“What happens if a big asteroid hits Earth? Judging from realistic simulations involving a sledge hammer and a common laboratory frog, we can assume it will be pretty bad.”

David Barry, Jr.

Friday Fun Activity!

- Review basic asteroid facts
- Watch an interesting movie!
- Take a short quiz!

Where Did Asteroids Come From?

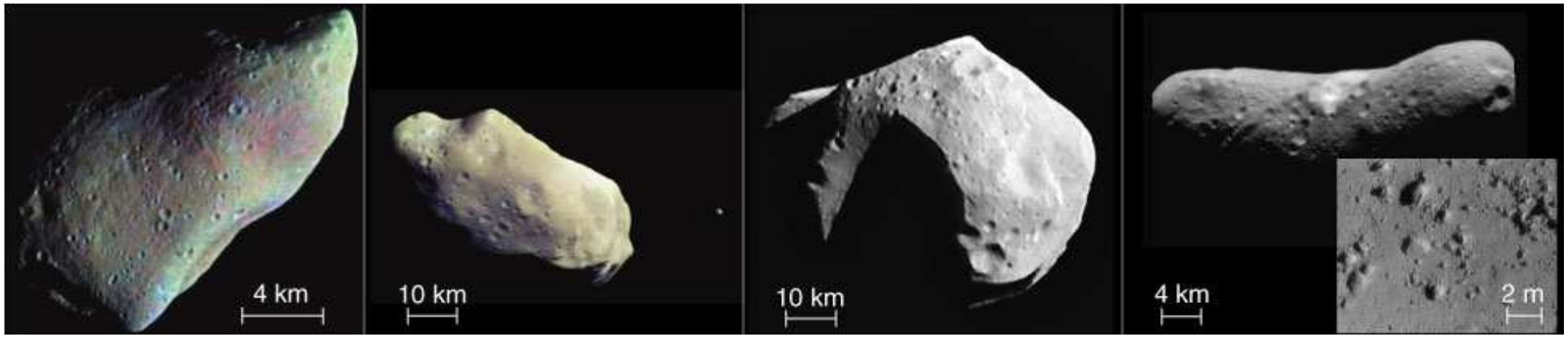
- Remnant planetesimals
- Jupiter's gravity prevented accretion into another planet
- Pristine scraps from solar system formation
- First asteroid discovered only 200 years ago
- Now, over 150,000 cataloged
- There are likely over a million asteroids larger than 1 km

Fig 12.1

Many Shapes & Sizes

- Made mostly of rocks and metals
- Ceres (largest known asteroid) is a dwarf planet
  - Has enough mass to have become spherical
- Most are potato shaped
- Some have Moons!

Ceres



Gaspra, Galileo image | Ida & Dactyl, Galileo image | Mathilde, NEAR Image | Eros, NEAR image | Fig 12.2

The Asteroid Belt

- Most asteroids are in a belt between Mars & Jupiter
- Mostly in prograde orbits, like the planets
- Generally higher eccentricity and inclination
- Trojan asteroids lead or follow Jupiter in its orbital path
- A few get close to Earth – “Near Earth Asteroids”
  - Some of these have an Earth crossing orbit!

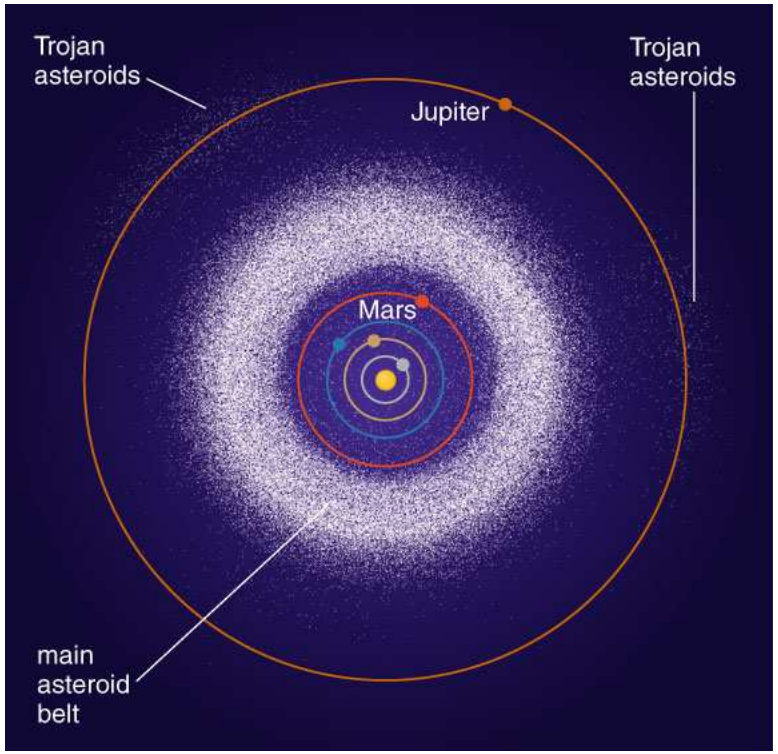


Fig 12.4

Orbital Resonances

- Asteroids with orbital periods of simple fractions of Jupiter's period are nudged out of their place due to resonance
- Jupiter and the asteroid will return to same alignment periodically, when Jupiter will tug on the asteroid, creating the *Kirkwood gaps*
- So, why is there a surplus at the 1:1 resonance?
  - These are the Trojan asteroids sharing Jupiter's orbital path at the points where gravity of the Sun & Jupiter balance to provide a stable homes

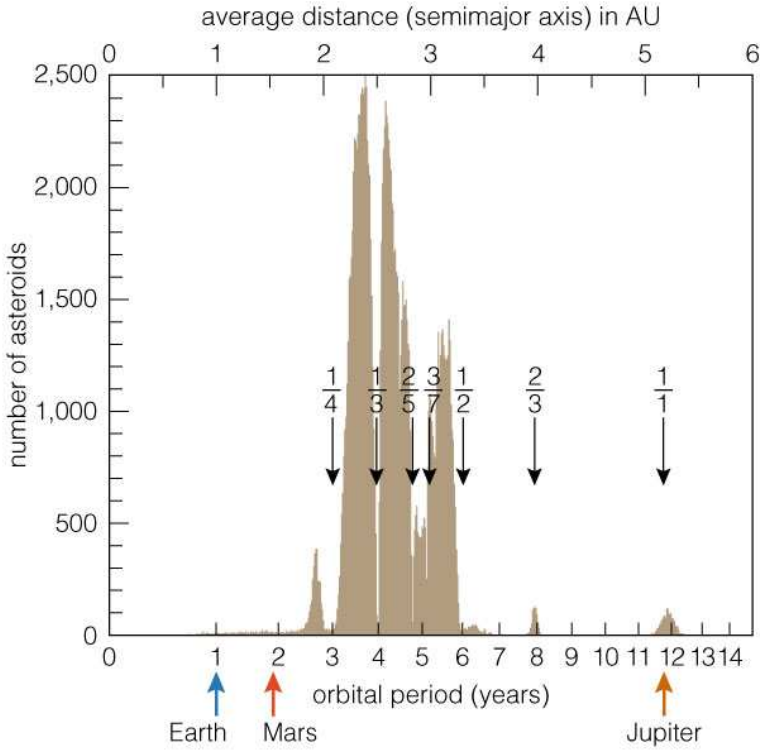
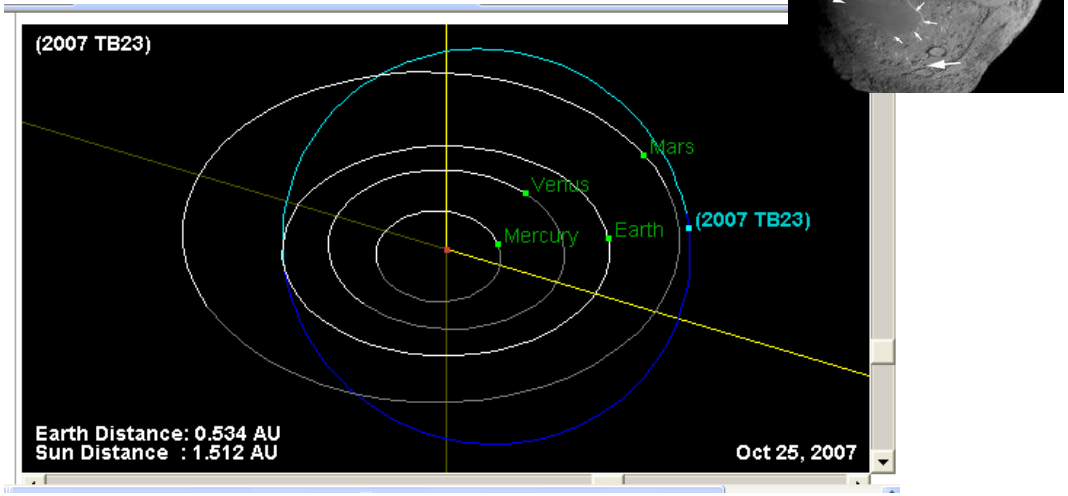


Fig 12.5

NASA's NEO Program

- http://neo.jpl.nasa.gov
- Lists closest approaches
  - Past & Future
- Orbits of some near Earth objects
- The Torino Scale
- NEAR landed on Eros in Feb 2001
- Deep Impact crashed into Comet Tempel 1 July 4, 2005



THE TORINO SCALE

Assessing Asteroid/Comet Impact Predictions

No Hazard	0	The likelihood of collision is zero, or is so low as to be effectively zero. Also applies to small objects such as meteors and bolides that burn up in the atmosphere as well as infrequent meteorite falls that rarely cause damage.
Normal	1	A routine discovery in which a pass near the Earth is predicted that poses no unusual level of danger. Current calculations show the chance of collision is extremely unlikely with no cause for public attention or public concern. New telescopic observations very likely will lead to re-assignment to Level 0.
Meriting Attention by Astronomers	2	A discovery, which may become routine with expanded searches, of an object making a somewhat close but not highly unusual pass near the Earth. While meriting attention by astronomers, there is no cause for public attention or public concern as an actual collision is very unlikely. New telescopic observations very likely will lead to re-assignment to Level 0.
	3	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of localized destruction. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by the public and by public officials is merited if the encounter is less than a decade away.
	4	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of regional devastation. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by the public and by public officials is merited if the encounter is less than a decade away.
Threatening	5	A close encounter posing a serious, but still uncertain threat of regional devastation. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than a decade away, governmental contingency planning may be warranted.
	6	A close encounter by a large object posing a serious, but still uncertain threat of a global catastrophe. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than three decades away, governmental contingency planning may be warranted.
	7	A very close encounter by a large object, which if occurring this century, poses an unprecedented but still uncertain threat of a global catastrophe. For such a threat in this century, international contingency planning is warranted, especially to determine urgently and conclusively whether or not a collision will occur.
Certain Collisions	8	A collision is certain, capable of causing localized destruction for an impact over land or possibly a tsunami if close offshore. Such events occur on average between once per 50 years and once per several 1000 years.
	9	A collision is certain, capable of causing unprecedented regional devastation for a land impact or the threat of a major tsunami for an ocean impact. Such events occur on average between once per 10,000 years and once per 100,000 years.
	10	A collision is certain, capable of causing a global climatic catastrophe that may threaten the future of civilization as we know it, whether impacting land or ocean. Such events occur on average once per 100,000 years, or less often.

Fig. 2. Public description for the Torino Scale, revised from Binzel (2000) to better describe the attention or response that is merited for each category.

Protective Measures

What to do if one has a bulls-eye on Earth?

- Blow it up?
  - Requires lot of energy
  - Fragments may still hit us
- Deflect it?
  - Gravity tug
  - Nearby explosion
- Paint it?
  - Yarkovsky effect

Movie Time!

Comet Hunters

Asteroid Seekers