27. Satellites of the Giants
Inventory of Moons

- 6 large moons ($D > 1500$ km) — most somewhat active
- 12 medium ($D > 300$ km) — past, present activity?
- 150+ small ($D > 1$ km) — no internal activity
Large & Medium Moons

- spherical due to self-gravity
- composed of ices & rock
- most* formed in disks around parent planets
- most* orbit in same direction as planets spin

* Triton is exception!
Small Satellites of Saturn

- too small to be spherical
- orbit both directions!

Calypso (22 km)

Pandora (84 km)

Telescopio (24 km)

Hyperion (180 km)

Phoebe (220 km)

Janus (180 km)
**Activity: Galilean Satellites**

Wide range of geological activity:

— Io is *most volcanic* object in solar system!

— Callisto exhibits very little activity.
Ganymede and Callisto

Ganymede has a mixture of old and new terrain, and hints of tectonic activity.

Callisto has a old and very heavily cratered terrain, with a possible subsurface ocean.
Europa: an Ice-Covered Ocean?

Exaggerated colors

Fractures in crust

Pwyll: Impact crater

“Natural” colors

Natural and False Color Views of Europa
Europa: Rafts of Ice
What warms Europa’s subsurface ocean?
Io: Volcanic Moon

Loki Patera: active center

Pele: Io’s largest volcanic plume

Topography and Volcanos on Io
Io: Volcanic Moon

Why so active?
Tidal Heating of Io

Io is alternately stretched and squeezed in its elliptical orbit around Jupiter, creating heat through friction.

Over time, this friction *should* make Io’s orbit more and more circular; what *keeps* Io’s orbit elliptical?
$m_1 = 0.001 \ M \quad m_2 = 0 \quad P_1:P_2 = 2:1$
2:1 Mean-Motion Resonance
Laplace Resonance: Io, Europa, & Ganymede

4:2:1 Mean-Motion Resonance
Titan: a Moon With Atmosphere

Thick smog of $N_2$ and hydrocarbons ($CH_4, C_2H_6$, etc)!
Titan’s Climate

- Surface temperature: 94° K (-179° C)
- Clouds of CH$_4$, C$_2$H$_6$, other hydrocarbons
- CH$_4$ falls as rain, forms rivers & lakes
- Seasonal changes in CH$_4$ lakes
- CH$_4$ replenished by cryo-volcanism
Hydrocarbon Lakes on Titan

Reflection of Sunlight off Titan Lake

Radar Shows Evidence of Seas
Meandering Riverbeds on Titan
**Terrestrial Planet Geology**

- Internal heat, primarily from radioactive decay, can cause volcanic and tectonic activity.
- Only large planets retain enough internal heat to stay geologically active today.
- Example: Mars (photo above) probably retains some internal heat. If it had been smaller, like Mercury, it would be geologically "dead" today. If it had been larger, like Earth, it would probably have much more active and ongoing tectonics and volcanism.

**Jovian Moon Geology**

- Tidal heating can cause tremendous geological activity on moons with elliptical orbits around massive planets.
- Even without tidal heating, icy materials can melt and deform at lower temperatures than rock, increasing the likelihood of geological activity.
- Together, these effects explain why icy moons are much more likely to have ongoing geological activity than rocky terrestrial worlds of the same size.
- Example: Ganymede (photo above) shows evidence of recent geological activity, even though it is similar in size to the geologically dead terrestrial planet Mercury.