# Solar System Junk

So far, we've taken a brief look at the 8 planets of the solar system, their array of moons or natural satellites, and how we think such a system formed. Most of the material in the solar nebula either fell into the Sun or was swept up by the forming planets; **however, a large number of bodies were left over as Junk or the debris of planet building**. **Are these things important? Yes, they can give insight into early Solar System conditions, could be a source of raw materials in the future, and, if they collide with the Earth, there could be some very important consequences.**

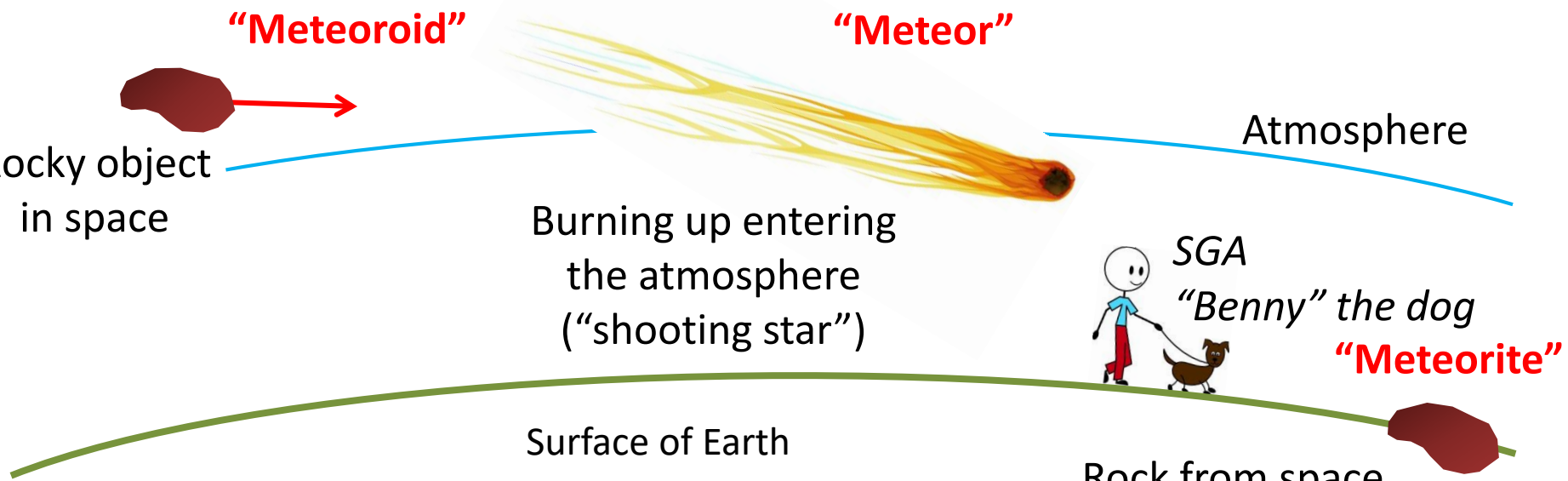
**This Junk falls into two basic classes:**

- **Meteoroids and Asteroids** are leftover rocky planetesimals from the inner solar system.
- **Cometary Bodies** are leftover icy planetesimals from the outer solar system

Note: eventhough we'll talk about them separately, meteoroids and asteroids are pretty much the same thing. Generally asteroids are larger and have a more extensive history of collisions *("collisionally evolved")*

# Meteoroids

**Some (picky?) Terminology:**




**All the same object, but different names for different phases.**

For example, the Peekskill Meteor from 1992

What would call the object the man is holding? **(LC)**

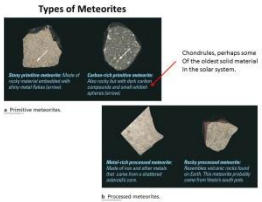
**Are Meteorites dangerous?** Only, if you get hit, ask Ann Hodges

Or The Donahues from Wethersfield, CT

Or Prince Edward Island in 2024

# Meteorites

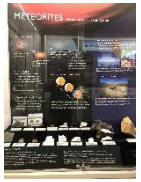
## What do we learn from Meteorites?




**Meteorites come in two classes:**

- **Primitive:** true planetesimals left over from the formation of the solar system. Radiometric dating gives them an **age of about 4.6 billion years**. Stony primitives made of metal and rock are from the inner solar nebula. Carbon-rich primitives are from the region of the asteroid belt.

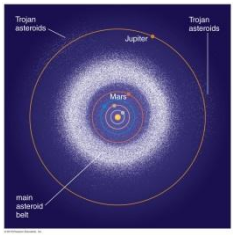
- **Processed:** were at one time part of a larger body (e.g. a large asteroid) that had differentiated. An impact then threw debris into a solar orbit. **Several processed meteorites are known to have come from the Moon and Mars** *(how do they know this?)* *The Isotope abundances match actual samples.*




The MU Geology department has some nice meteorite samples on display in Shideler

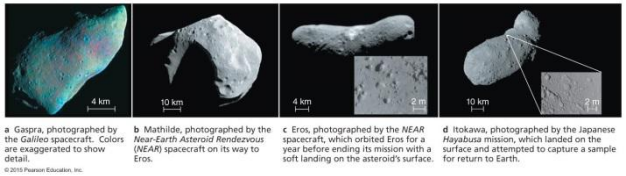
# Asteroids

Asteroids are objects like meteoroids only larger ranging in size from a few meters to a few 100 kilometers across. They are primarily found in two places in the Solar System (although they can be found any where in the inner solar system):




- **The Asteroid Belt**: between the orbits of Mars and Jupiter
  from about 2.2 AU to about 3.3 AU
  Note, there's less than a Lunar mass of material in the Asteroid belt.
- **The Trojan Asteroids:** a stable equilibrium point orbiting 60$^{o}$ ahead and behind Jupiter.

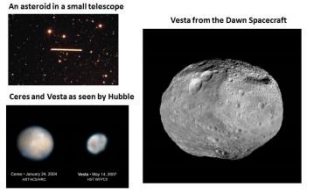
**What do asteroids look like? Some are too small to pull themselves into spherical shapes.**




**a** Gaspra, photographed by the *Galileo* spacecraft. Colors are exaggerated to show detail. **b** Mathilde, photographed by the *Near-Earth Asteroid Rendezvous* (*NEAR*) spacecraft on its way to Eros. **c** Eros, photographed by the *NEAR* spacecraft, which orbited Eros for a year before ending its mission with a soft landing on the asteroid's surface. **d** Itokawa, photographed by the Japanese *Hayabusa* mission, which landed on the surface and attempted to capture a sample for return to Earth.



The two largest are **Ceres** (now called a dwarf planet) and **Vesta**. In the last few years, the Dawn mission has gone into orbit first around Vesta and then around Ceres. This has revolutionized our views of these large asteroids.

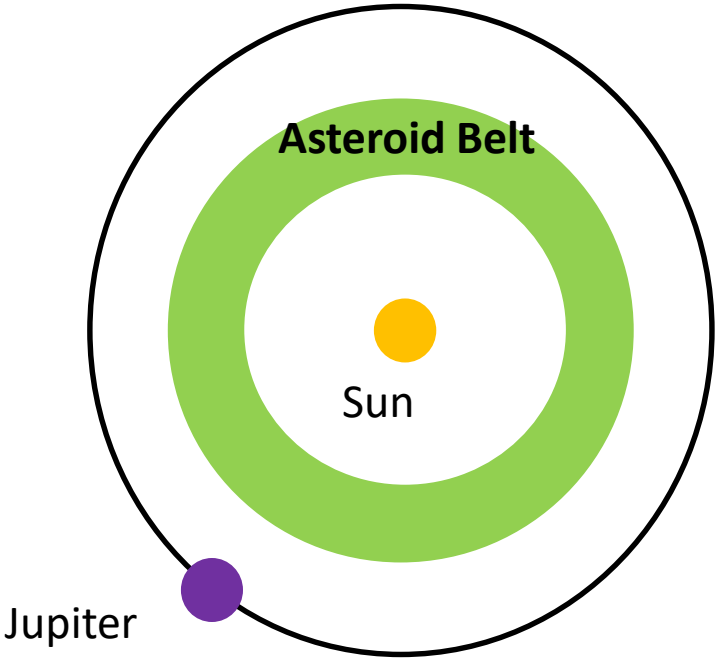



Here's what we've learned from Dawn

Have you heard of Osiris-Rex and the asteroid Bennu?

# Asteroids

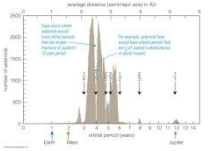
**Why do we have an Asteroid Belt? (LC)**




Some people say that the Asteroid belt is a destroyed planet; however, it's really a planet that never formed.

The presence of Jupiter prevented the solid material in the region of the asteroid belt from accreting into planet.

In fact, Jupiter continues to whittle away at the Asteroid Belt.



What about how Asteroids are portrayed in the movies;
*Is C-3P0 right? Are the odds of a collsion really 3,720 to 1?*

In reality, the asteroids in our belt are very far apart from each other; the chance of a collision is very very low. Many of our spacecraft have successfully gone through the belt.

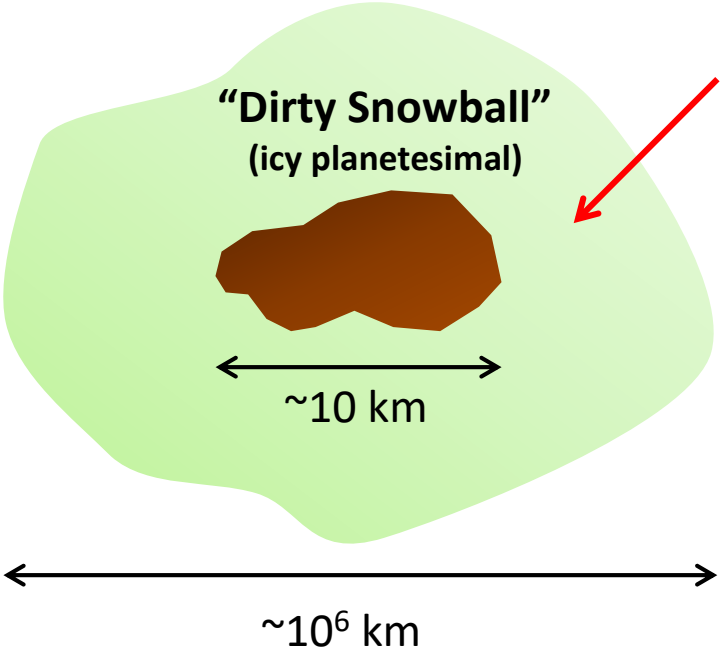
# Comets

The bodies that we call comets are icy planetesimals left over from the formation of the Solar System, but **eventhough they are small (~ few km), we've been observing comets forever.**

**A Common Misconception**: comets do not streak across the sky; They move slowly through the stars over a few weeks.

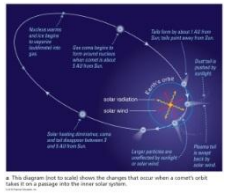
**What is a comet and why can we see them?**

**Are any comets visible now?**




When the comet gets close to the Sun, The ice evaporates and forms a large **Coma** of gas that is highly reflective. It is the coma that we see from the Earth.

Sunlight and the Solar Wind then push material away from the Sun in a tail.

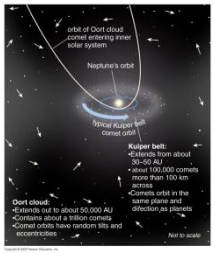


# Comets

As the figure shows, every comet leaves a trail of debris along its orbit that is not blown away by sunlight or the Solar Wind. If the Earth passes through one of these trails, we can have a **Meteor Shower.** (See the table in your text for the dates of the major meteor showers; *I've had limited success viewing meteor showers*; what's the most important thing to bring to watch a meteor shower (LC))

**Where do Comets come from?**

The icy planetesimals that are the cometary bodies come from two places:

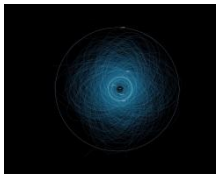



- **The Kuiper Belt:** disk region beyond Neptune; these are planetesimals that never formed into planets. (found more than 1100 of these Kuiper Belt Objects (KBO's)
- **The Oort Cloud:** Spherical cloud of ~$10^{12}$ comets that extend to ~50,000AU. These planetesimals were scattered into these orbits by the Jovian planets right after formation of the Solar System.

**Today, we know that Pluto is just one of the larger KBO's**

**A new source of comets, Interstellar – three discovered since 2019**

# Asteroid and Comet Impacts on the Earth



There are many asteroids whose orbits bring them close to the Earth. Although they are rare, collisions are inevitable.

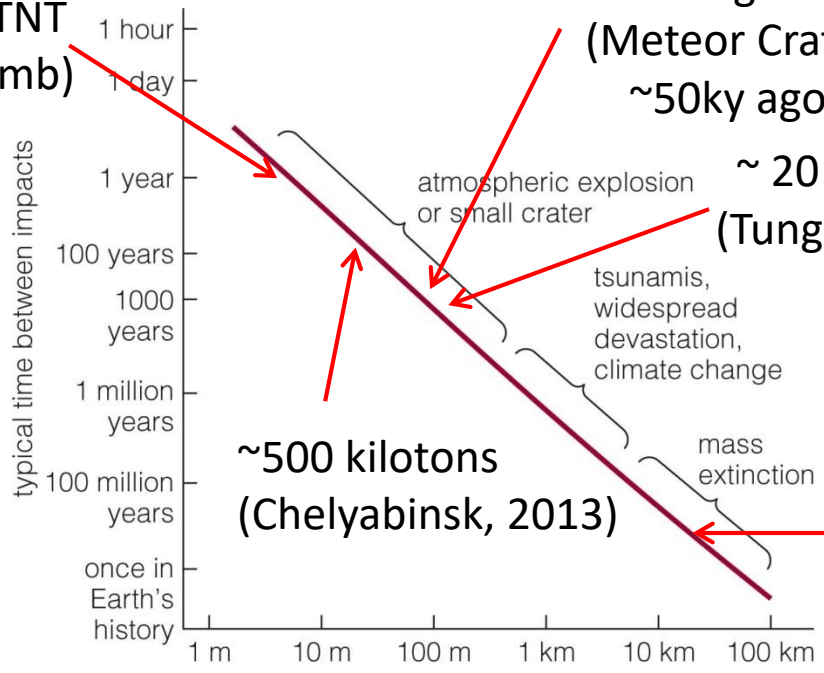
What happens when a small asteroid (~ 10 km across) hits the Earth? Just ask the dinosaurs - we'll see the details about the KT Event in a video next class. **Here's a preview clip.**

**What is the frequency of impacts?**

~ 20 kilotons TNT (Hiroshima bomb)

~10 Megatons (Meteor Crater, ~50ky ago)

~ 20 Megatons (Tunguska, 1908)




~500 kilotons (Chelyabinsk, 2013)

> 1 million Megatons (KT event, 65 My ago)

What happened in 2013 in Chelyabinsk, Russia?

Will an asteroid hit Earth in 2032? Is there a way to protect ourselves?

(LC)