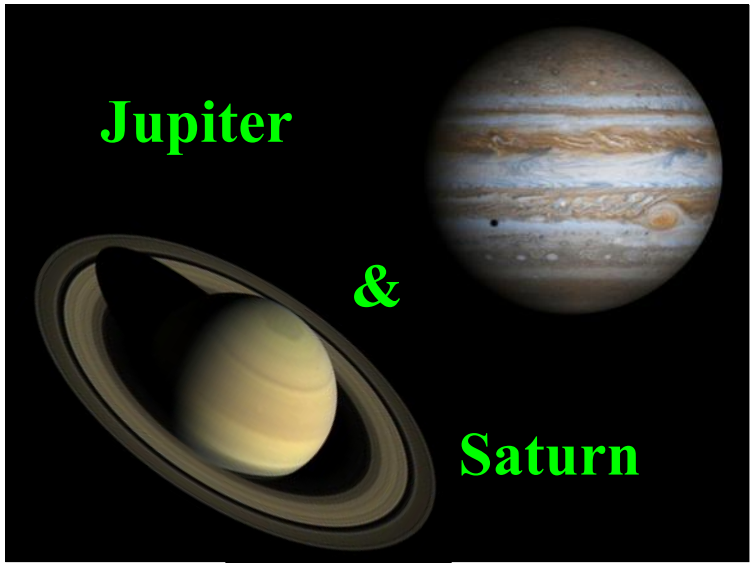


Basic information (J, S)

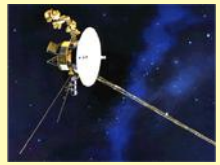
Density (avg, g/cm^3):	1.33	0.69
Distance from Sun (avg, AU):	5.2	9.5
Orbital Period (years):	11.9	29.5
Rotation Period (equatorial, hrs):	~10h	~10h
Albedo:	0.50	0.34
Moons (confirmed, 2019):	79	82
Tilt of rotational axis:	3º	27º
Equatorial diameter (x Earth):	~11	~9

Jupiter *"Ruler of the Gods"*

- *brightest* planet after *Venus*
- *radiates ~2x more energy* than it receives from Sun
- could hold *1300 Earths!*

- only *1/1000 mass of the Sun* but *2.5* x *mass of **all** other planets combined!*

Exploring Jupiter

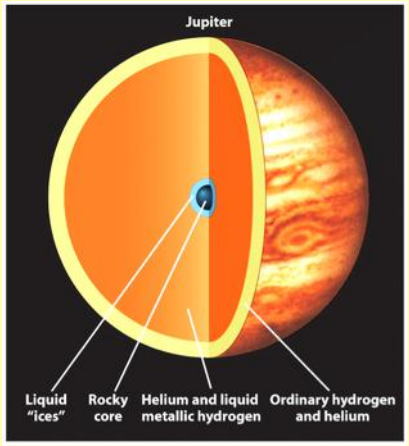


- ***Galileo** via **telescope** (1600's)*
- ***Pioneer 10** & **Pioneer 11** (1973/74)* *NASA*
- ***Voyager 1** & **Voyager 2** (1979)*

NASA

- ***Galileo** orbiter & probe (1995)* *NASA*
- ***orbited** until 2003; **crashed into Jupiter***
- ***Cassini, New Horizons** flybys (2000,2007)* *NASA*
- ***Juno** **polar** orbit (2016)* *NASA*

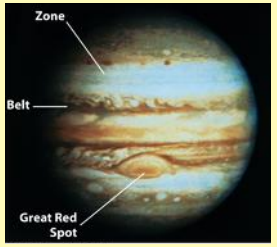
Interior Structure



Atmosphere

- *light **zones** (high, cool), dark **belts** (low, warm)*
- ***ammonia** & **water** ices*
- *different colours?*
- windspeeds: *500+ km/h*
- temperature: *100 K* at top

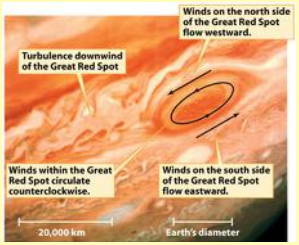
***Q:** What fuels the winds?*



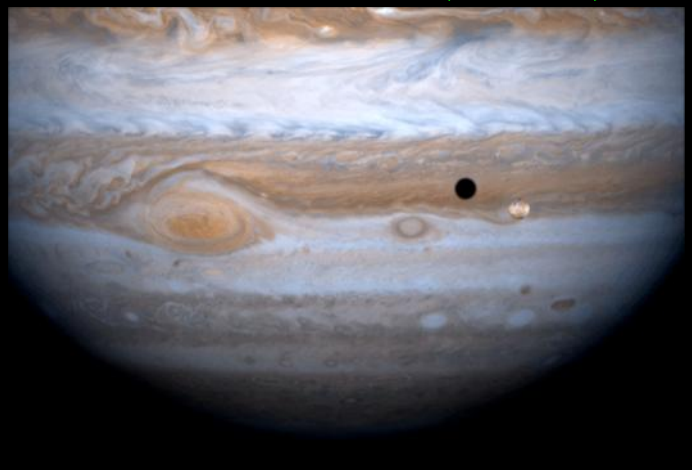
Great Red Spot

- ***Great Red Spot**:* giant *storm* ***~1.5 Earths wide*** *(and slowly shrinking)*
- visible for *400 years*

***Q:** How has it lasted so long?*
- *trapped* by *opposing* winds; no ground to *dissipate* energy



Clouds, *GRS* (& Io!)



Jupiter S (Juno)

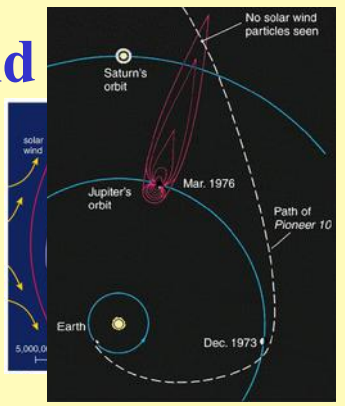
Magnetic Field

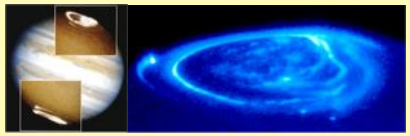
- *much* stronger than Earth's field (~20x)
- reaches to *Saturn's orbit!*
- stronger ***dynamo*** – *why?*

• *rapid rotation* & **lots** of *metallic hydrogen*

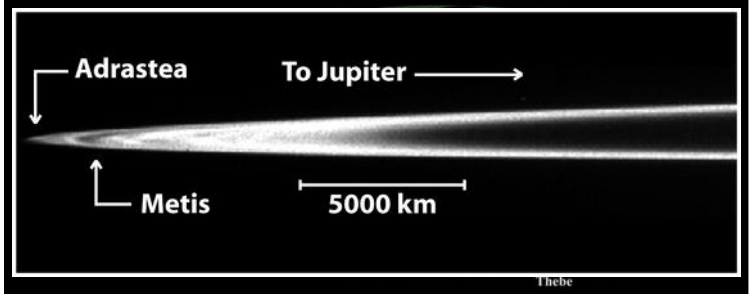
Q: *What features exist on Jupiter as a result?*

• *aurora* at poles!





Jupiter's *rings* (*Voyager*)



• probably *dust sized* rocky grains from *impacts*

CLICKER: Why does Jupiter contain so much metallic hydrogen in its interior?

(a) closer to the Sun, more metallic material
(b) very massive, with high internal pressure
(c) metallic hydrogen common beyond Frost Line
(d) collision combined metal from 2 protoplanets

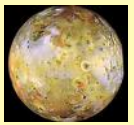
The Galilean Moons

Q: Why "Galilean" moons?

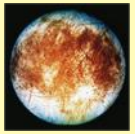
- 4 *largest* moons; found by *Galileo*

- *Io, Europa, Ganymede, Callisto*
- ***"I Eat Great Carrots"***
- named for *Jupiter's (Zeus) lovers*

- ***Io:*** tidal forces *heat interior*
- *~* ***300*** *active volcanoes!*

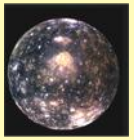


- ***Europa:*** smooth *icy surface*
- *possible salty "ocean"* ***beneath ice***



- ***Ganymede:*** ***solar system's*** **largest** *moon*
- *larger than Mercury!*

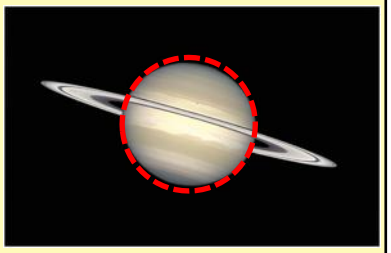
- ***Callisto:*** heavily *cratered surface*
- *among oldest objects in solar system*



Saturn

Saturn *"The Ringed Planet"*

- *second largest* planet
- most ***oblate*** planet (*~10% flattened*)



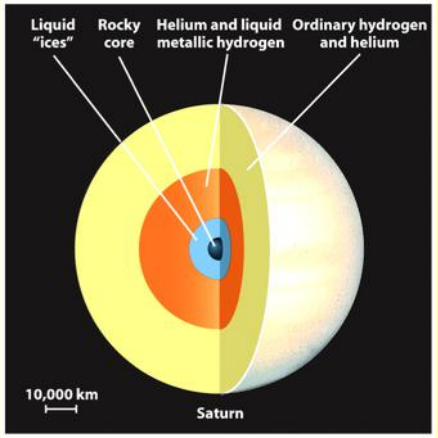
- its ***density*** is so low it would *float in water*

Exploring Saturn

- ***Galileo***, ***Huygens***,***Cassini*** (*1600's*)
- ***Pioneer 11*** (*1979*) *NASA*
- ***Voyager 1*** & ***Voyager 2*** (*1980/81*) *NASA*

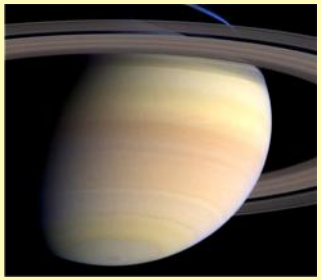
- ***Cassini*** orbiter & ***Huygens*** probe *NASA* (*2004-2017*)

Interior Structure

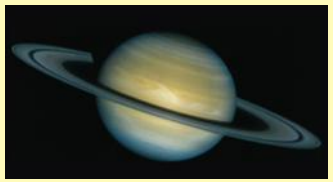


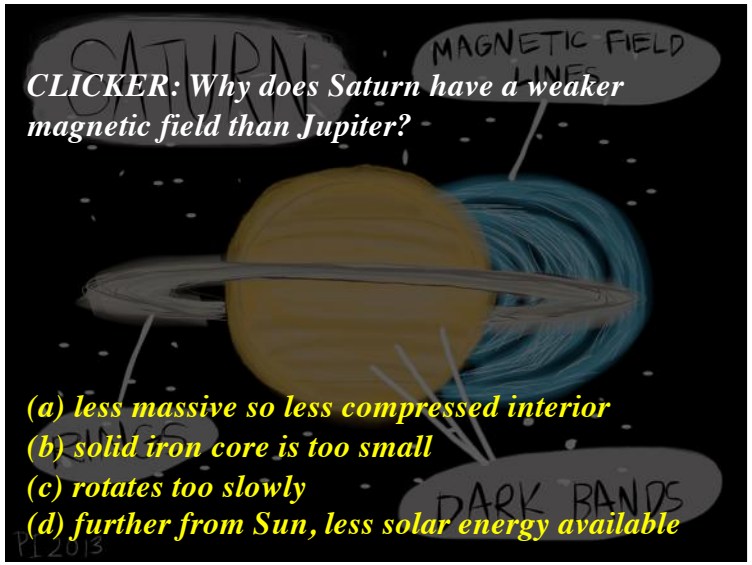
Atmosphere

- *clouds similar to Jupiter*
- ***less*** defined, turbulent & compressed ***Q:*** *Why?*



- *cooler than Jupiter* but not by as much as expected
- *helium precipitation* may release *heat*
- ***Great White Spot***

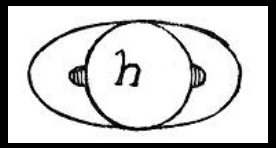


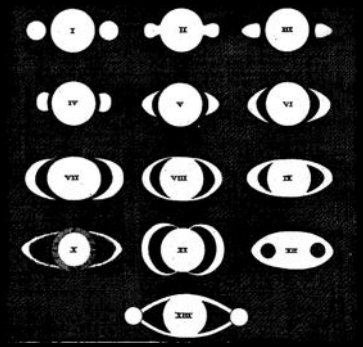


CLICKER: Why does Saturn have a weaker magnetic field than Jupiter?

(a) less massive so less compressed interior
(b) solid iron core is too small
(c) rotates too slowly
(d) further from Sun, less solar energy available

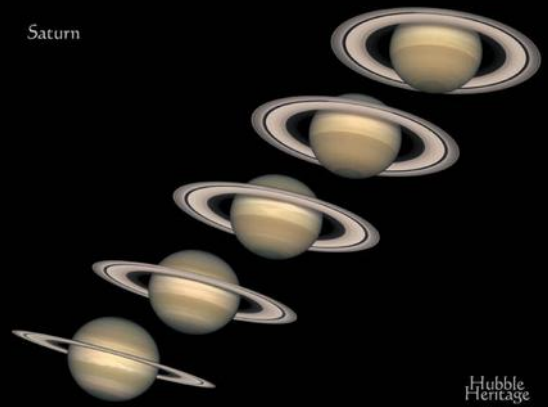
Rings





- ***Galileo*** *did not recognize* they were *rings* (1610)
- ***Huygens*** first to suggest "rings" (1655)

Rings from Earth



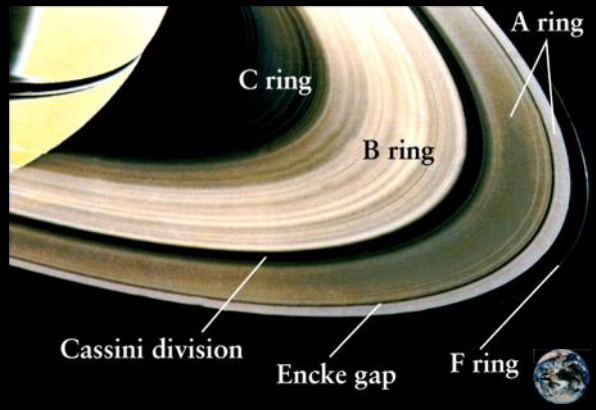
- 274,000 km *wide* (~*21* Earths)
- ~10 m *thick*
- *mostly <1 m* icy chunks

- big moons **cannot** form within "*Roche Limit*" - *tidal forces*

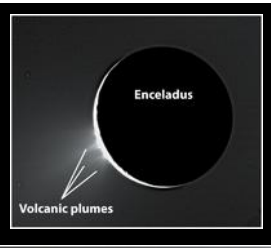
- *gaps* exist in the rings
- *largest:* ***Cassini Division***

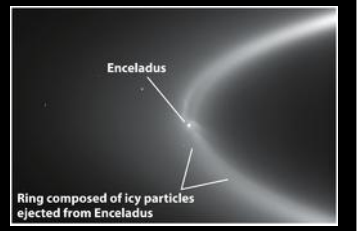
(eg) if *diameter of rings* was like a *football field*, *rings* would be ***thinner*** *than a sheet of paper*

Ring System



Enceladus





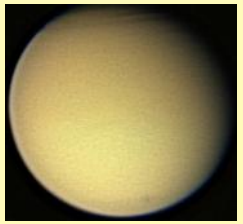
- *watery geysers **erupt** from its surface!*
- *source of ring material?*

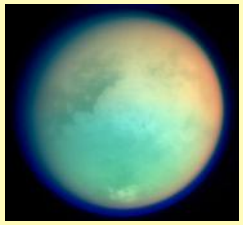
Titan

- *largest* of Saturn's moons,
  2nd largest in solar system

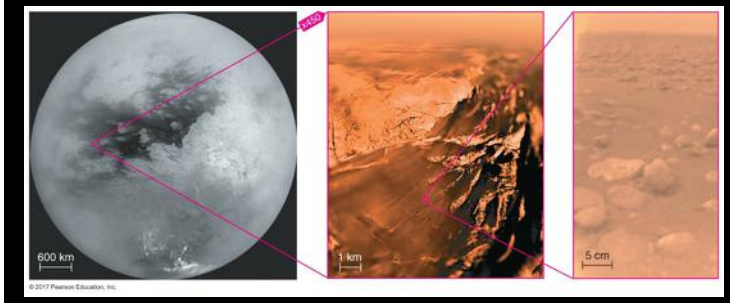
- thick N_2 atmosphere from
  photo-dissoc of ***ammonia*** *(NH_3)*
- *surface pressure* 1.5 bars
- *surface temp ~95 K (-178° C)*

- thick layer (200 km) of *clouds/smog*
- features: ***hydrocarbon rivers*** & ***lakes***
- ***Cassini*** landed ***Huygens*** probe *(2004)*





Titan's Surface



- **views of Titan from *Cassini/Huygens***

CLICKER: Why does Saturn have rings?

(a) left over from formation of the solar system
(b) captured cometary material
(c) remnants of a former giant moon of Saturn
(d) ongoing collisions/eruptions by its moons