



Discovering the Essential Universe

Tenth Edition

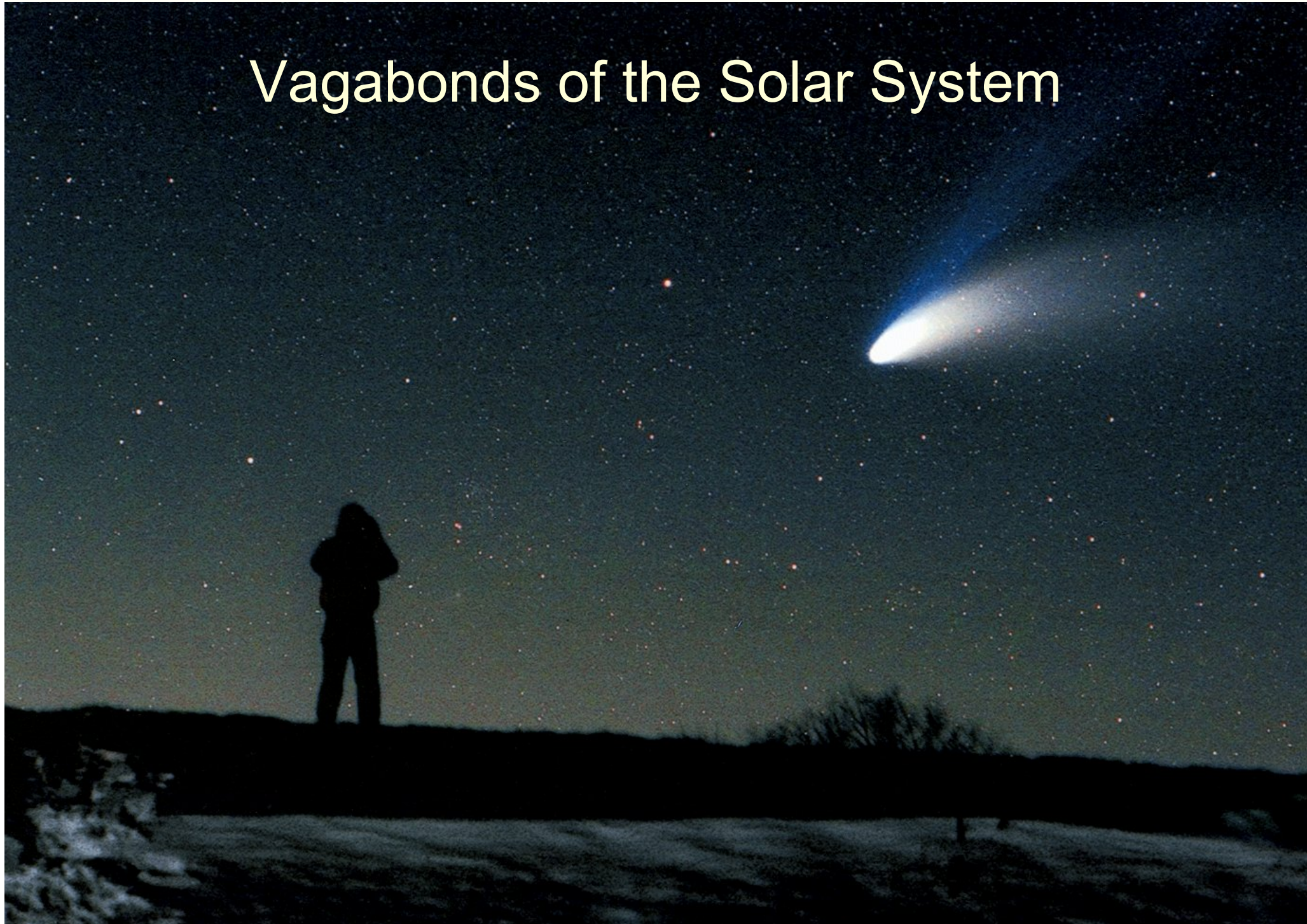
CHAPTER 8

Dwarf Planets and Small Solar System Bodies

In this chapter you will discover...

- the properties of dwarf planets
- the properties and orbits of asteroids
- the properties and orbits of comets
- the properties of meteoroids, meteors, and meteorites
- that wayward asteroids have, and could again, threaten life on Earth

Vagabonds of the Solar System



Pluto



Seen from New Horizons flyby

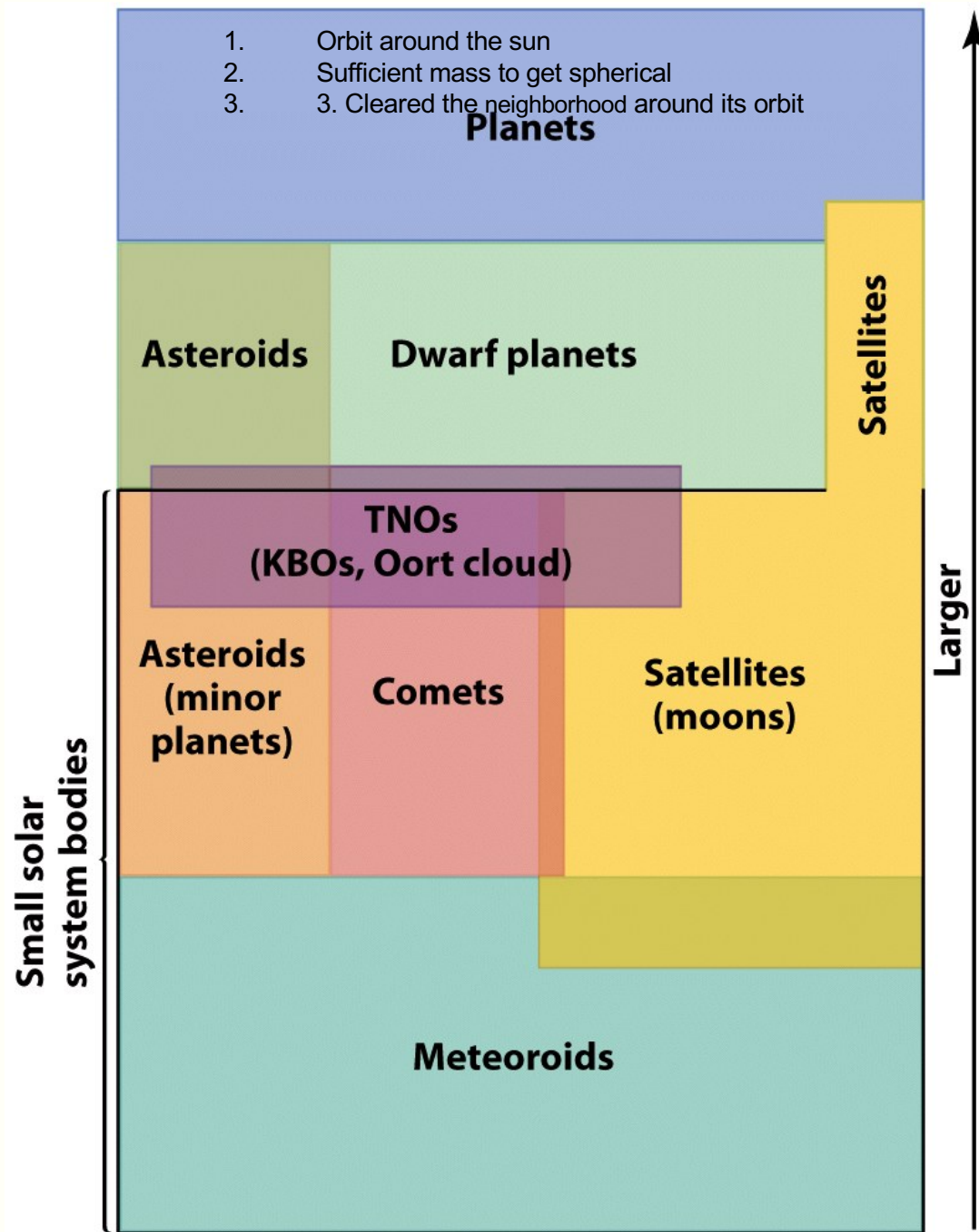


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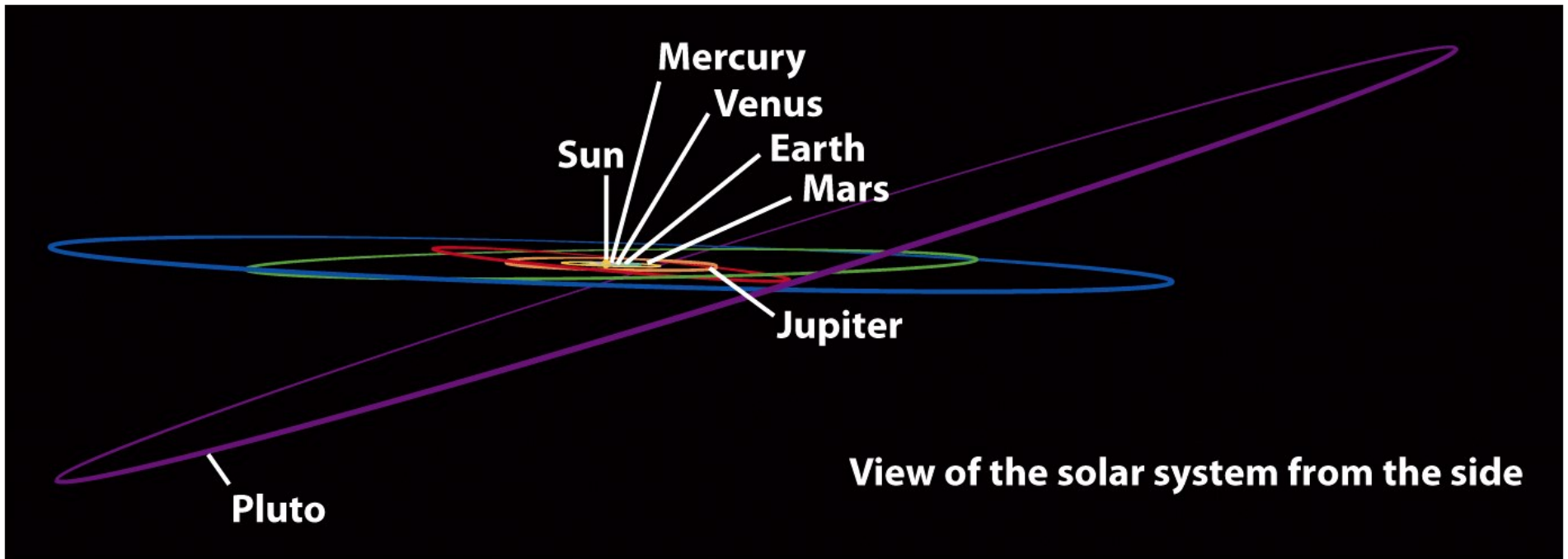
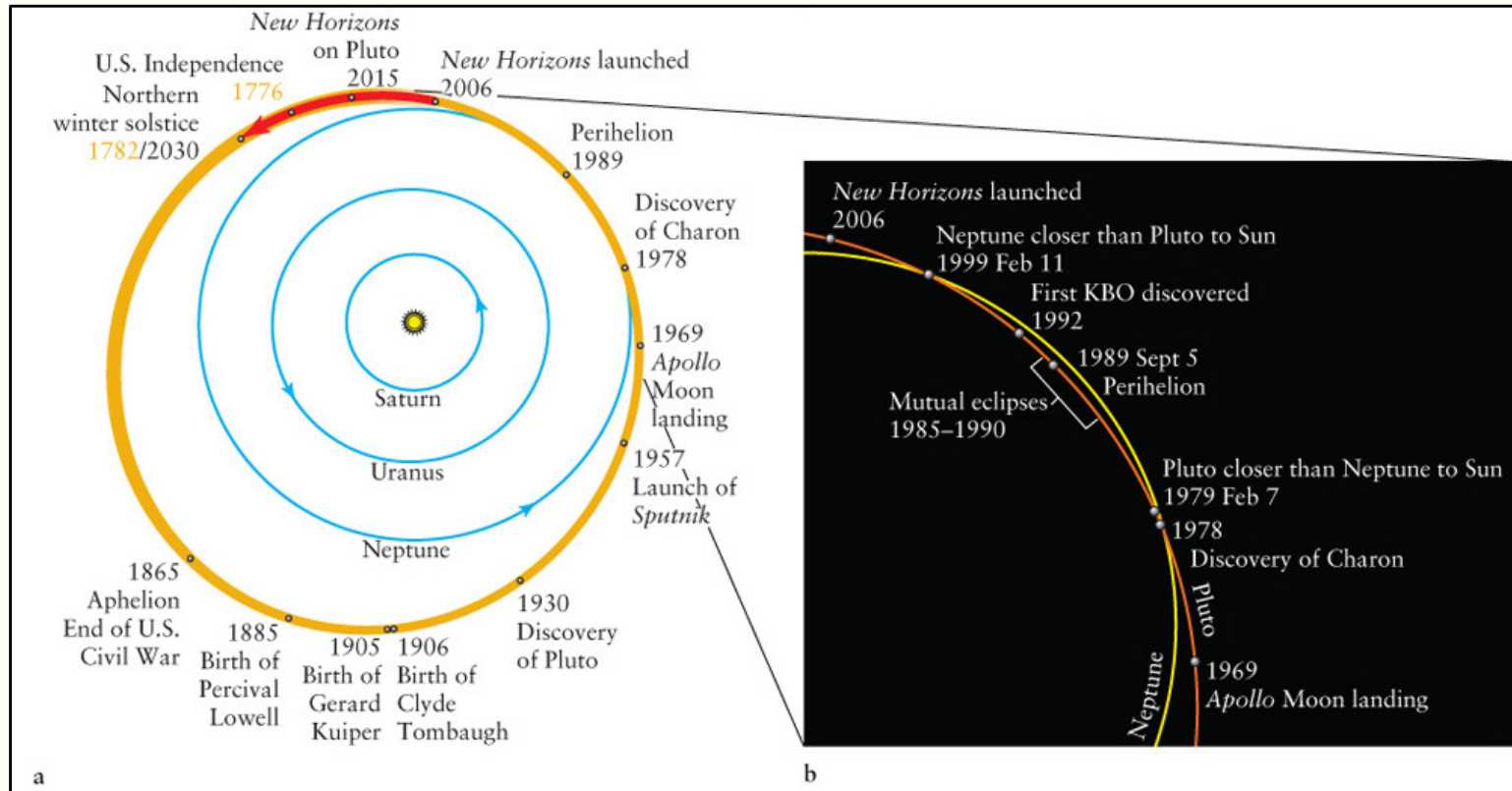


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Orbit of Pluto



(a) The high-eccentricity orbit of dwarf planet (and KBO) Pluto stands out compared to the orbits of the outer three planets. Notice how many significant events occurred on Earth during Pluto's present orbit of the Sun. (b) Details of Pluto's passage inside the orbit of Neptune. The two bodies will never collide.

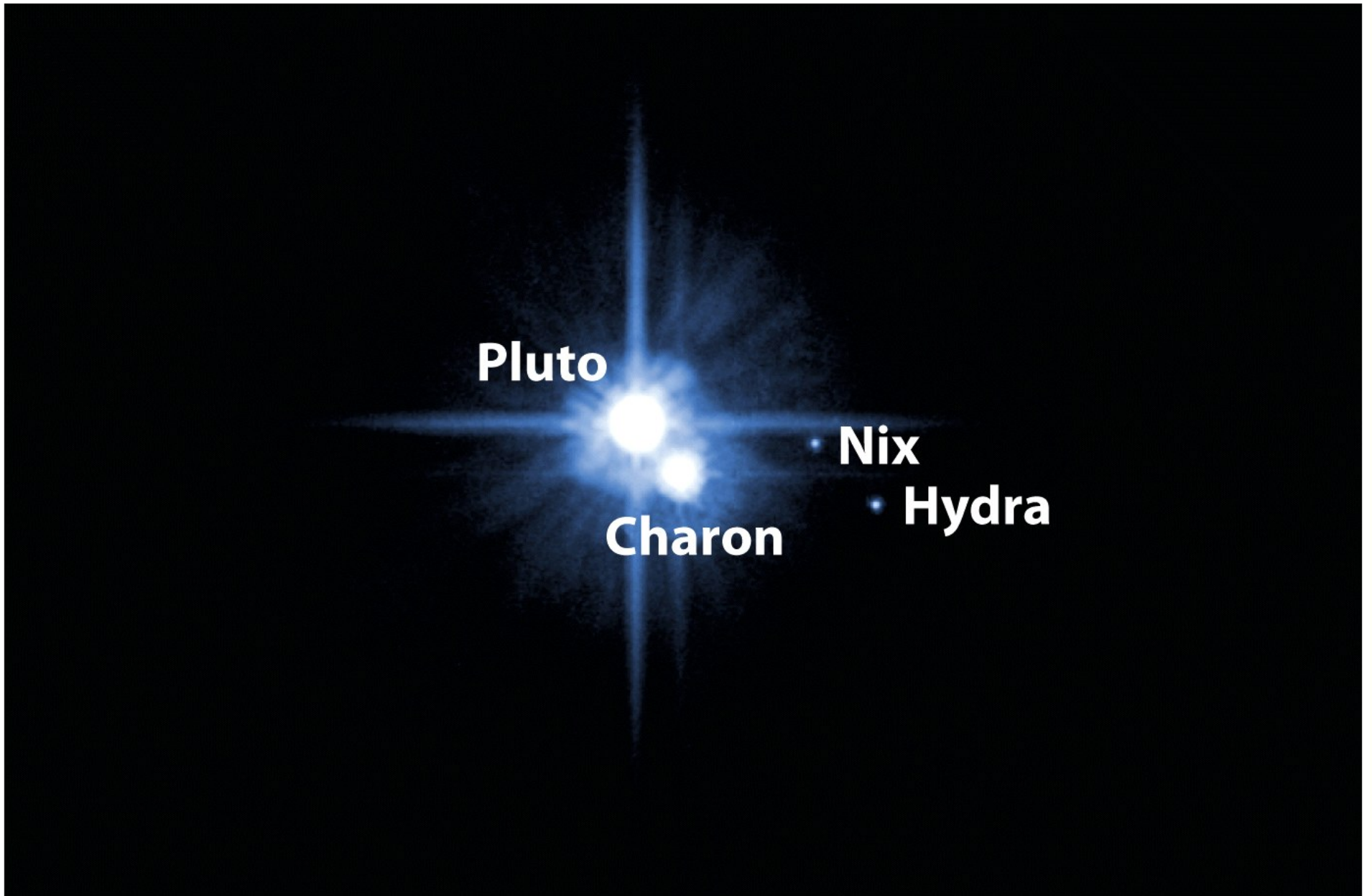


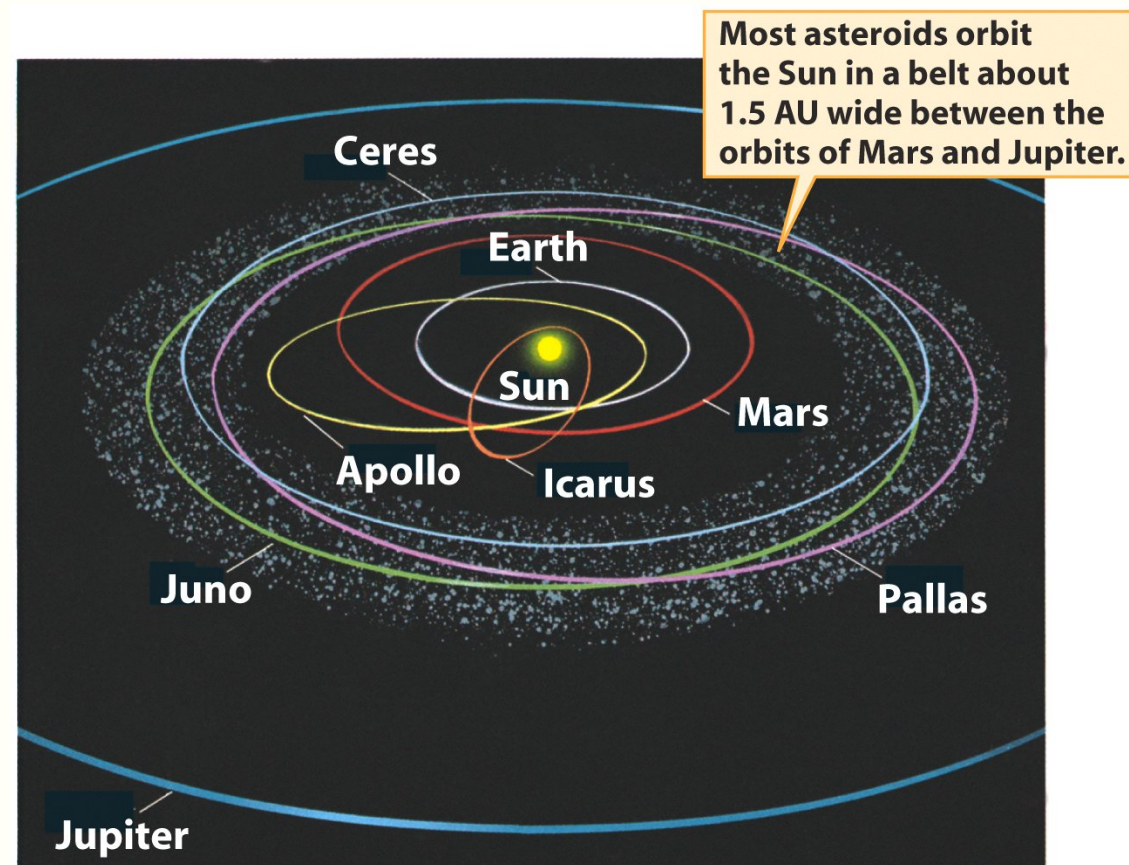
Figure 9-6

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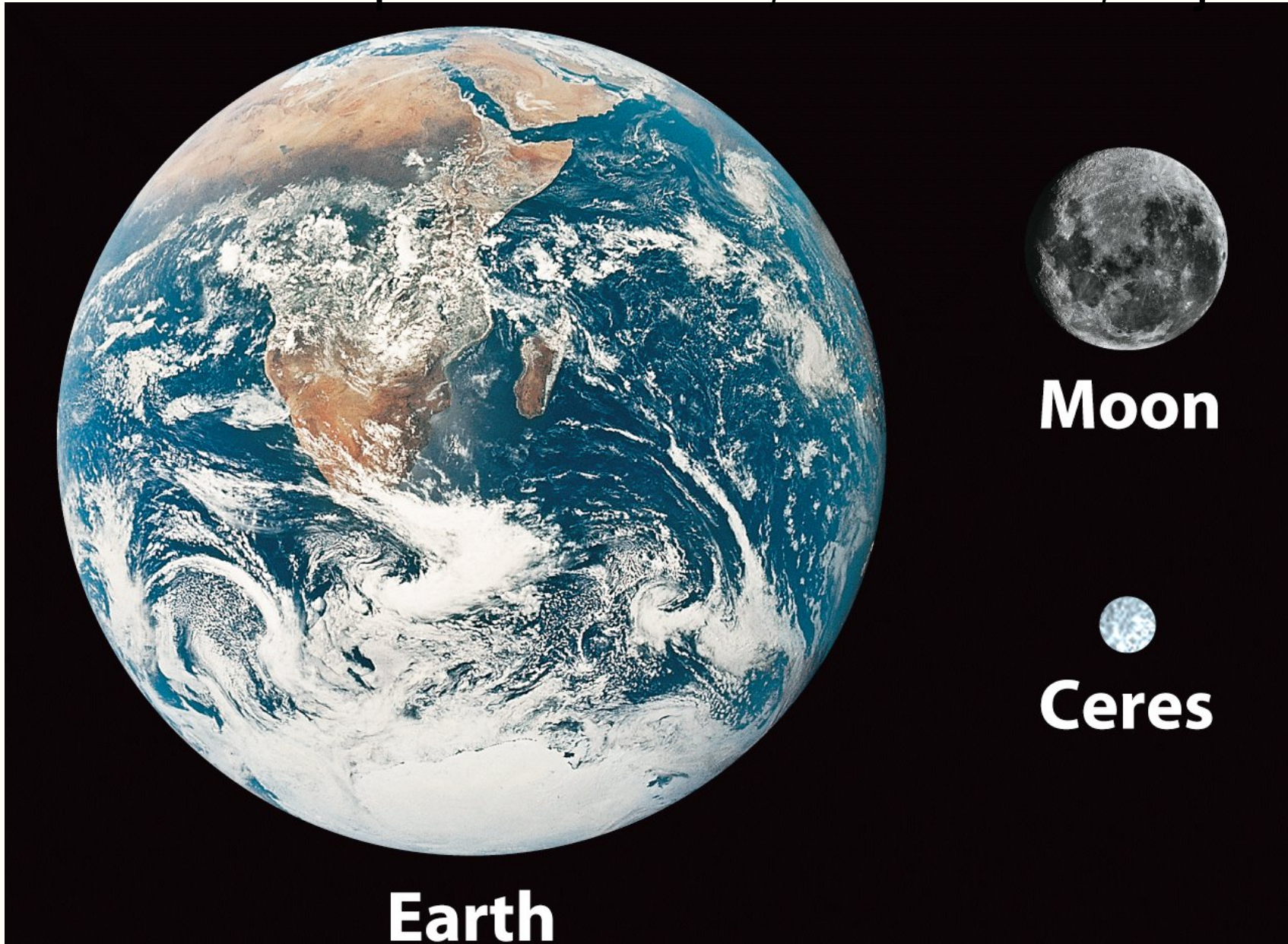
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A search for a planet between Mars and Jupiter led to the discovery of asteroids

- Astronomers first discovered the asteroids while searching for a “missing planet”
- Thousands of asteroids with diameters ranging from a few kilometers up to 1000 kilometers orbit within the asteroid belt between the orbits of Mars and Jupiter



The asteroids are the relics of planetesimals that failed to accrete into a full-sized planet, thanks to the effects of Jupiter and other, Mars-sized, objects.

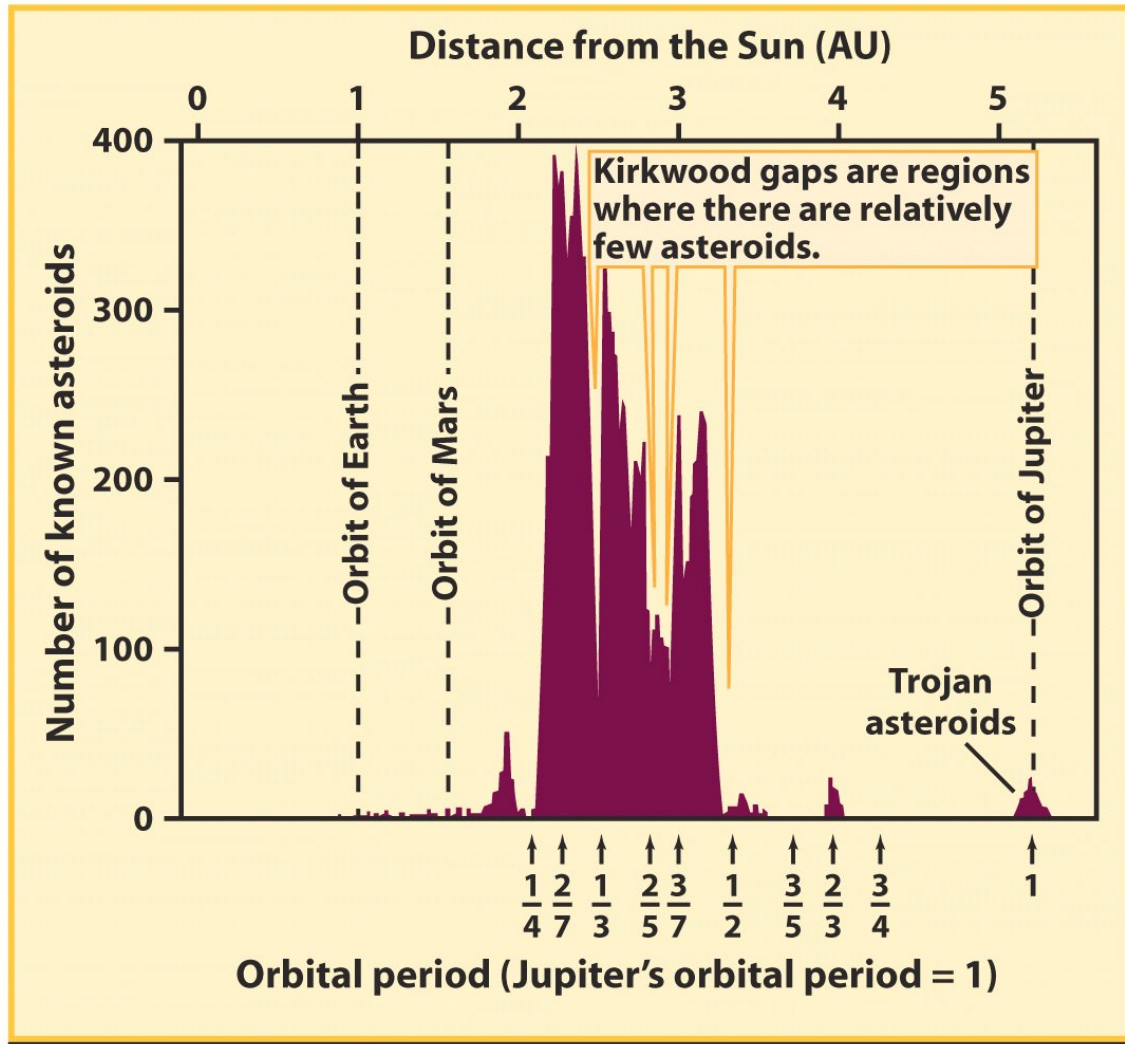


Earth

Moon

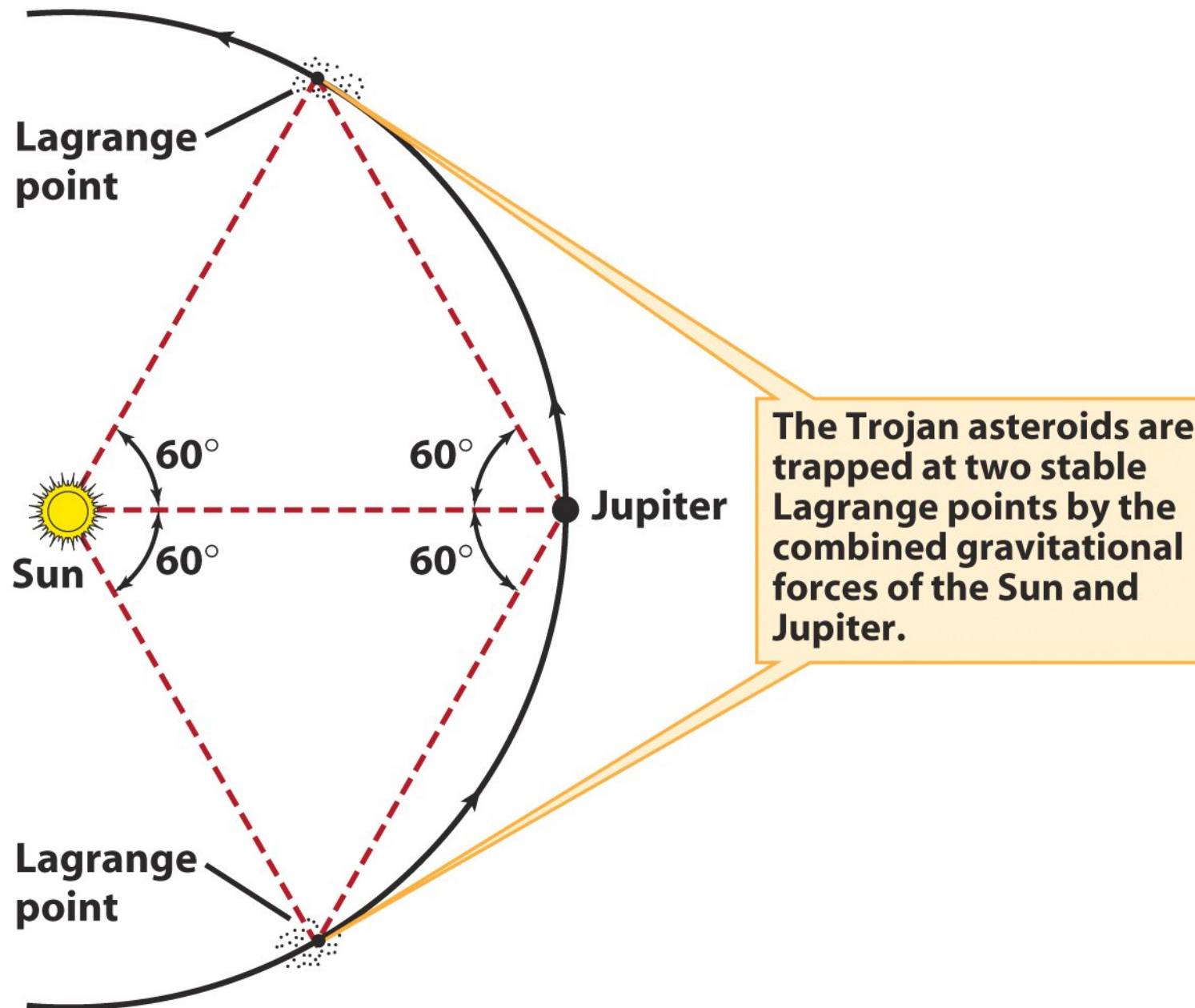
Ceres

Jupiter's gravity helped shape the asteroid belt

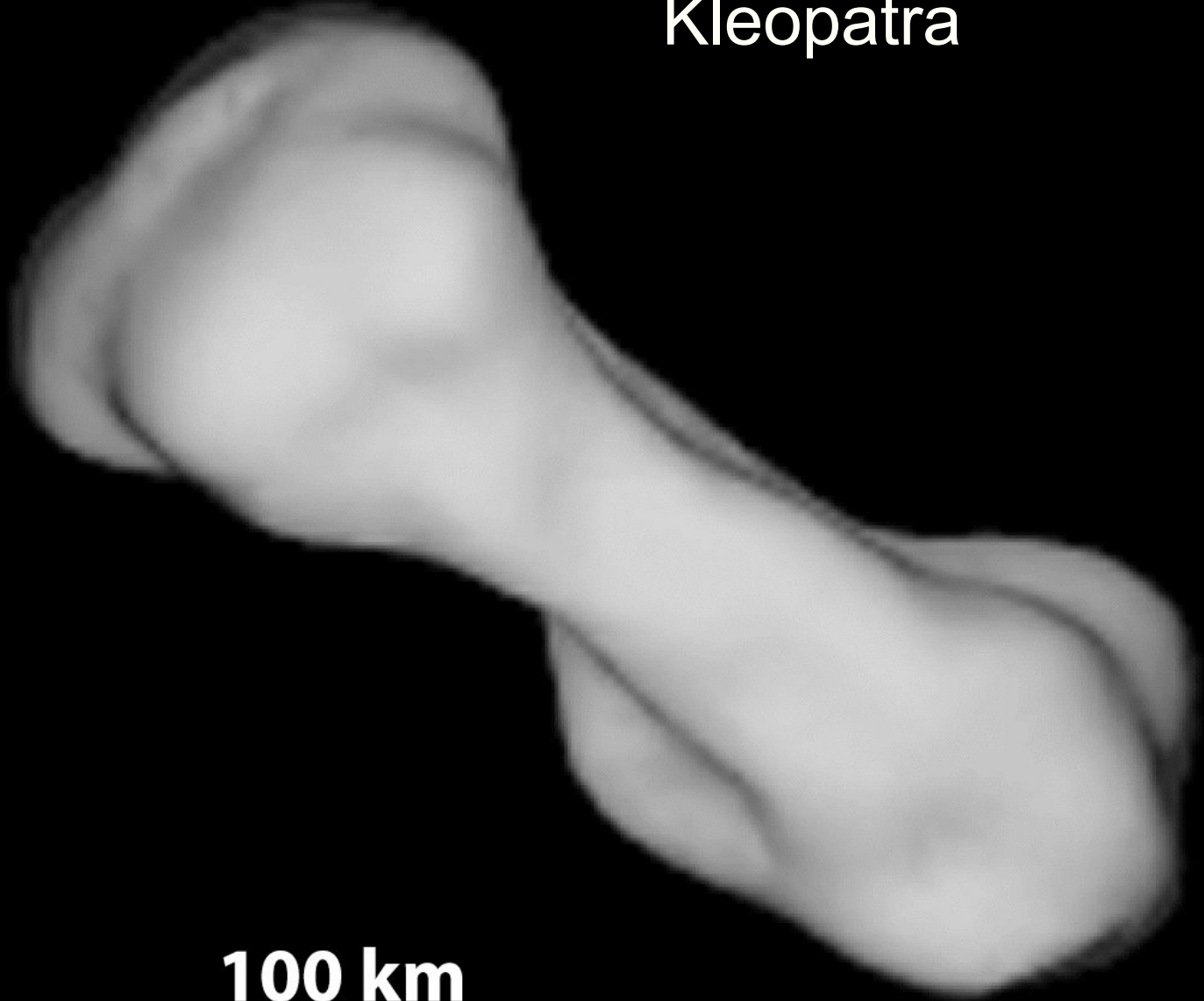


- Even today, gravitational perturbations by Jupiter deplete certain orbits within the asteroid belt
- The resulting gaps, called Kirkwood gaps, occur at simple fractions of Jupiter's orbital period

Jupiter's gravity also captures asteroids in two locations, called Lagrangian points, along Jupiter's orbit



Kleopatra



100 km



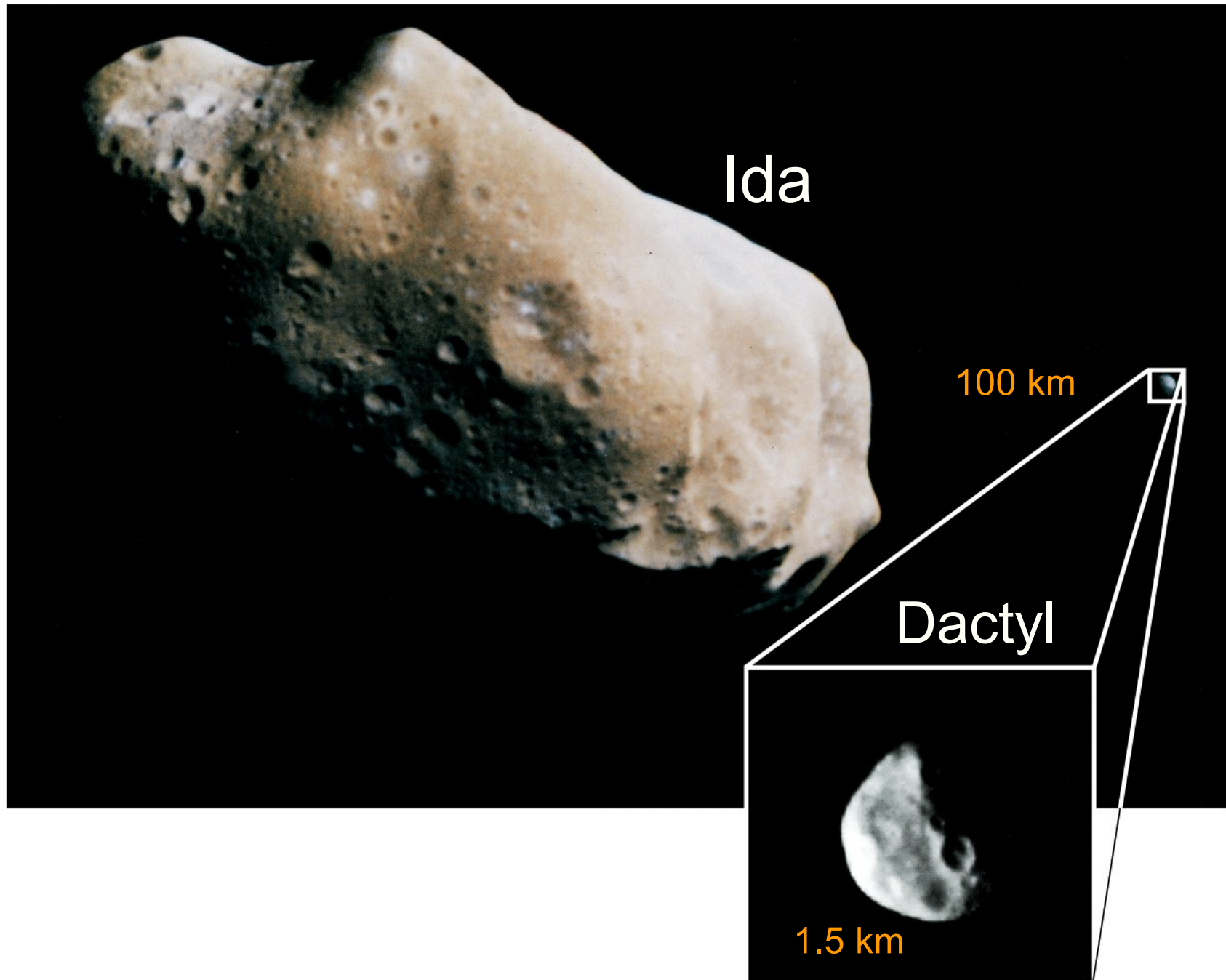
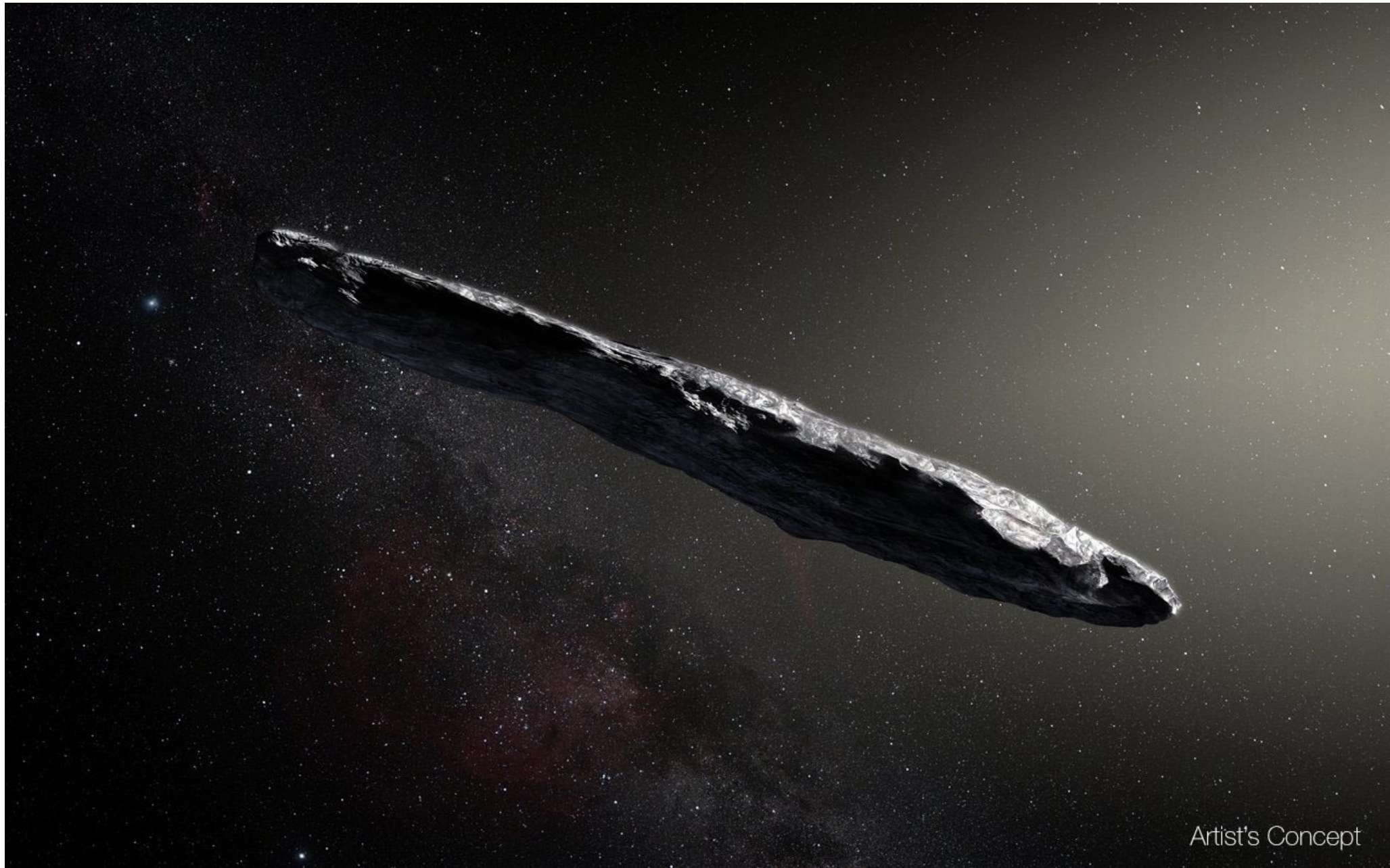


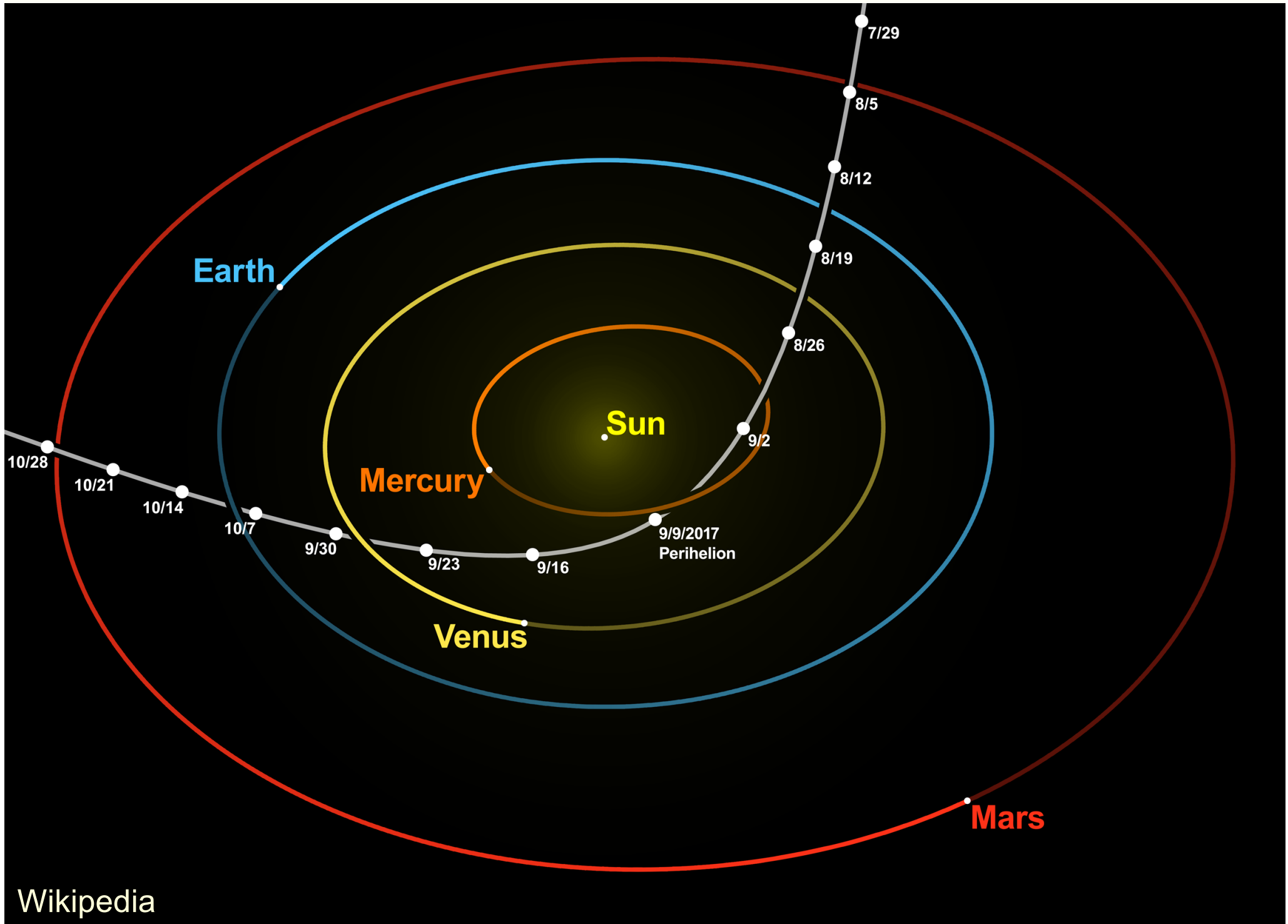
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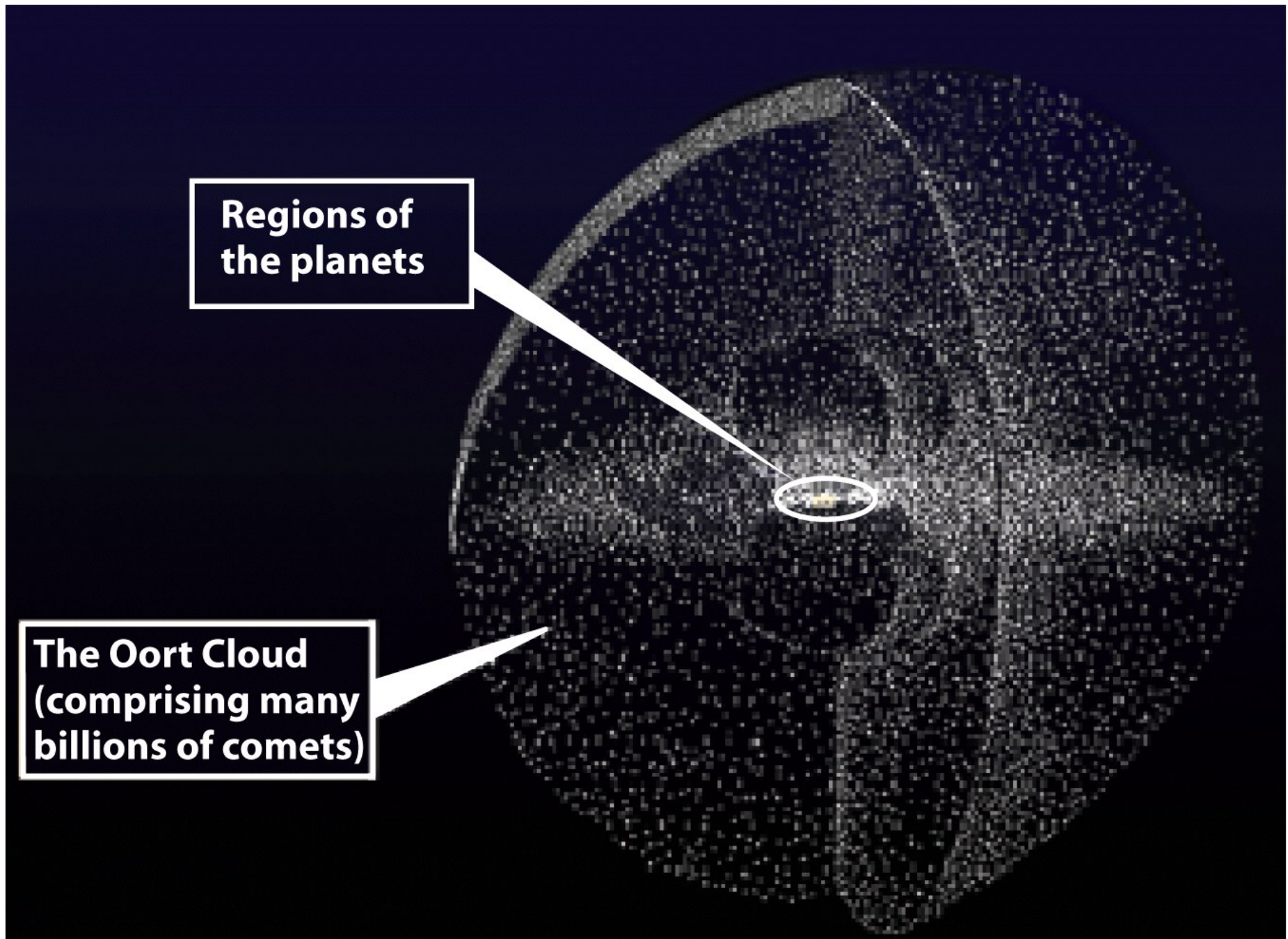
Oumuamua – first interstellar visitor



Artist's Concept

NASA solar system





**Regions of
the planets**

**The Oort Cloud
(comprising many
billions of comets)**

Figure 9-18a part 1

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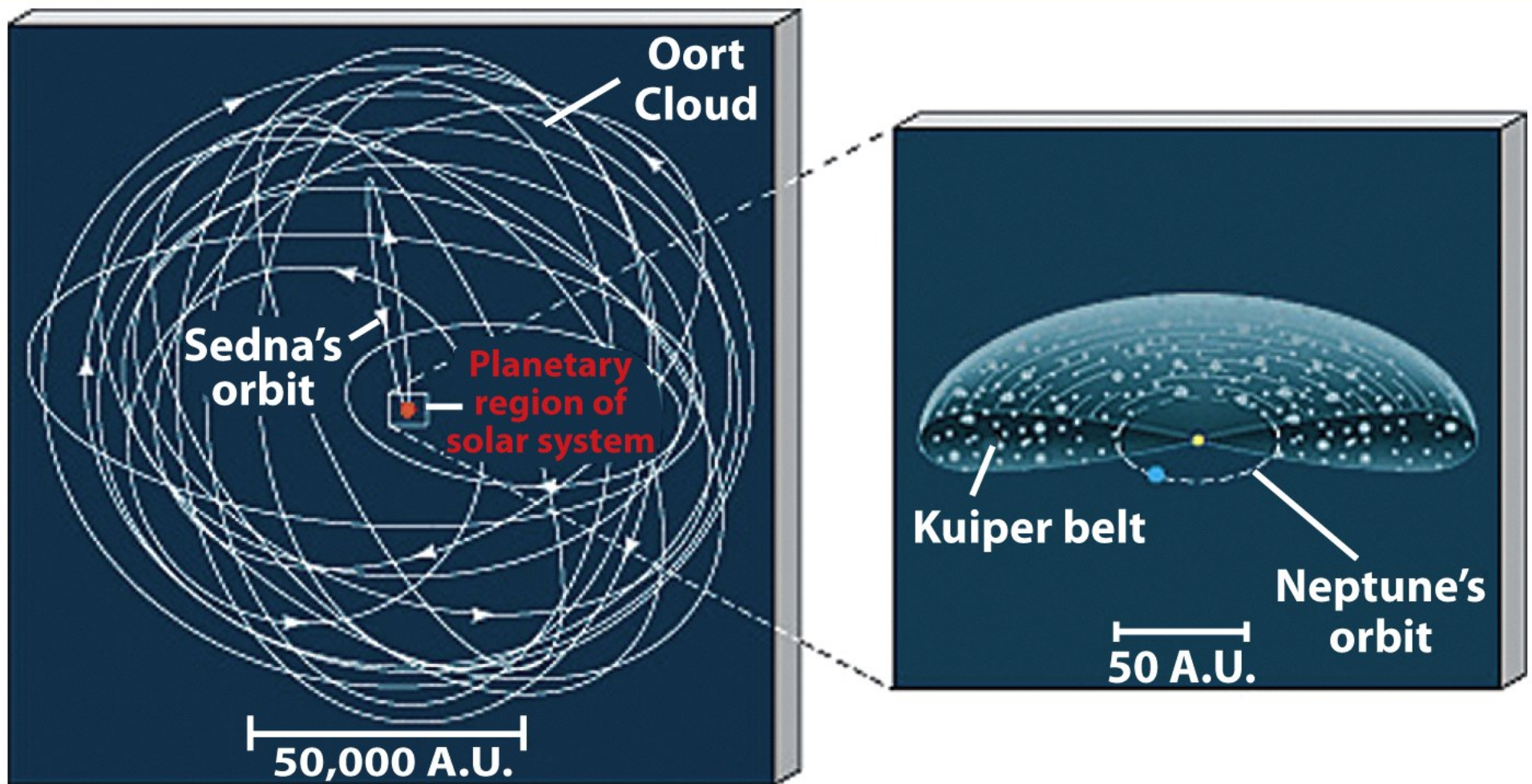


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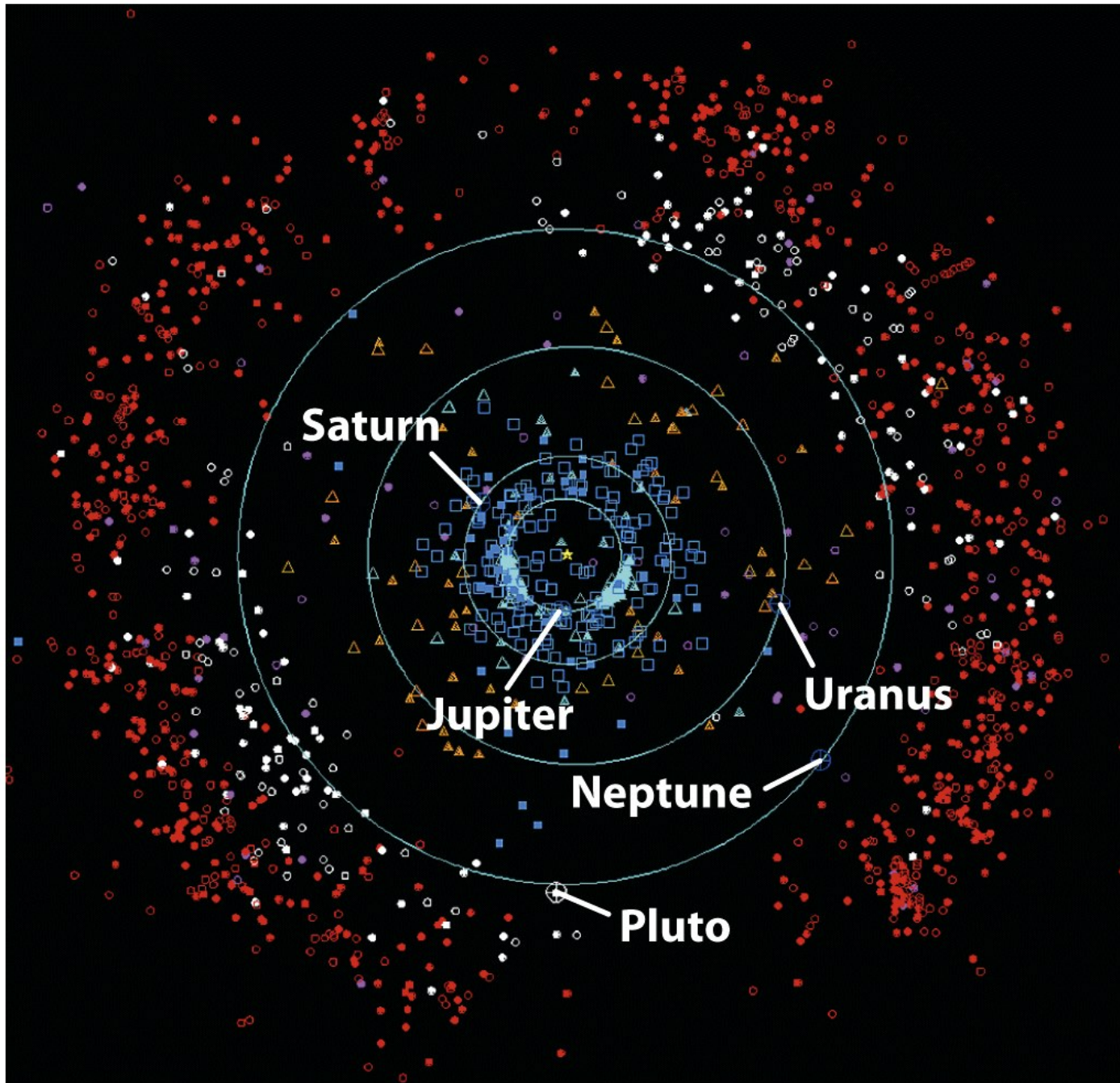
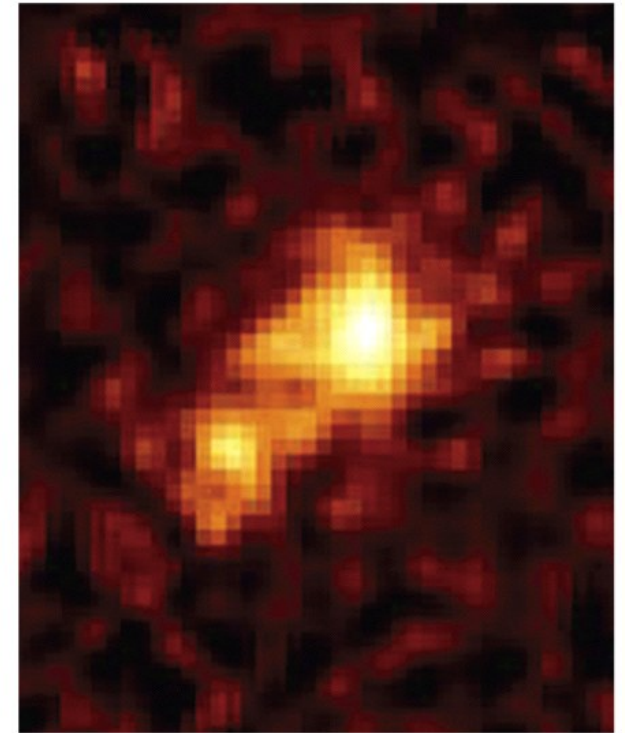
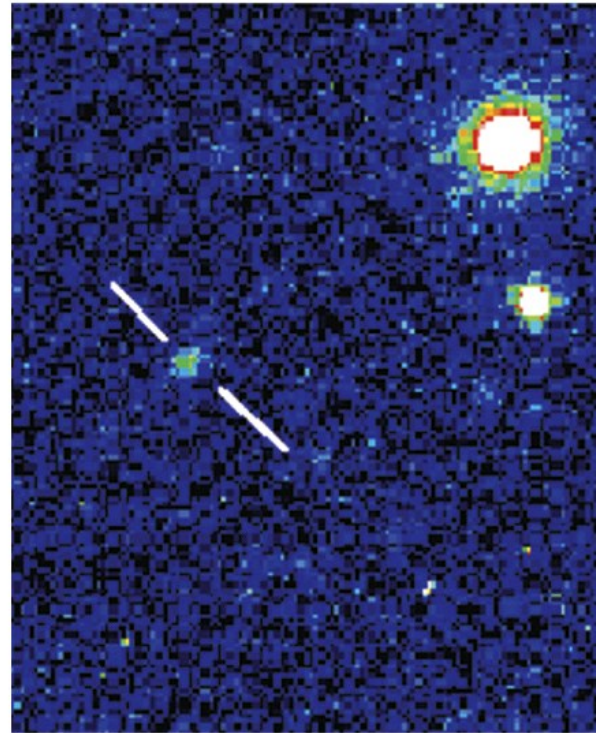
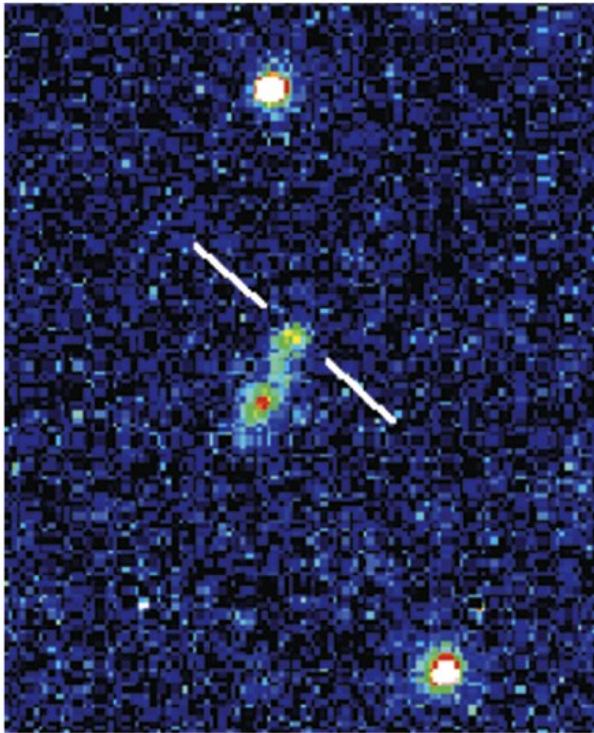


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Kuiper belt objects

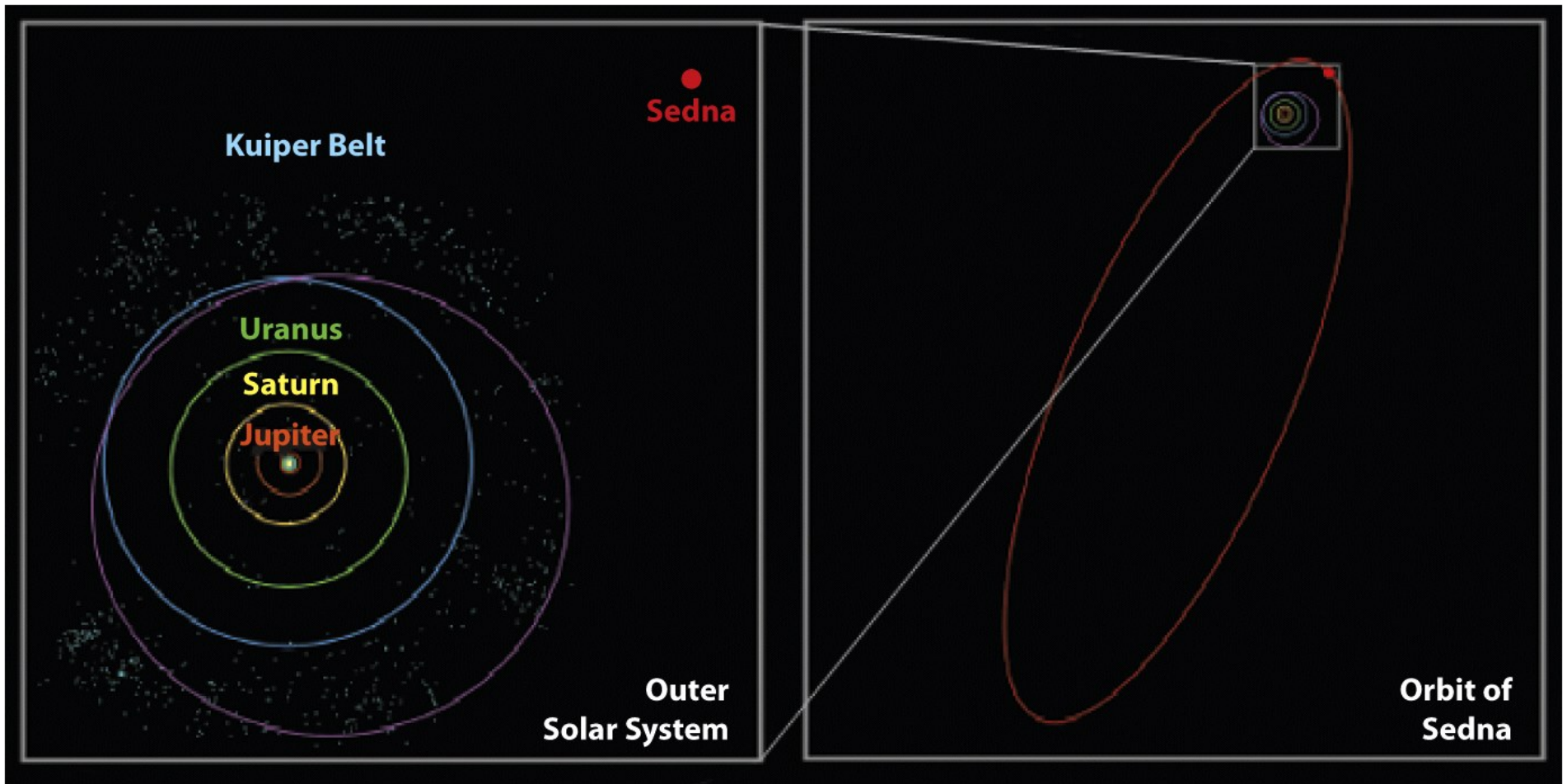


a

b

c

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a

b

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Comet West

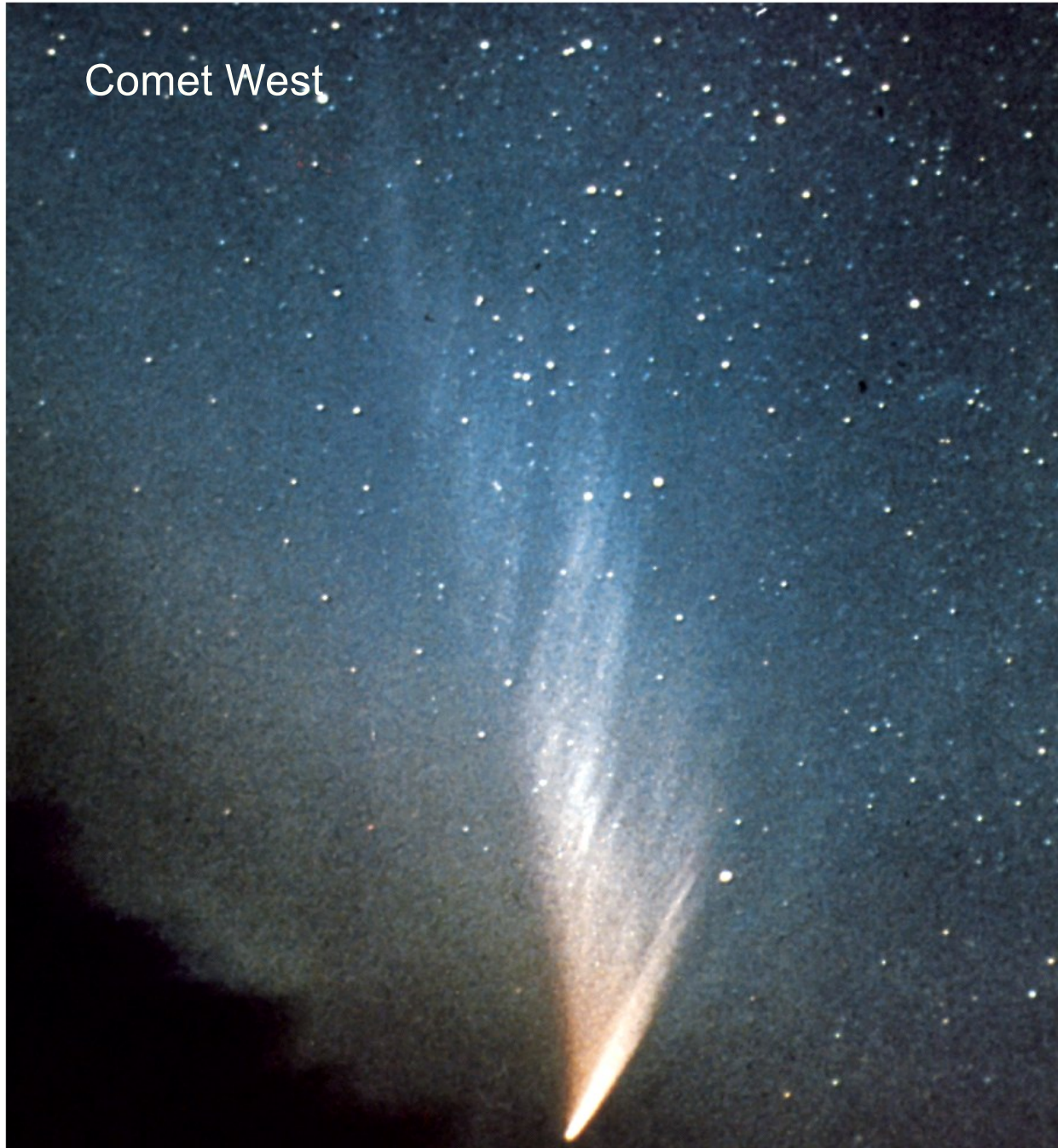


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Comet Halley

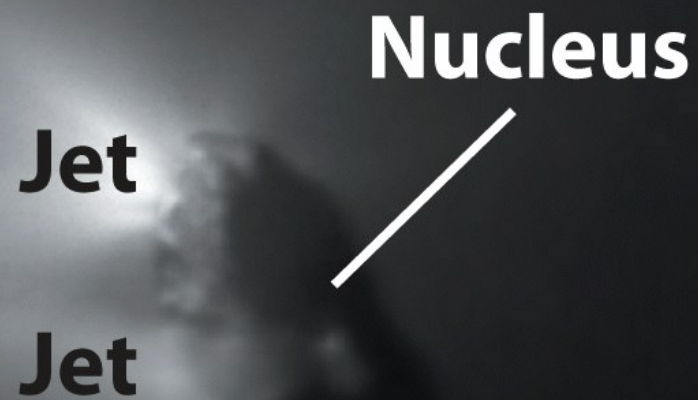


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Comet Hale-Bopp

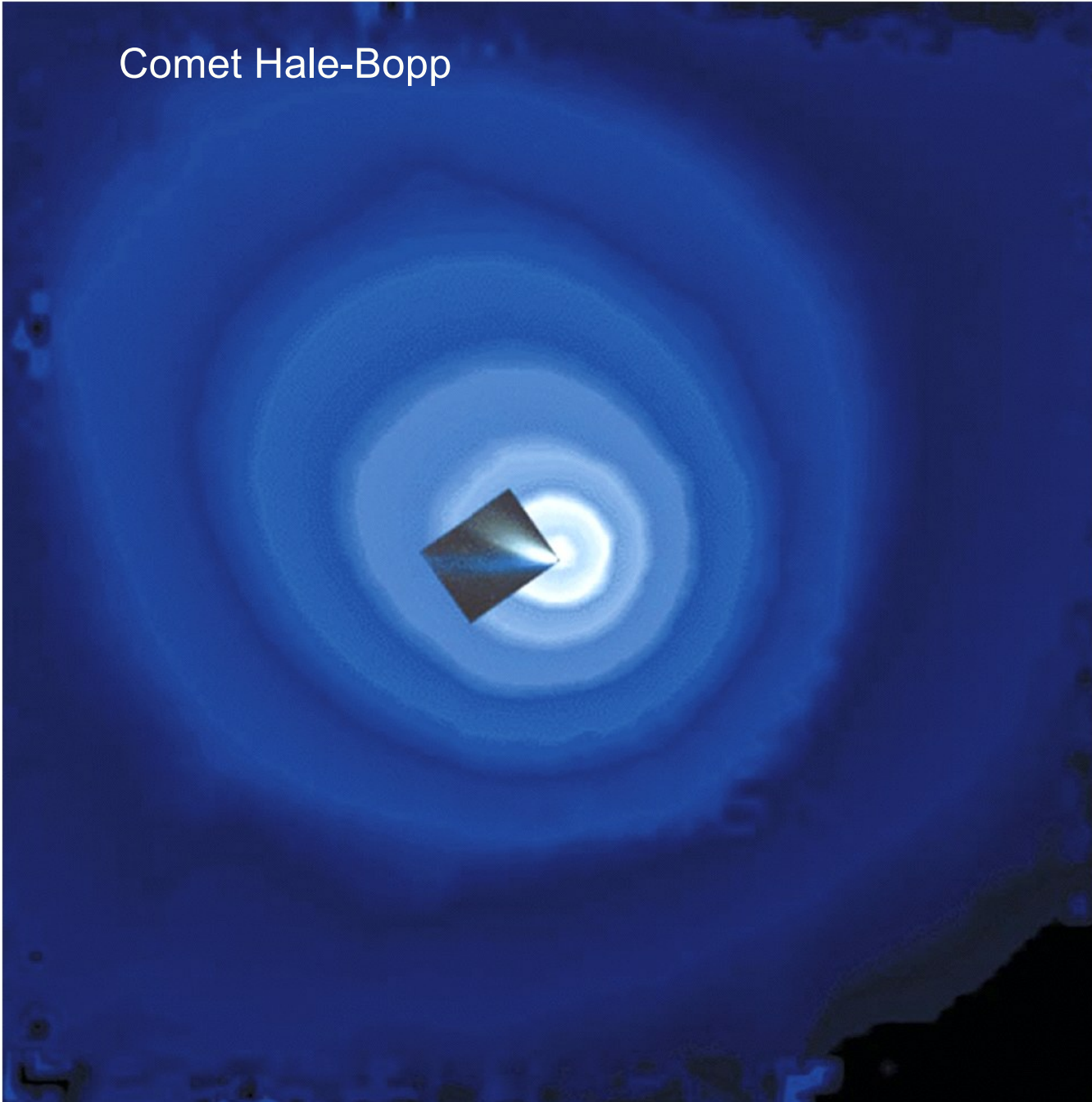
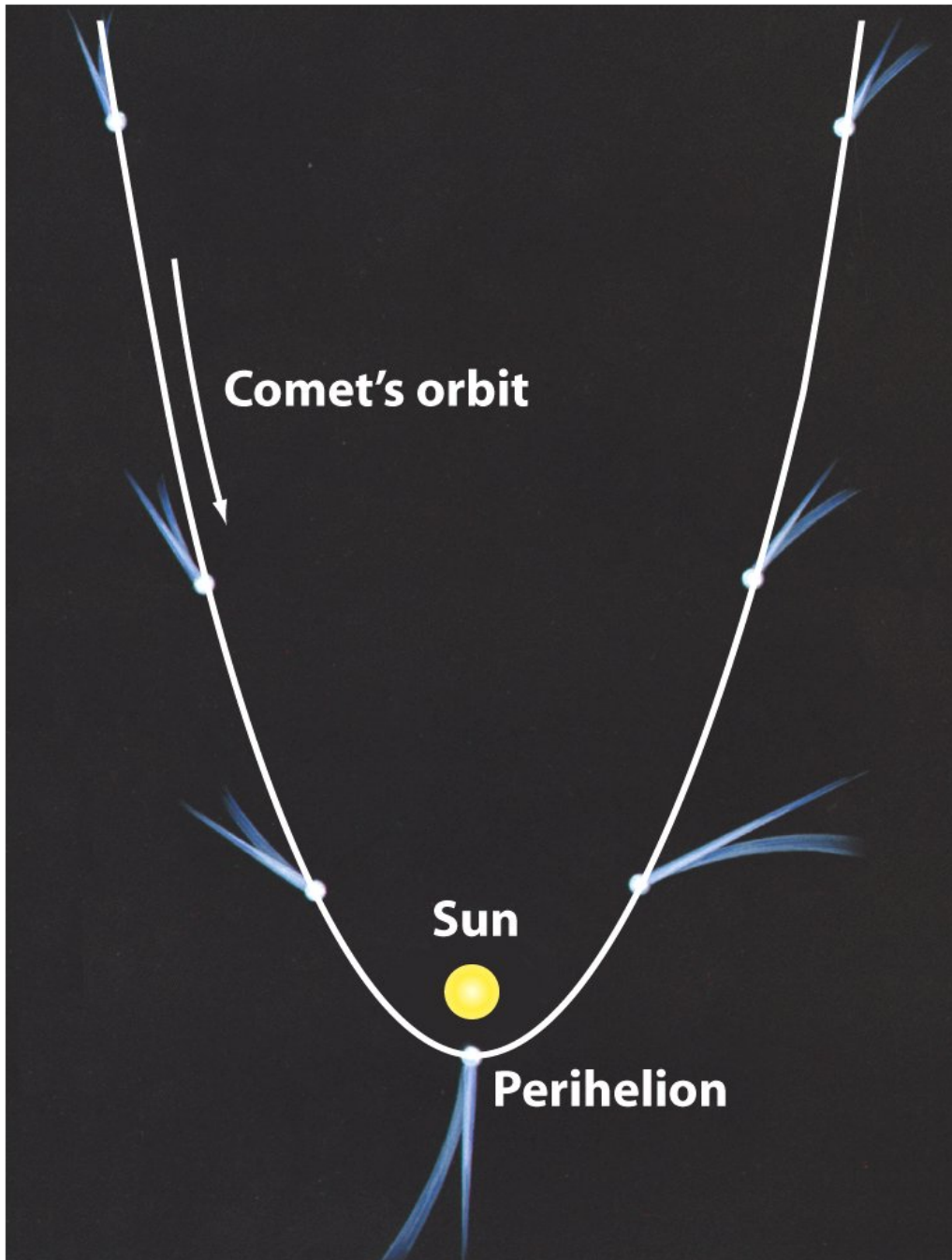


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- A comet is a chunk of ice with imbedded rock fragments that generally moves in a highly elliptical orbit about the Sun

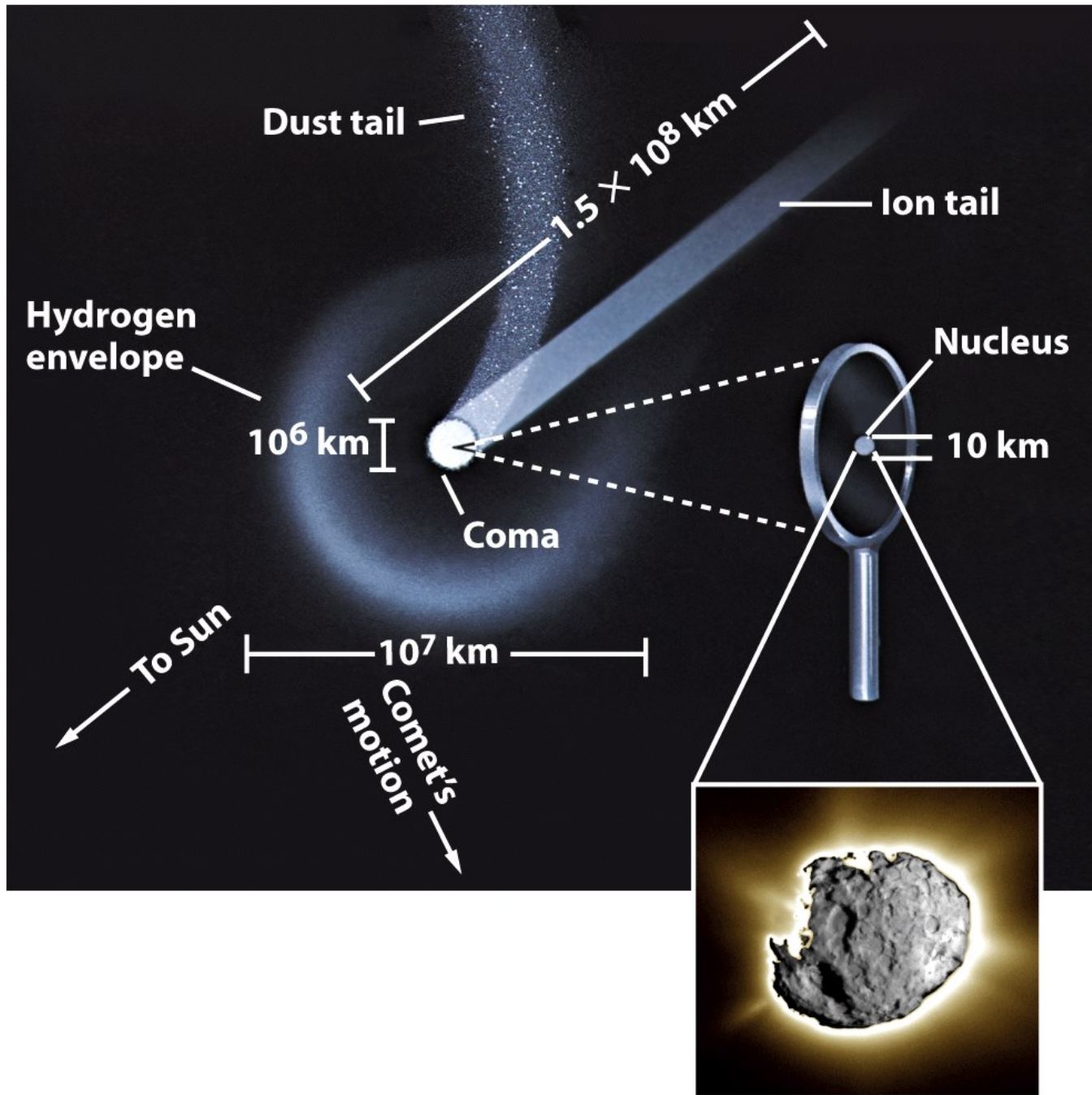


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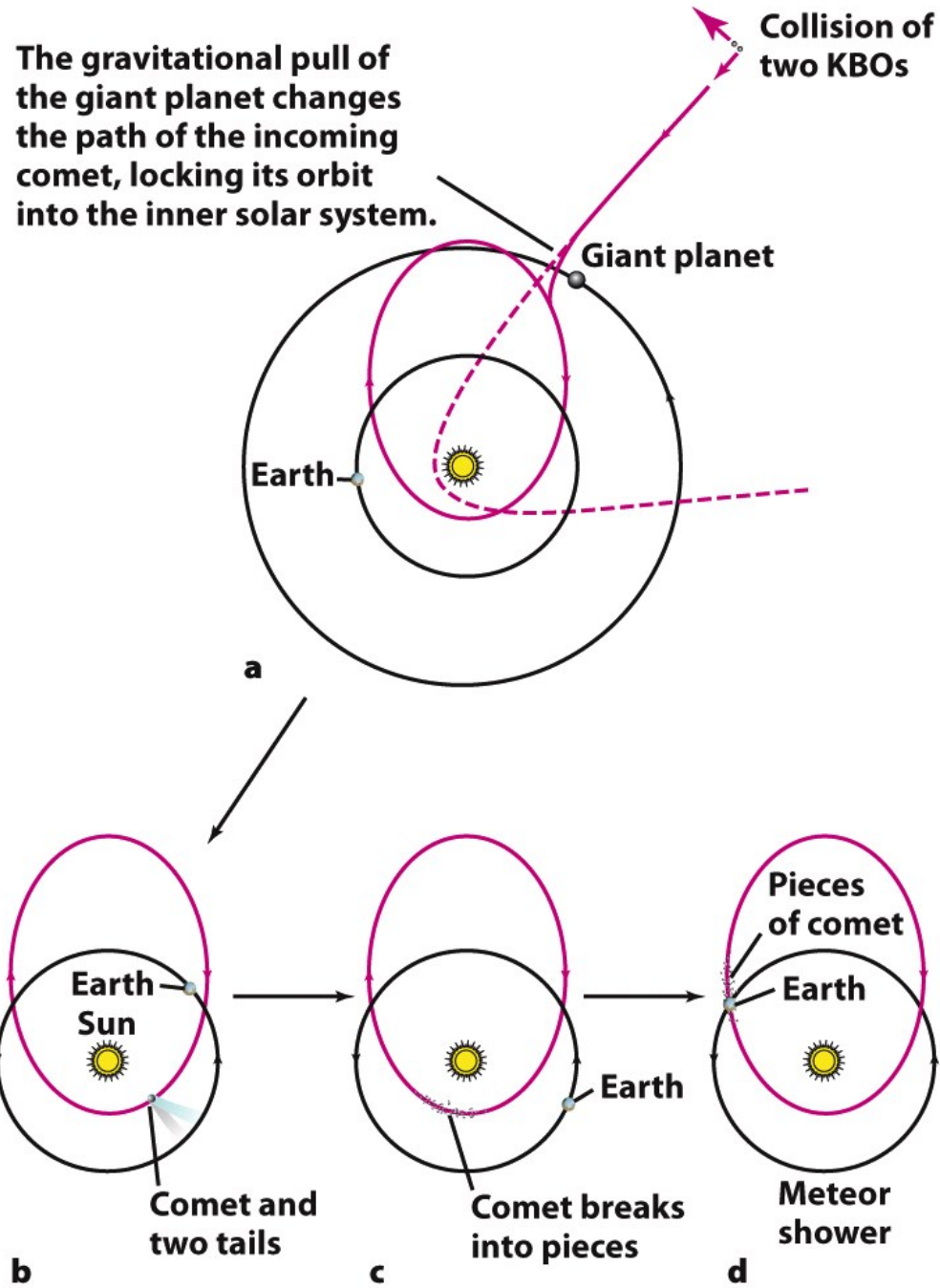
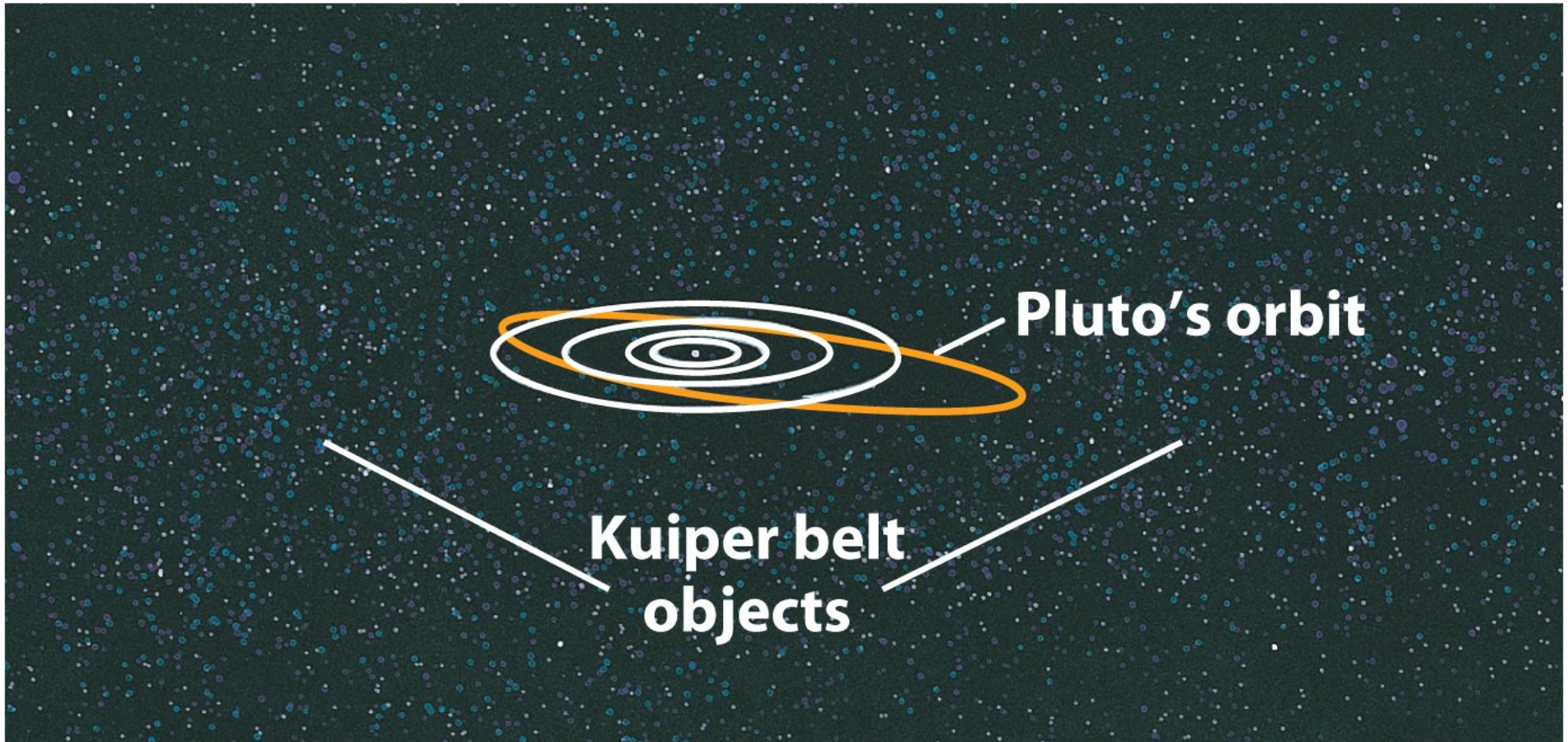


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Comets originate either from a belt beyond Pluto or from a vast cloud in near interstellar space



- The Oort cloud contains billions of comet nuclei in a spherical distribution that extends out to 50,000 AU from the Sun
- Intermediate period and long-period comets are thought to originate in the Oort cloud
- As yet no objects in the Oort cloud have been detected directly

Meteoroids, Meteors and Meteorites

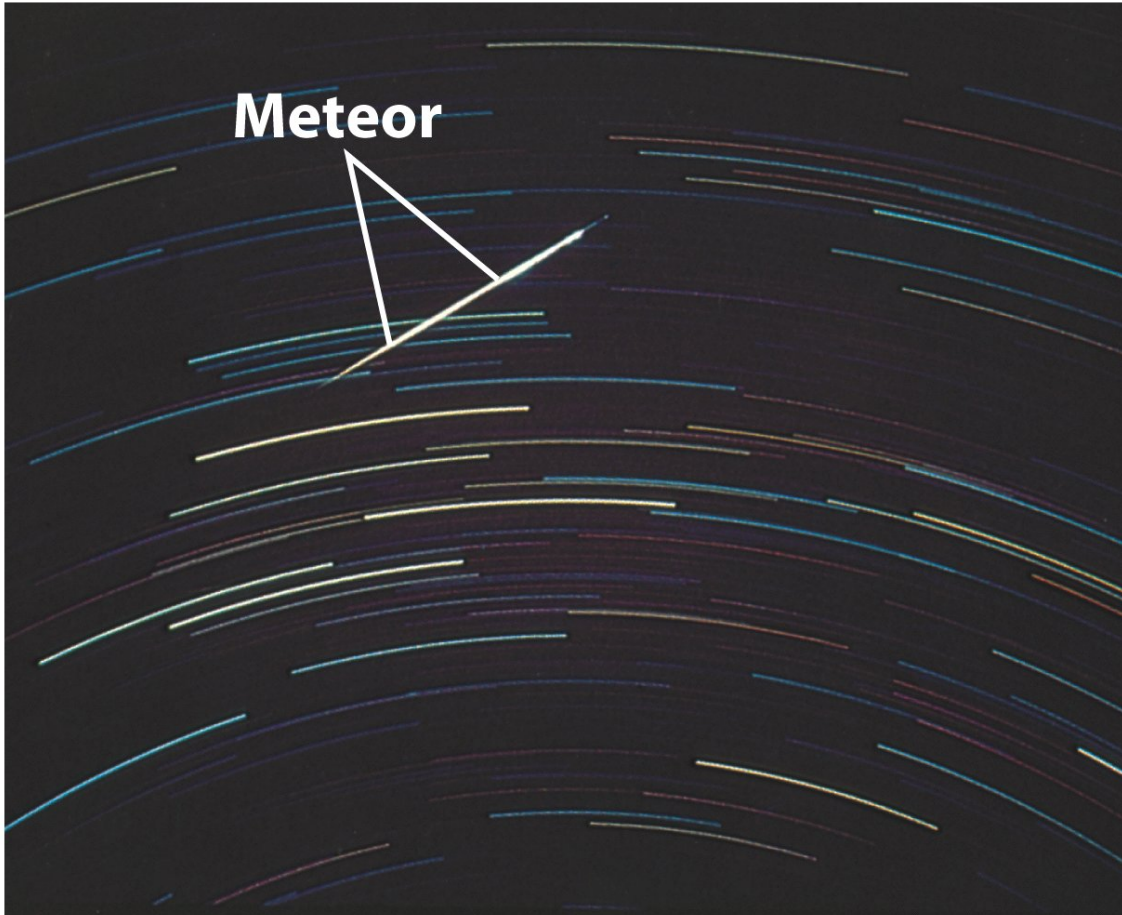


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Small rocks in space are called meteoroids



- If a meteoroid enters the Earth's atmosphere, it produces a fiery trail called a meteor
- If part of the object survives the fall, the fragment that reaches the Earth's surface is called a meteorite



The origin of meteor showers

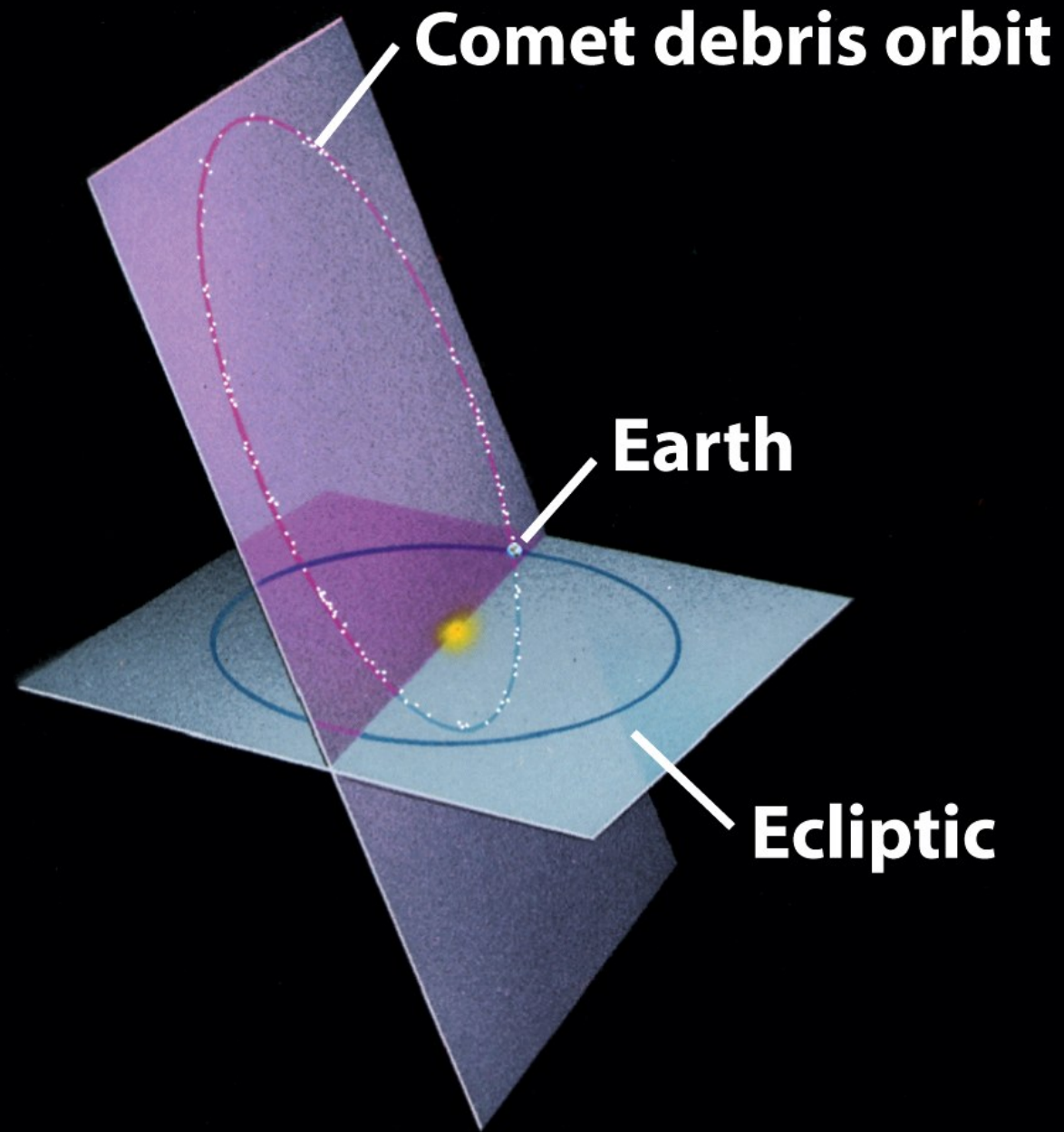


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Meteor shower



Figure 9-38 part 1

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PROMINENT YEARLY METEOR SHOWERS

Shower	Date of maximum intensity	Typical hourly rate	Constellation
Quadrantids	January 3	40	Boötes
Lyrids	April 22	15	Lyra
Eta Aquarids	May 4	20	Aquarius
Delta Aquarids	July 30	20	Aquarius
Perseids	August 12	80	Perseus
Orionids	October 21	20	Orion
Taurids	November 4	15	Taurus
Leonids	November 16	15	Leo Major
Geminids	December 13	50	Gemini
Ursids	December 22	15	Ursa Minor

Figure 9-38 part 2

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Meteor shower impacts

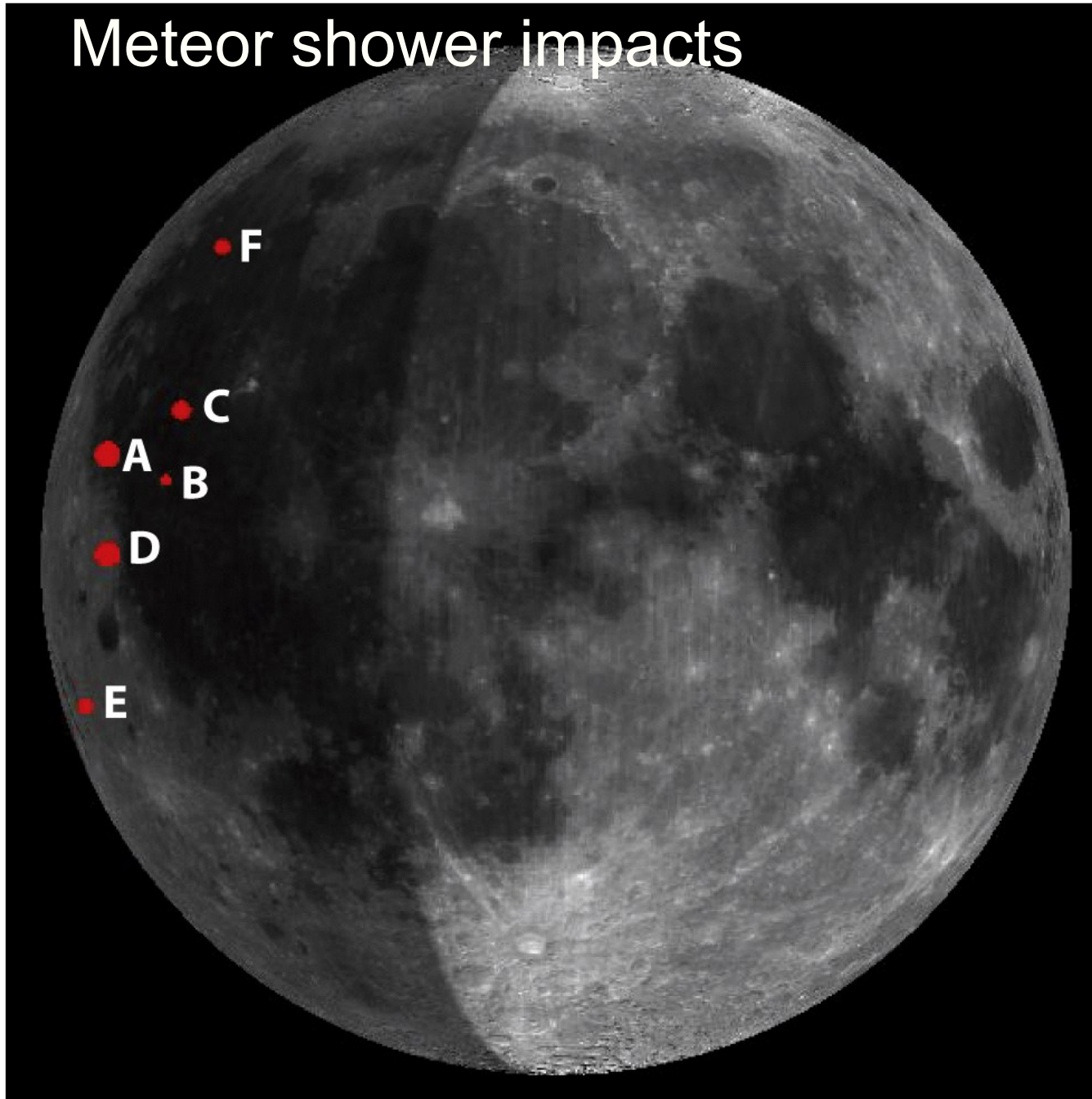
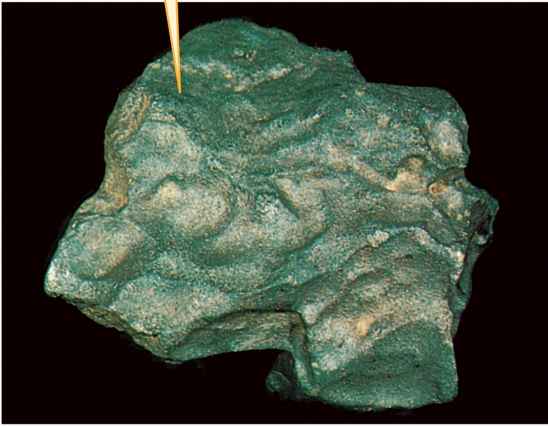


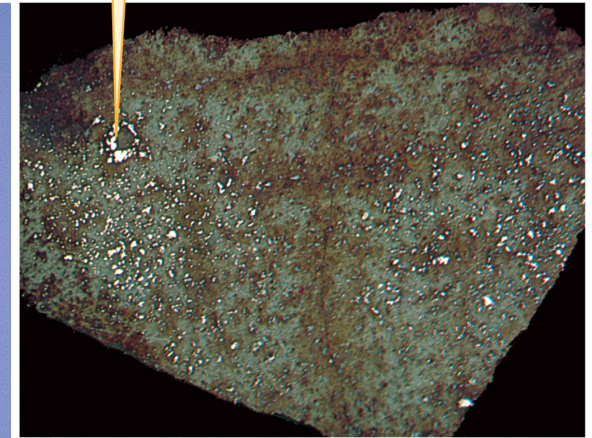
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Meteorites are classified as stones, stony irons, or irons, depending on their composition

Many stony meteorites are coated with dark fusion crusts...



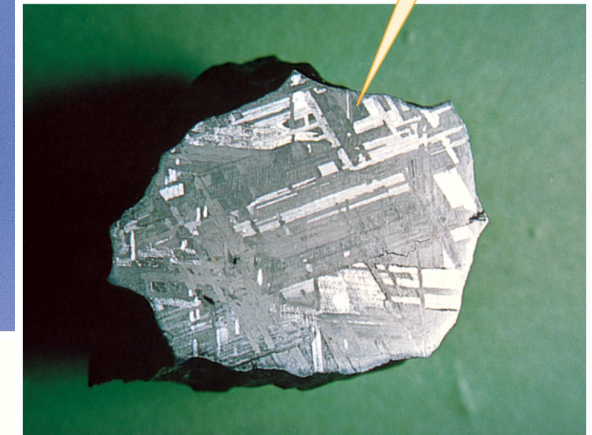
...but when cut and polished they reveal tiny specks of iron in the rock.



Iron meteorites are composed of nickel-iron minerals and are characterized by a surface covered with depressions...



...and when cut and polished, by interlocking crystals in a Widmanstätten pattern.



Some meteorites retain traces of the early solar system

- Rare stony meteorites called carbonaceous chondrites may be relatively unmodified material from the solar nebula
- These meteorites often contain organic material and may have played a role in the origin of life on Earth



- Analysis of isotopes in certain meteorites suggests that a nearby supernova may have triggered the formation of the solar system 4.56 billion years ago



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1908, asteroid exploded in atmosphere over Tunguska region

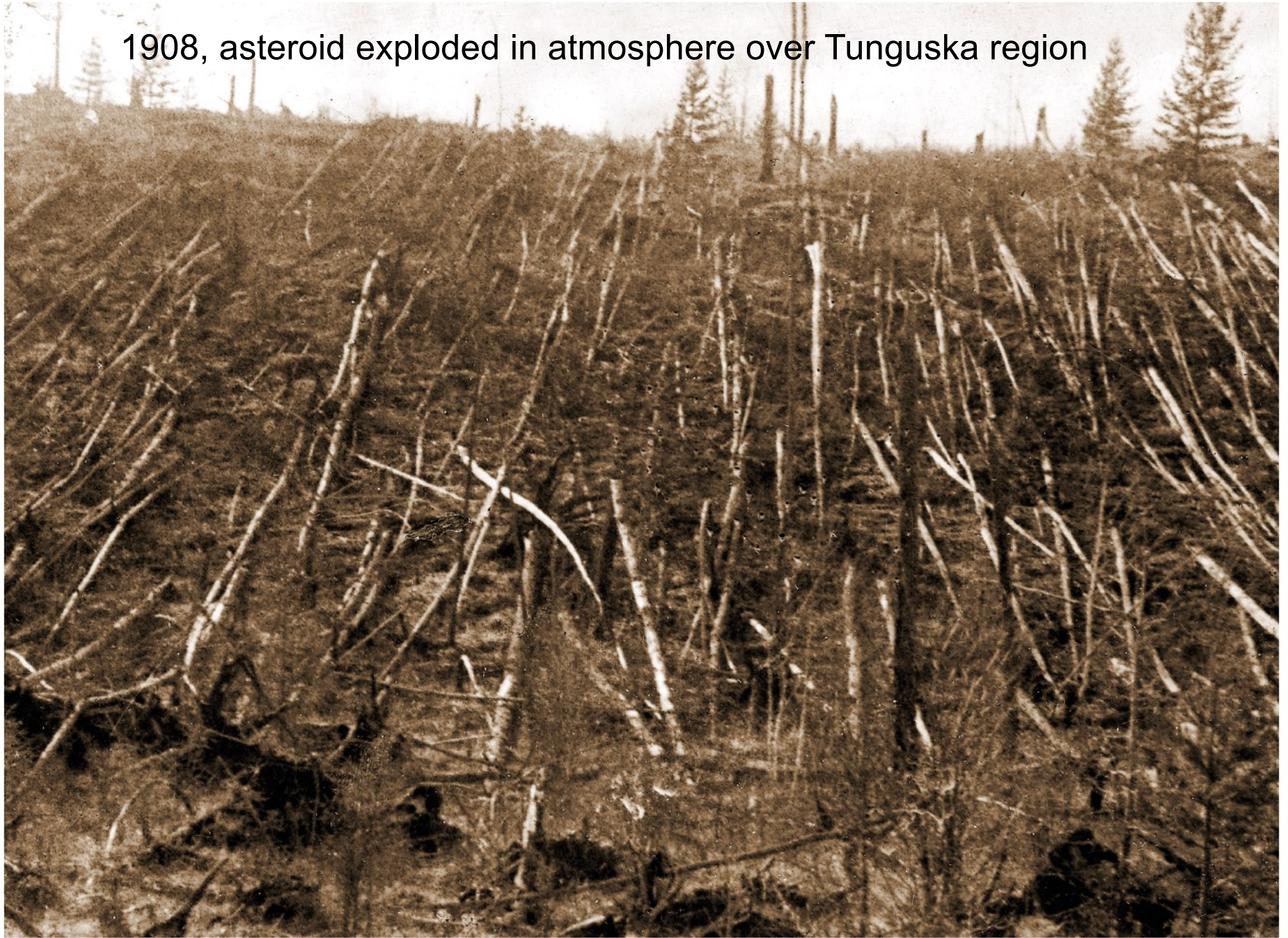


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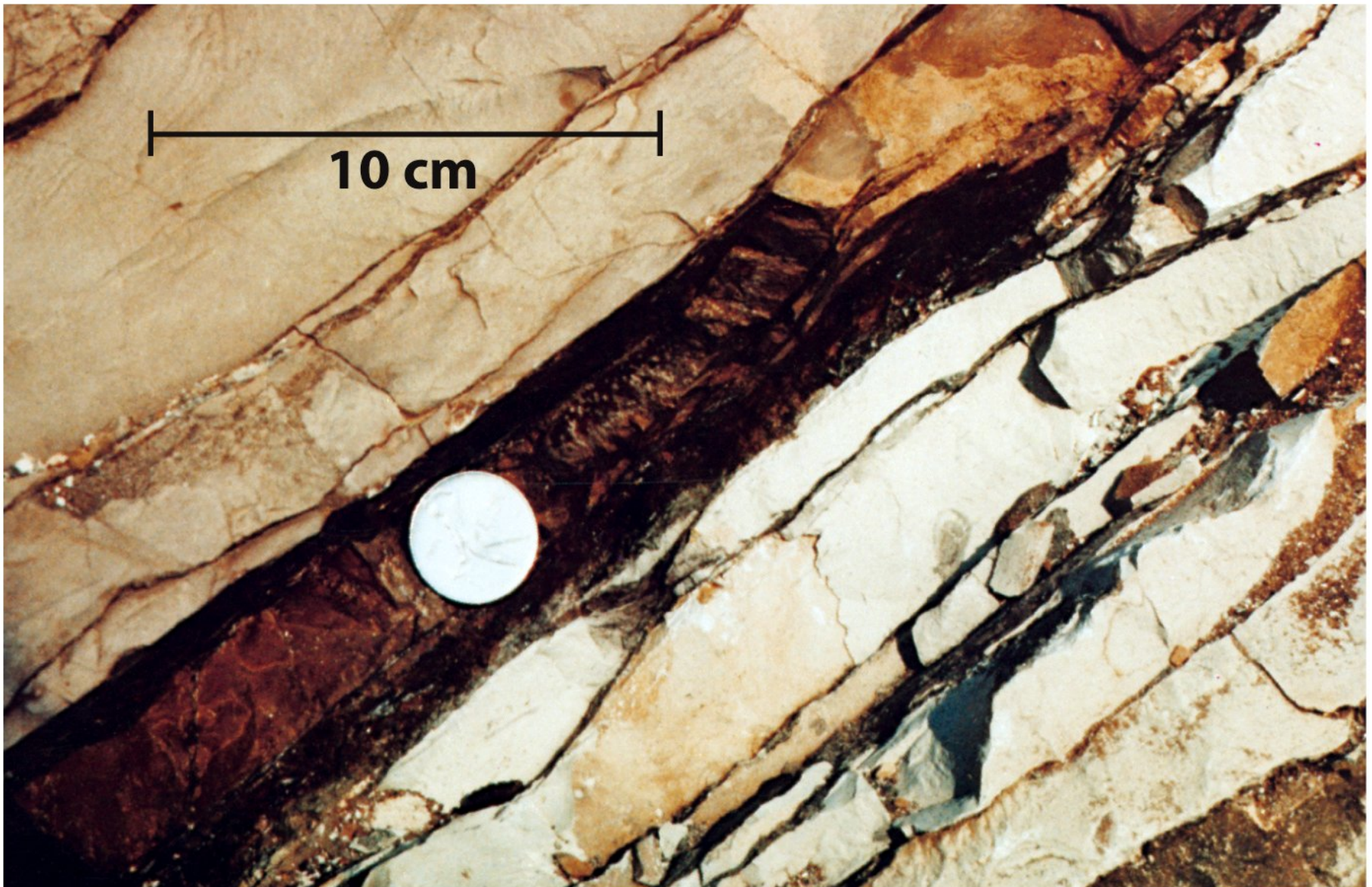
Asteroids are found outside the asteroid belt and have struck the Earth

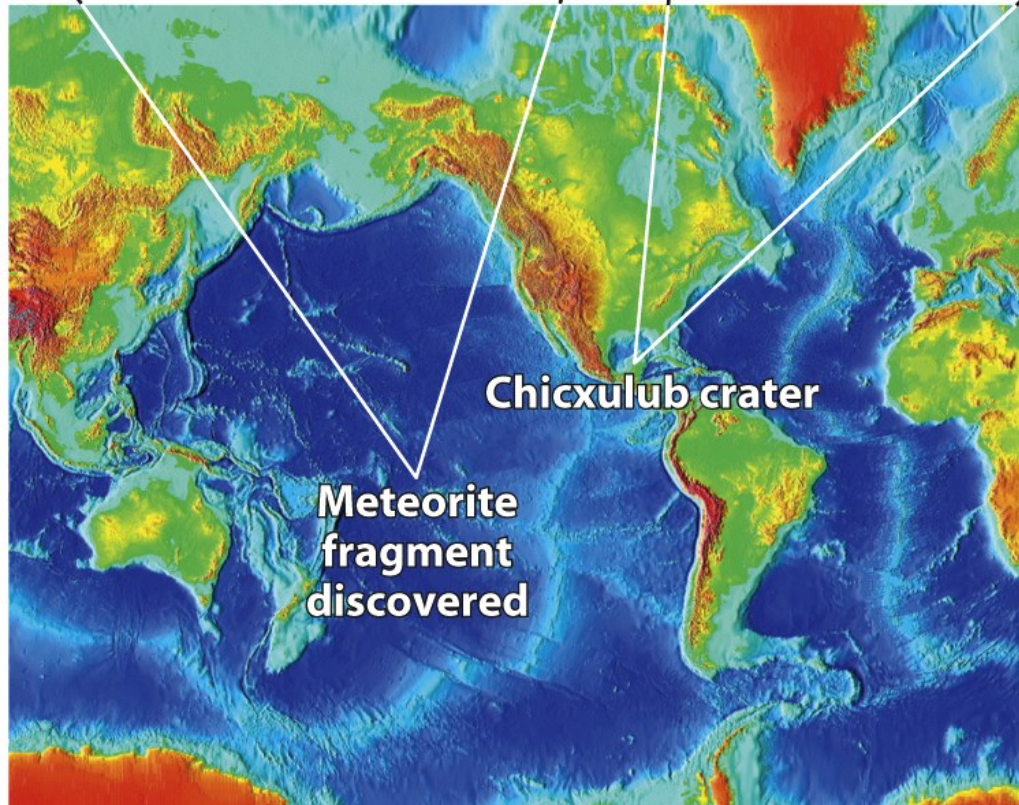
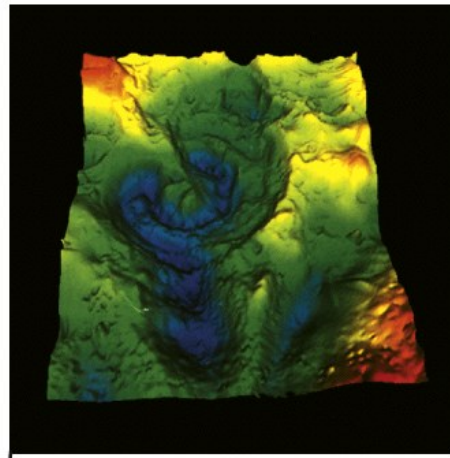
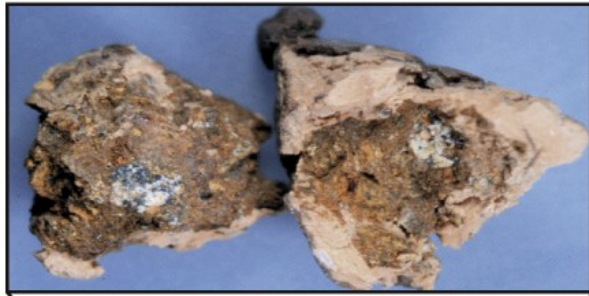
Some asteroids, called near-Earth objects, move in elliptical orbits that cross the orbits of Mars and Earth

If such an asteroid strikes the Earth, it forms an impact crater whose diameter depends on both the mass and the speed of the asteroid



An asteroid may have struck the Earth 65 million years ago, possibly causing the extinction of the dinosaurs and many other species





65 Mill years ago:
demise of the
dinosaurs

250 Mill years ago:
greater mass
extinction - 80 - 90%
of species of life
perished

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