

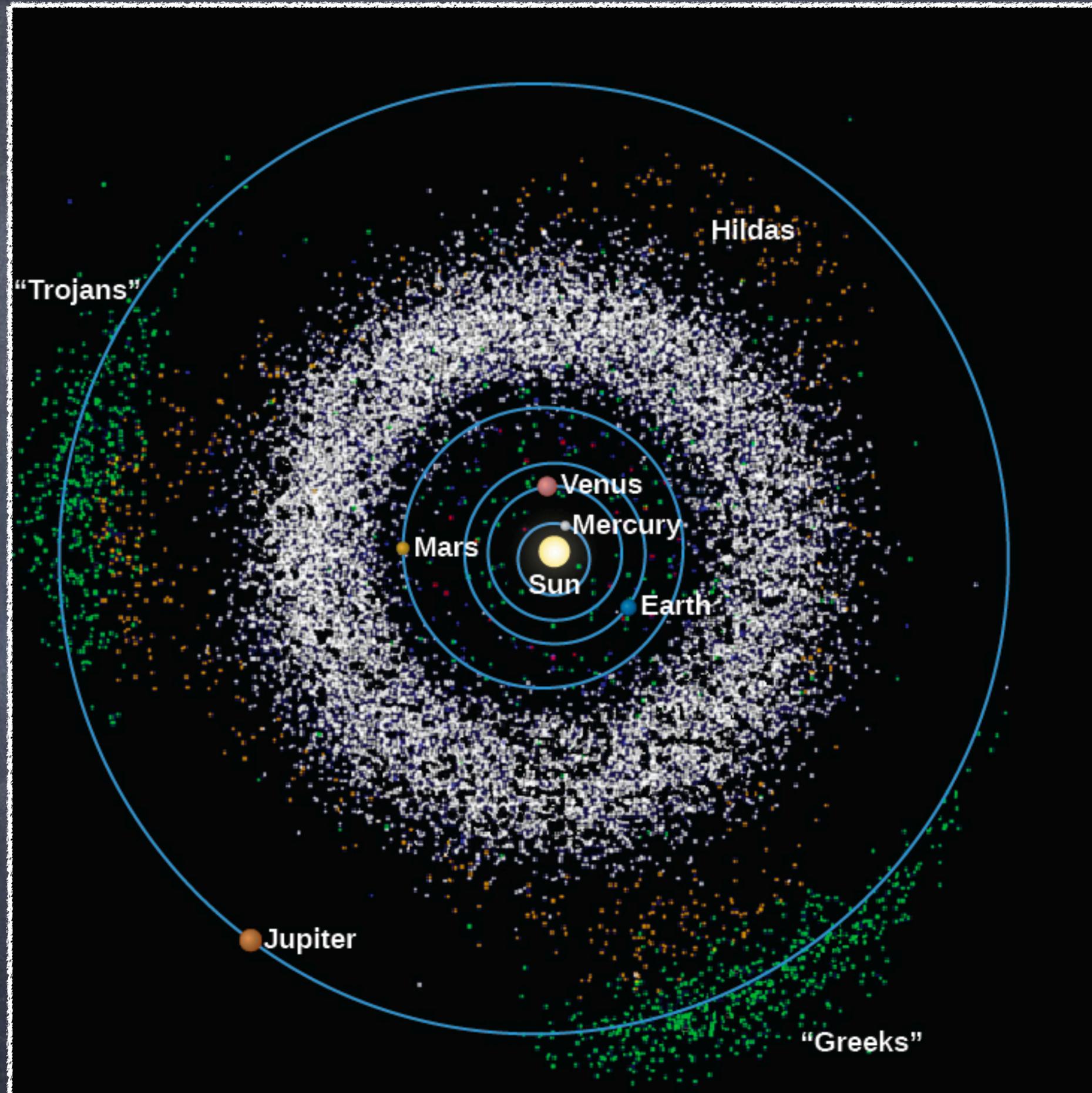
# Astroids and Comets

Chapter 13

# Astroids

- The first astroid was discovered in 1801, but thought to be a planet. As a few more were discovered in the next few years it became obvious these objects were not planets, but a new type of object that became called an astroid.
- We now know of millions of astroids, but very few of them are large. The first discovered and largest, Ceres, is almost 1000km across. Two more are larger than 500km across and 12 more are larger than 250km across. The number increases rapidly with decreasing size.
- The astroids revolve around the Sun like the planets and in the plane of the ecliptic. More than 75% of astroids are in a belt between Mars and Jupiter.

- The vast majority of asteroids are found in the asteroid belt.
- They are made of rock and metal. They are classified as S, C or M type for stony, carbon or metal.





**Mathilde**



**Gaspra**



**Ida**

An asteroid with a moon



The moons of Mars look like captured asteroids.



Some asteroids look more like rubble piles and are probably not a single rock but many rocks held together loosely by gravity.



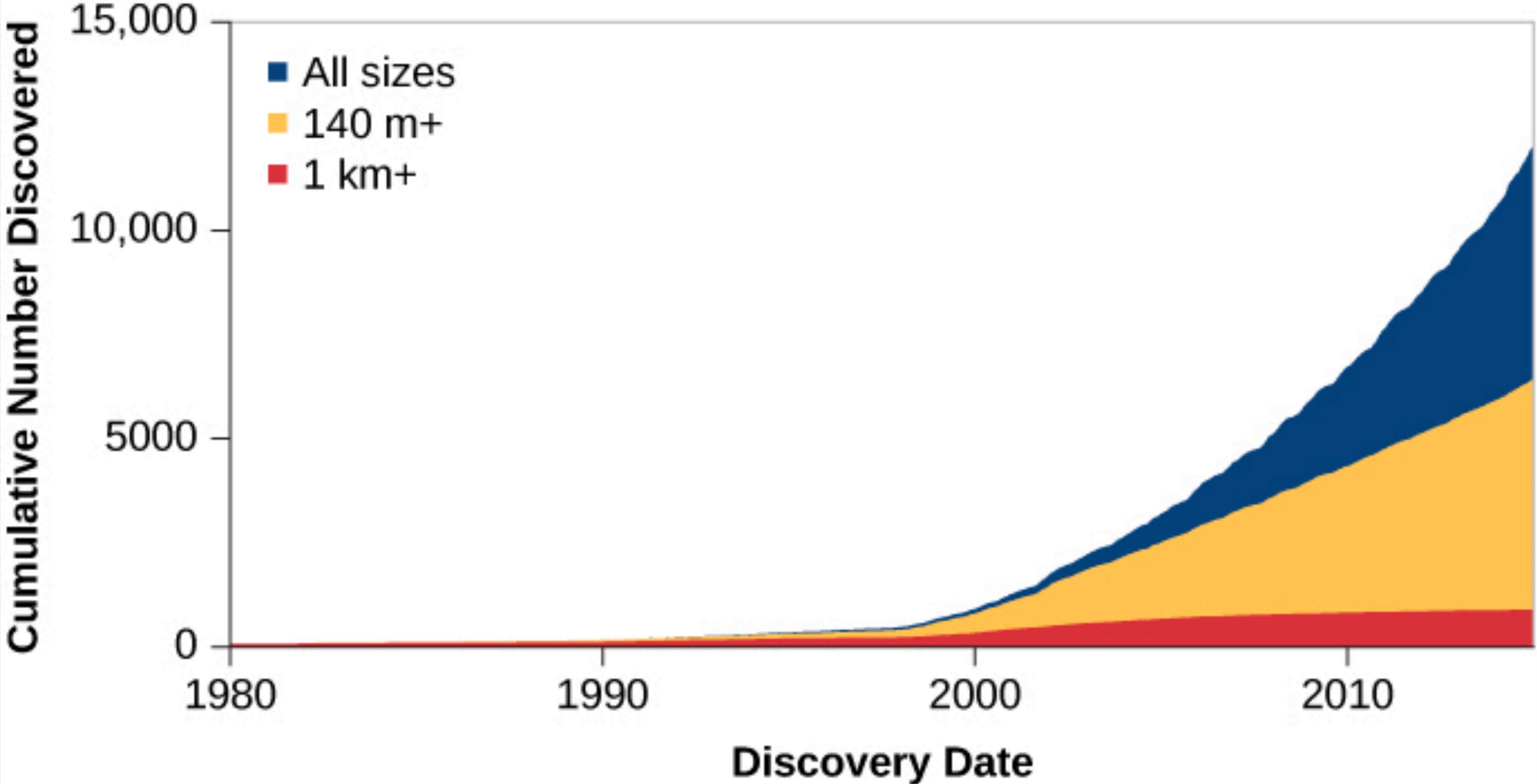
# Near Earth Objects (NEOs)

- The vast majority of asteroids are in the asteroid belt, but some are not and a small fraction of those have orbits that cross Earth's orbit.
- They rarely actually impact the Earth, but when they do the effect can be devastating.
  - In 2013 a small (~20m) asteroid exploded over the city of Chelyabinsk with an energy of 500 kilotons, 30 times the energy of nuclear bombs dropped in WWII.
  - In 1908 a larger object (~40m) exploded over the Tunguska River in Siberia with an energy of 5 megatons. The area was unpopulated but forest the size of a city was knocked over.
  - 65 million years ago an impact contributed to the extinction of the dinosaurs.

The Chelyabinsk meteor could be seen streaking through the sky before it exploded. The Tunguska impact knocked down trees over hundreds of kilometers.



# Near-Earth Asteroids Discovered



# Defending the Earth

- If we detect an asteroid that will hit the Earth with enough warning (years to decades) it is not that hard to nudge it a teeny bit so that it ends up not hitting the Earth.
- If we discover it shortly before it will hit the Earth, like is constantly shown in the movies, the possibility of spotting it becomes incredibly hard.
- Thus all realistic defense of NEOs comes from early detection.

# Comets

- Comets are also small objects that orbit the sun, they differ from asteroids in that they are mostly made of ice instead of rock and metal.
- Comets become very easy to see when they get close to the sun because the ice melts and creates a halo around them and a tail that are very bright.
- Newton suggested they orbit the sun in very elongated orbits and Halley developed these ideas in 1705, noting that some comets may have been repeat visits.
- In fact what is now called comet Halley has been observed every 74-79 years since 239 BCE.

## Comet Halley

few comets are short period comets like this  
most have periods so long we have only seen  
them come by once.

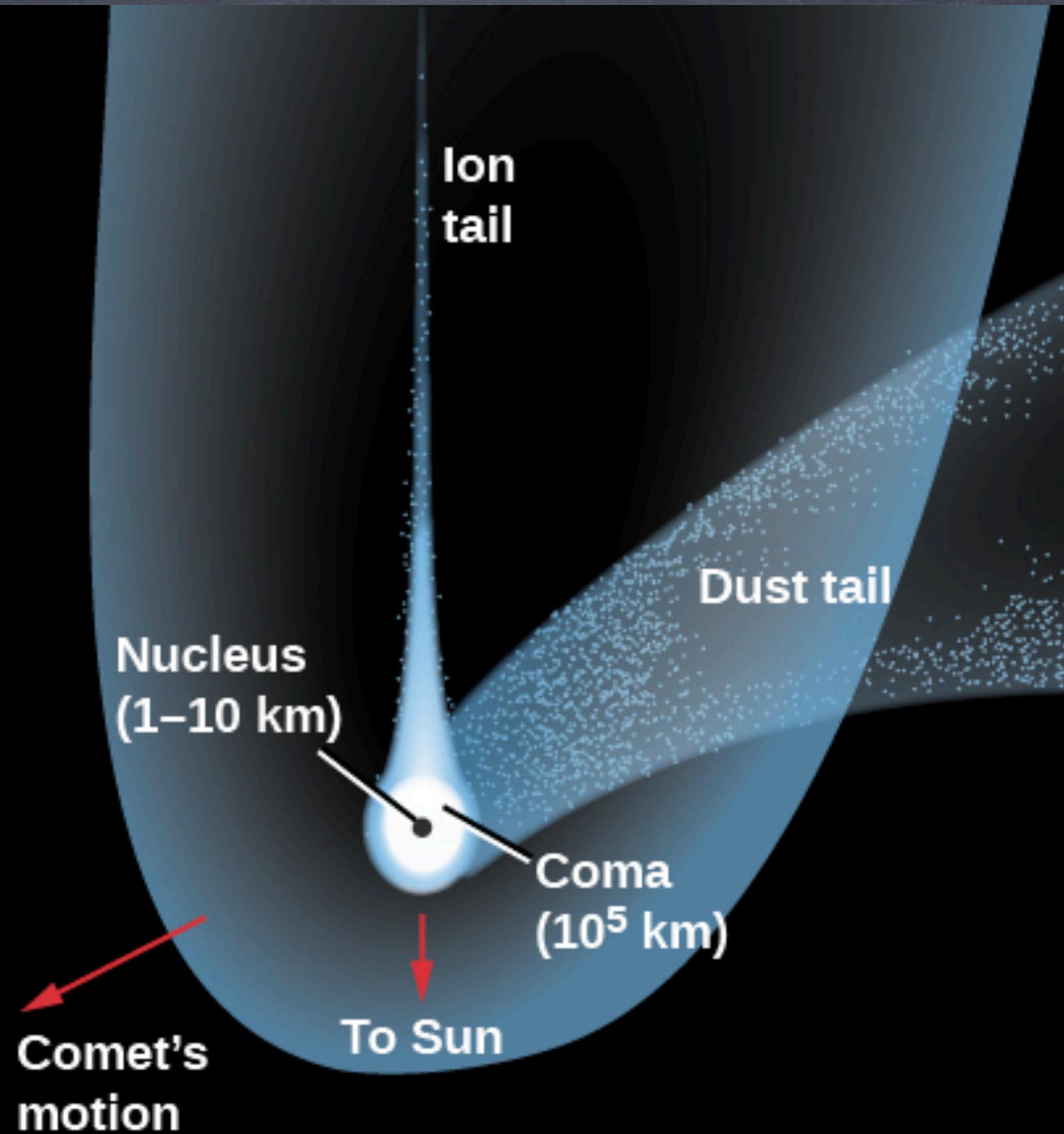


A comet is composed of a small nucleus, a thousands of times bigger coma, a dust tail and an ion tail.

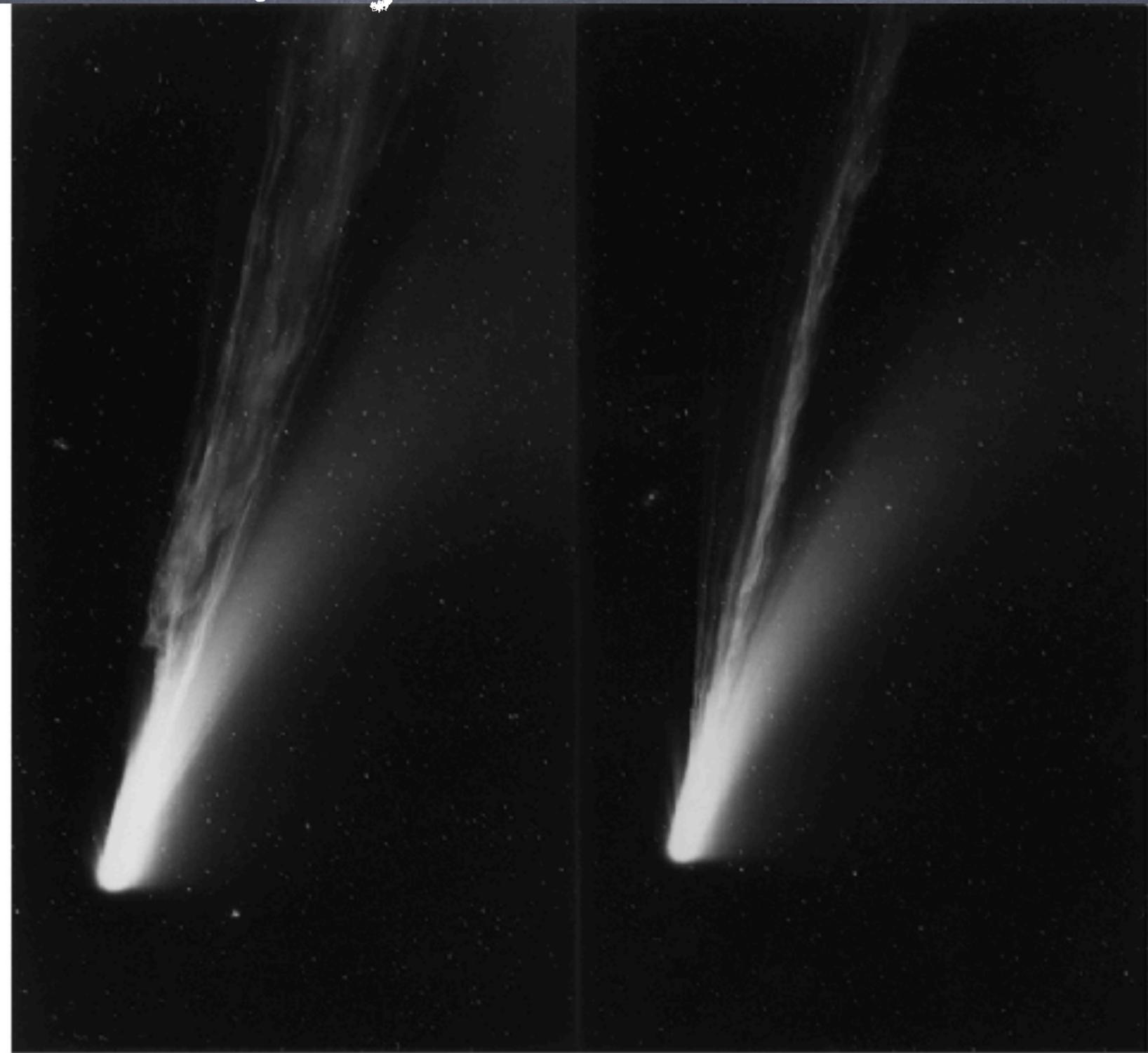
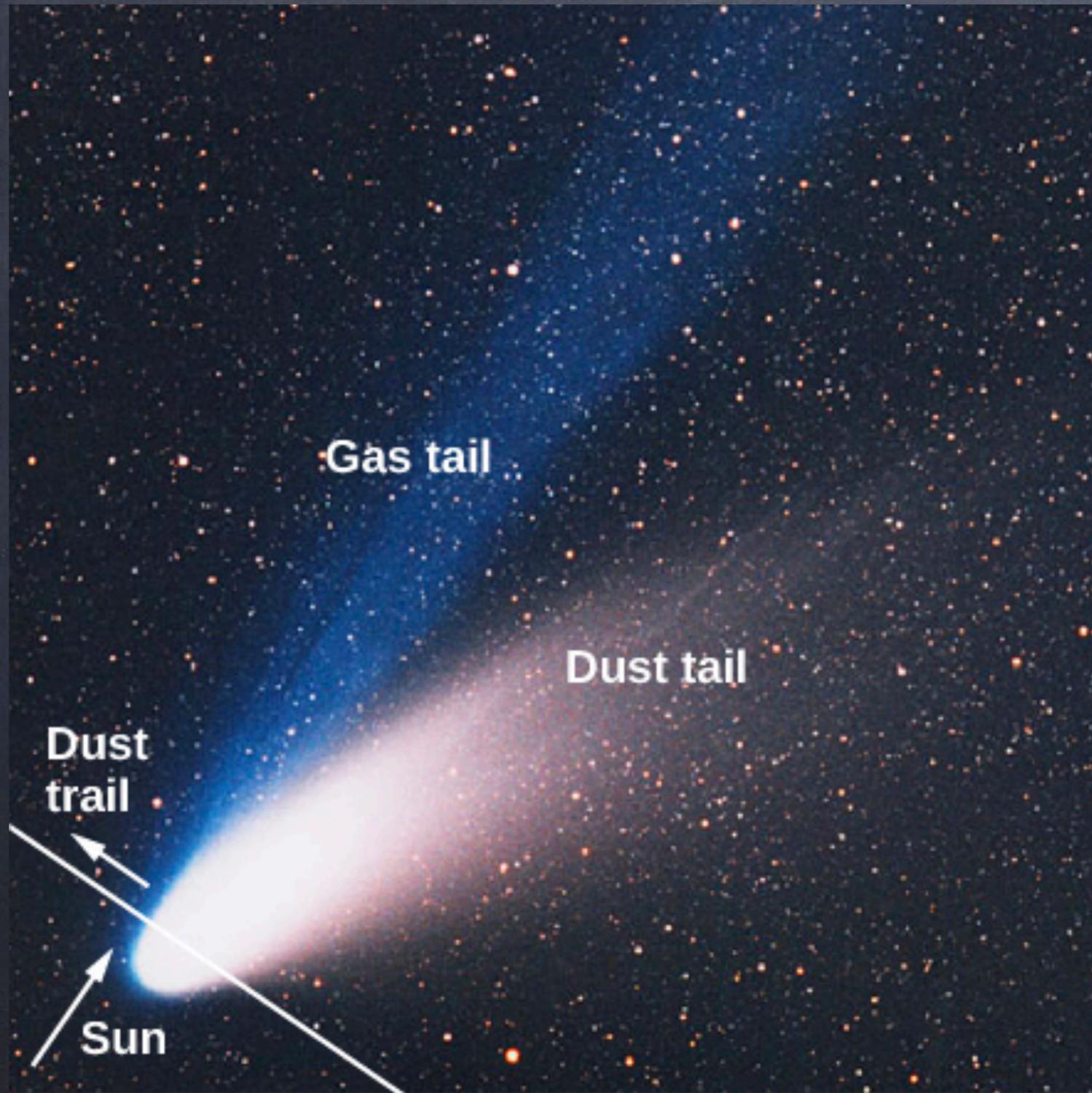
The **nucleus** is the ice, rock and dust that makes up the comet.

The **coma** is the material that has come off of the solid nucleus because of heating by the sun. The coma is not bound and must be replenished by new melting of the nucleus.

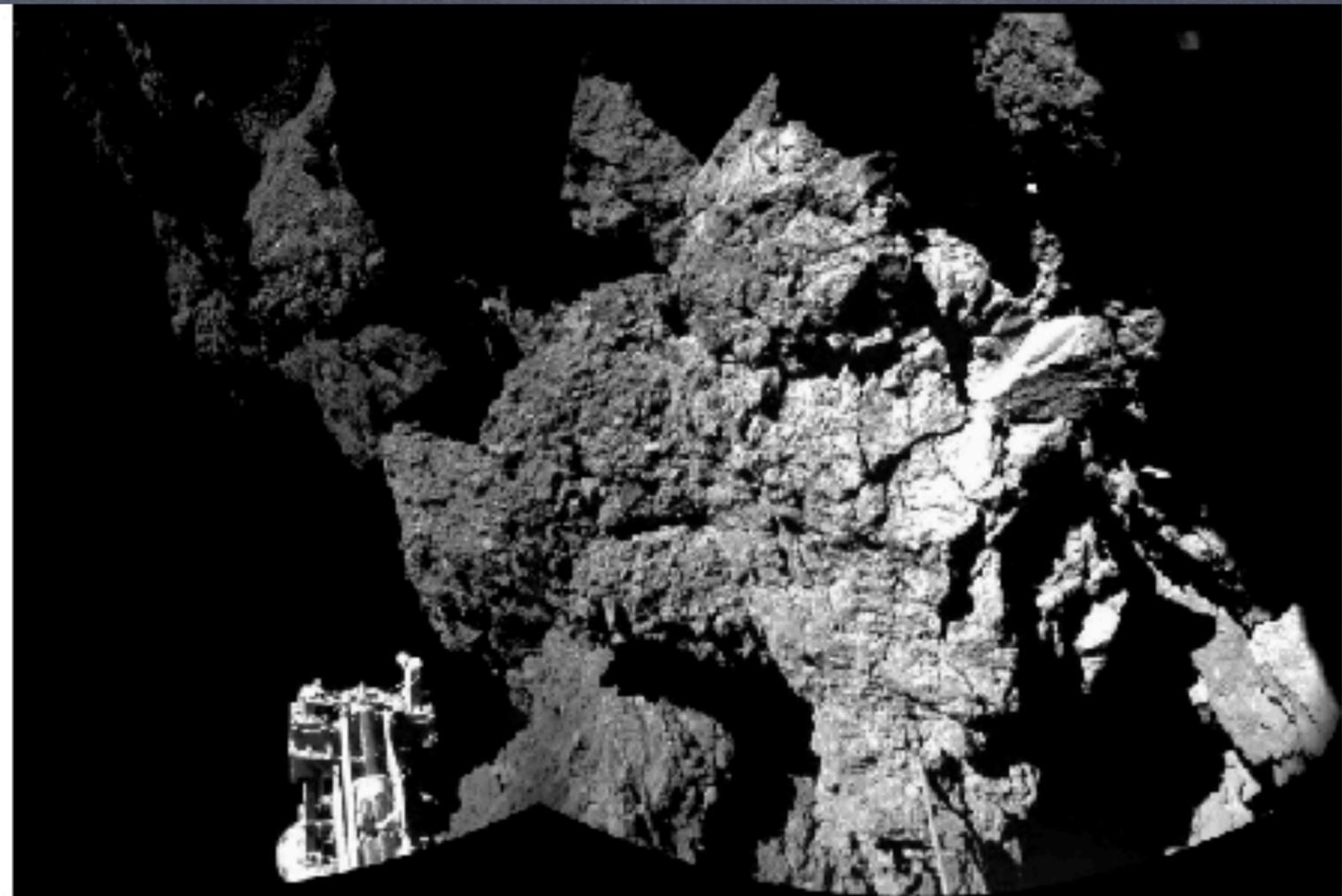
The coma is why comets are easy to see, they are actually very large if unsubstantial.



The comet tails do not show the direction of the comet's motion, but are blown back by the sun. The ion or gas tail points away from the sun, while the dust tail is slightly bent from the sun



Close up pictures of comet nuclei before becoming comets. Evaporation happens in jets, not uniformly.



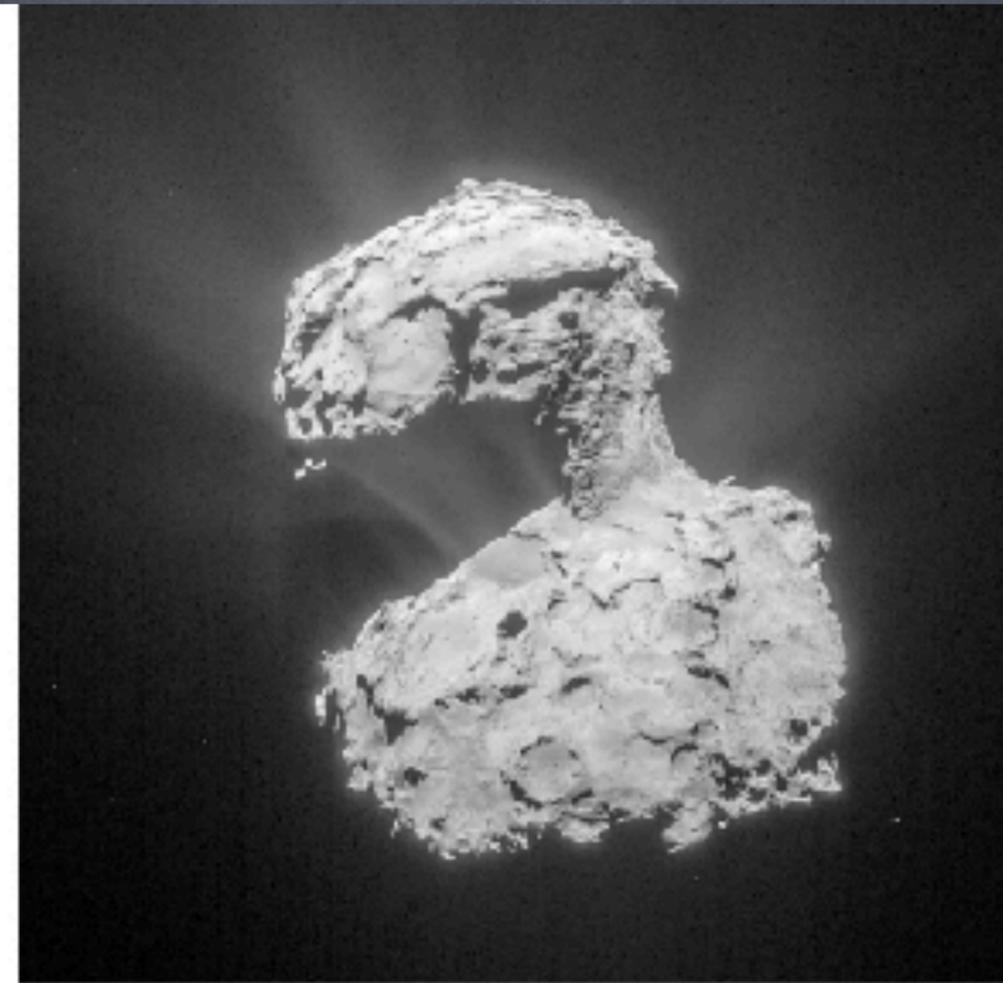
Photography capturing a jet of mostly water as the comet is heated. The uneven evaporation gives comet nuclei their unusual shapes.



(1)



(2)



(3)