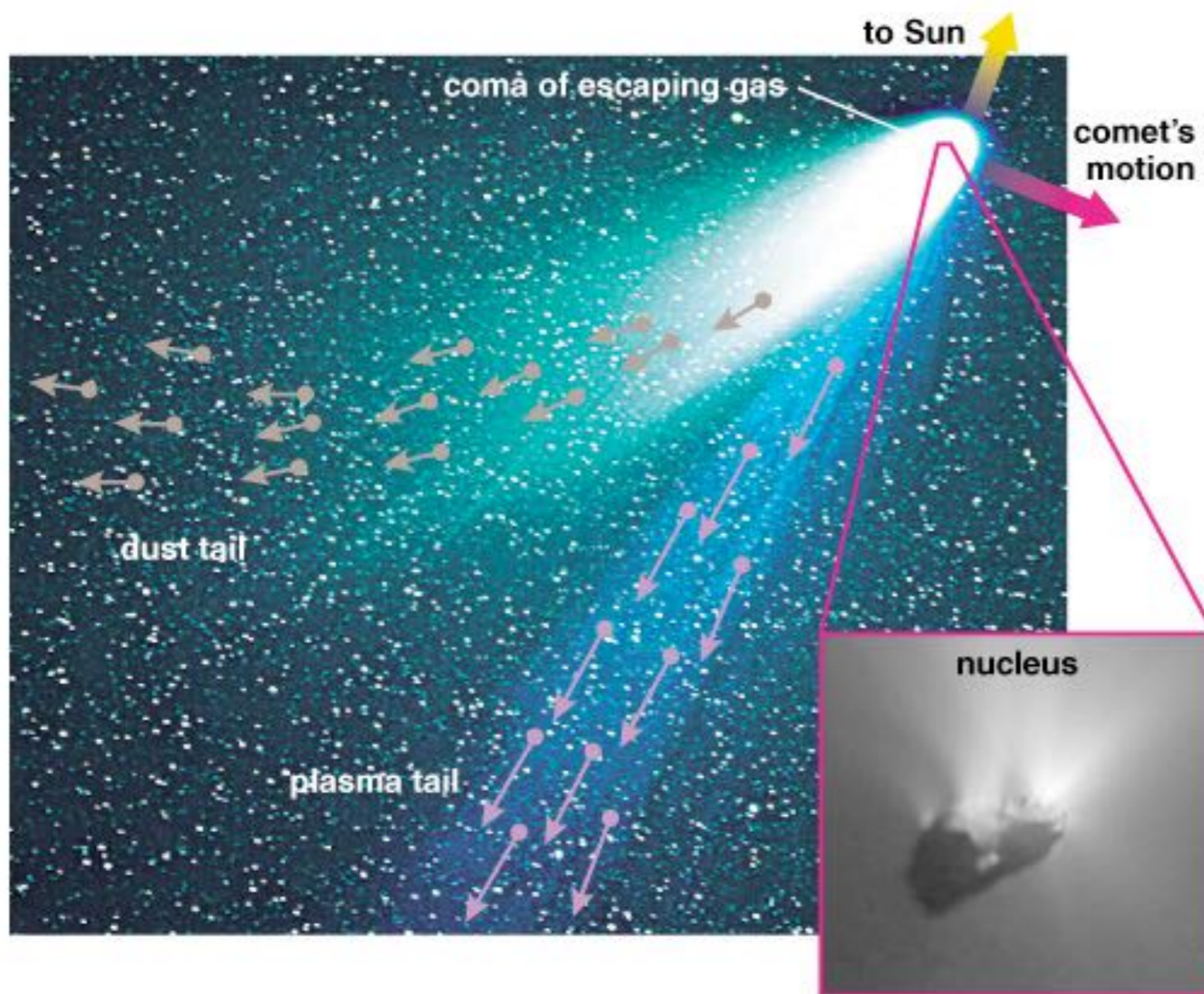
A relatively small and rocky object that orbits a star.

**Most asteroids are too small for their self-gravity to make them round**

Ida



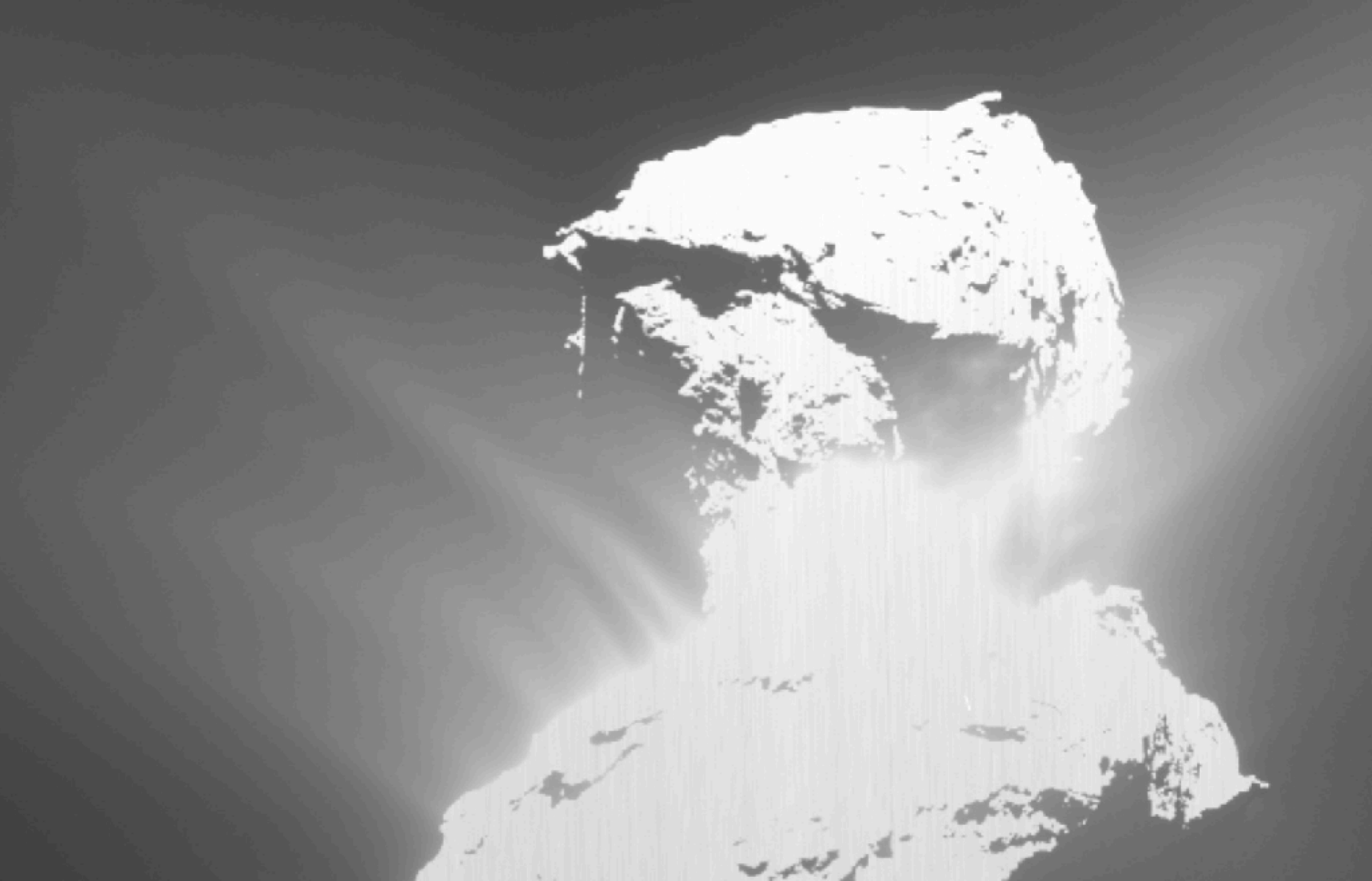
# Comet



A relatively small and icy object that orbits a star.

# Comet 46P

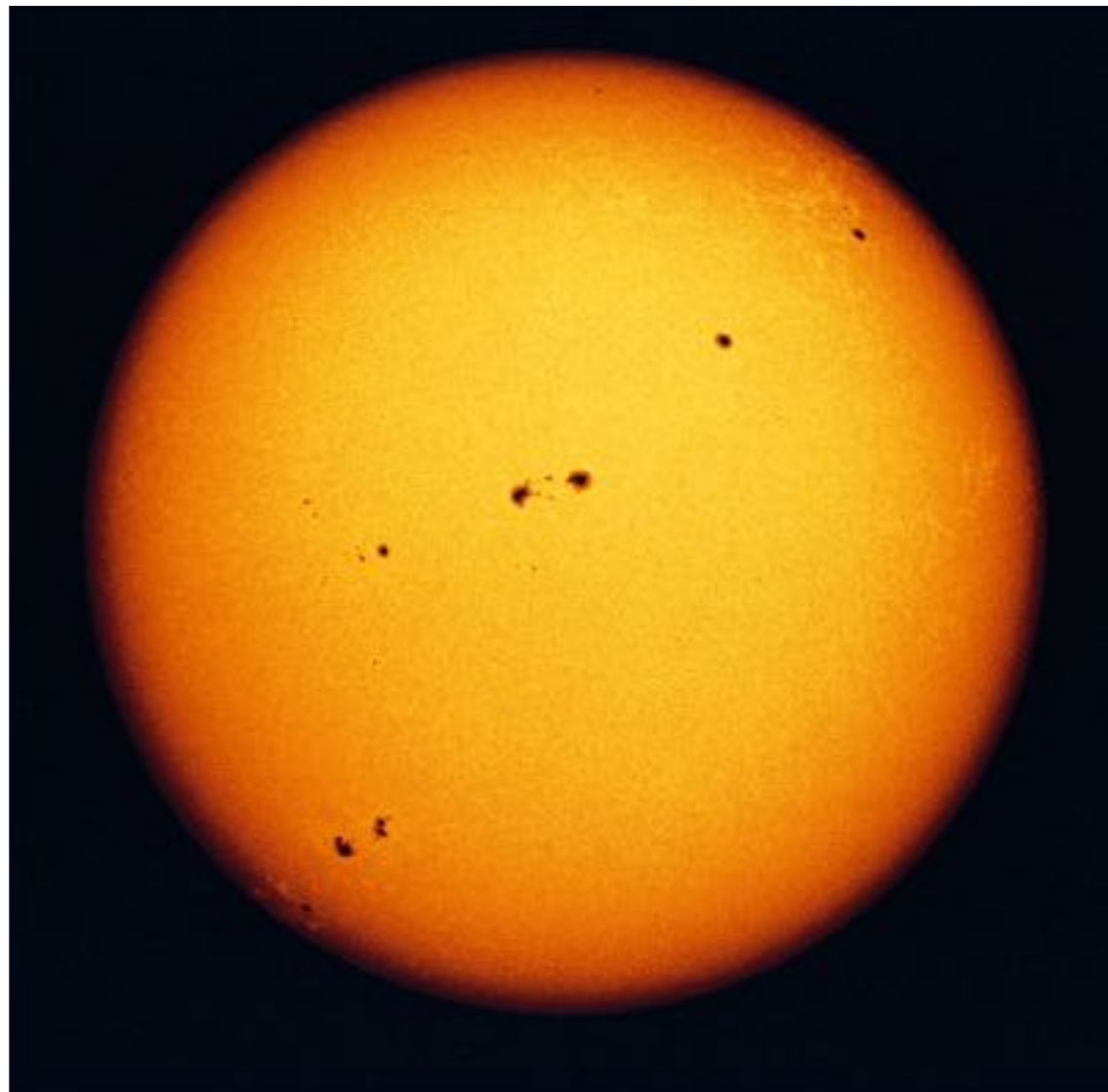




Comet 67P  
Outburst imaged by Rosetta last year.

# Star

A large, glowing ball of gas that generates heat and light through nuclear fusion



**The sun releases more energy every second than a billion H-bombs**

**The sun as seen through the 9.5" telescope atop A.W. Smith during the partial eclipse Monday August 21, 2017**

**Sunspots are magnetic storms on the surface of the sun that appear dark because they're not quite as hot as the surrounding gas.**



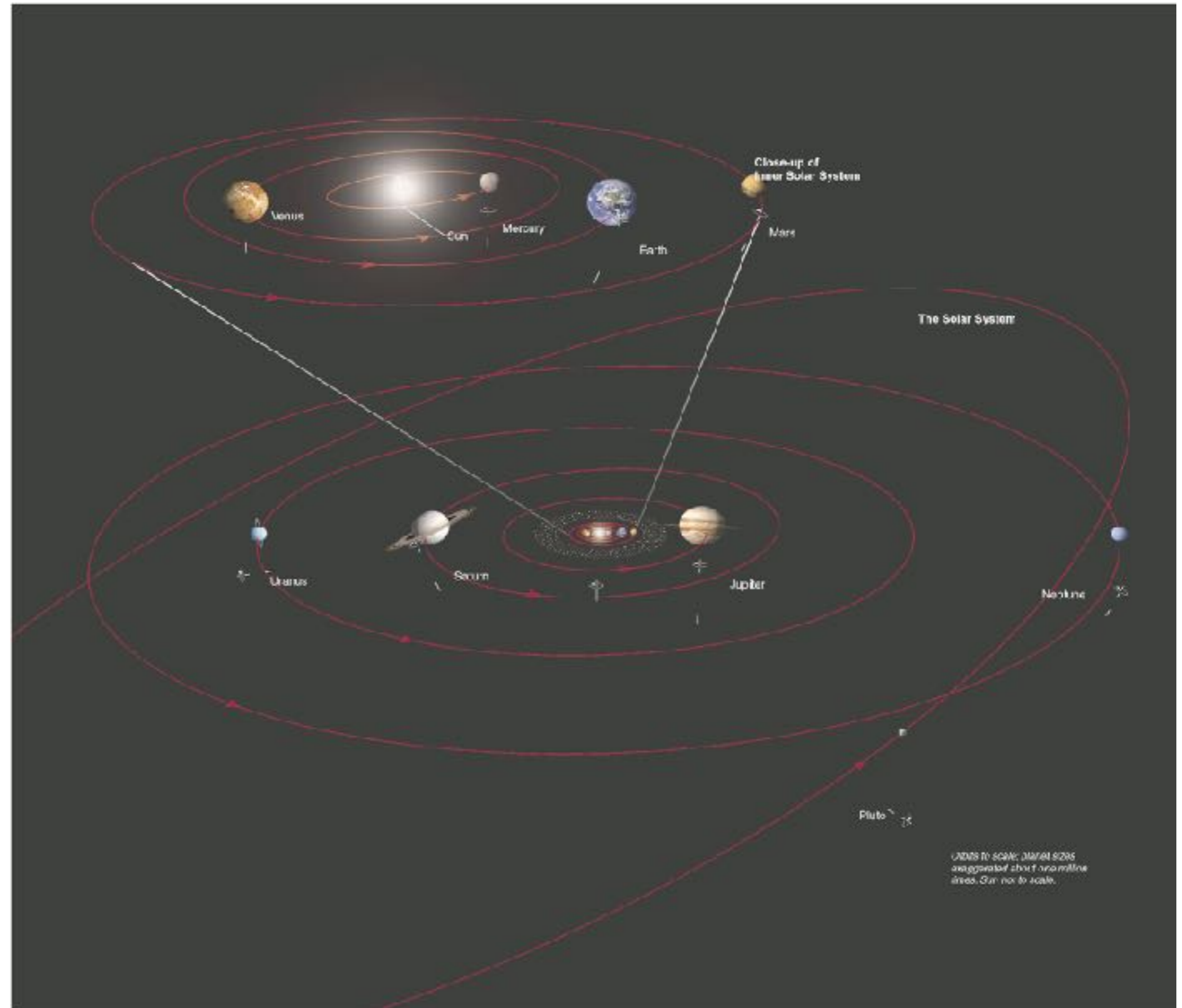
**Sun**

**sunspots**

**moon**

# Solar (Star) System

A star and all the material that orbits it, including its planets and moons



# Nebula



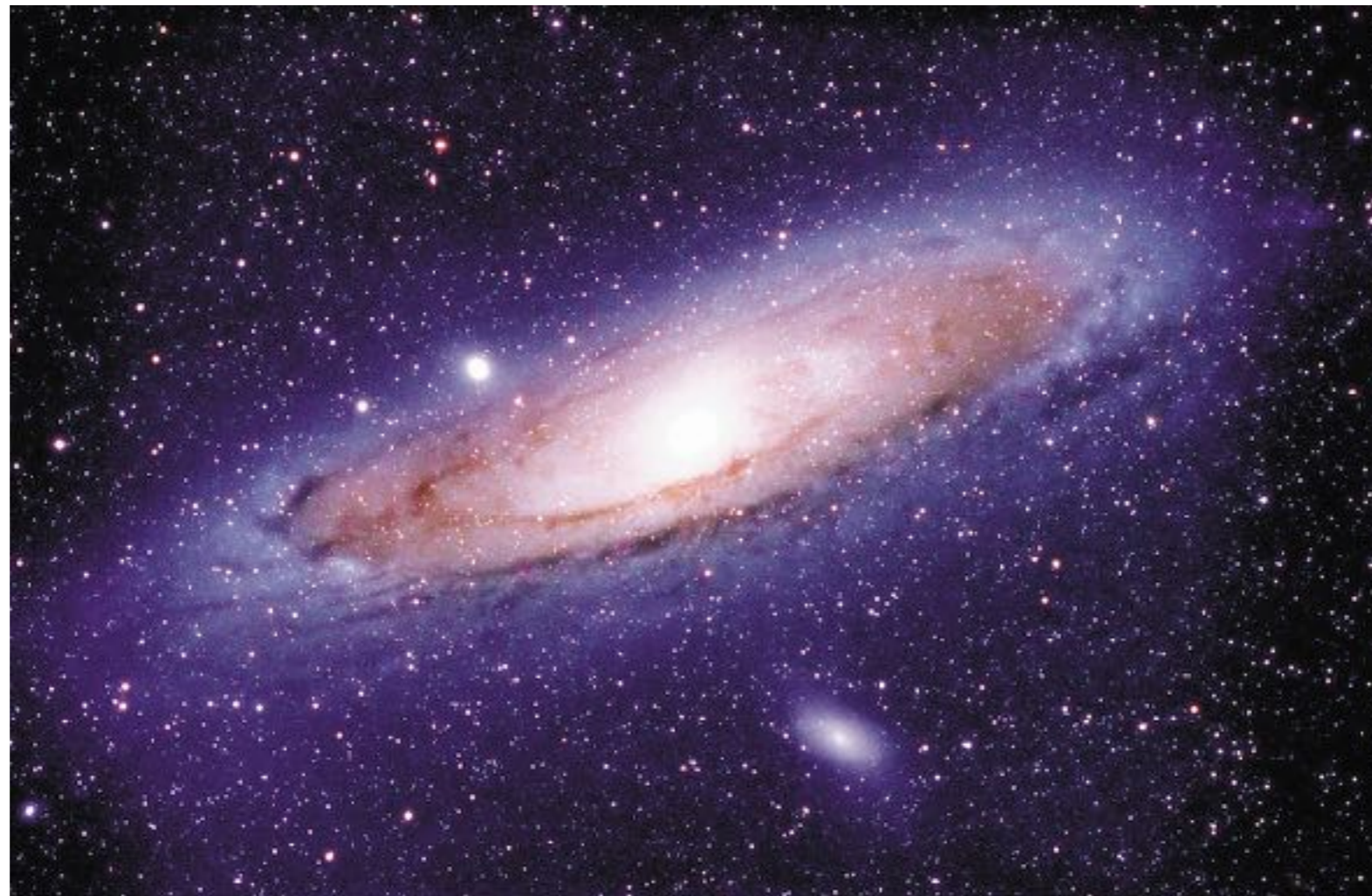
An interstellar cloud  
of gas and/or dust

Typically larger than the solar system - may contain many stars



# Galaxy

A great island of stars in space, all held together by gravity and orbiting a common center



100s of billions of stars

# Universe

The sum total of all matter and energy;  
that is, everything within and between  
all galaxies

100s of billions of galaxies...  
in the observable portion of the universe

Powers of Ten video

<https://www.youtube.com/watch?v=0fKBhvDjuy0>



# Scientific Notation

- $10^0 = 1$
- $10^1 = 10$
- $10^2 = 100$
- ...
- $10^6 = 1,000,000$
- similarly...
- $10^{-1} = 0.1$
- $10^{-6} = 0.000001$

Units important!

$1 \text{ g cm}^{-3} = 1,000 \text{ kg m}^{-3}$   
density of water

$5.5 \text{ g cm}^{-3}$   
average density of the Earth

$10^{-29} \text{ g cm}^{-3}$   
approximate average density  
of the universe

# Definition: **Light-Year**

- The **distance** light can travel in one year.
- About 10 trillion kilometers (6 trillion miles).  
( $10^{13}$  km)

$$d = c \times t$$

distance = (speed of light) x (travel time)

## Light travel time & distance

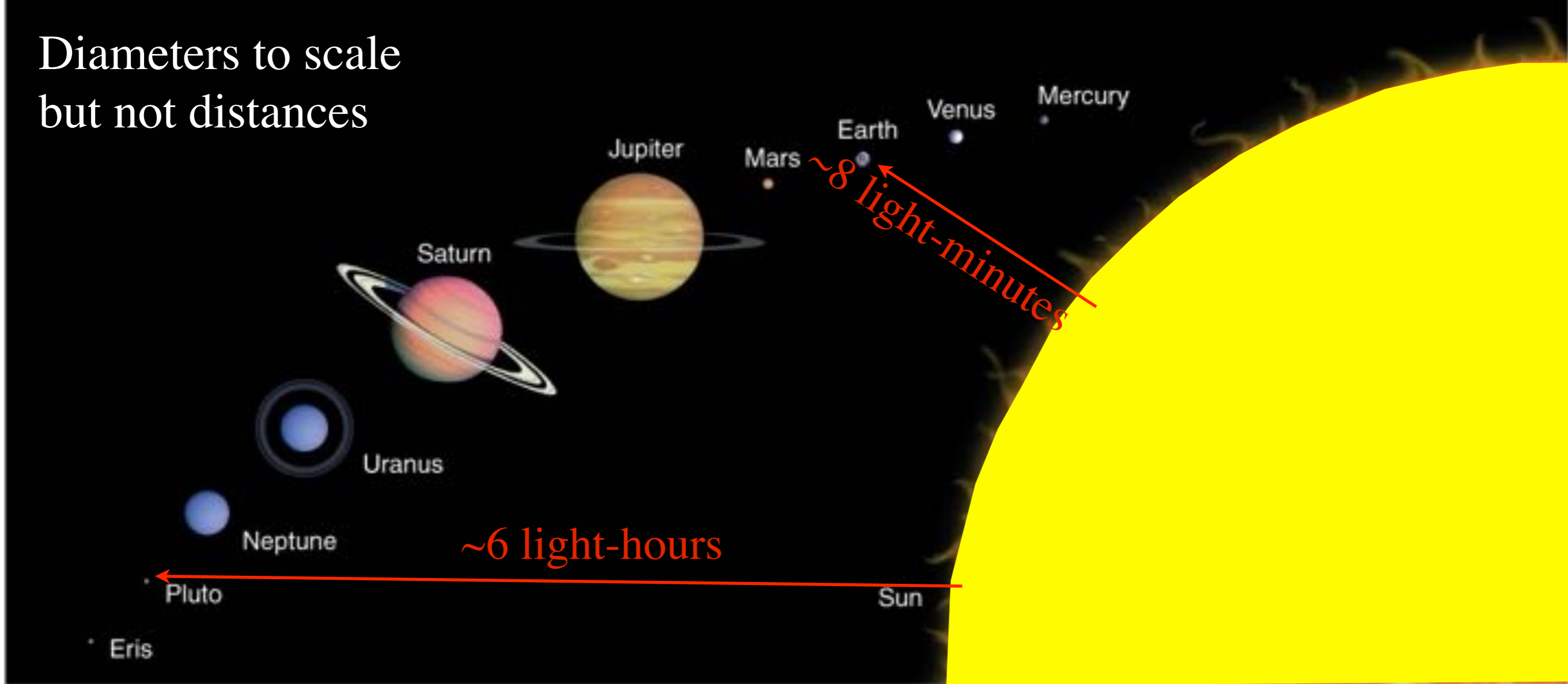
- Light travels at a finite speed (300,000 km/s).

<b>Destination</b>	<b>Light travel time</b>
Moon	1 second
Sun	8 minutes
Sirius	8 years
Andromeda Galaxy	2.5 million years

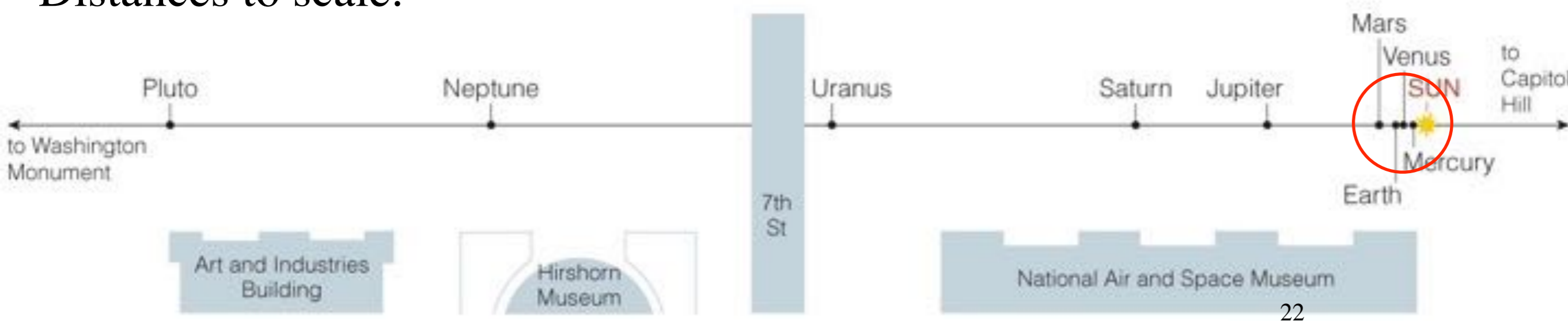
- Thus, we see objects as they were in the past:

*The farther away we look in distance,  
the further back we look in time.*

Diameters to scale  
but not distances

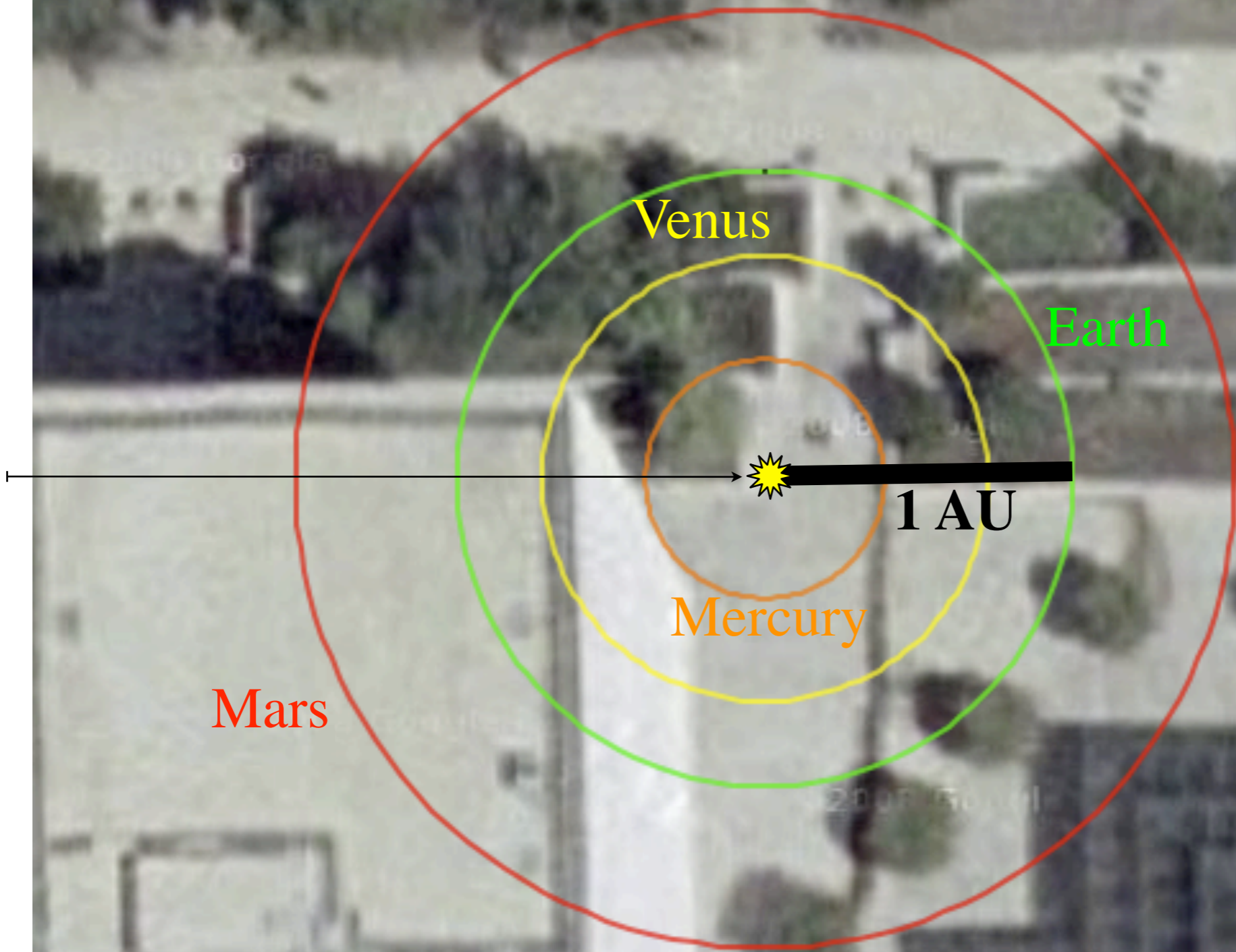


Distances to scale:



Smithsonian Institution on the National Mall in Washington, DC

The sun is 13 cm in diameter on this scale



AU = Astronomical Unit

Smithsonian Institution on the National Mall in Washington, DC

To same scale



Pluto  
40 AU

Smithsonian Institution on the National Mall in Washington, DC



One light year  
is about 63,000 AU

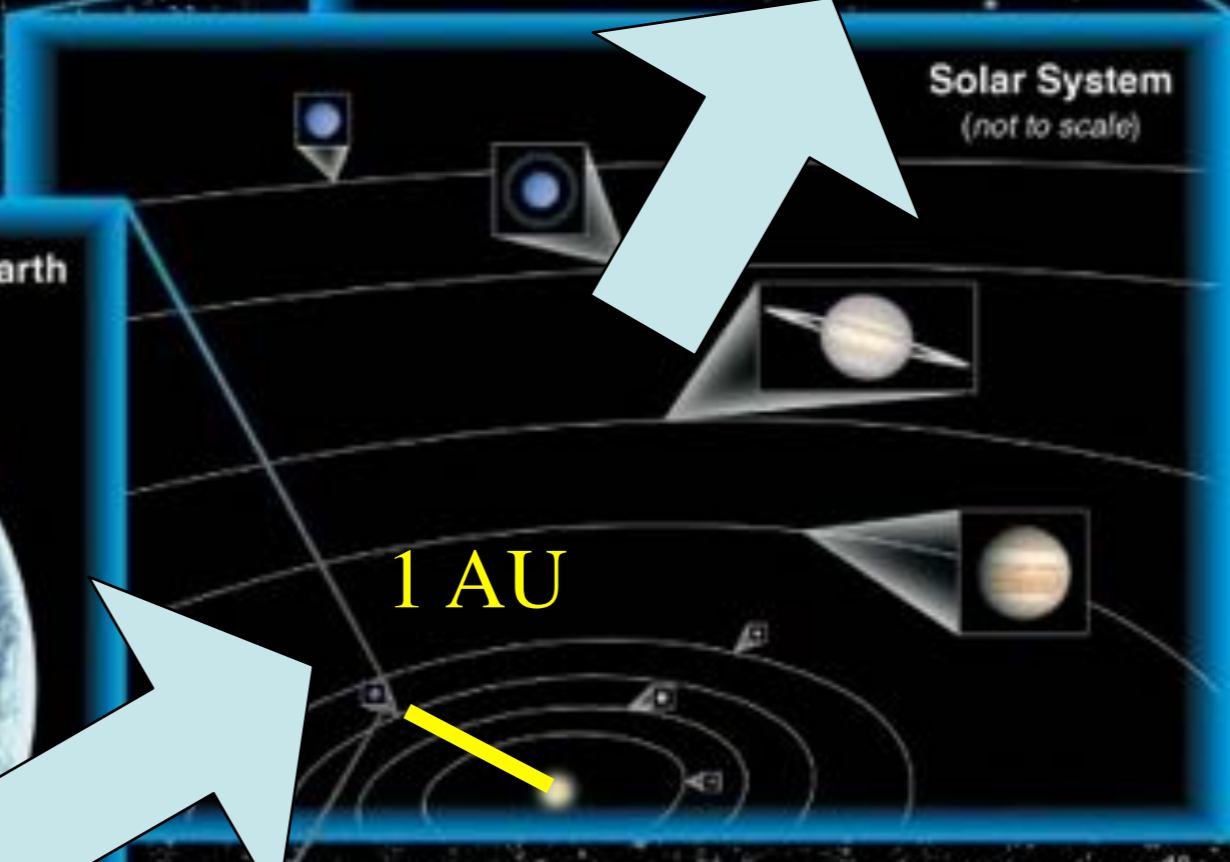


approx. size:  $10^{18}$  km



Milky Way Galaxy  
26,000 light-years

zoom out: one hundred million



Solar System  
(not to scale)

1 AU

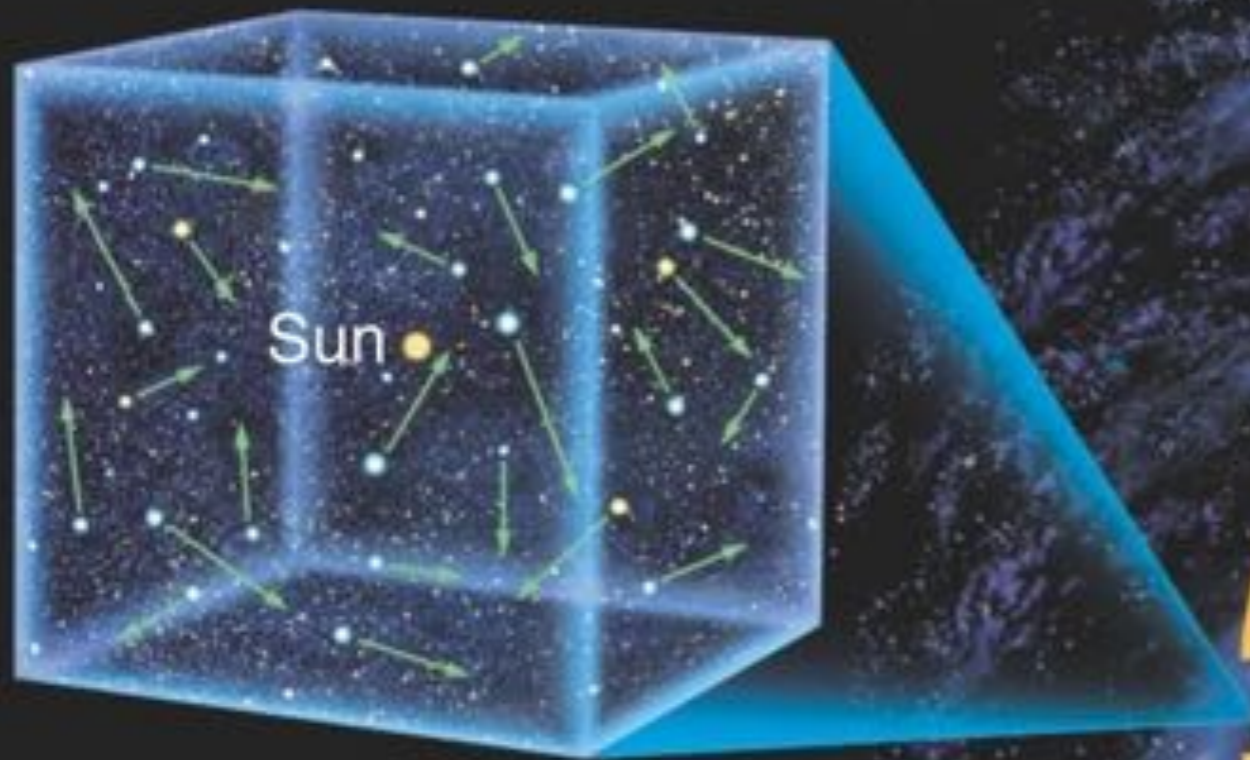
approx. size:  $10^{10}$  km

zoom out: one million



Earth

approx. size:  $10^4$  km

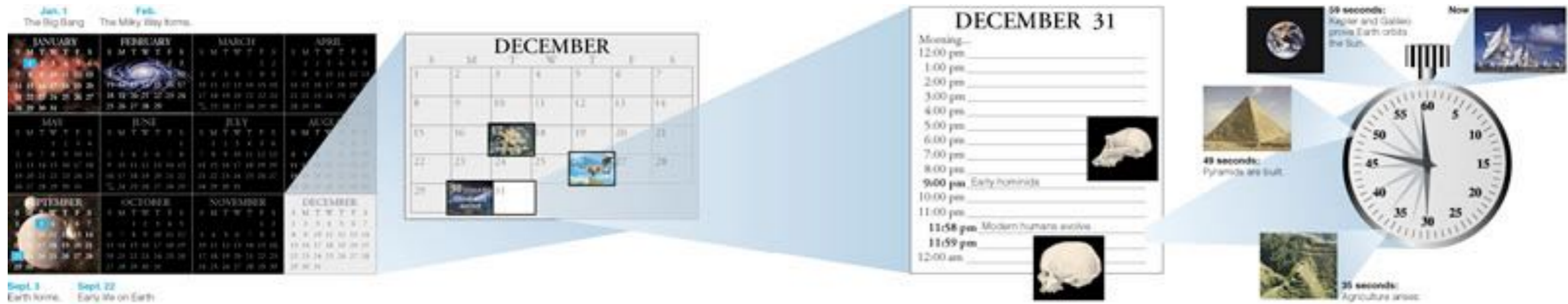


From the sun to the center of the Milky Way Galaxy is about 26,000 light-years

The difference from 28,000 light-years reflects the uncertainty in this measurement.

# Space is Huge; Time is Deep: The Universe is Ancient

- The Cosmic Calendar: A scale on which we compress the history of the universe into 1 year.



© 2007 Pearson Education, Inc., publishing as Addison-Wesley

The Universe is about 14 billion years old, so at this scale, 1 month represents a little more than 1 billion years.

# THE HISTORY OF THE UNIVERSE IN 1 YEAR

January 1:  
The Big Bang

February:  
The Milky Way forms

September 3:  
The Earth forms

September 22:  
Early life on earth

December 17:  
Cambrian explosion

December 26:  
Rise of the dinosaurs

December 30:  
Extinction of the dinosaurs





December 31:

9:00 pm:  
Early hominids evolve



11:58 pm:  
Modern humans evolve

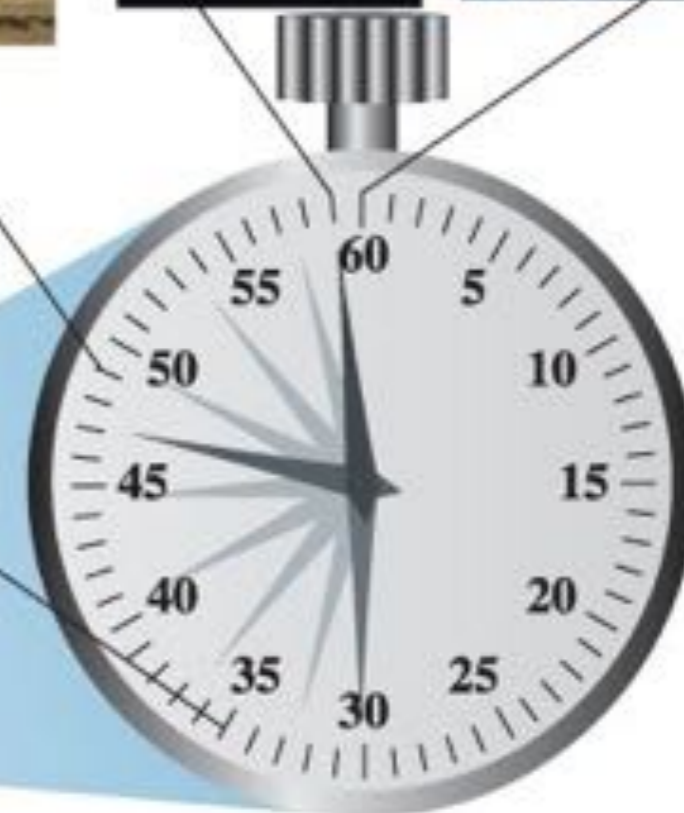
25 seconds ago:  
Agriculture arises

11 seconds ago:  
Pyramids built

1 second ago:  
Kepler and Galileo  
show that Earth  
orbits the Sun

No w

DECEMBER 31	
Morning...	
12:00 noon	
1:00 pm	
2:00 pm	
3:00 pm	
4:00 pm	
5:00 pm	
6:00 pm	
7:00 pm	
8:00 pm	
9:00 pm	
10:00 pm	
11:00 pm	
11:58 pm	
11:59 pm	
12:00 midnight	



# Astronomy covers astronomical scales:

- The Universe is MUCH larger than
    - Galaxies which are MUCH larger than
      - Stars which are MUCH larger than
        - Planets which are MUCH larger than
          - » Moons, comets, and asteroids, which are MUCH larger than
            - PEOPLE
- The Universe is incredibly ancient
  - but does have a finite age
    - the oldest stars are ~13 billion years old
    - the sun, earth, & solar system are 4.5 billion years old
    - new stars are still forming today