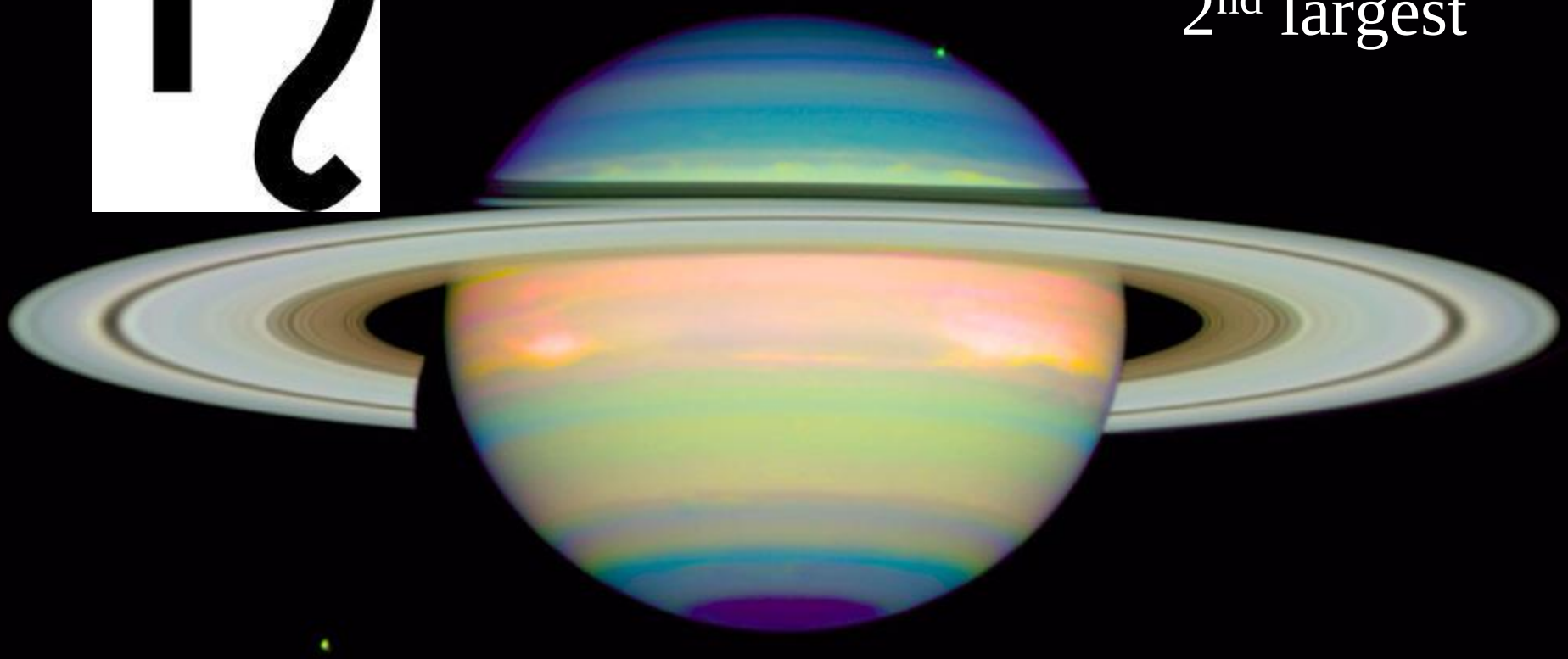


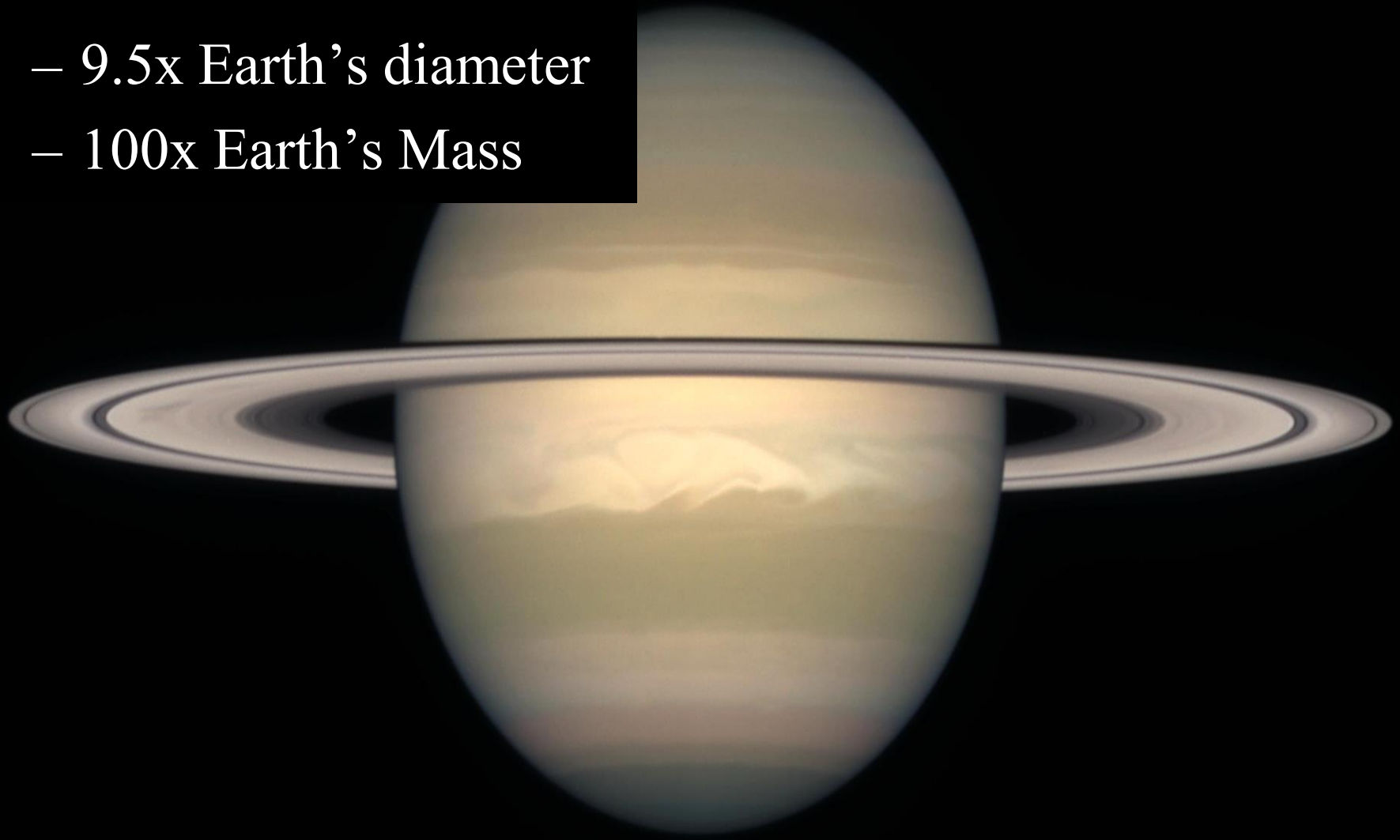
SPACE.COM

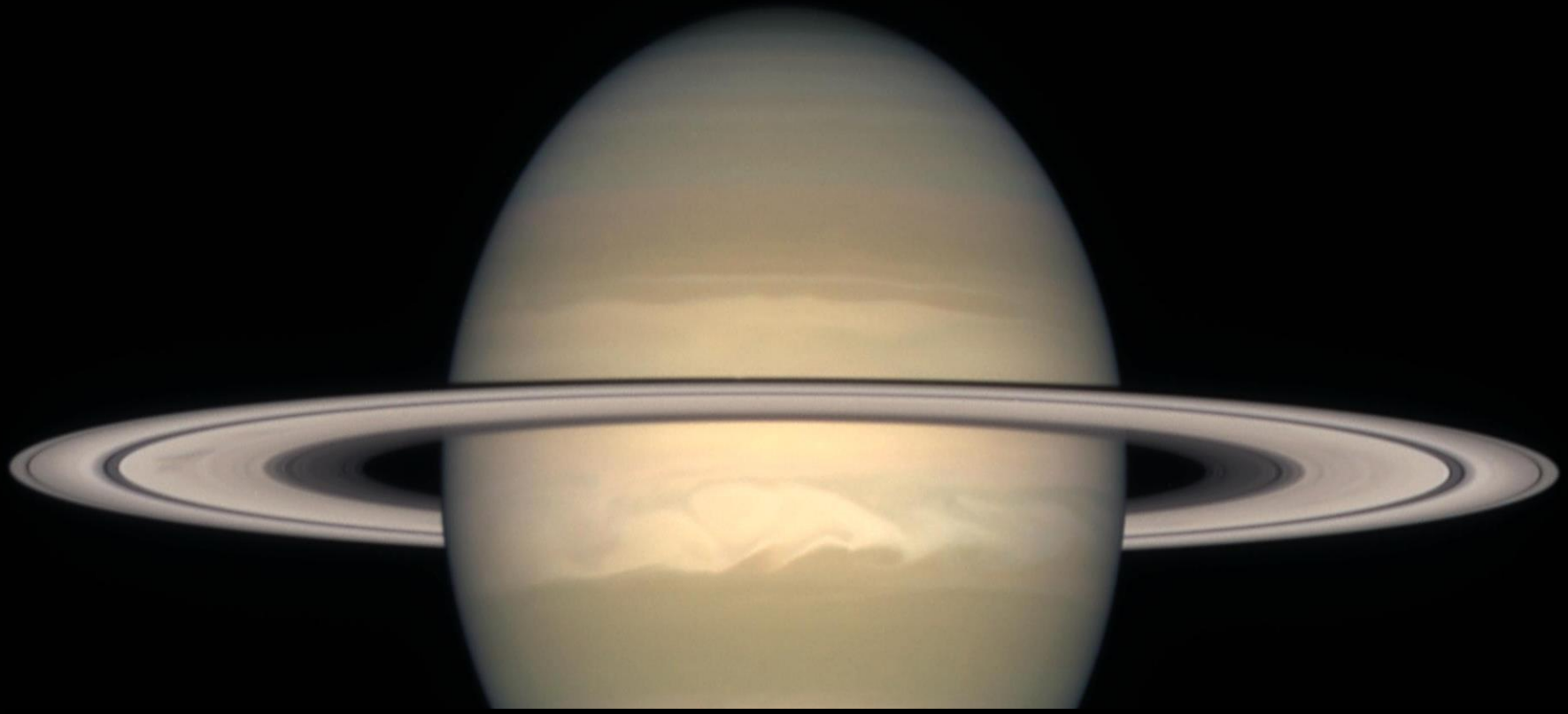
Hubble Space Telescope, NASA/STSCI

Saturn

2nd largest

- Saturn
  - 9.5 AU from the Sun
  - 9.5x Earth's diameter
  - 100x Earth's Mass





- Saturn Rotation:
  - Polar Rotation is **10 hours 40 minutes**
  - Equator Rotation is 10 hours 14 minutes

Since the poles and the equatorial region rotate differently **Scientist call this:**

Differential Rotation

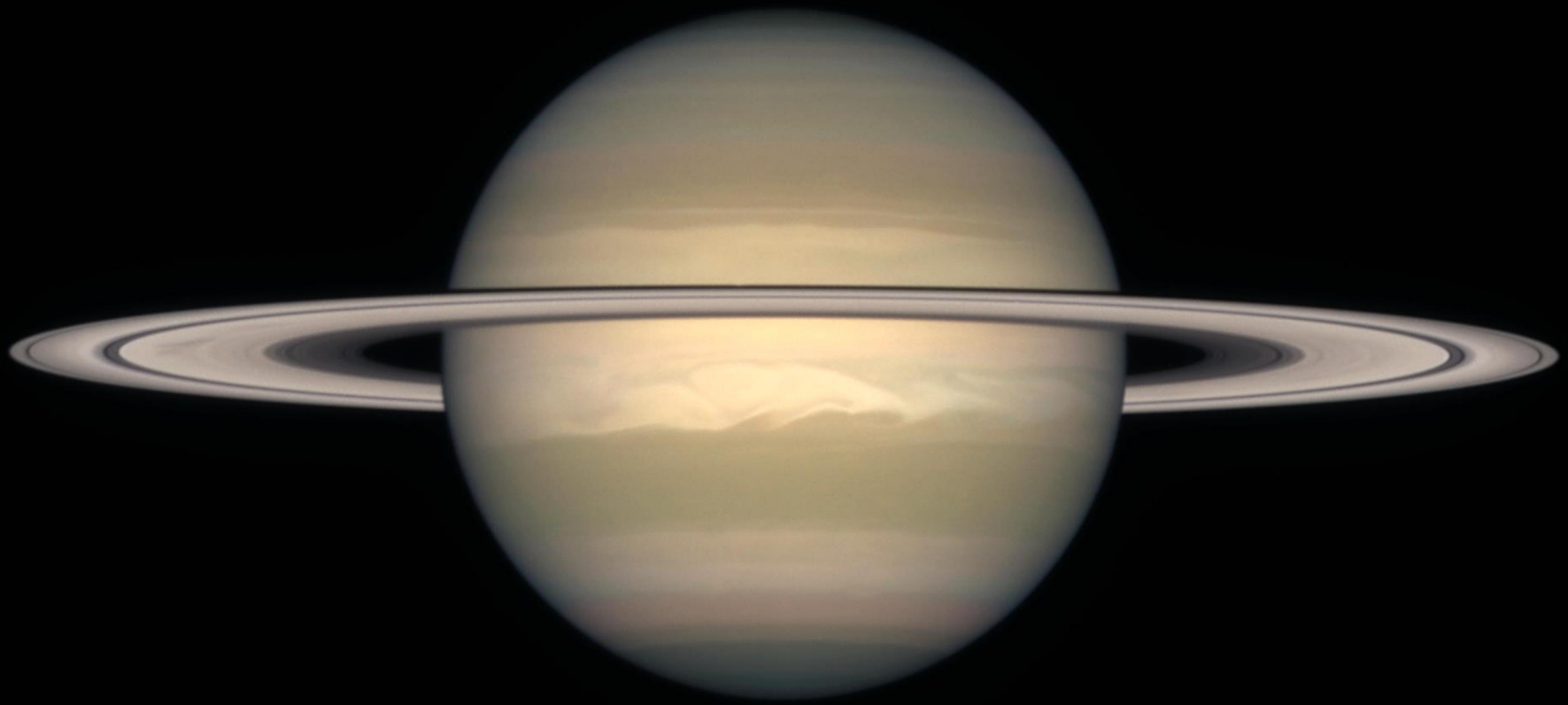
Saturn: God of the Harvest

Jovian planets are noticeably oblate because they are fluid bodies of gas and they also keep their hydrostatic equilibrium.

Its equator is

about 10% wider

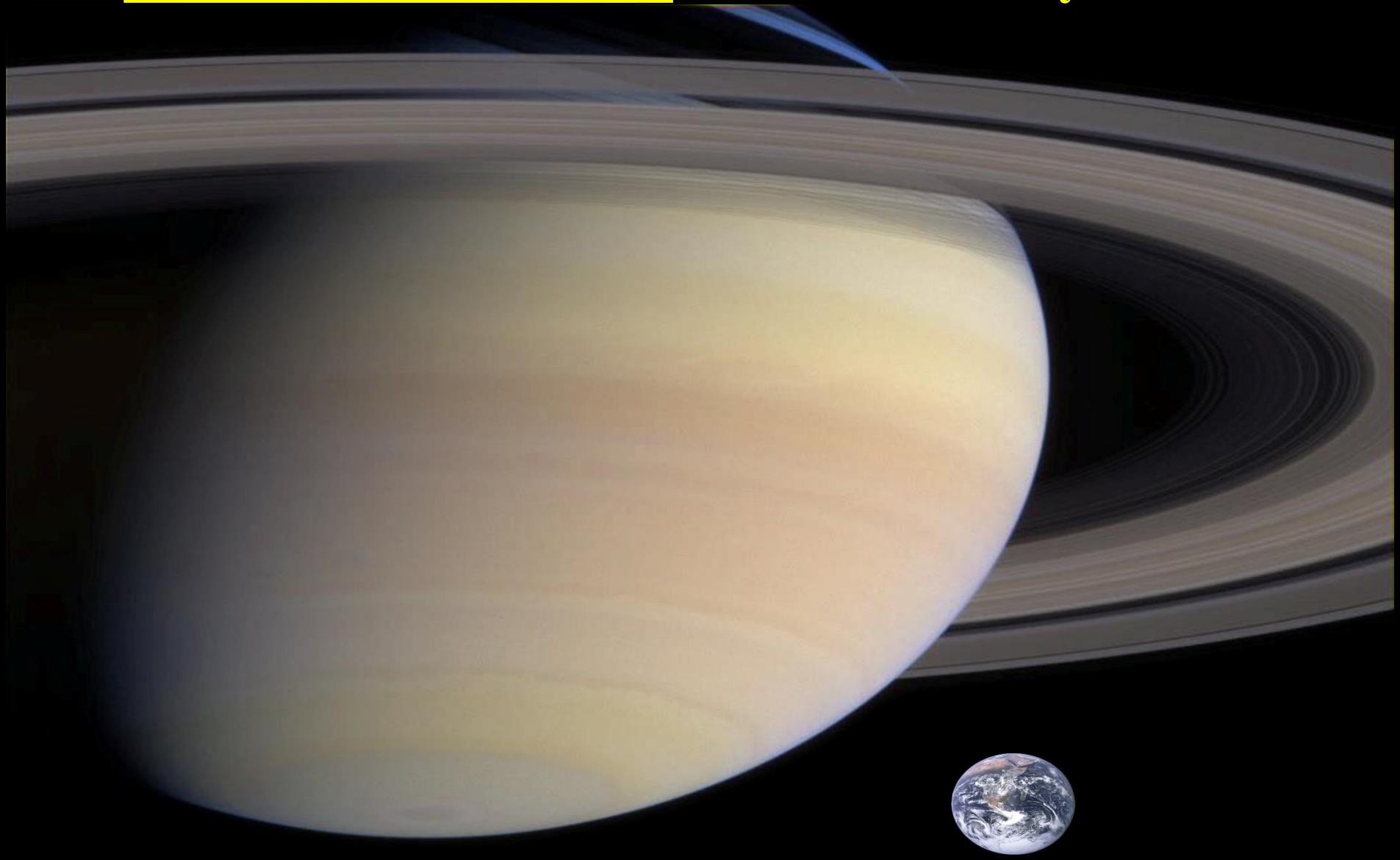
- Saturn goes around the sun
  - **REV: 29.45 years**



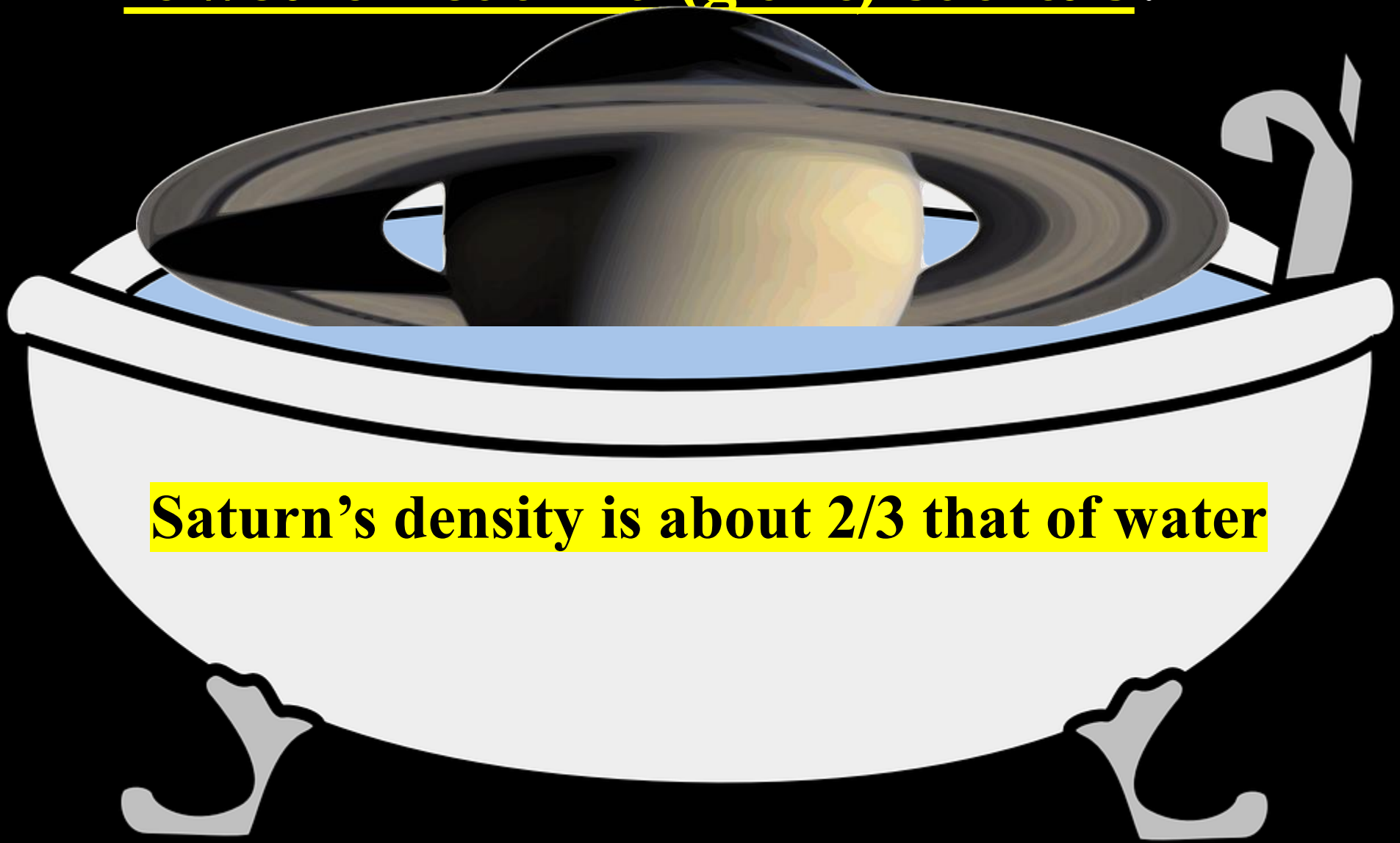
- Saturn
  - Tilt is 27° *similar to Earth's tilt*

- *Although Saturn is almost the same size as Jupiter, Its gravity is about 2.5 times less, because of Saturn's lower mass and density*

- Saturn
  - **<u>DENSITY is ONLY 0.7</u>… which means you would**?



- Saturn
  - **It would float in a (giant) bathtub**?

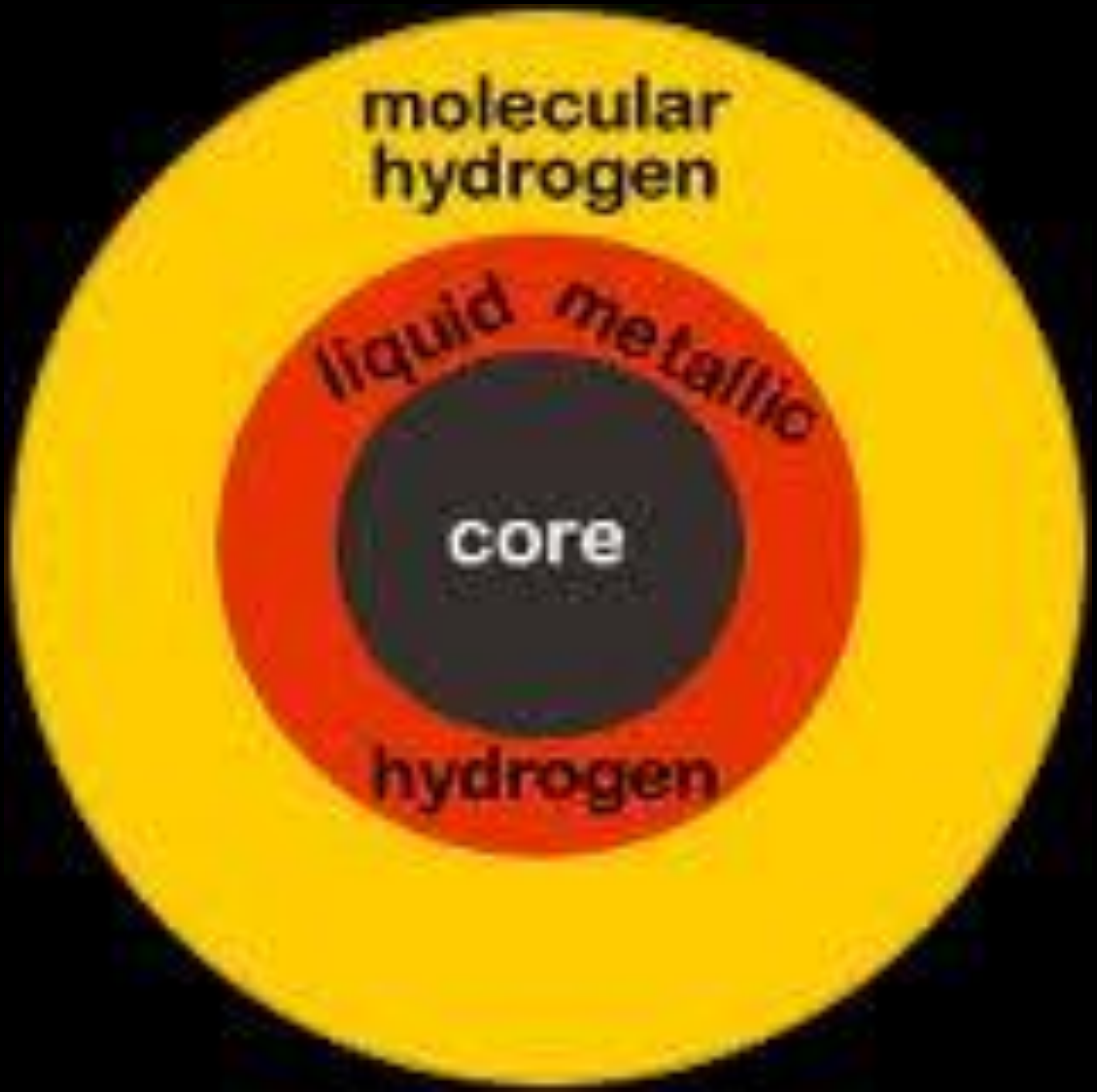


Saturn's density is about 2/3 that of water

***Cassini*-Huygens space craft was launched on 15 October 1997 on a Titan-IVB/Centaur from Cape Canaveral.**

- **The *spacecraft arrived at Saturn* in July 2004**

Several **spacecrafts have visited Saturn, like Voyager 1 & 2 but the one that gave us the most information was Cassini**

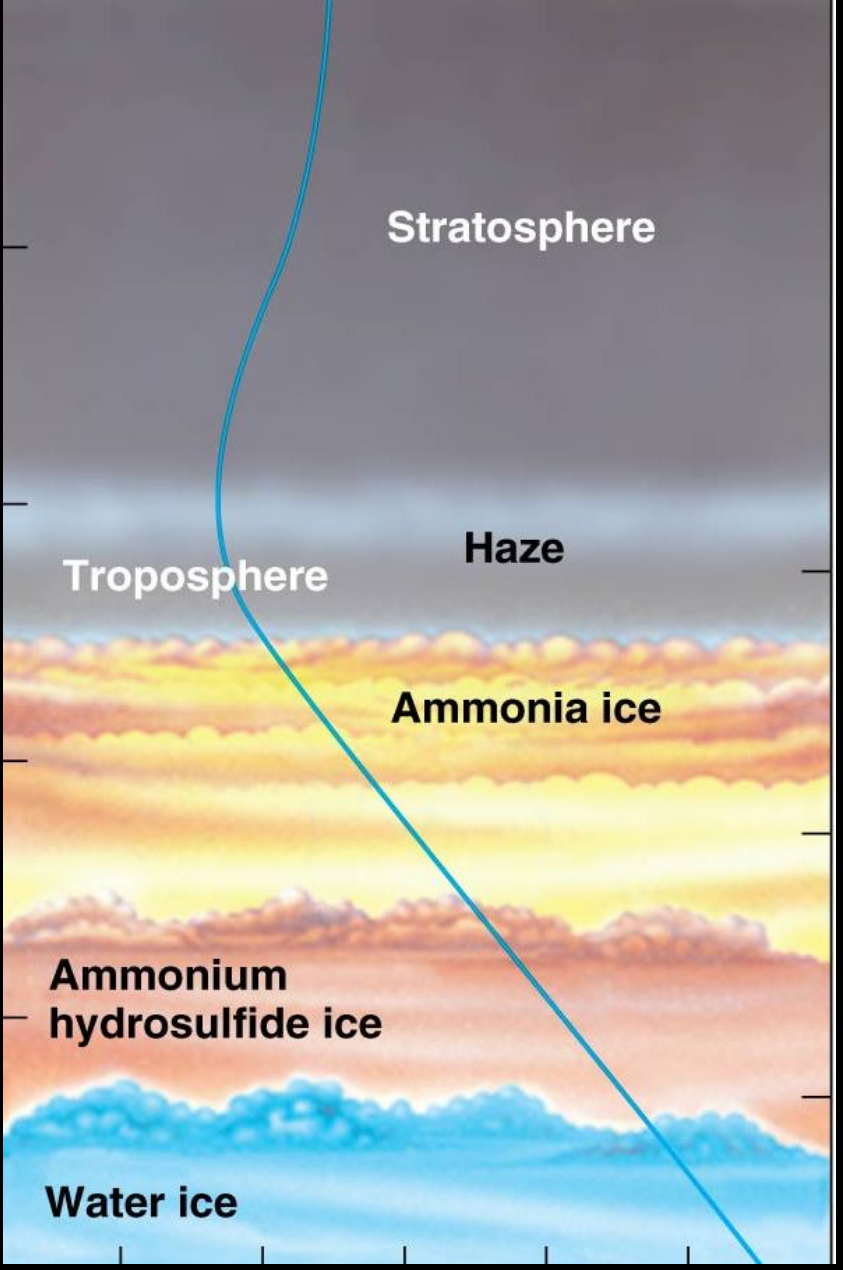


The Interiors of the Gas Giants

96% H_2,
3% He
1% JUNK,
traces of hydrogen-rich compounds

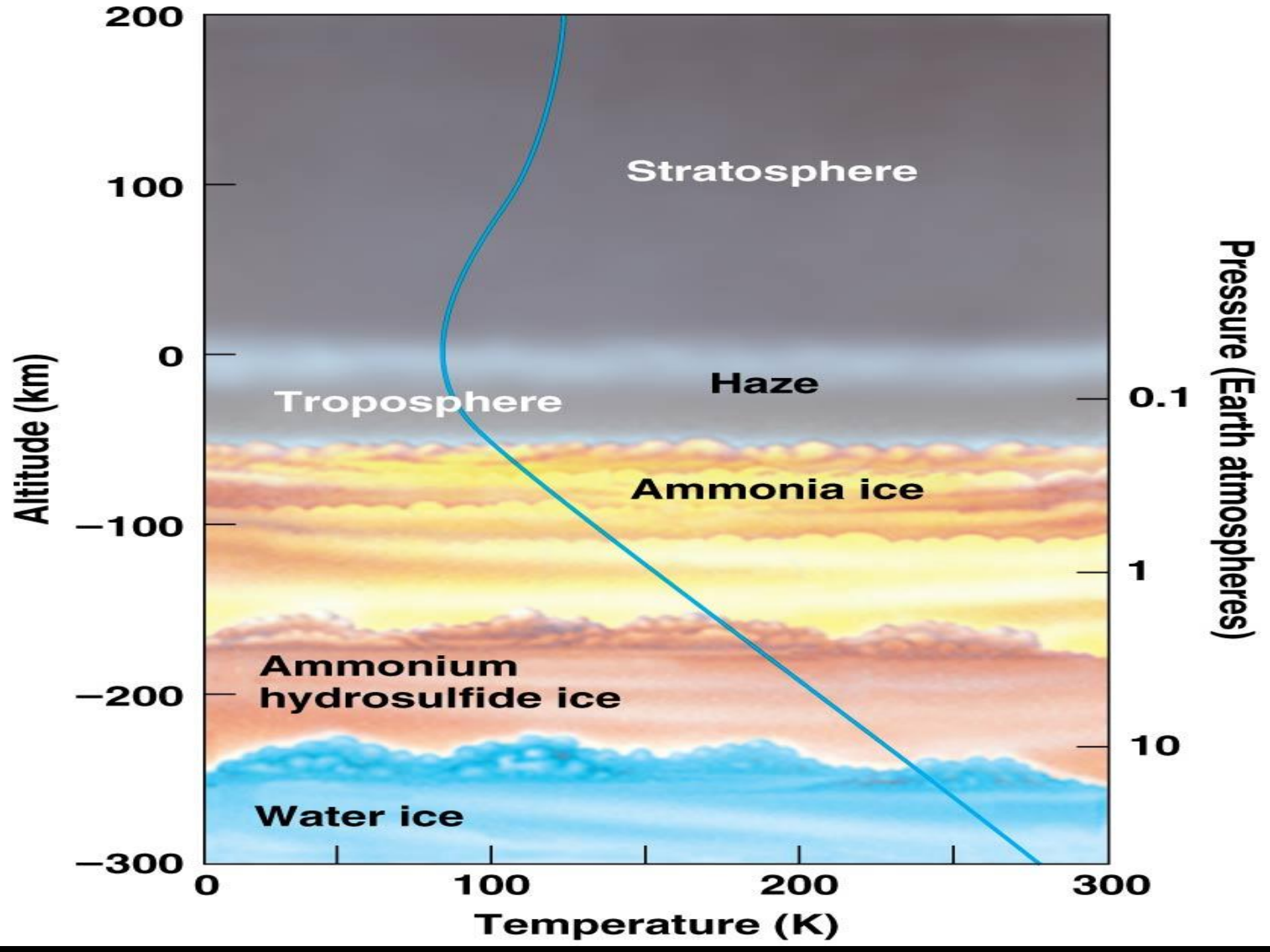
The Appearance of Saturn

- Parallel bands of clouds
  - Similar to Jupiter's, but not as distinct
- Even flatter than Jupiter!



There are **hundreds of Km deep Hydrogen** layers of the Atmosphere

- ***NOT uniform and calm***
- ***but Thick ammonia cloud cover with <u>storms</u> of Metallic helium with different pressures systems***

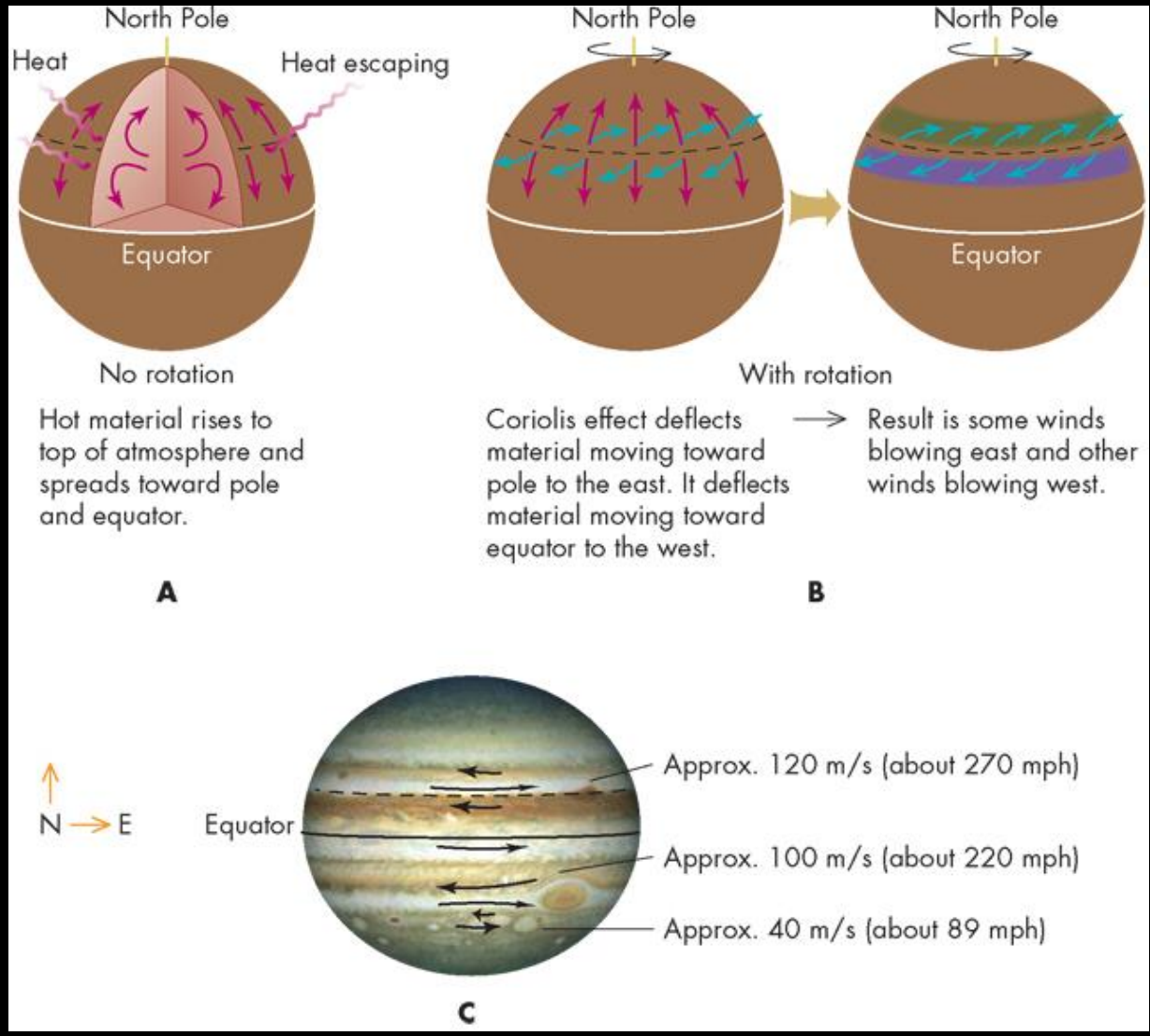

200
100
0
−100
−200
−300
Altitude (km)
Stratosphere
Haze
Troposphere
Ammonia ice
Ammonium
hydrosulfide ice
Water ice
0
100
200
300
Temperature (K)
0.1
1
10
Pressure (Earth atmospheres)

- Outer atmosphere has a temperature of 130K = -225.67° Fahrenheit
- ***There is a less abundant amount of Helium here than Jupiter has***

Storms on Saturn

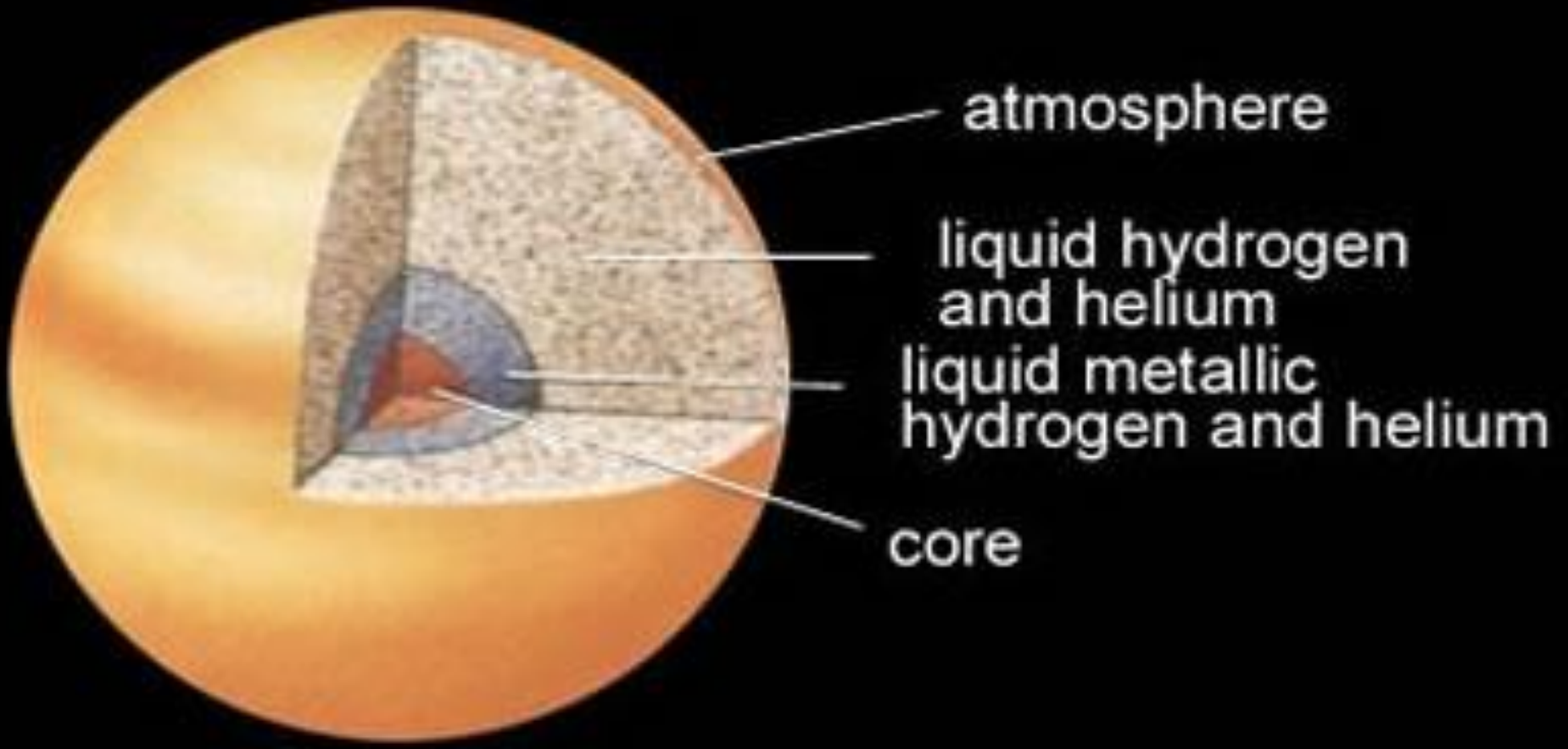
- Saturn, though it appears calmer, it is not
  - Storms are deeper in its atmosphere
- **HUGH hexagonal storm in 2010 near the northern pole**

- Rapid rotation gives rise to strong **Coriolis forces**, and very **high winds!**
- ***Wind speed at this hexagonal storm is 500 Km/hr***

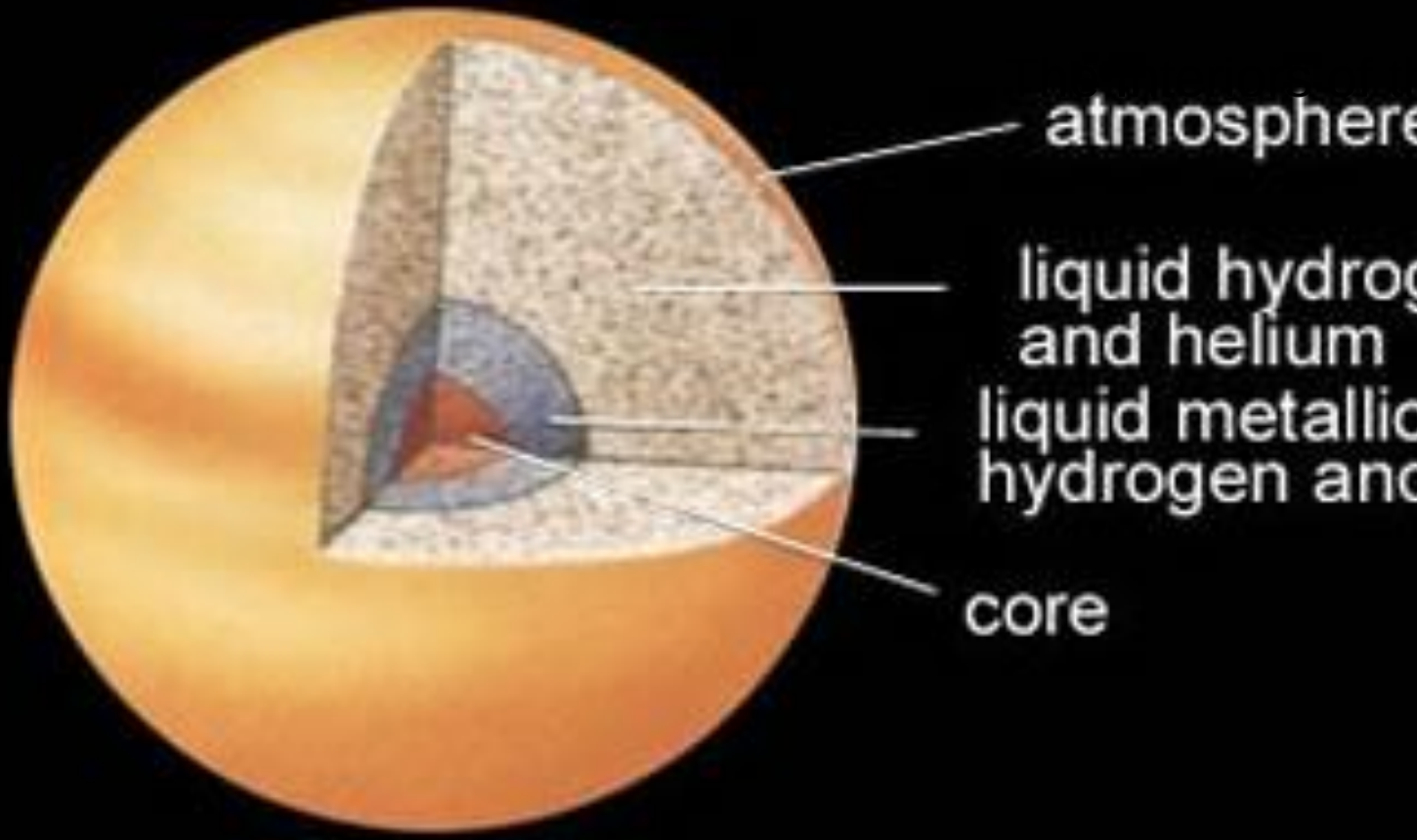


Saturn's rapid rotation gives rise to strong Coriolis forces, and very high winds!

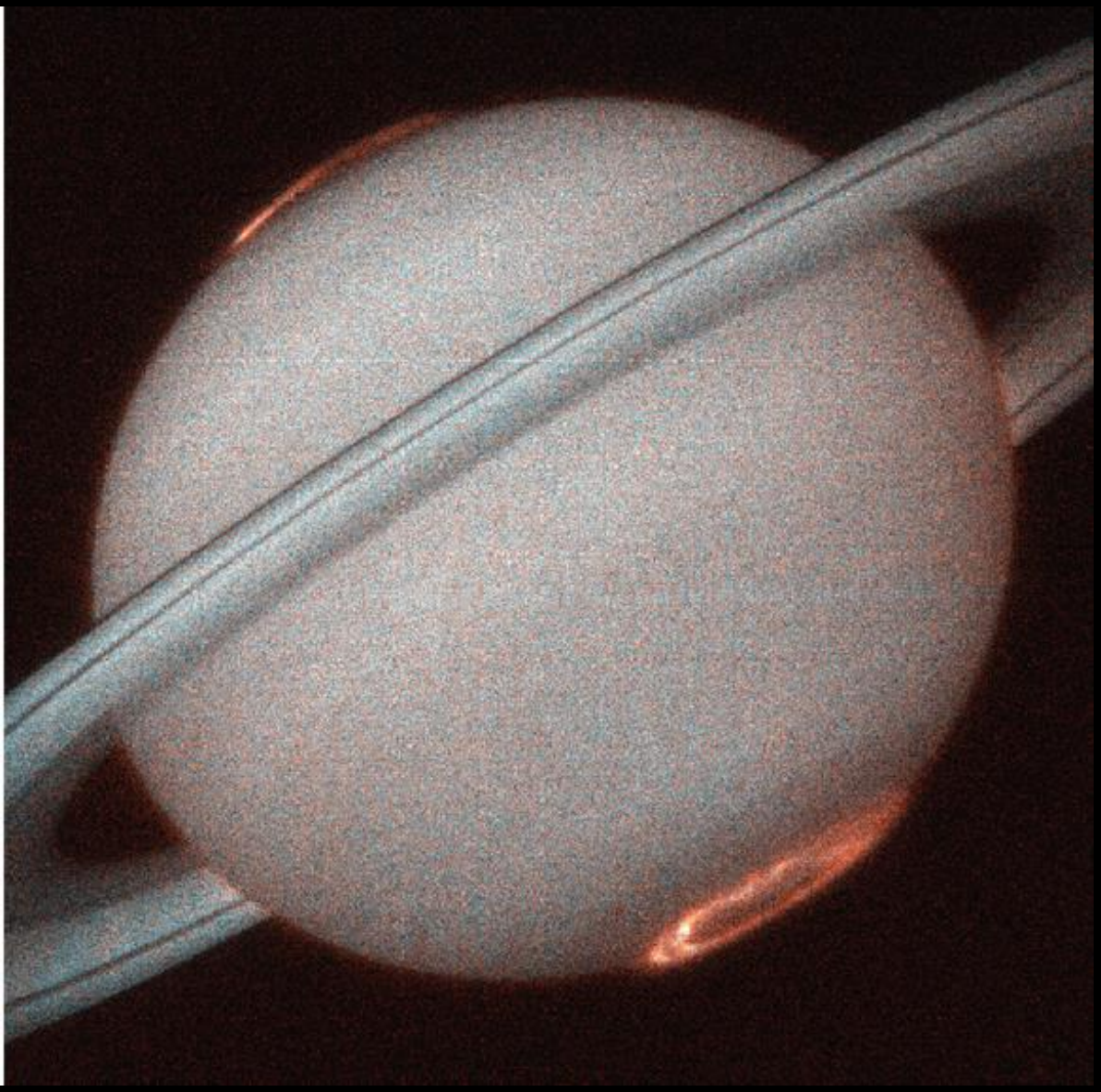
- Measured wind speeds are around ~375 Km/hr.



- Also has pressures high enough to create liquid metallic hydrogen
- Has a solid rocky core larger than the Earth



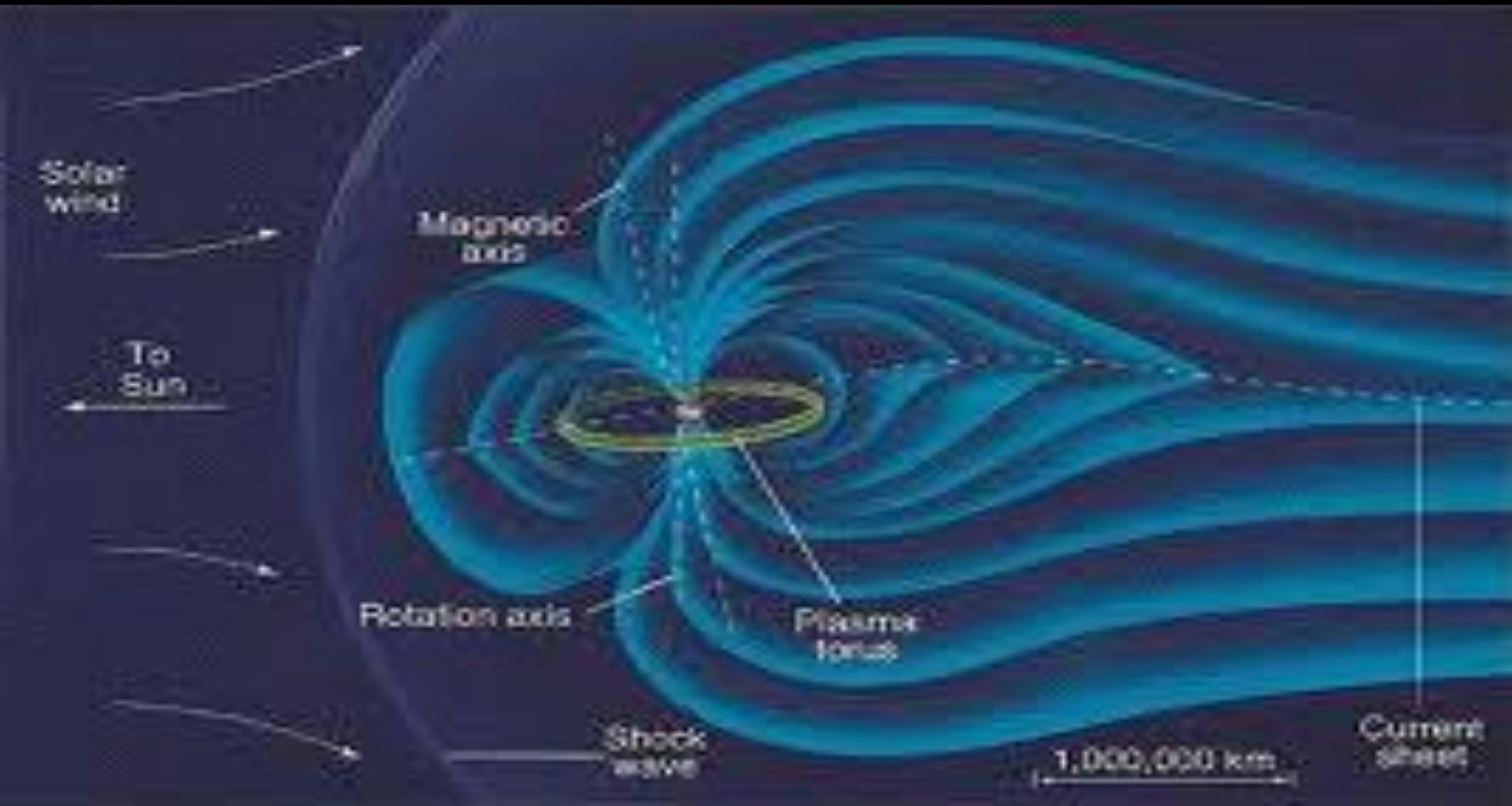
Saturn does radiate more excess heat than Jupiter does, ***because Helium rain falling inward generates heat as it descends***



Magnetic Fields

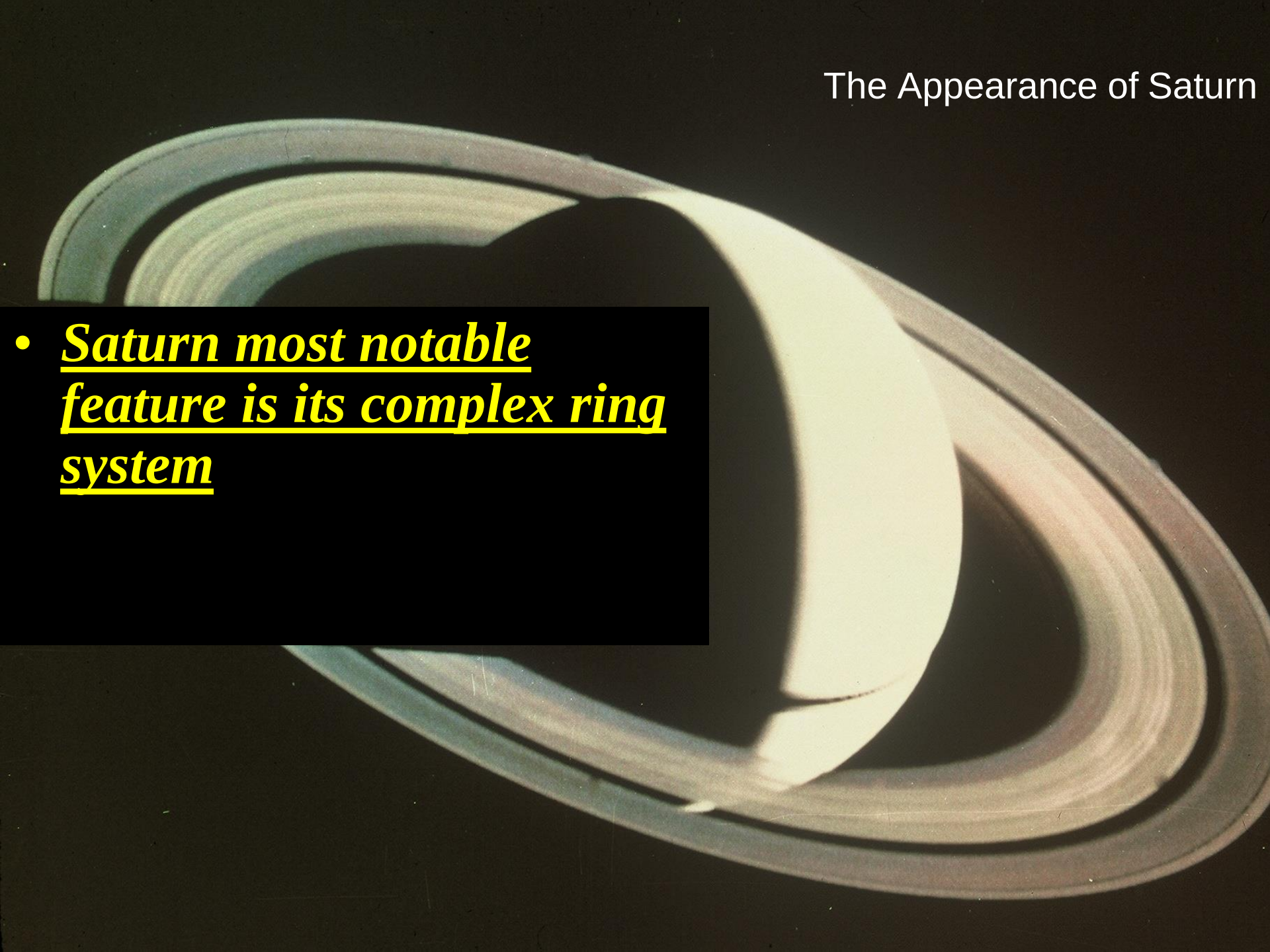
- The **liquid metallic hydrogen** in Saturn can **carry electrical currents**, similar to the liquid core of the Earth

- These currents generate very **large magnetic fields**
  - Saturn's field is **500 times** as strong as Earth's



- Both Jupiter and Saturn experience auroras

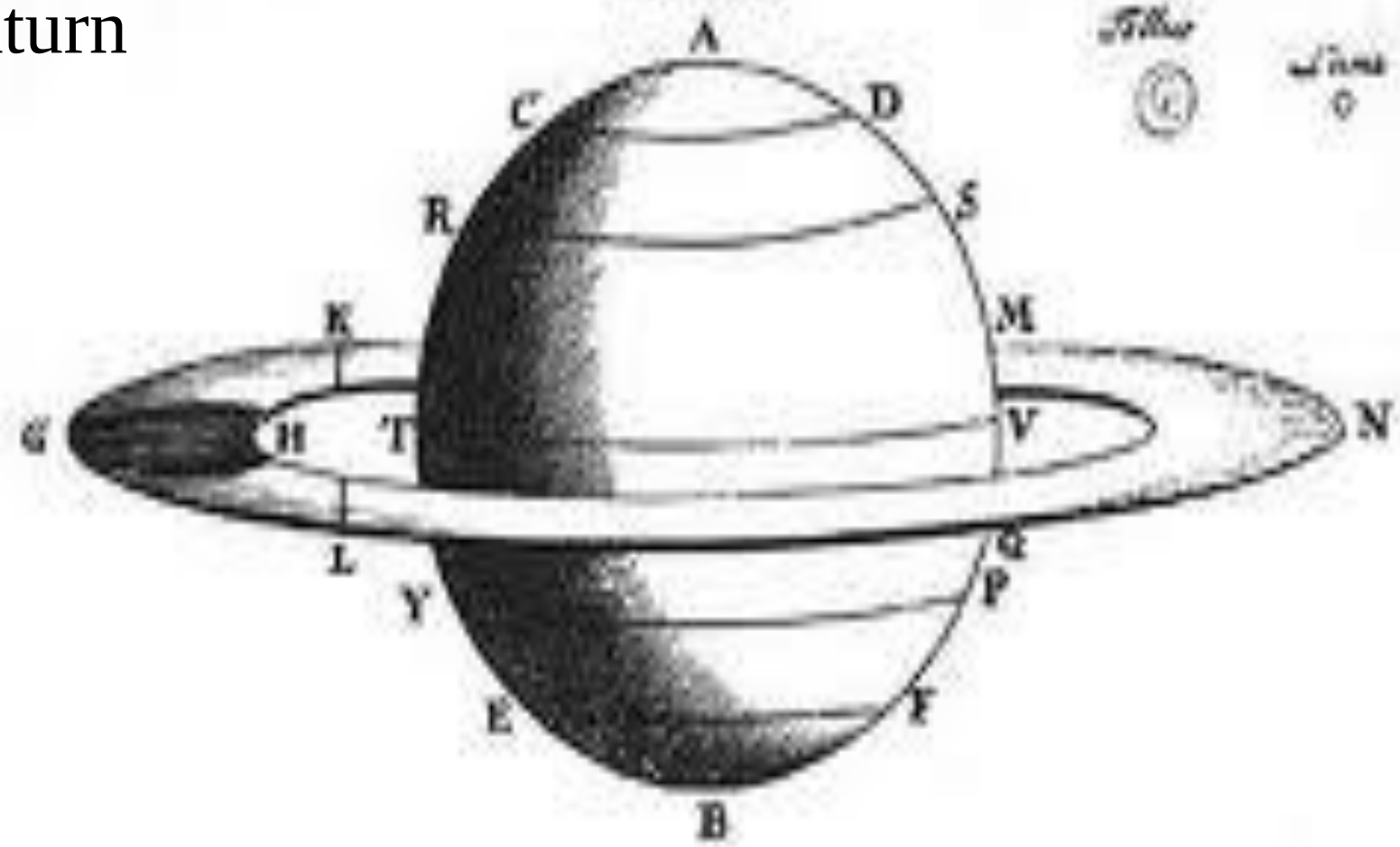
The Appearance of Saturn



- ***Saturn most notable feature is its complex ring system***

- **Galileo first saw the rings of Saturn, but didn't know what they were**

- Christiaan **Huygens** observed & correctly **interpreted that the rings** were **detached** from Saturn

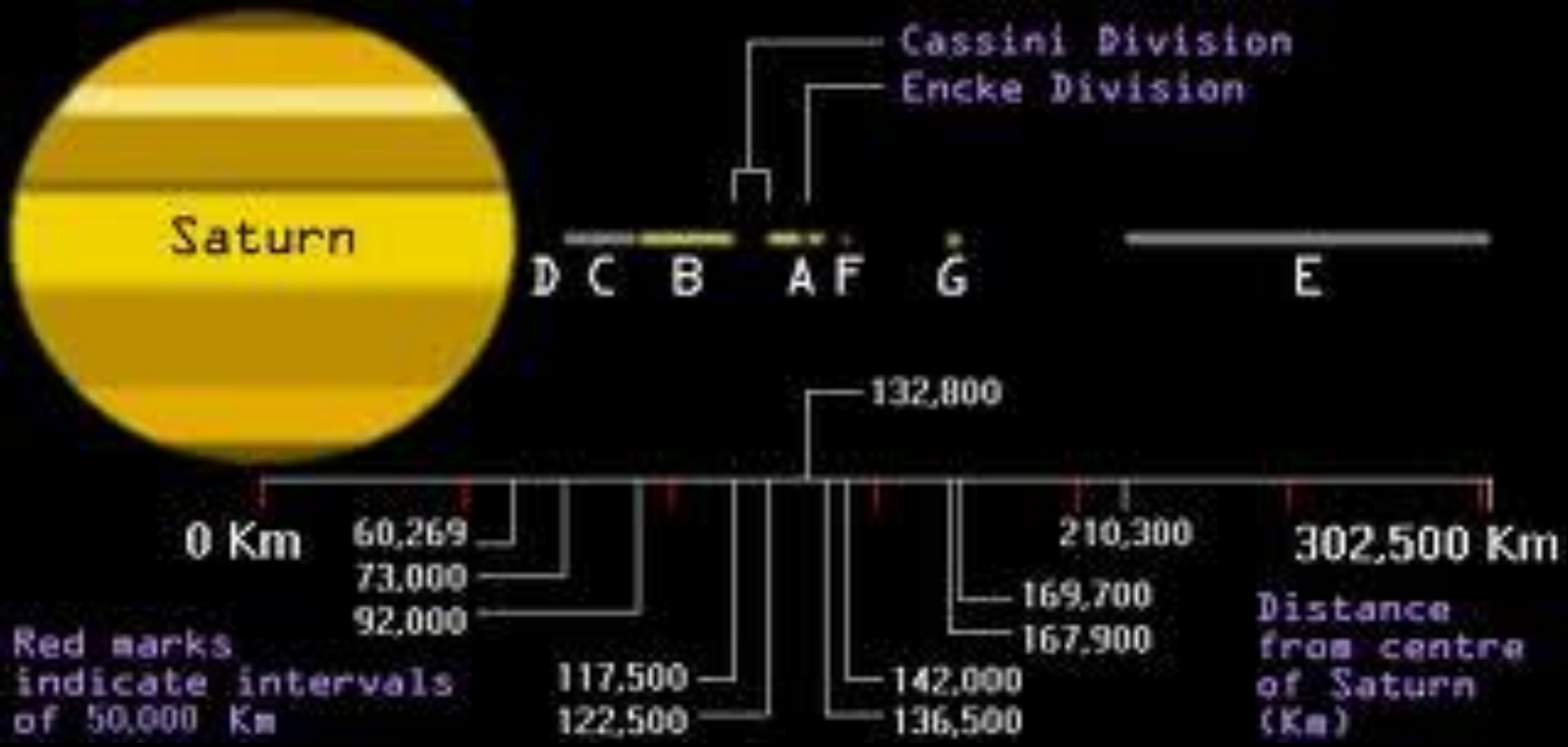


- James Clerk Maxwell **realized that the rings were not solid and were made up of small particles mostly of Ice & water, all following** Kepler's Laws!

$$c_0 = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \cdot 10^8 \text{ [m/s]} \quad \text{(free space)}$$

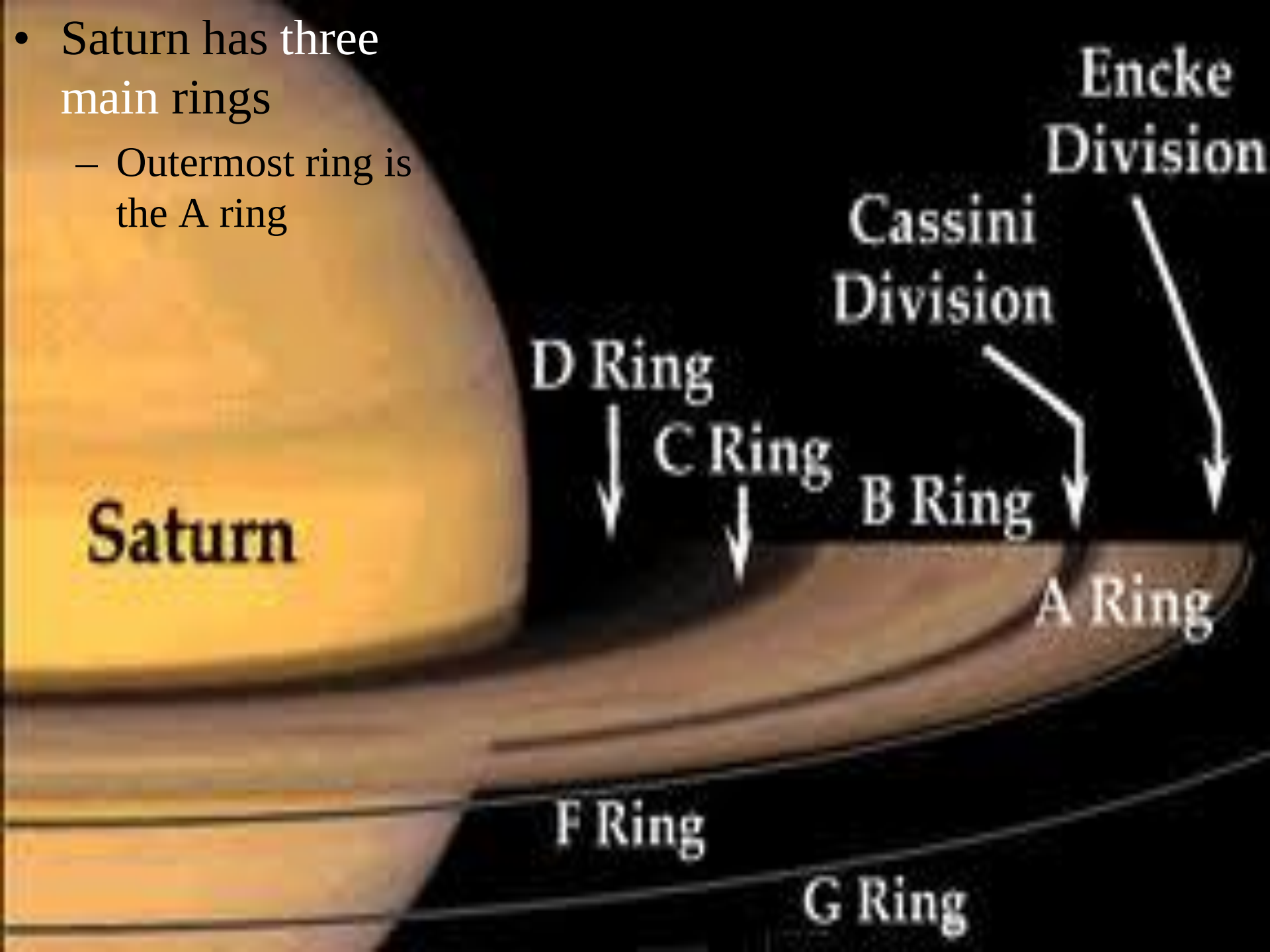
$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_r \varepsilon_0}} = \frac{1}{\sqrt{\mu_0 \varepsilon}} \quad \text{(dielectric)}$$

- **Saturn has three main rings with the average thickness only 10 meters**



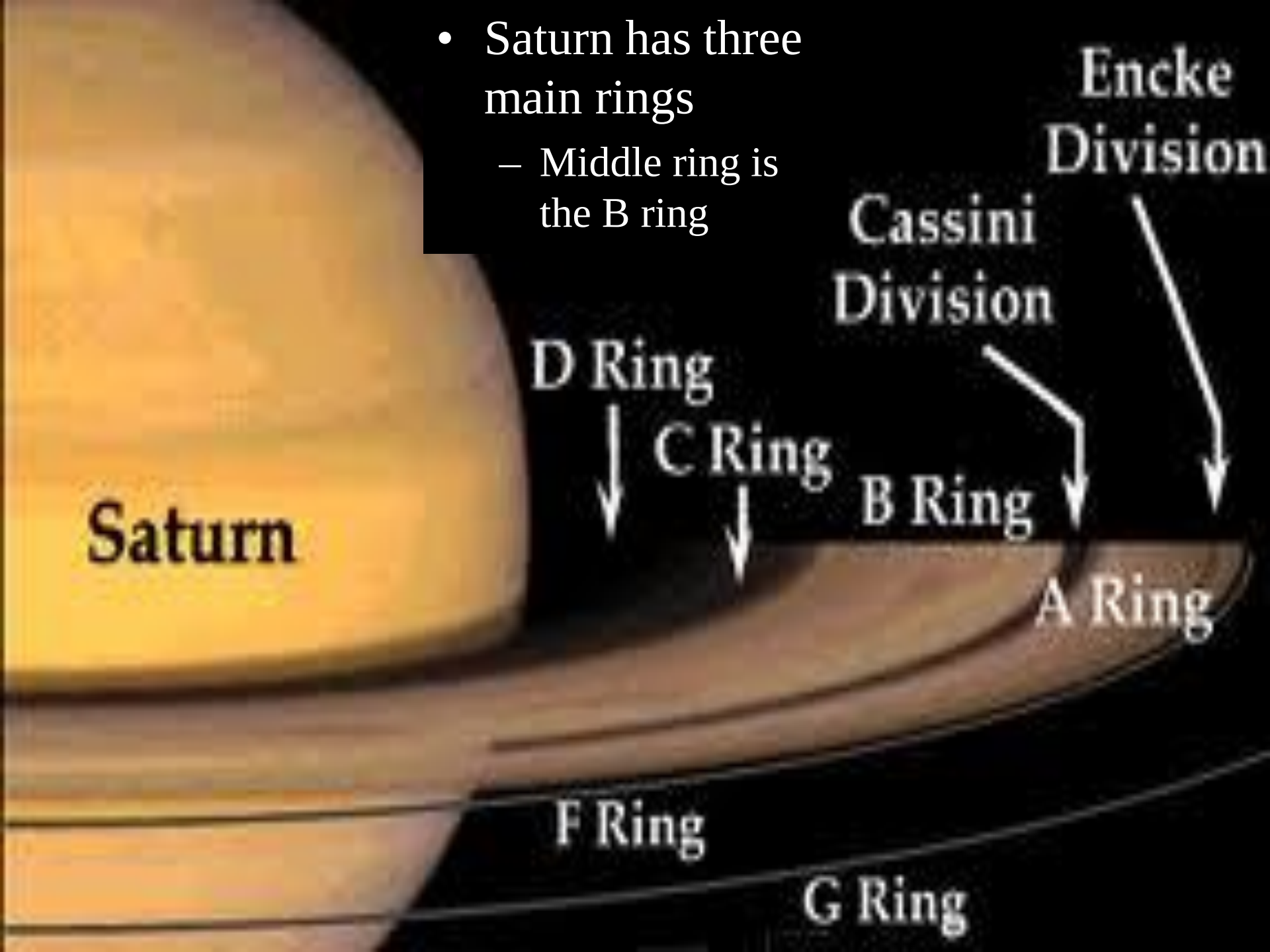
- Saturn has other rings that were given letters in the order of their discovery: D, c, b, a, F, G, and E: *E is made up of Salt/Baking soda*

- Saturn has three main rings
  - Outermost ring is the A ring

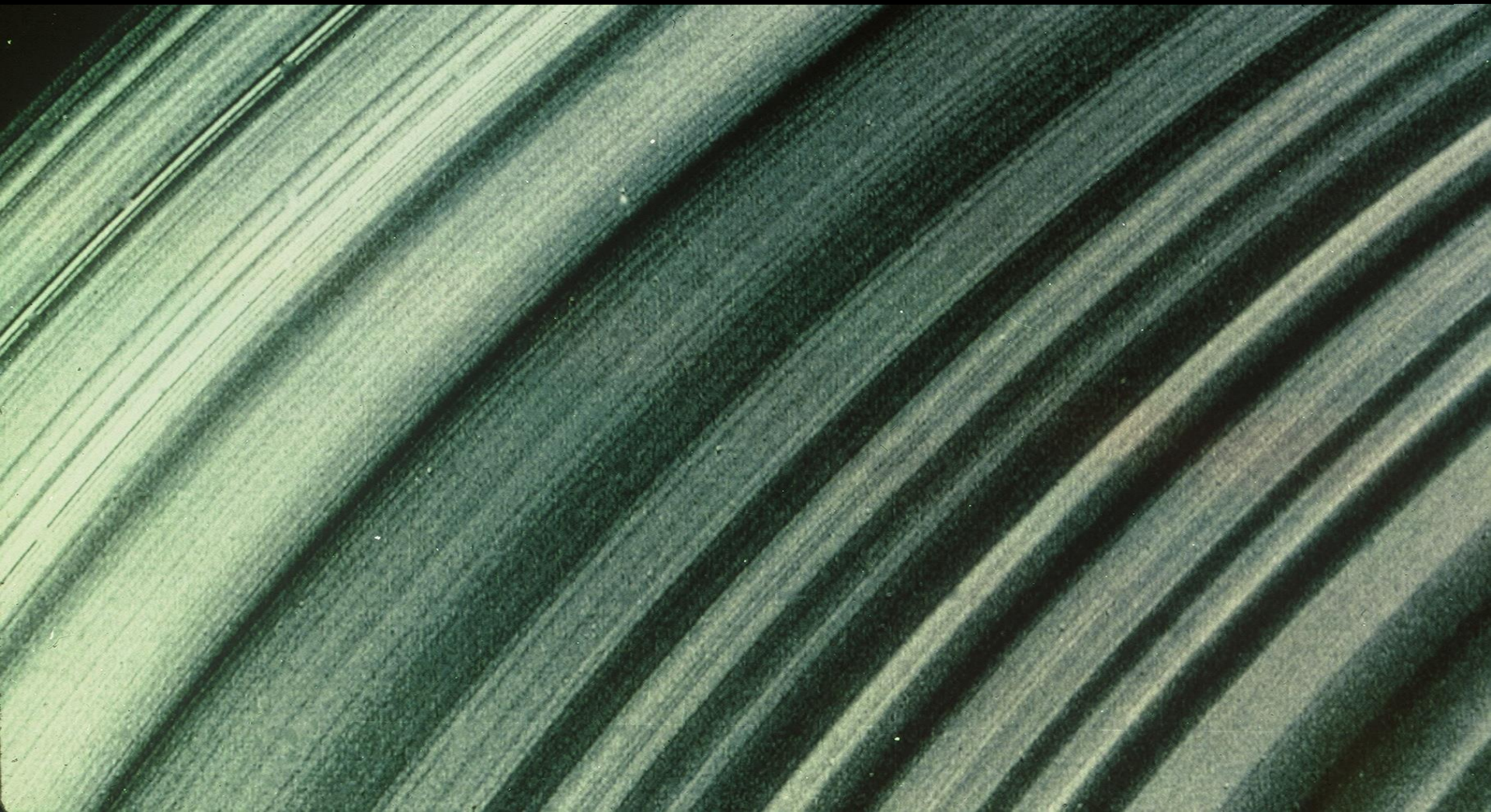


- Saturn has three main rings
  - Outermost ring is the A ring
  - Is almost transparent

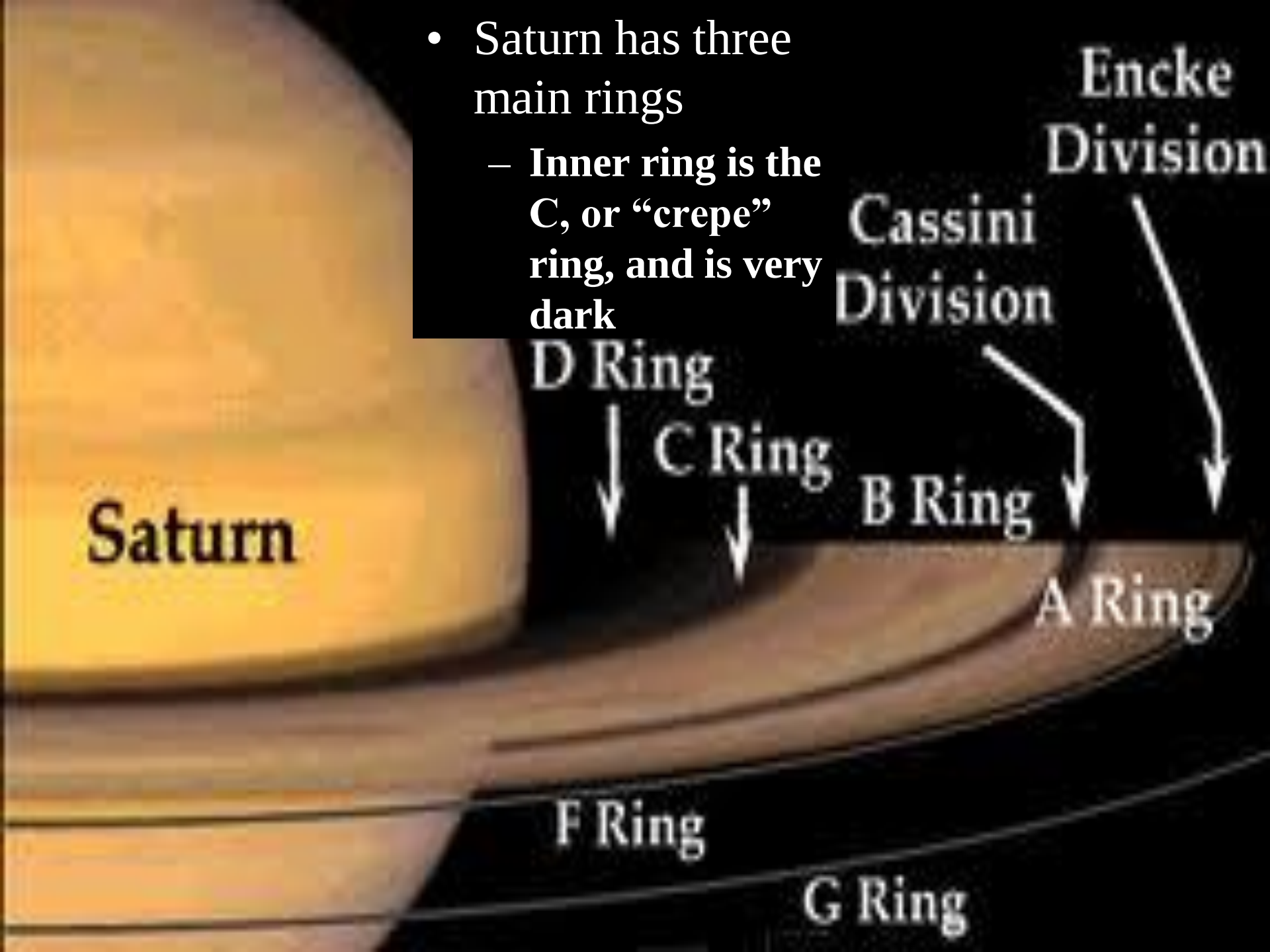
- Saturn has three main rings
  - Middle ring is the B ring



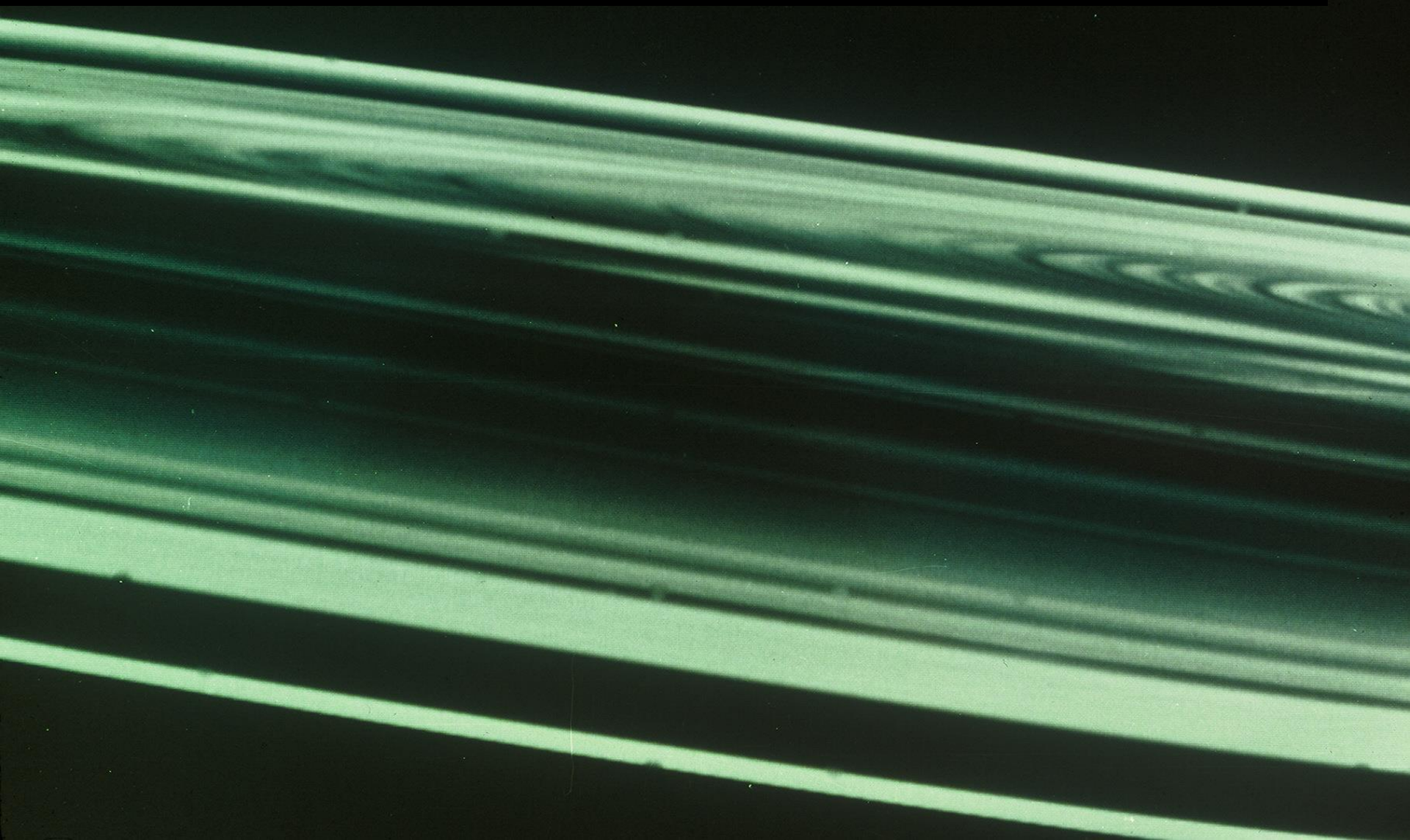
- Saturn has three main rings
  - Middle ring is the B ring
  - These are dense

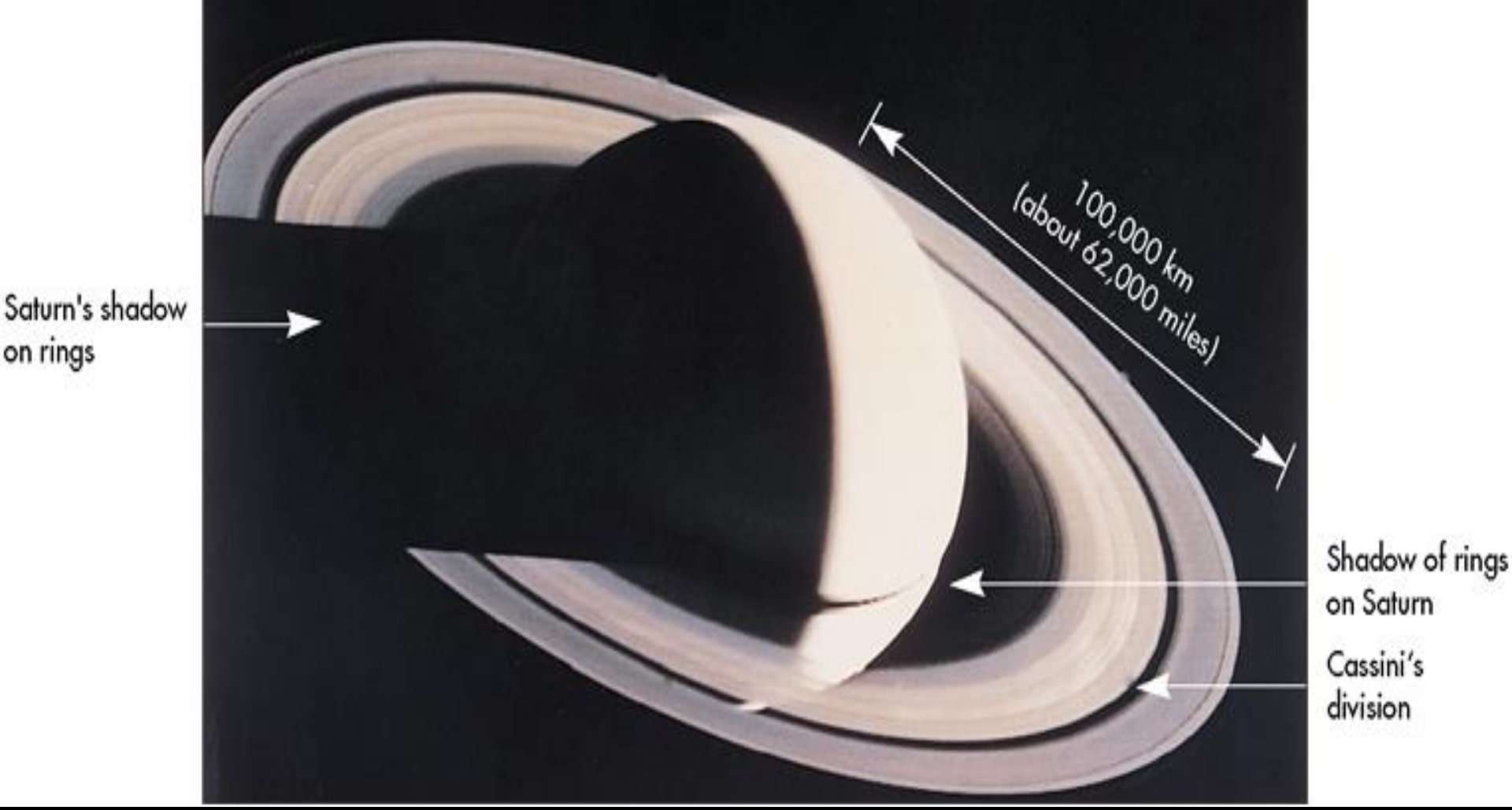


- Saturn has three main rings
  - **Inner ring is the C, or "crepe" ring, and is very dark**



- Saturn has three main rings
  - **The C, or “crepe” ring, is also more transparent than the A ring**

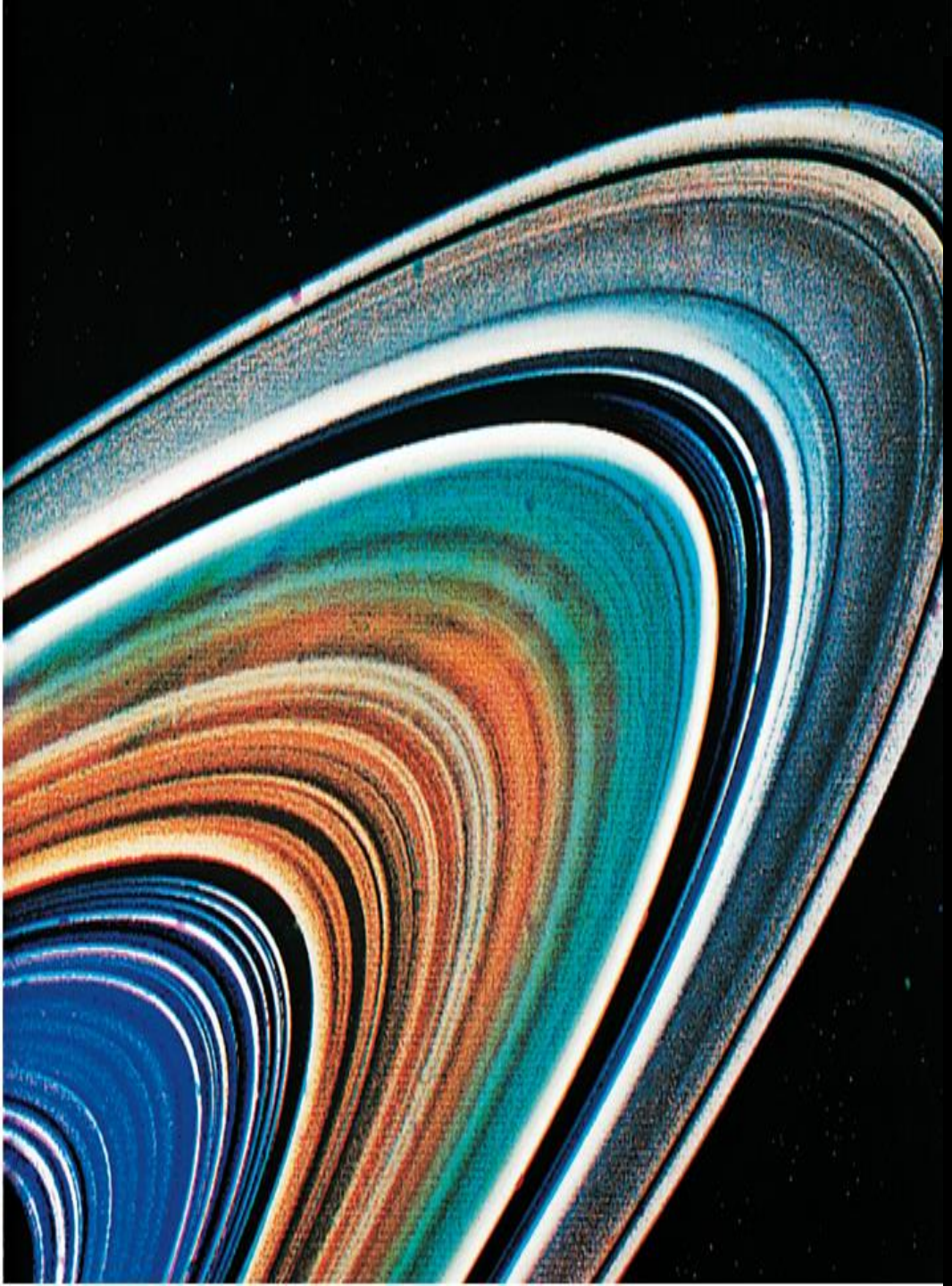




- Saturn has three main rings
  - The separation between the A and B ring is called the ***Cassini division***

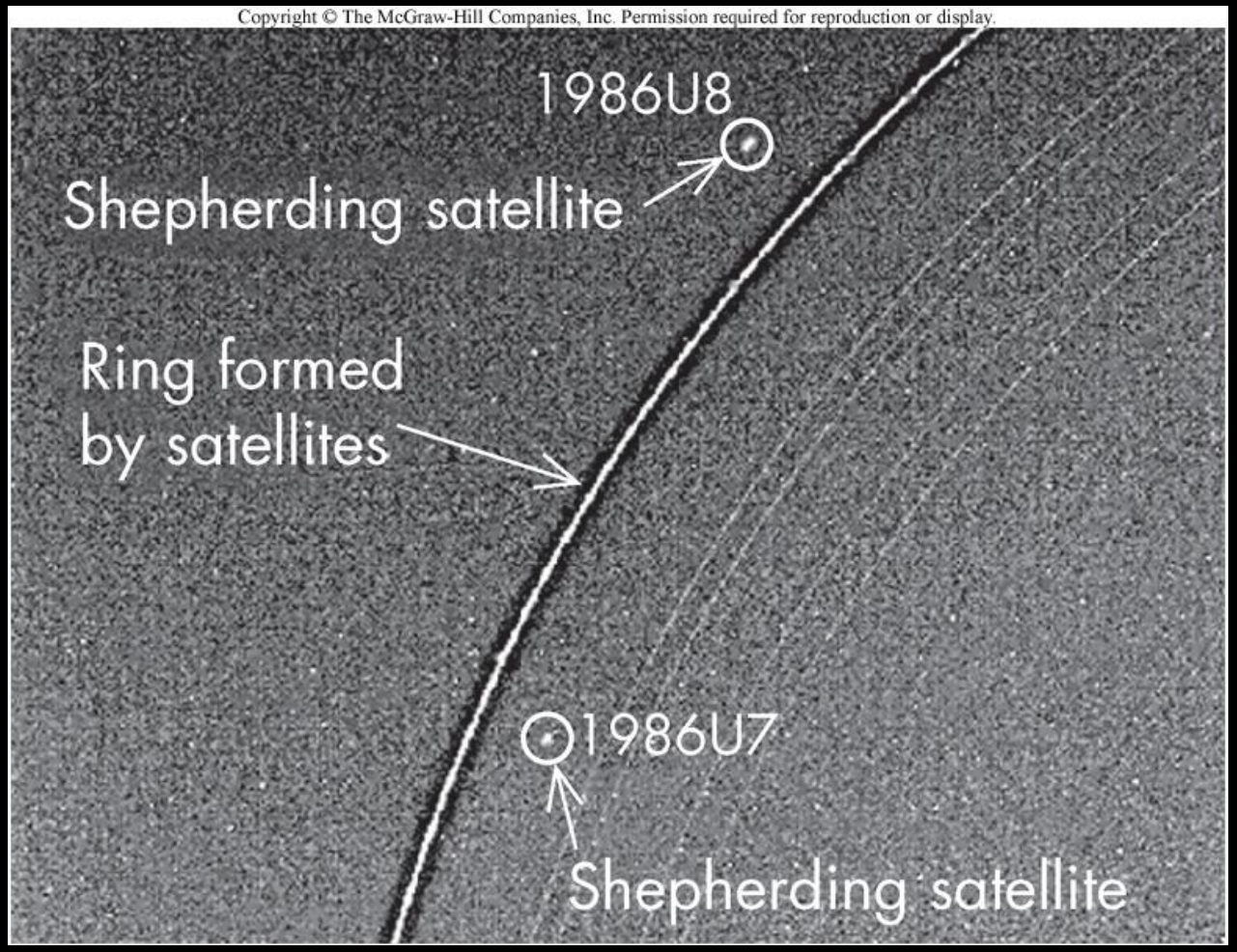
- **Composition mostly of icy particles and Water with some rocky debris from rubble piles**
  - Shine more brightly than a full moon on earth… called **RINGSHINE**
  - This makes them very noticeable and is from a recent breakup.
  - Maybe only a few hundred old

- If Saturn was the size of a piece of paper, that paper would be 10,000 thicker that the rings around it.



- A close examination of Saturn's rings shows that they are composed of tiny ringlets
  - These might be caused by gravitational influences of *very small moons*, creating waves in the main rings (*spiral density waves*)

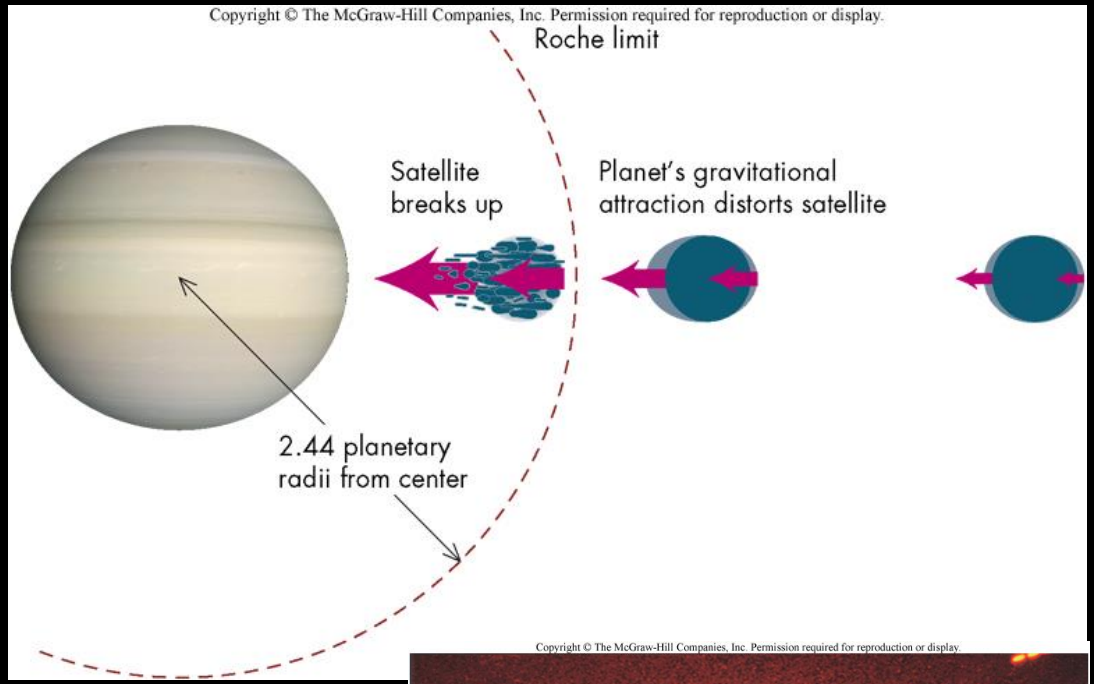
Shepherd Satellites

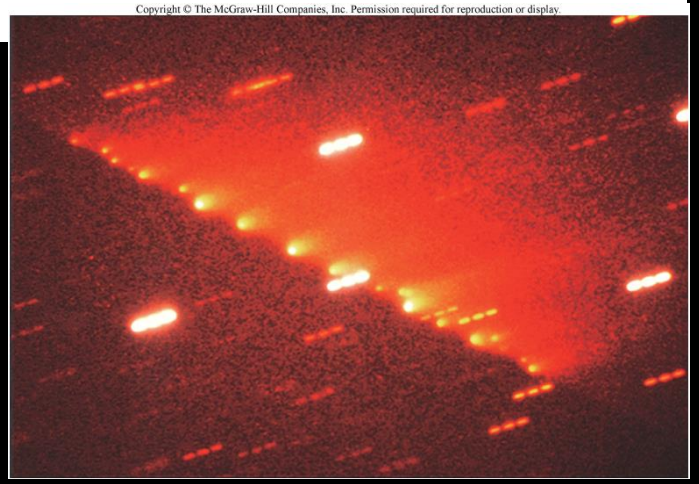


- The thin rings of the gas giants are maintained by shepherd satellites
- The gravitational pull of these small moons keeps ring particles in line!

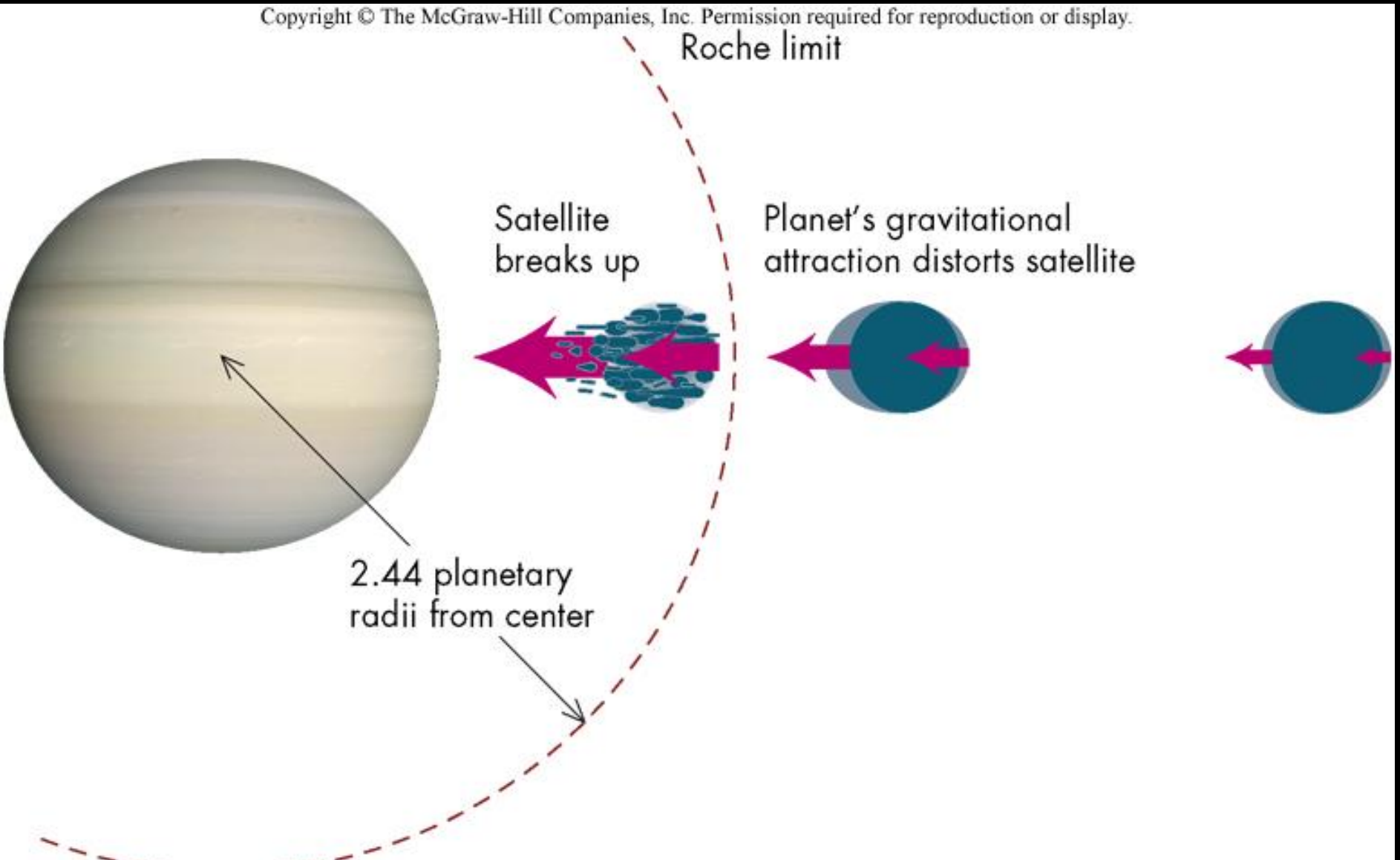
The Origin of Planetary Rings

- Solid bodies (chunks of rock or ice, or even the space station) are safe, as they are held together by forces other than gravity
- The fragments of the broken-up satellite go into orbit around the planet, forming a ring

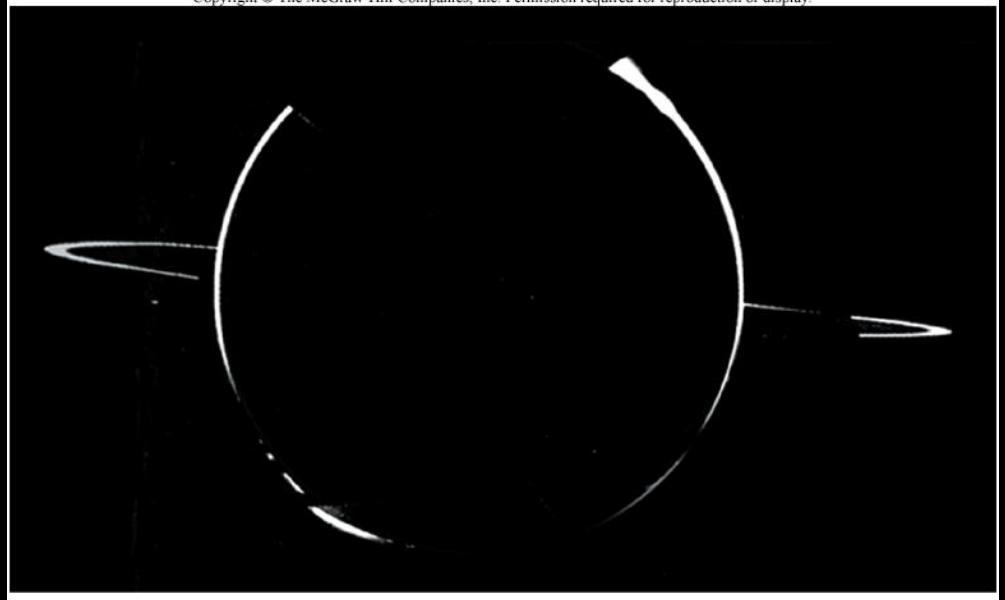




- *This is about 2.44 the planet's radius*

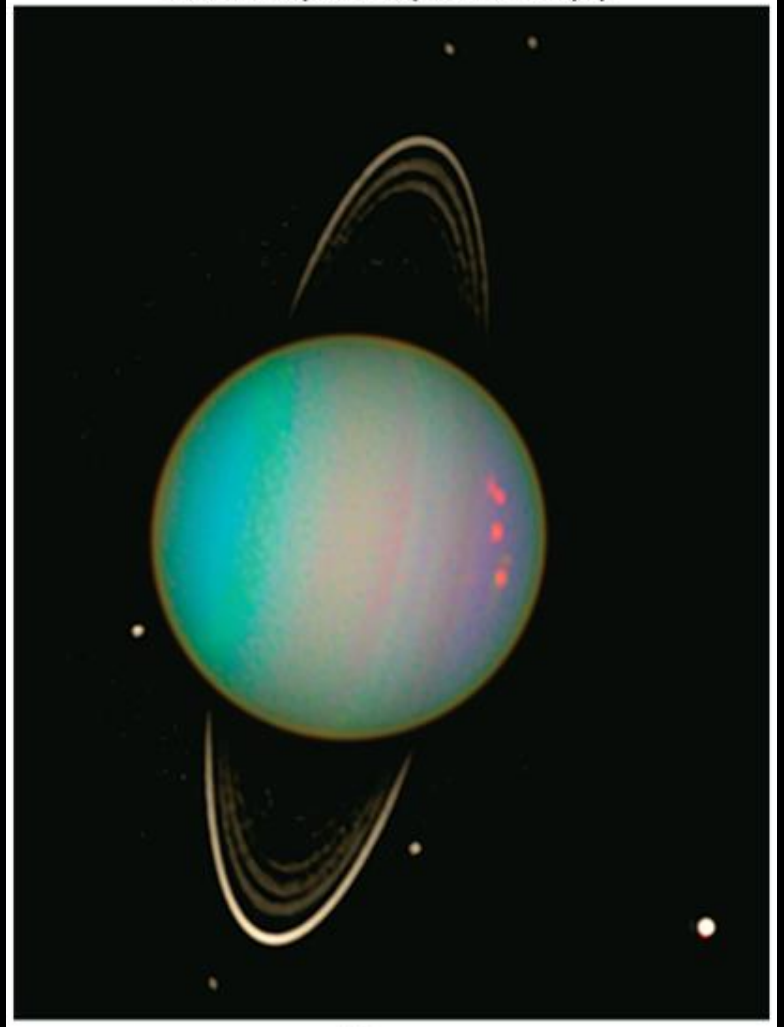


All of the Gas Giants Have Ring Systems



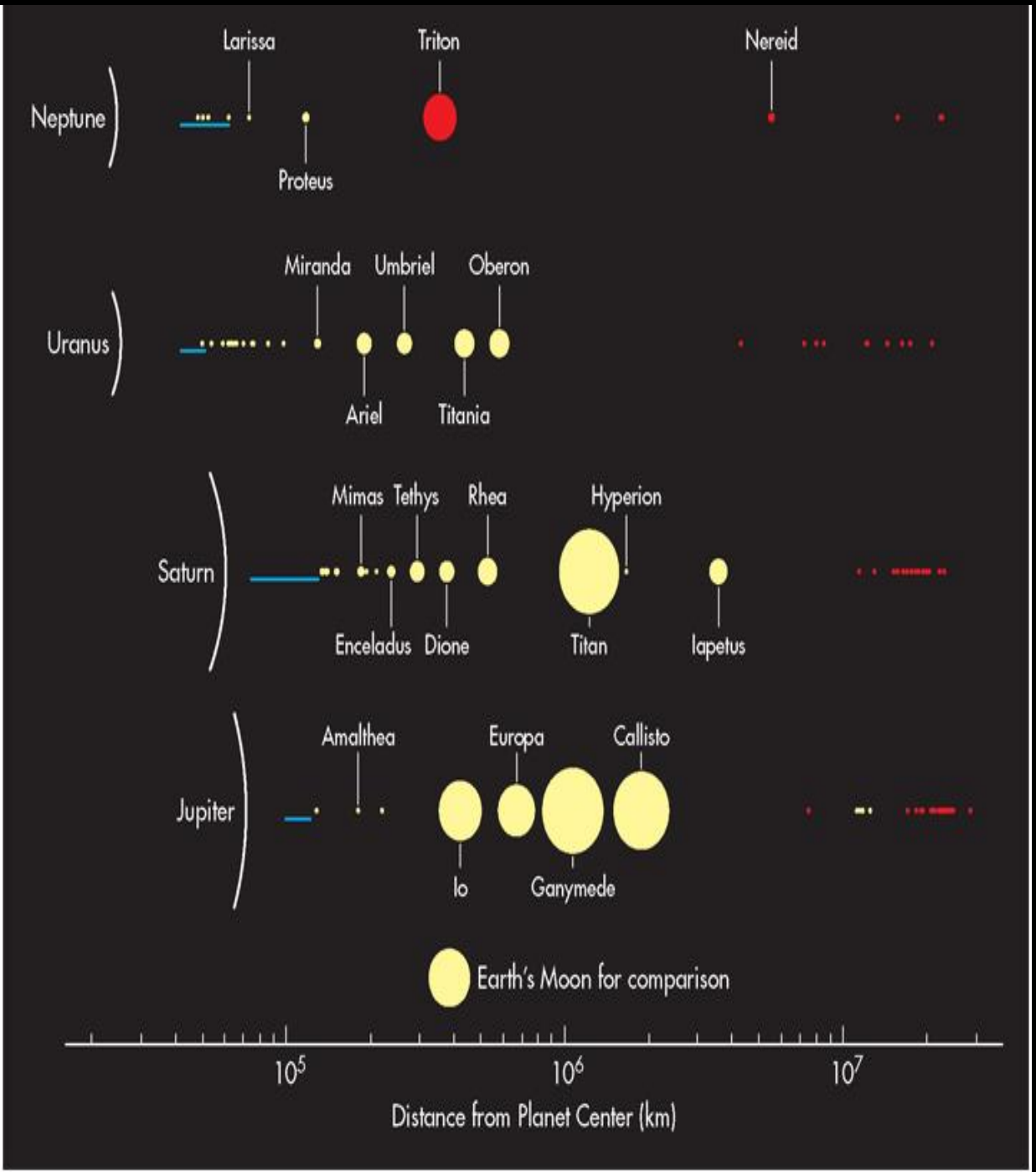
Jupiter

Neptune



Uranus

Satellites in the Outer Solar System

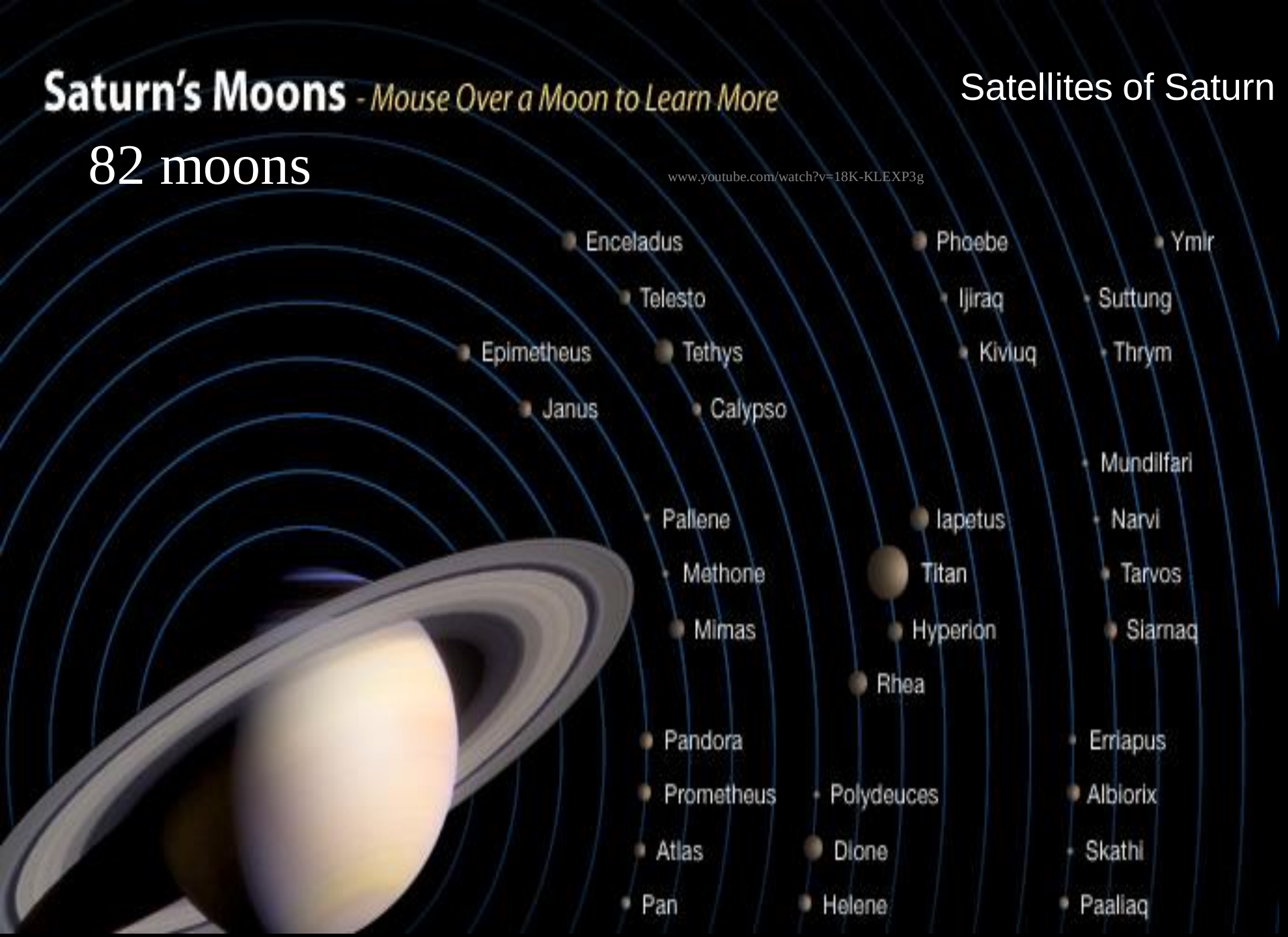


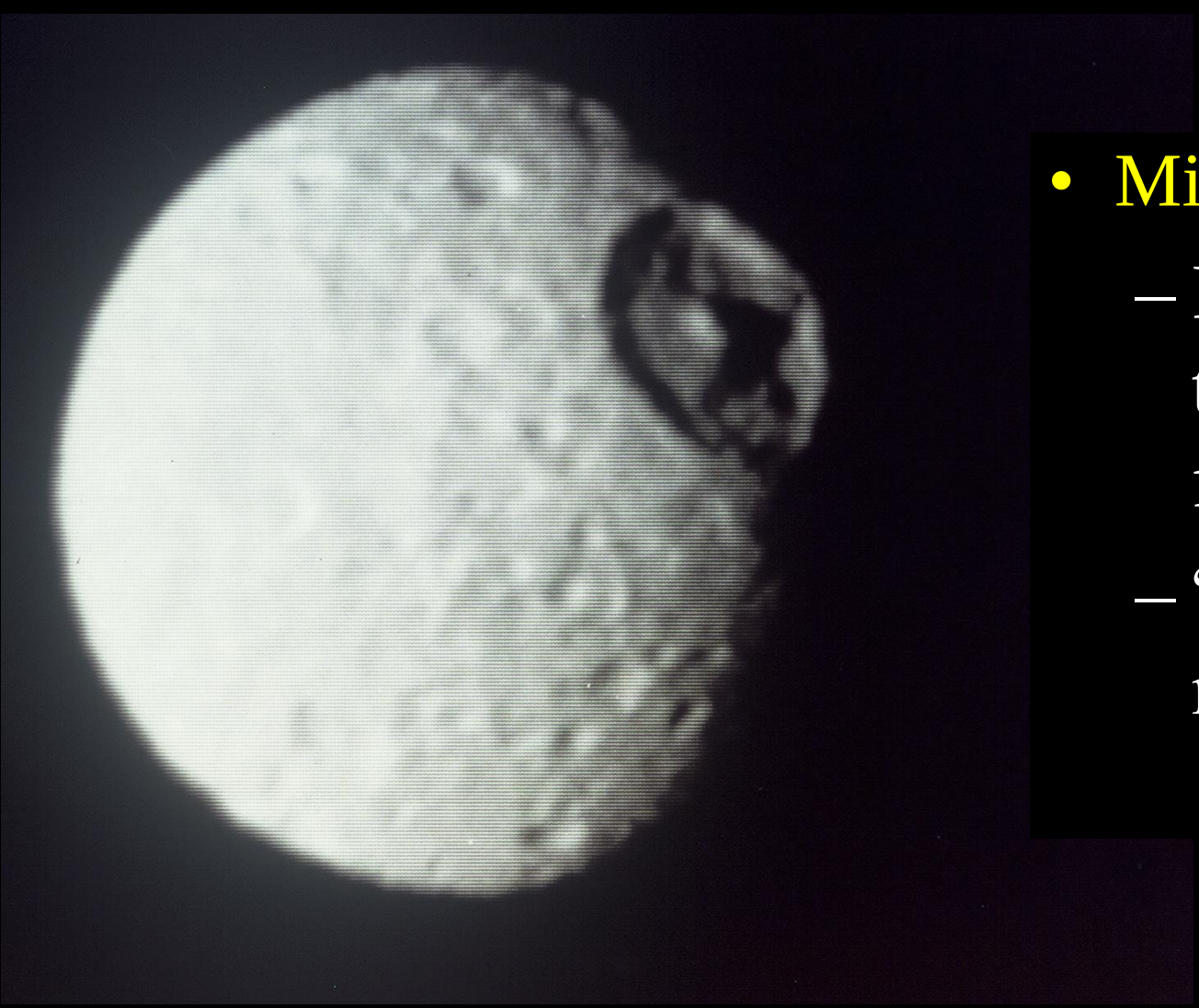
- Satellites of the giant planets range in size from larger than Mercury to small asteroid-like bodies

Satellites in the Outer Solar System

- Some of the satellites are in *regular orbits* (nearly circular, orbiting in the same direction that the planet spins, and near the planet's equator)
  - Probably formed along with the planets
  - Many of the orbits are irregular, and the satellites appear to be captured bodies

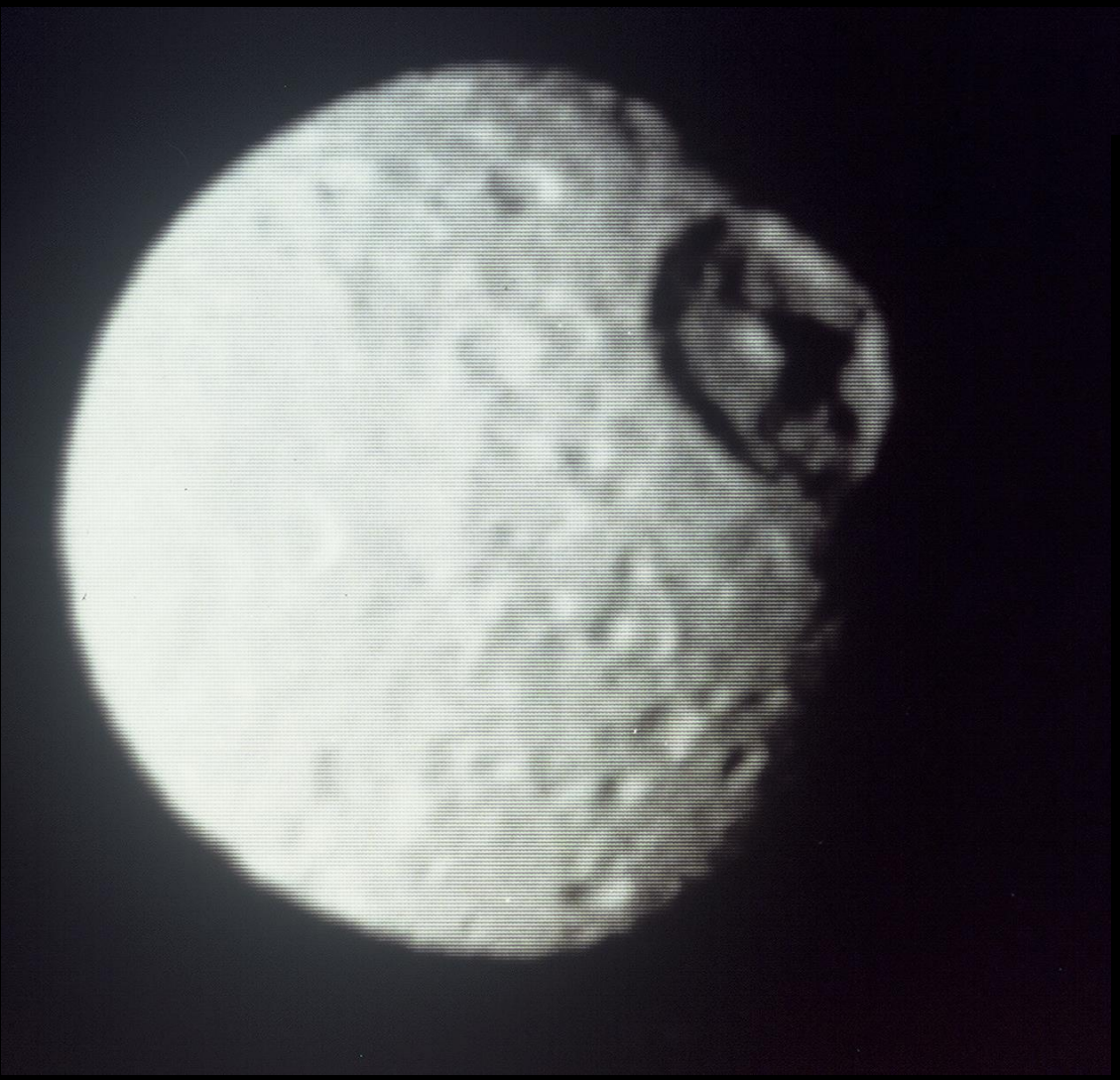
Satellites of Saturn



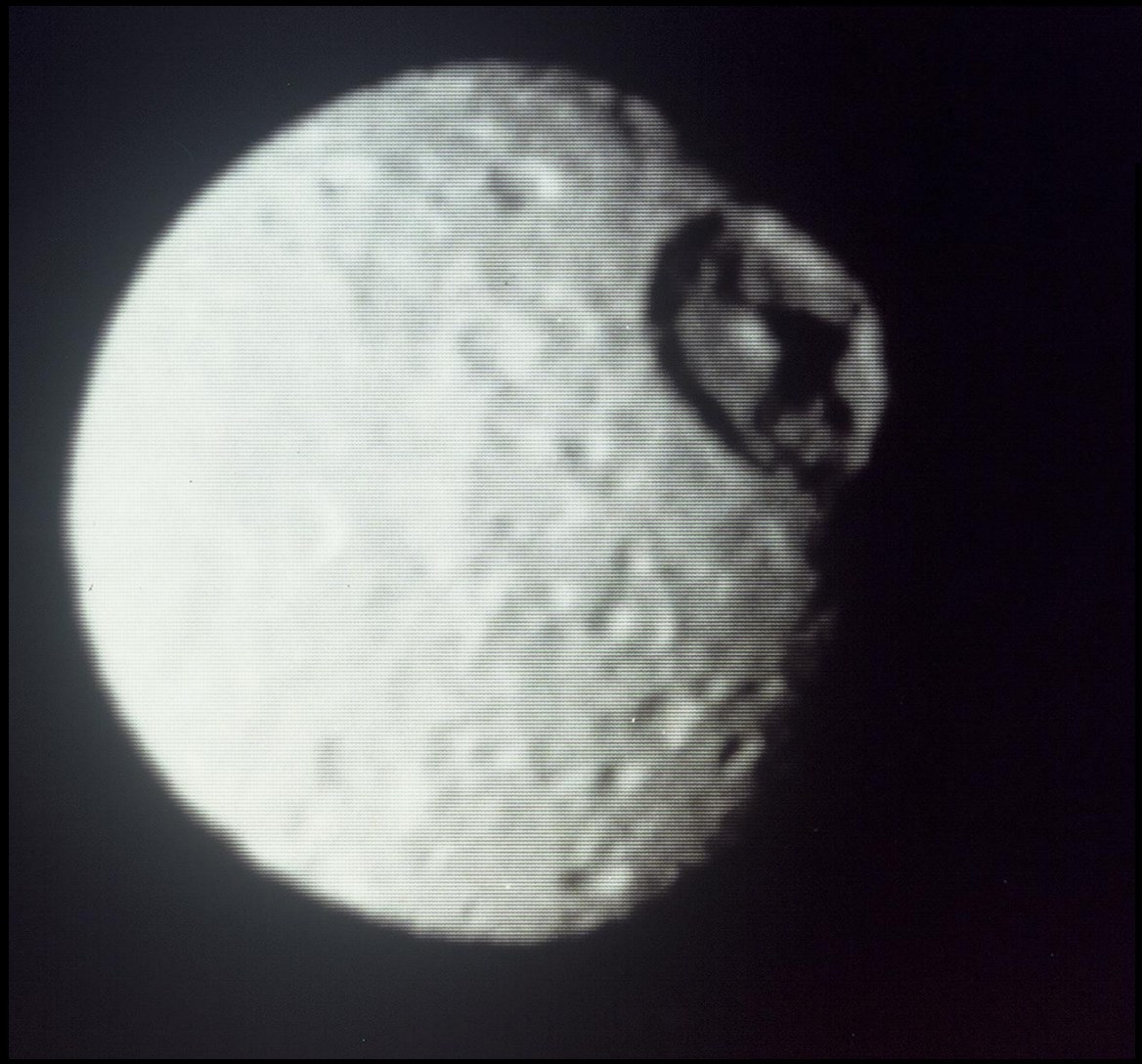


- Mimas
  - Probably one of the most famous moons
  - "that's no moon…

- Mimas
  - Probably one of the most famous moons
  - "that's no moon… that's a space station"



- Mimas
  - Was the model for the Death Star in Star Wars
  - This moon is also responsible for the Cassini Division



Saturn's Moon

- Mimas
  - is a dirty snowball
  - diameter 242.3 miles
  - ROT: 23 hours
  - REV: same
  - ONE moons orbiting it: Mimas' co-orbital (6.2 mi)
  - CO-orbital: 23 hours Rot and Rev: same

Saturn's Moon

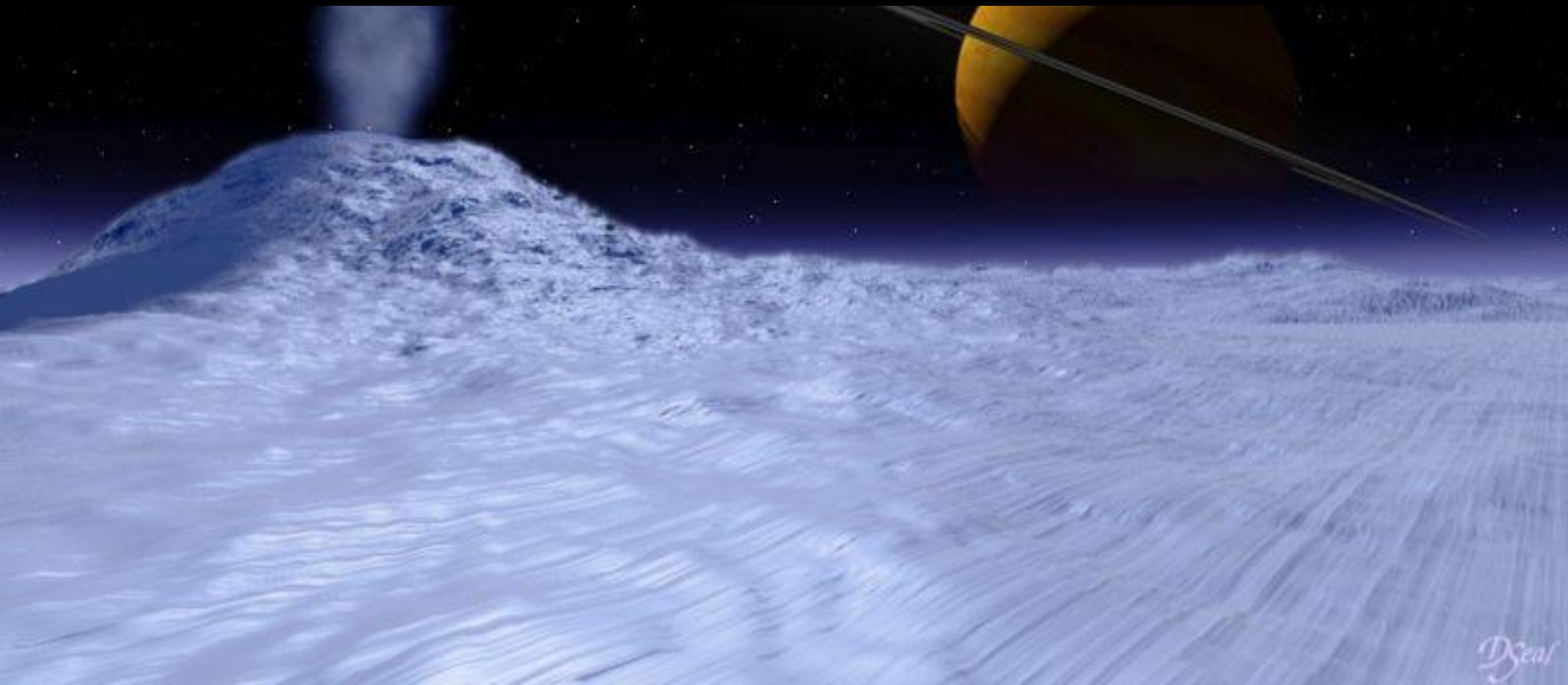
- **Enceladus**
  - ***The whitest in the solar system (due to ice & snow)***
  - **Snow boarders dream place**
  - **Size is 310.7 mile diameter**
  - **ROT & Rev: 1.37 days**

Enceladus

- **Fracture zones of ice, make it possible for liquid water, oceans, underneath its surface.**

Enceladus

- **Since the moon does lack impact craters on much of its surface and evidence of ice flows, thus a conclusion of underwater geological volcanic activity must be present.**
- **Since one (leading hemisphere) has greatly been reworked by tectonic and volcanic**



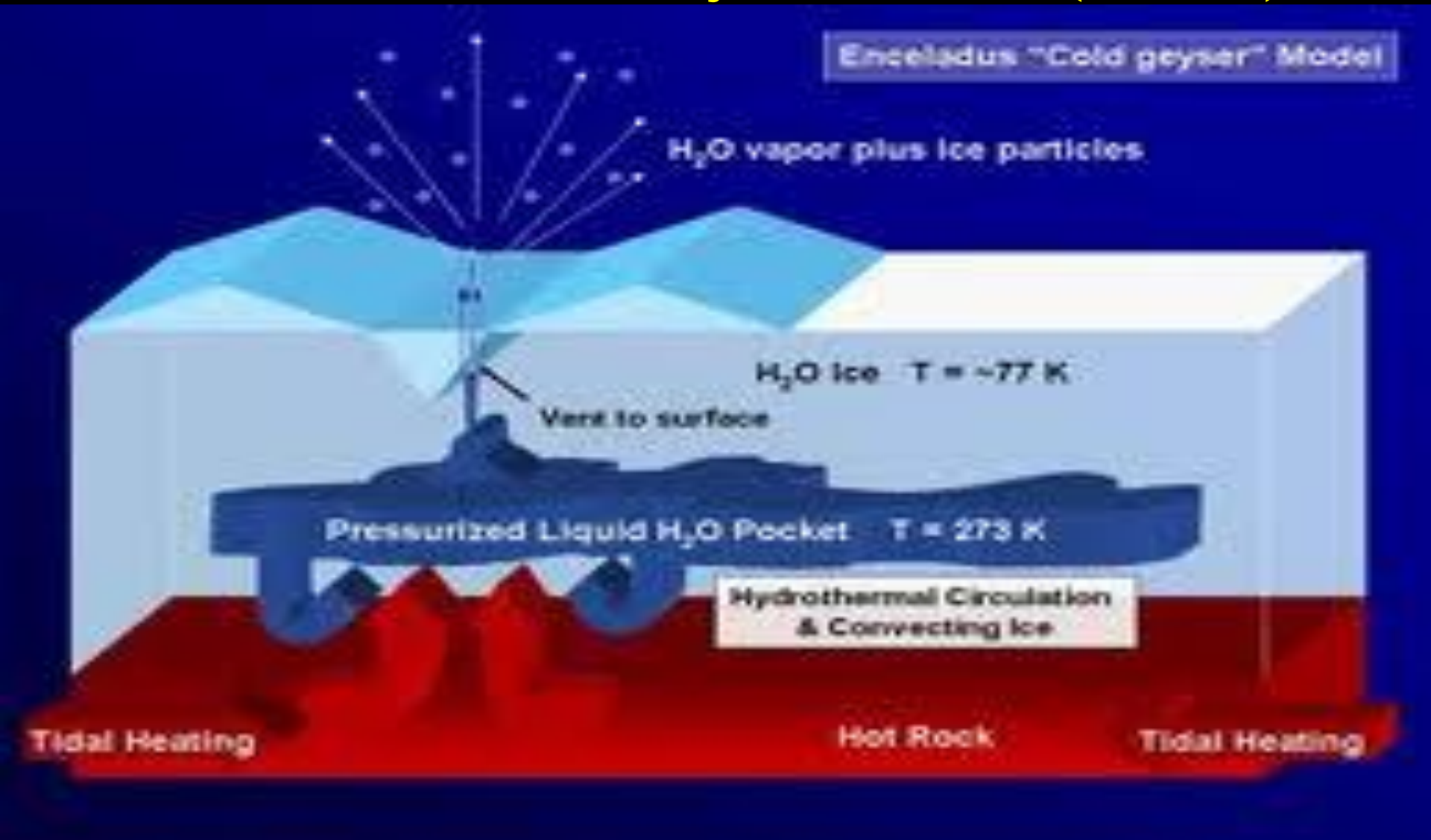
Enceladus

Found hundreds of geysers erupting think is water up hundreds of miles in the southern hemisphere from cracks nicknamed "Tiger stripes"

Enceladus

Saturn's Moon

– **Believe to have: Hydro-carbon (oceans)**



Enceladus

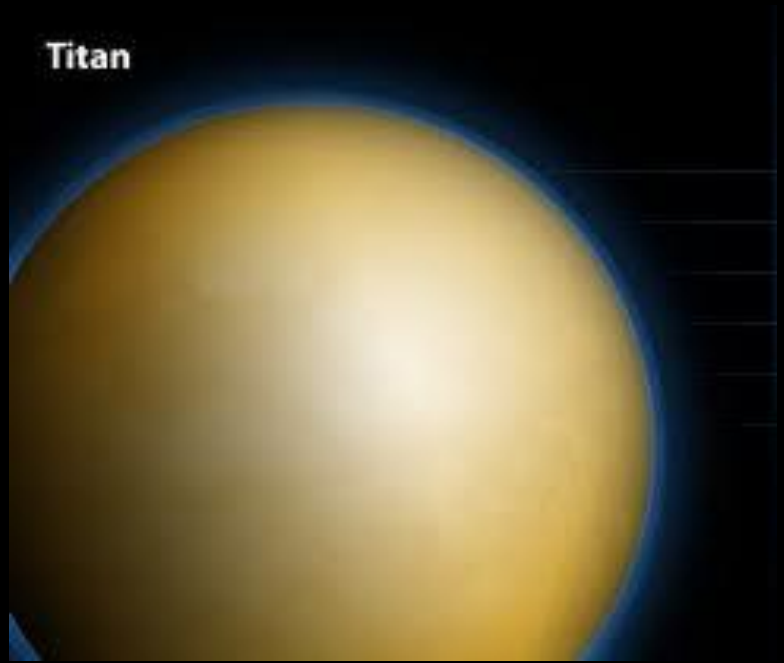
Saturn's Moon

– **Eruptions occurred to create an "E" ring" of Saturn**


Titan
2nd largest moon in the Solar system
(Bigger than Mercury)
Saturn's Moon

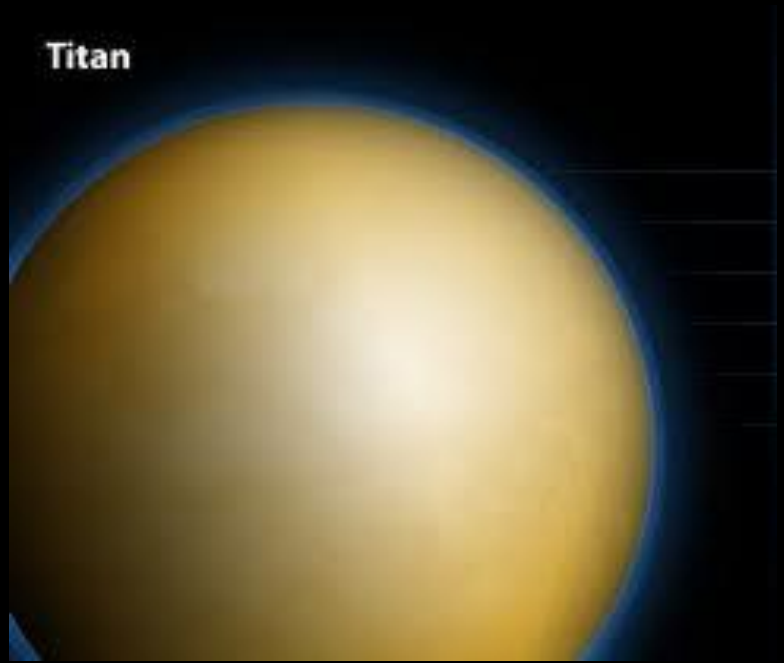
Here it is so cold (-290 degrees Fahrenheit or -179 degrees Celsius) that water ice plays the role of rock.

Titan may have volcanic activity as well, but with liquid water “lava” instead of molten rock.

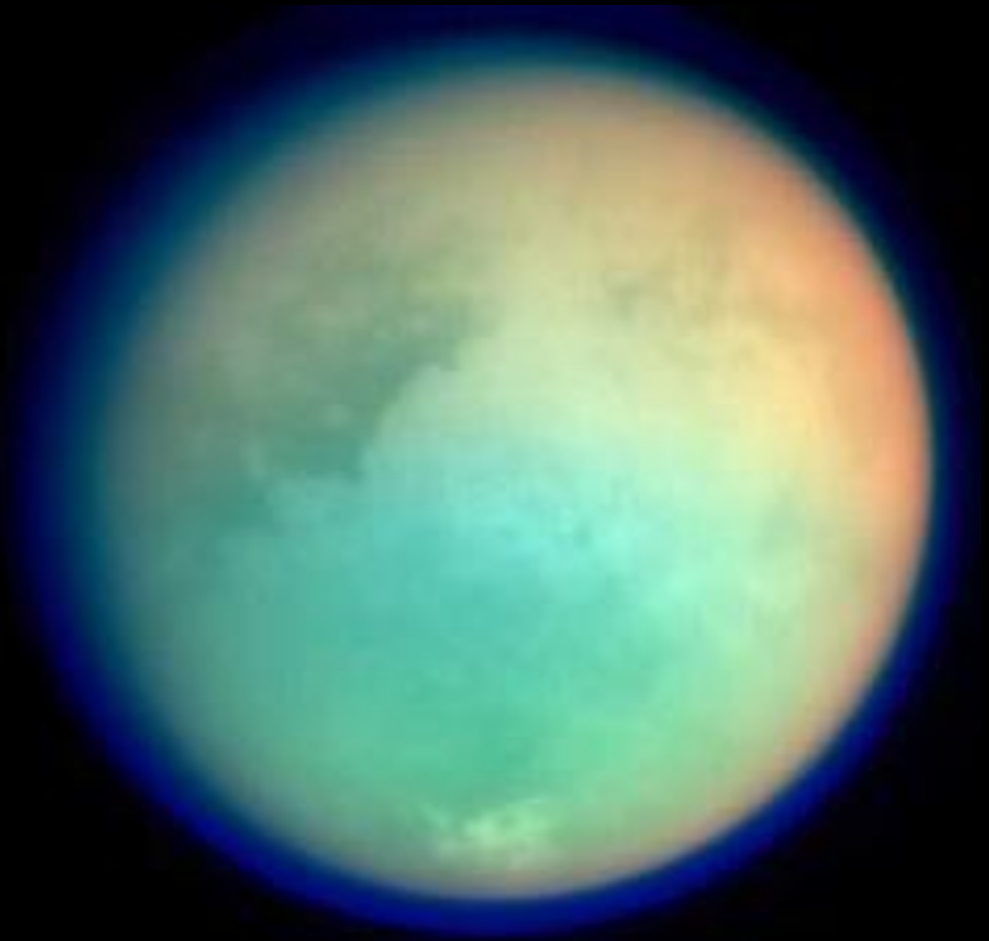


Titan's surface is sculpted by flowing methane and ethane, which carves river channels and fills great lakes with liquid natural gas.

No other world in the solar system, aside from Earth, has that kind of liquid activity on its surface.



Its Titan's fully developed atmosphere that really impresses people.



It is mostly nitrogen (about 95 percent) and methane (about 5 percent), with small amounts of other carbon-rich compounds.

TITAN

Saturn's Moon

- **How do we know so much about Titan?**

Saturn's Moon

TITAN

- **In December 2004 the Cassini-Huygens spaceprobe was ejected on a 22-day cruise to Titan.**
- Titan was discovered by an Astronomer named Christian Huygens in 1655

Saturn’s Moon

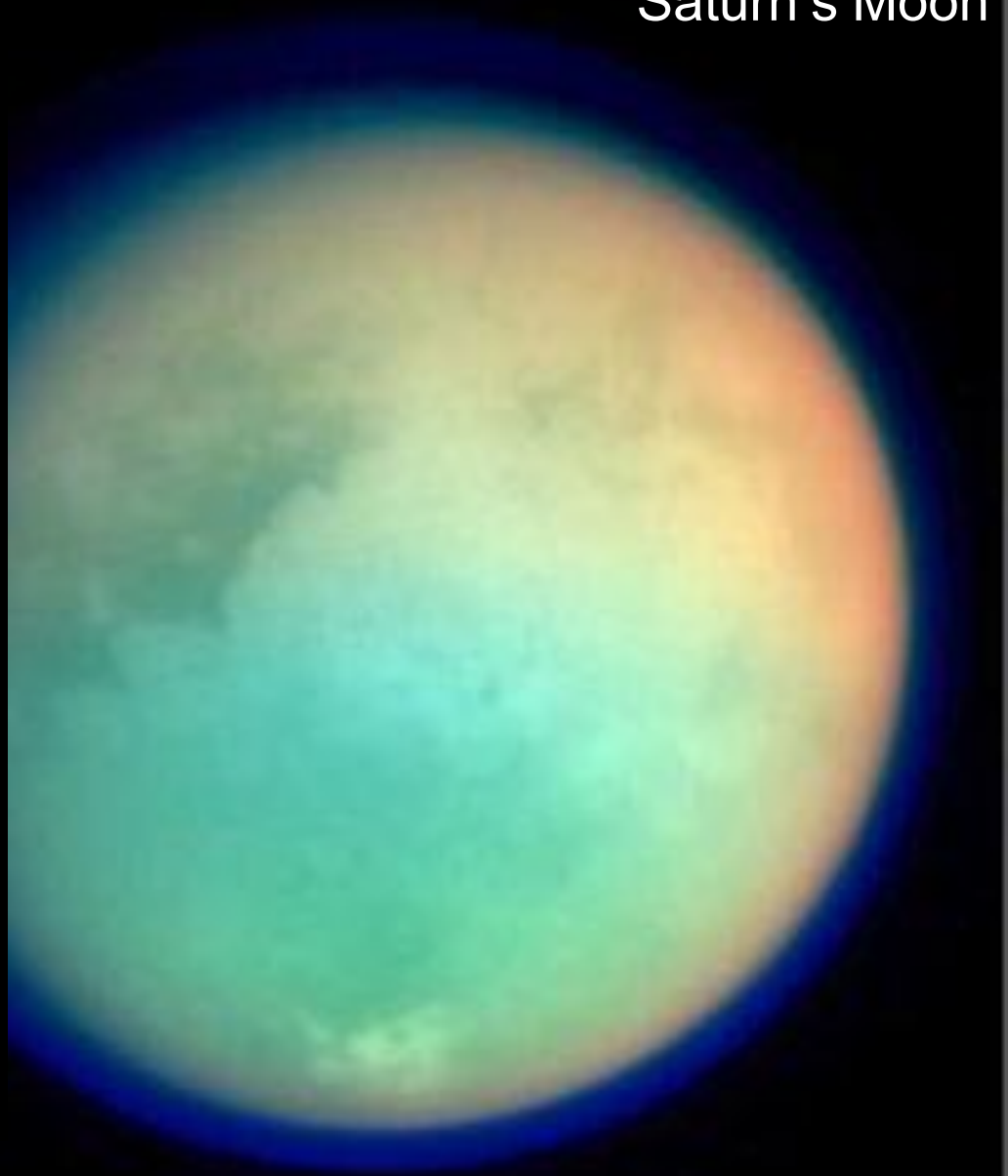
TITAN

- **Huygens reached the surface of Titan on 14 January 2005 and Cassini remains in orbit around Saturn.**

TITAN

- **3,200 miles (5,150 kilometers) in diameter**
- **Rotation & Rev: 383 hours (15.9 days)**
- **1/7 gravity of earth**

Saturn's Moon



TITAN

- Yet one of Titan's most noticeable features remains a mystery. An orange shroud of methane has long hidden the moon's surface from astronomers' eyes.

TITAN

- **Titan's thick atmosphere is mostly nitrogen (94%) but there is also methane (5%) and many other organic compounds (1%).**

TITAN

- But the **methane** has remains despite getting **steadily destroyed by the sun's harsh ultraviolet rays** and making up just 5 percent of the mainly nitrogen atmosphere.

TITAN

- Scientists are almost sure that the methane may get replenished by underground lakes or volcanic vents.

Saturn’s Moon

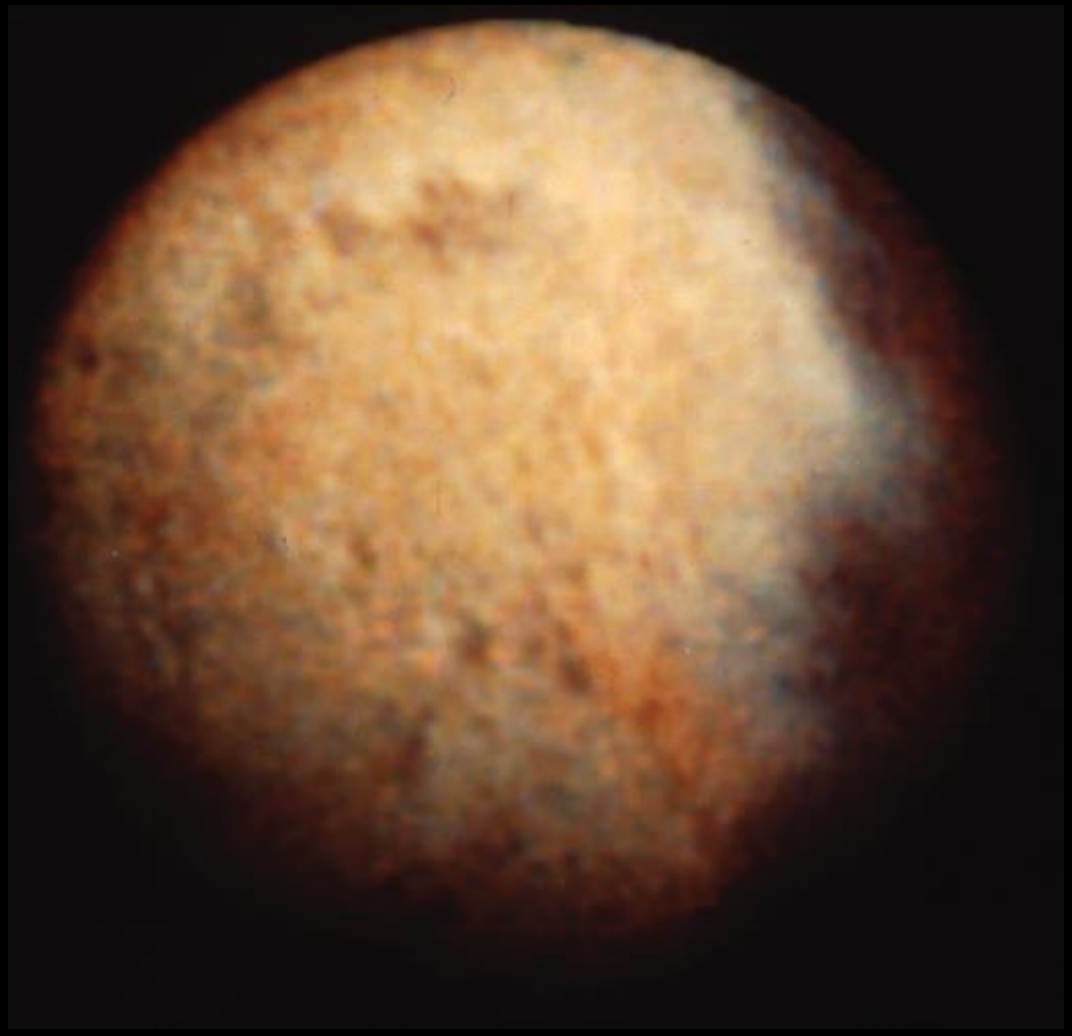
TITAN

- Titan's icy surface slides around like cheese on pizza sauce. That suggests the moon harbors a hidden ocean that may consist of water and ammonia.

TITAN

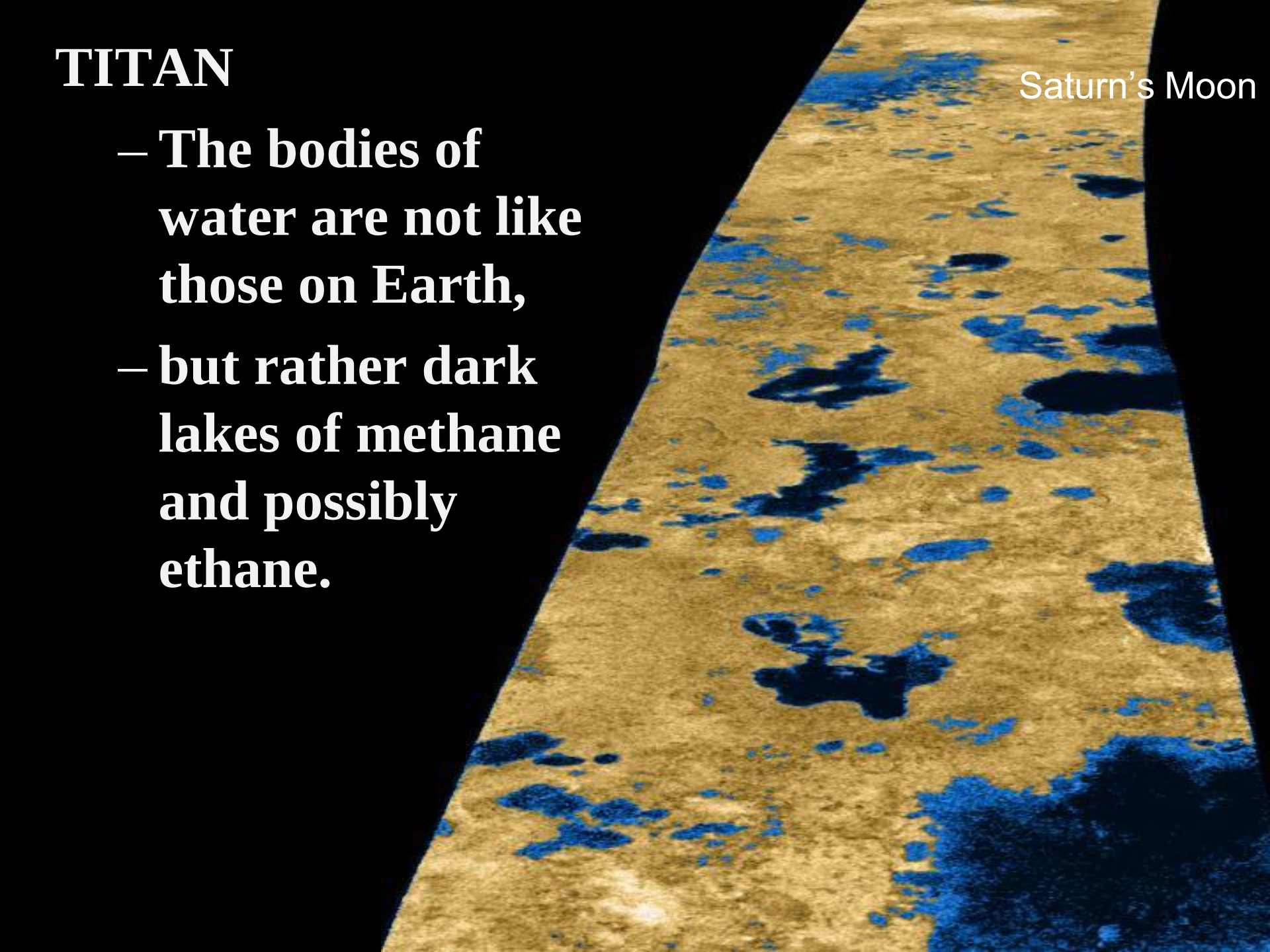
Saturn's Moon

- Cassini also detected larger bodies of liquid such as lakes, using optical cameras and radar. However, the south polar region of Titan appears to have fewer lakes.

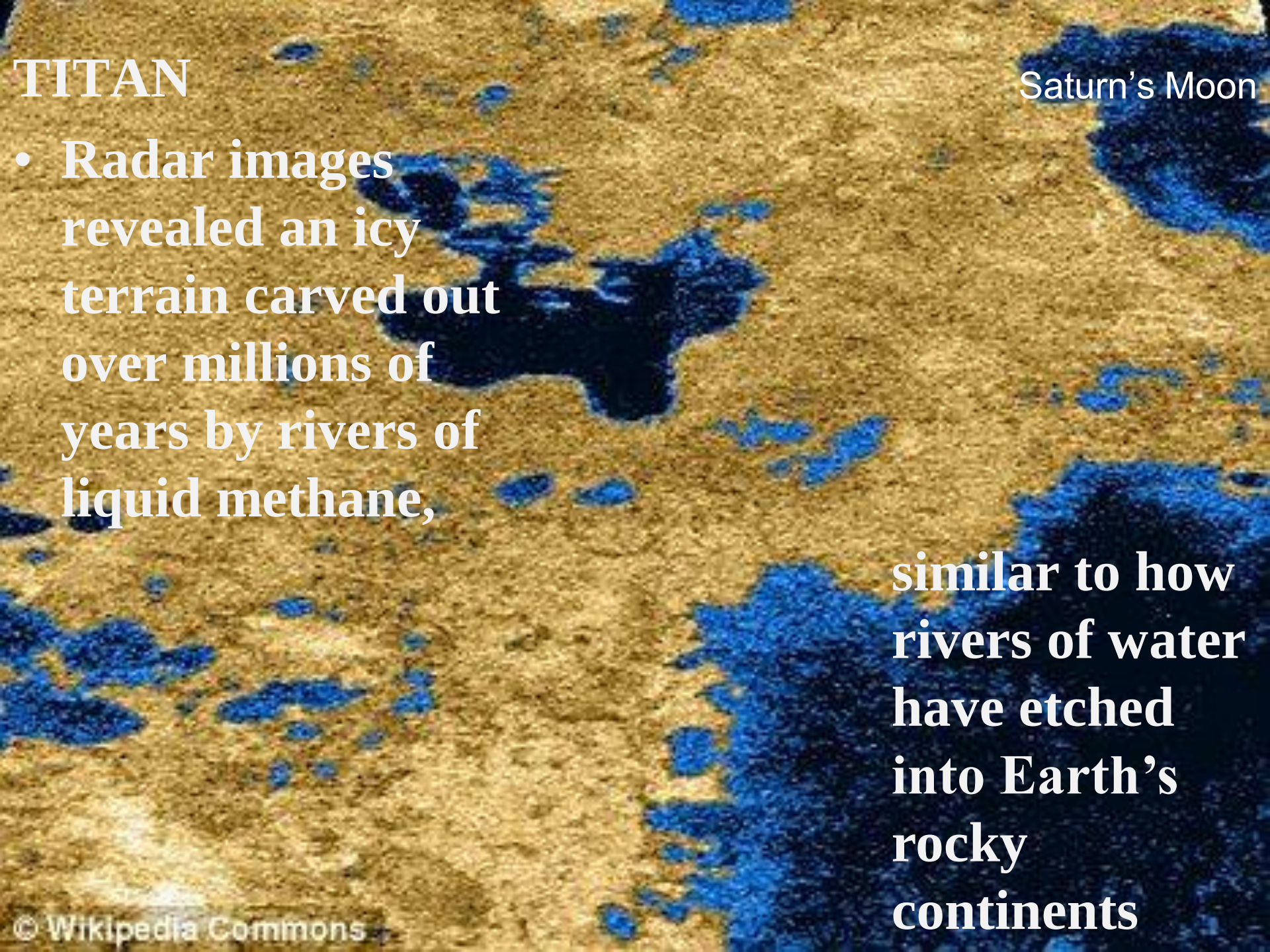


TITAN

- The bodies of water are not like those on Earth,
- but rather dark lakes of methane and possibly ethane.



Saturn's Moon



TITAN

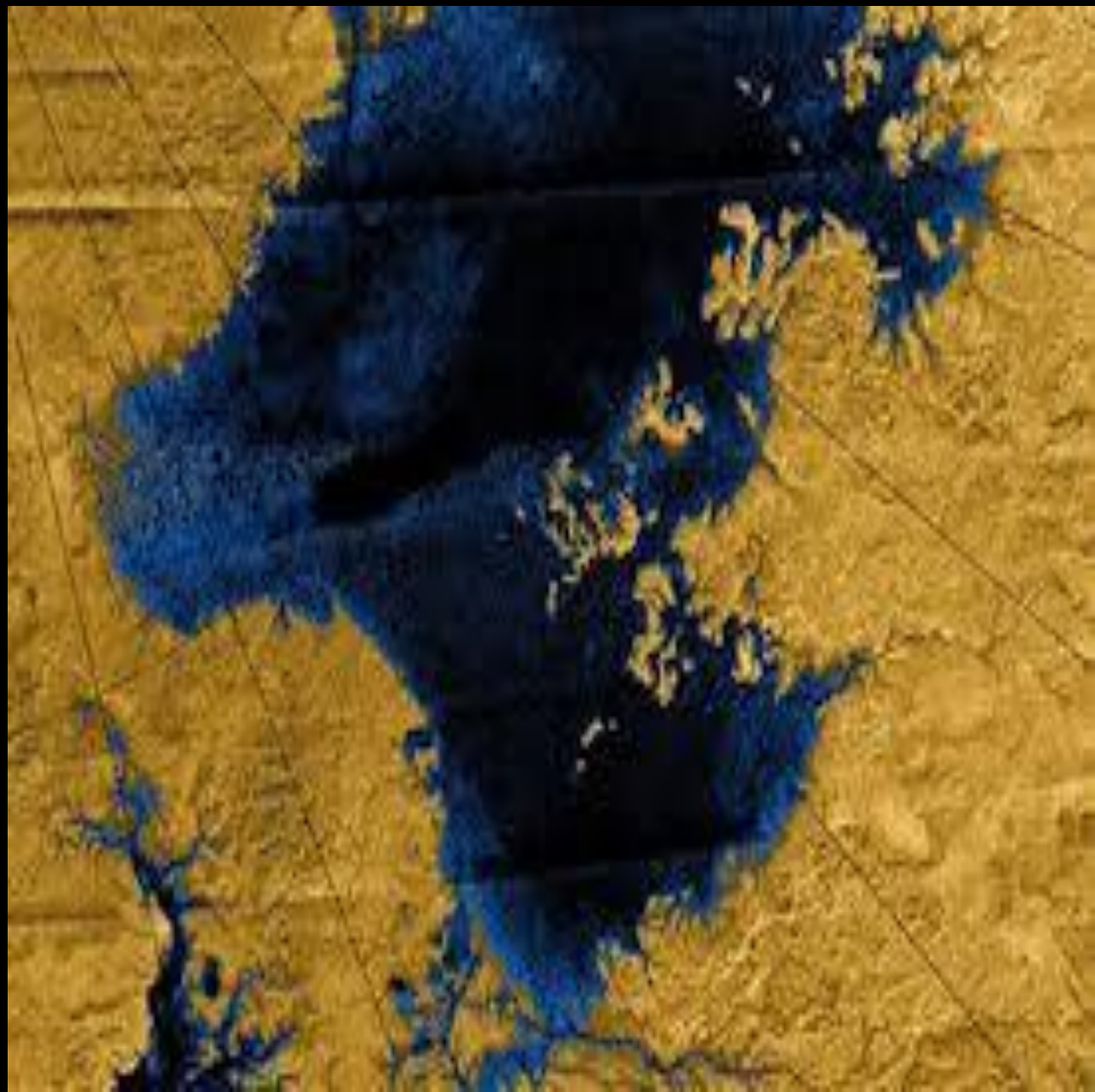
Saturn's Moon

- **Radar images revealed an icy terrain carved out over millions of years by rivers of liquid methane,**

similar to how rivers of water have etched into Earth's rocky continents

TITAN

- Titan's network of rivers have created surprisingly little erosion.



Saturn's Moon

TITAN

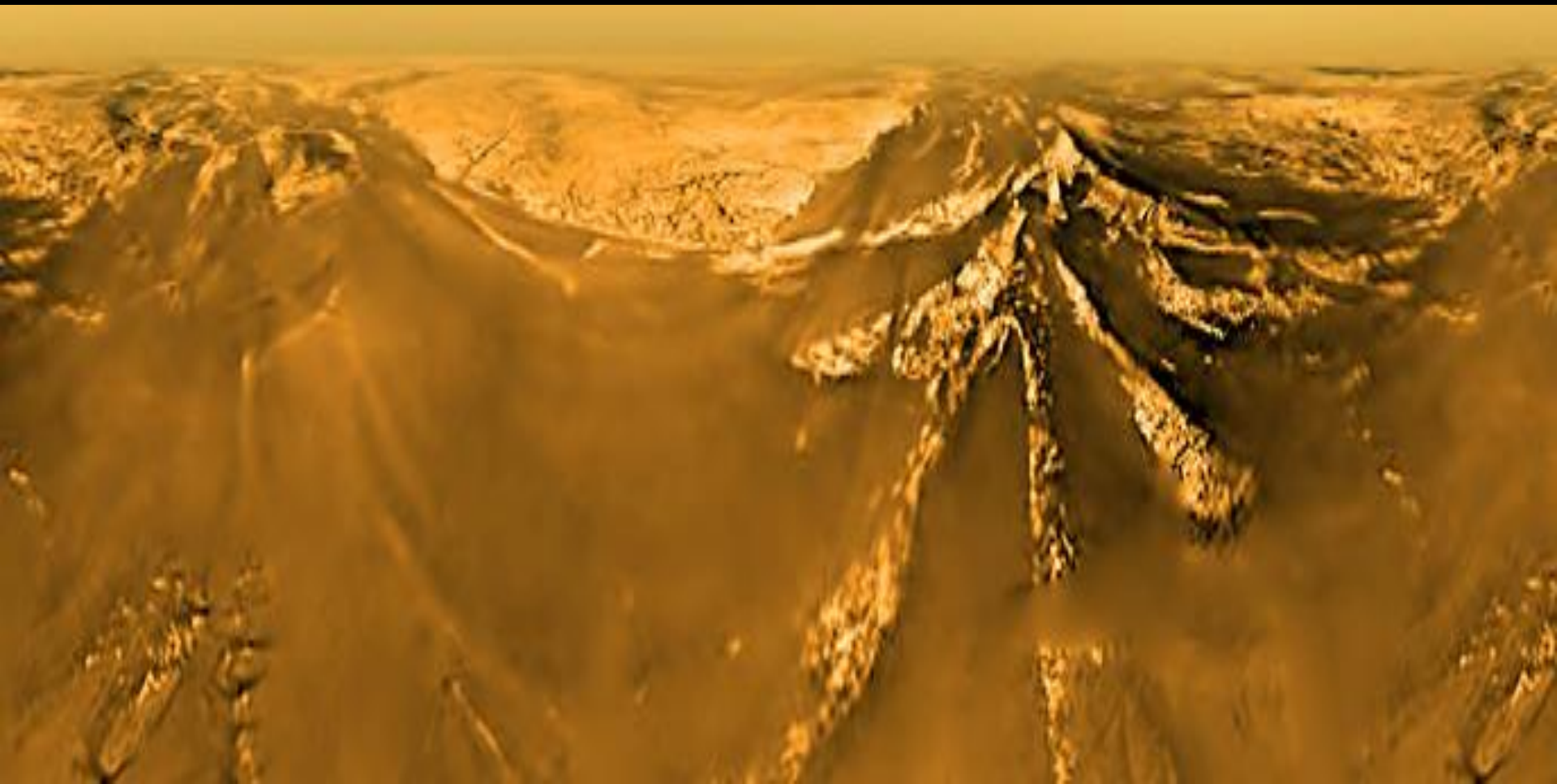
Saturn's Moon

- ***Rivers of liquid methane are likely the source of the hydrocarbon smog*** **that was detected in the moon's atmosphere that has long made it impossible to even see the surface.**
- ***Hydrocarbon's are the foundation for life!***

TITAN

Saturn's Moon

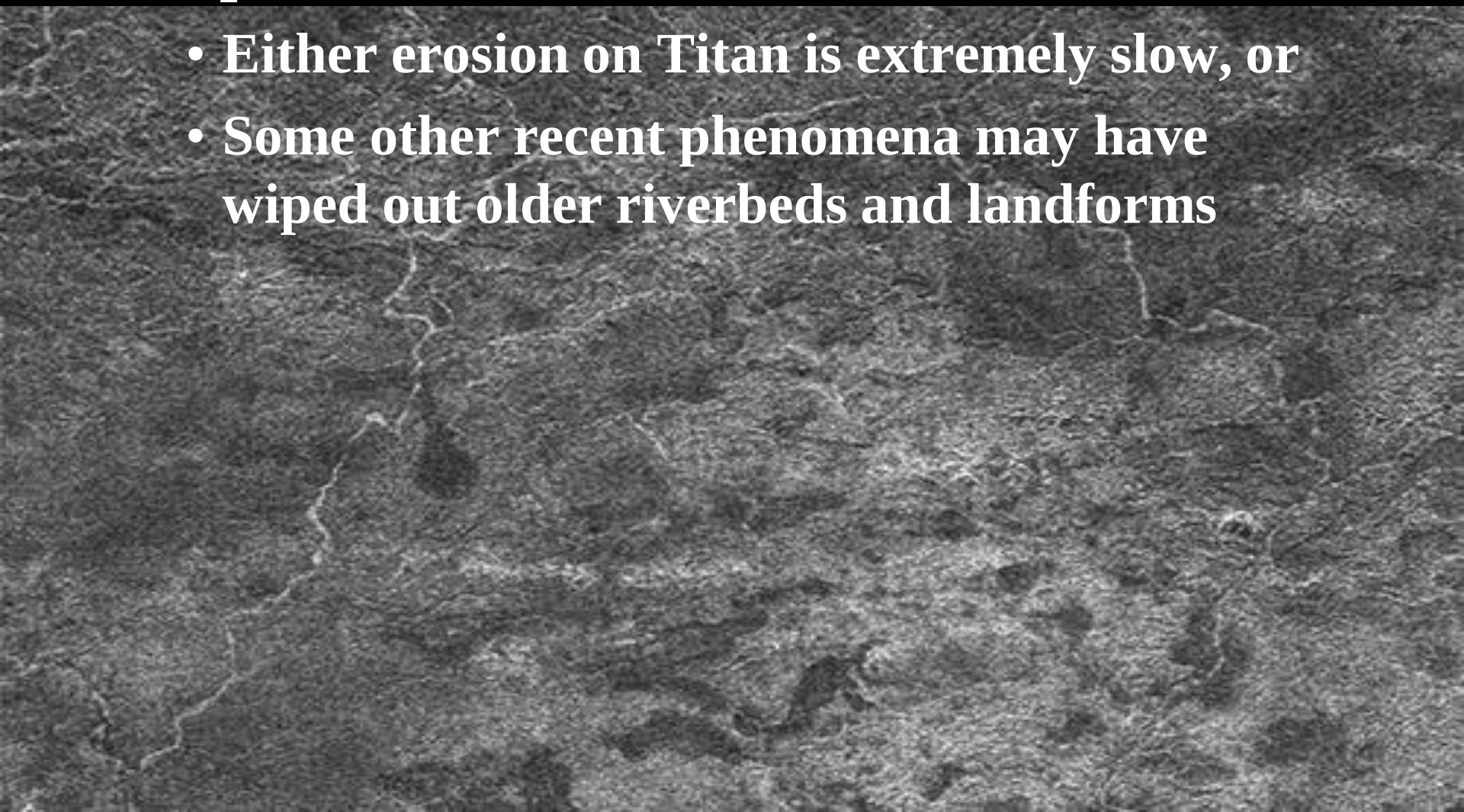
- **Large dunes (hills) can go on for hundred miles. It even has Cryovolcanoes that spew liquid water**



TITAN

Saturn's Moon

- **The researchers say there are two possible explanations:**
  - **Either erosion on Titan is extremely slow, or**
  - **Some other recent phenomena may have wiped out older riverbeds and landforms**



TITAN

Saturn’s Moon

- **It does rain and snow methane. But not as often as on Earth.**
- Falling and flowing methane may only form a temporary feature on Titan's surface.

TITAN

Saturn's Moon

- **When it does snow and/or rain, the drops are twice as large than on earth.**
- **They fall** like goo blobs of caramel

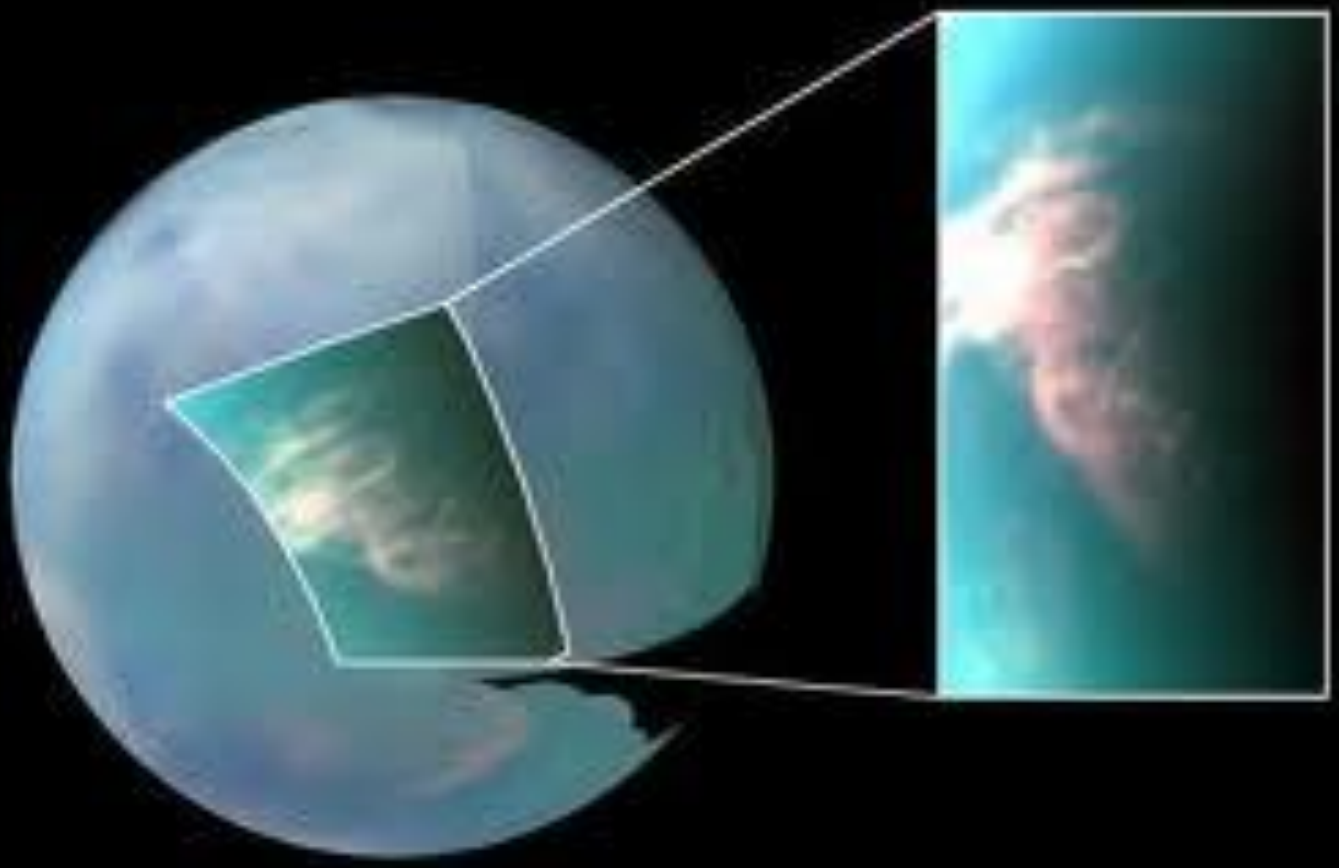
TITAN

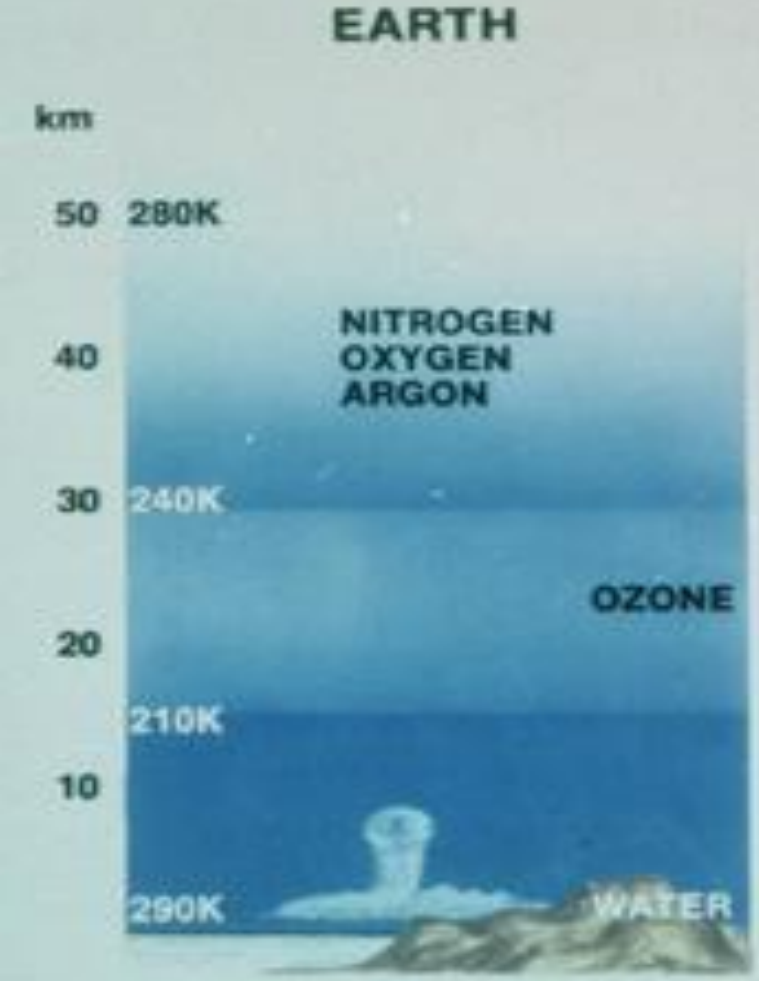
- Images reveal methane-containing clouds near Titan's poles. This could mean that *Titan has the equivalent of a weather cycle* similar to ours on Earth

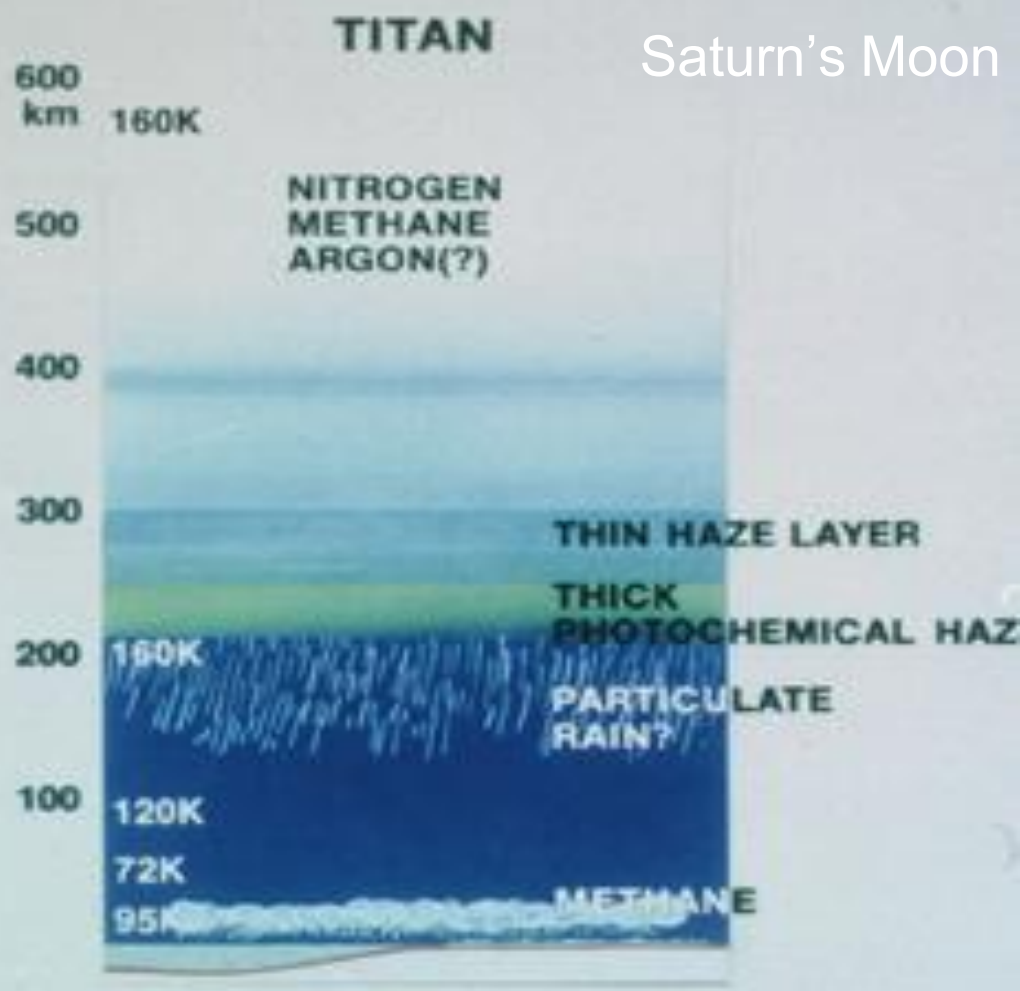
TITAN

Saturn's Moon

- This is a major discovery which means that the atmosphere is much more dynamic than previously thought.







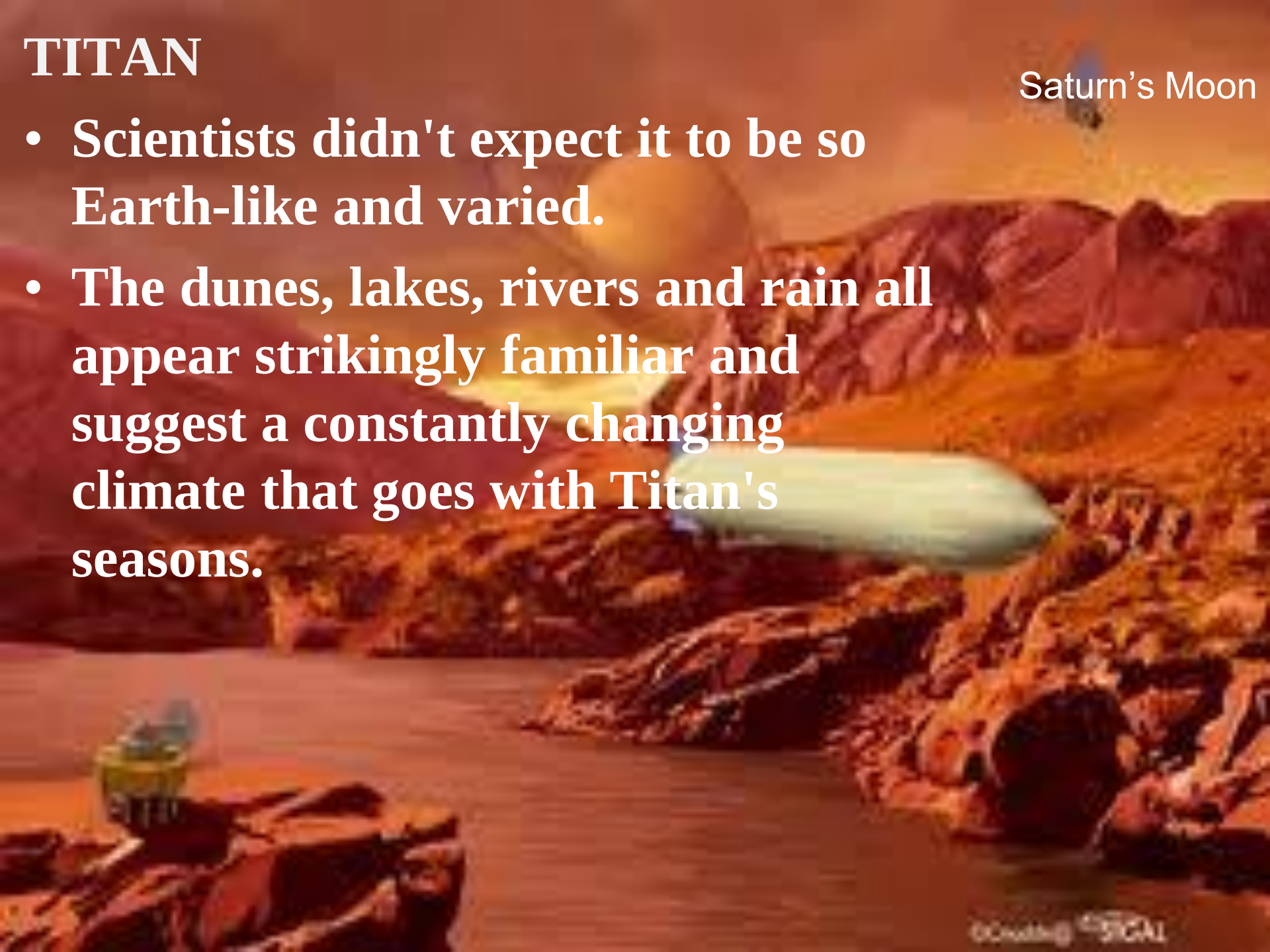
Saturn's Moon

This moon is much like Earth was some 4 billion years ago… maybe this is the next place for life?

TITAN

Saturn's Moon

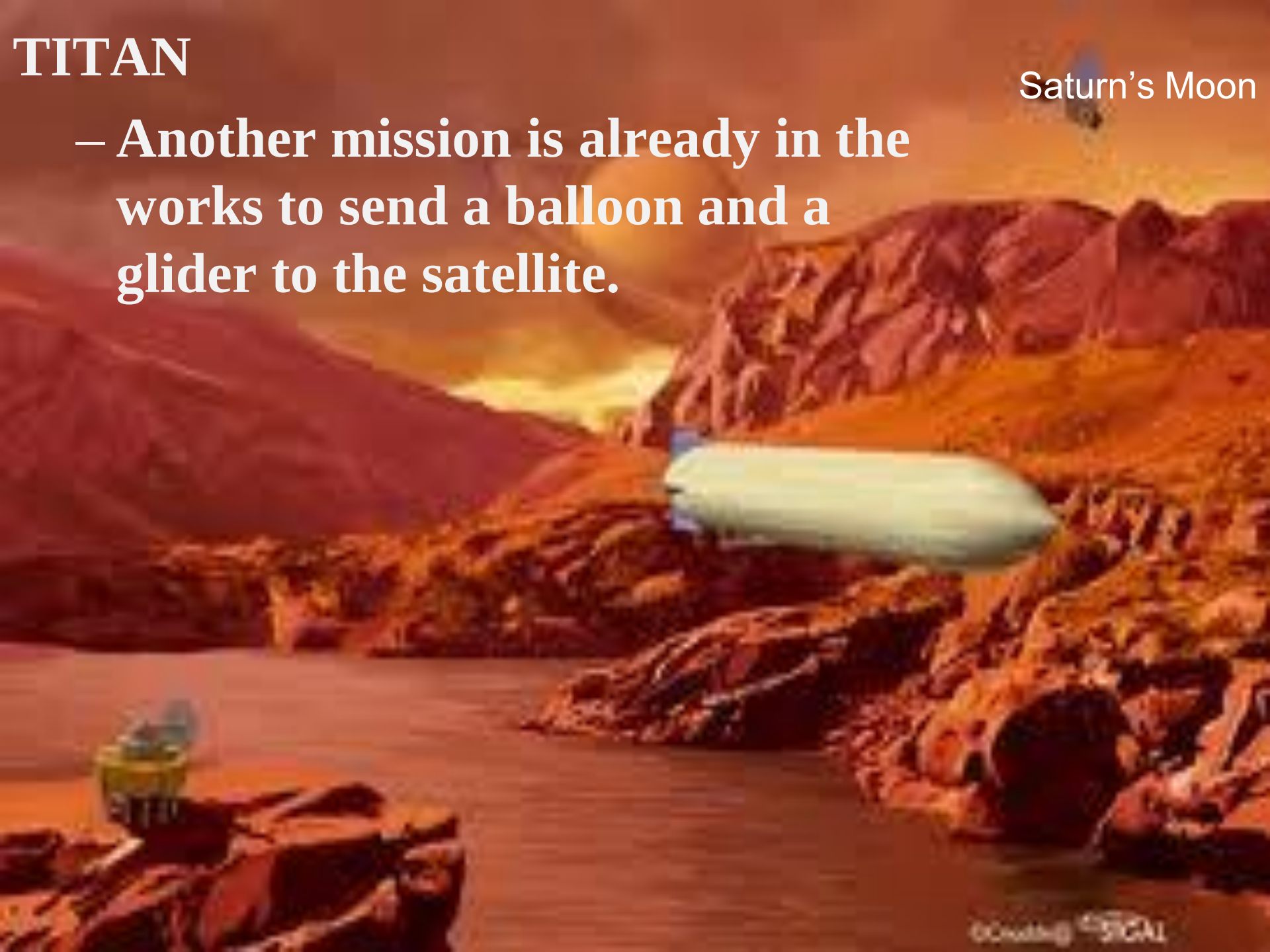
- **Scientists didn't expect it to be so Earth-like and varied.**
- **The dunes, lakes, rivers and rain all appear strikingly familiar and suggest a constantly changing climate that goes with Titan's seasons.**

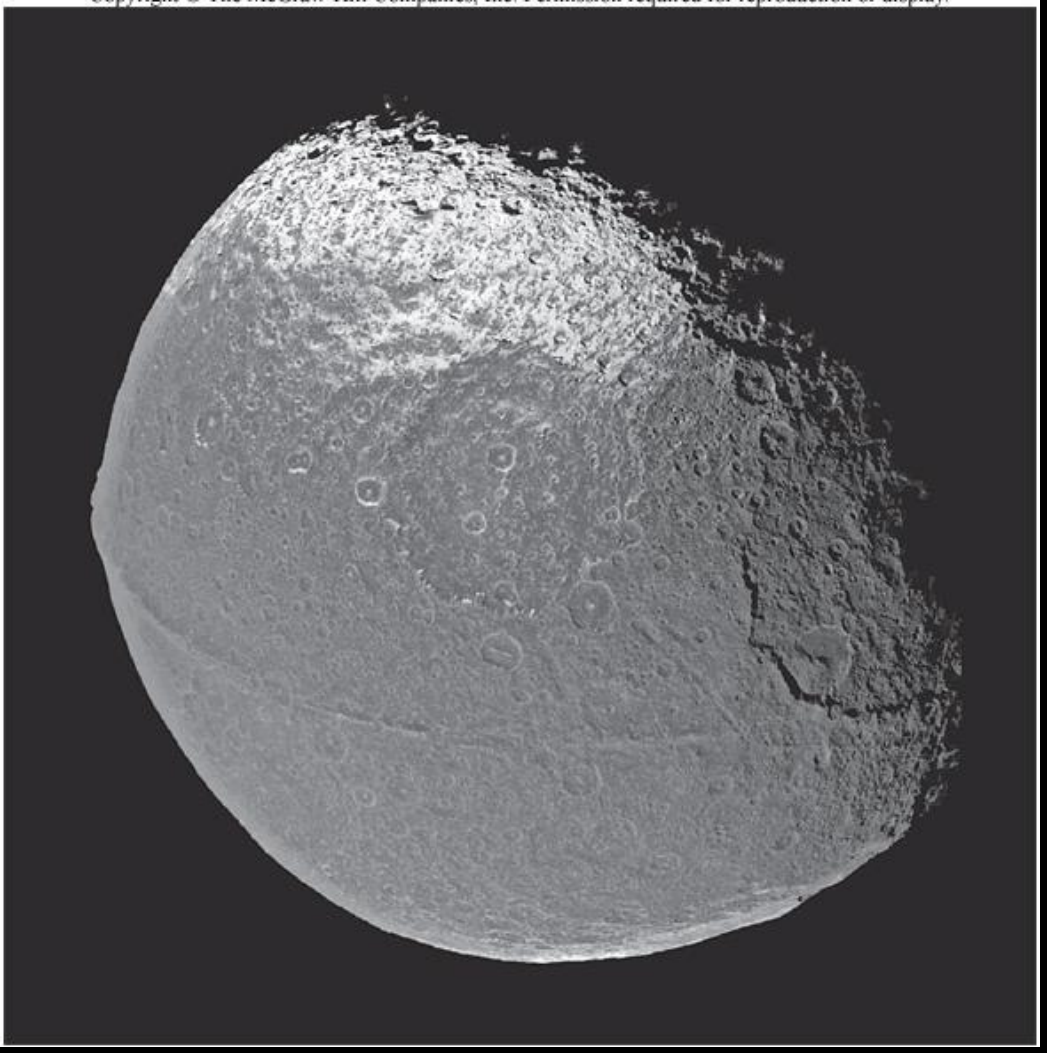


TITAN

Saturn's Moon

- **Another mission is already in the works to send a balloon and a glider to the satellite.**





Iapetus

- **an odd moon**
- **Third largest moon**
- **905.2 miles**
- **Rotation and Rev are the same: 1904 hours (79.33 days)**
- **Tidally locked with Saturn, so the same face always points toward the planet**

Saturn's Moon

Iapetus

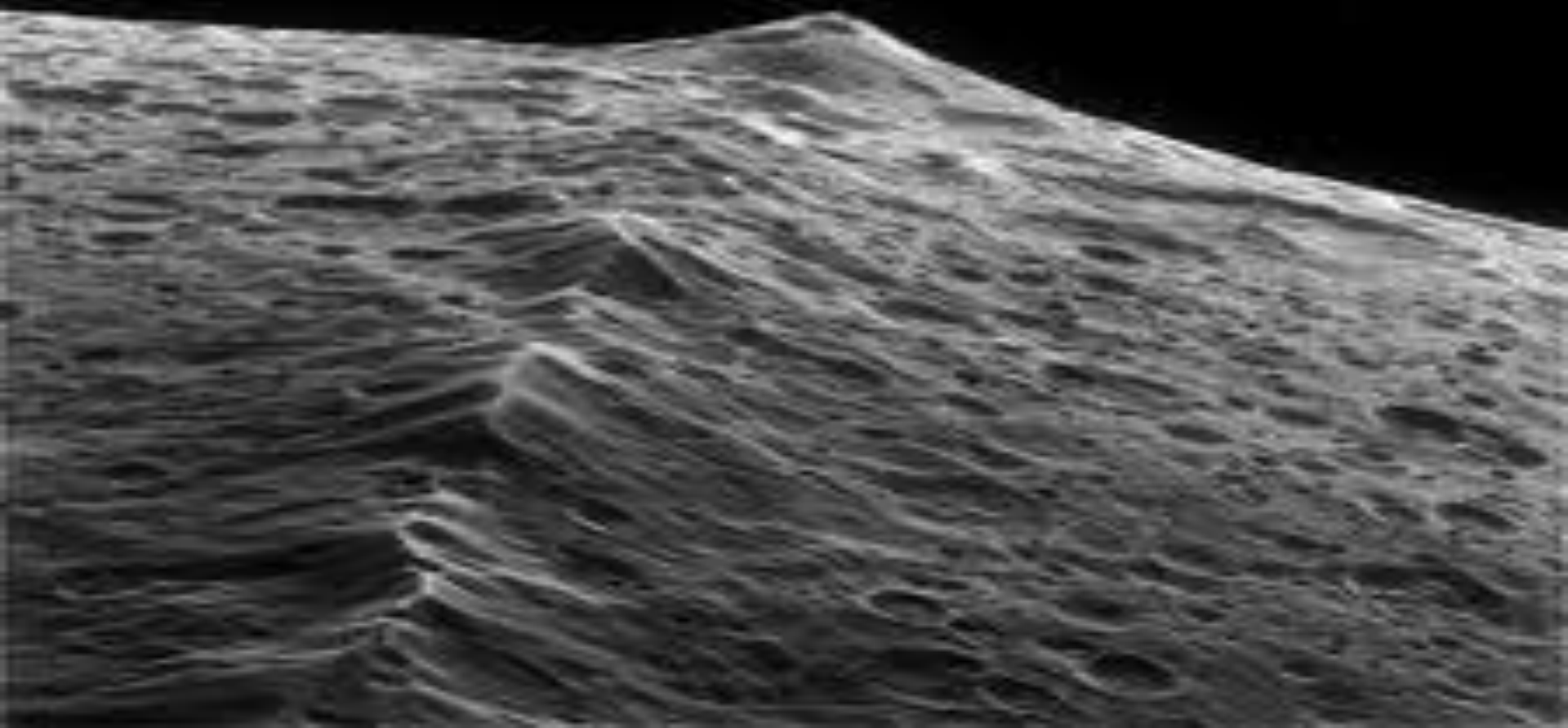
- an odd moon
- **Unique feature:**
  - **One side of the planet hemisphere is as black as tar**
  - **The other** half **(back side) is an icy white.**

Iapetus: an odd moon

- Leading hemisphere is dark due to deposits of dust or soot, either from early volcanoes on the moon, or residue from another moon's destruction

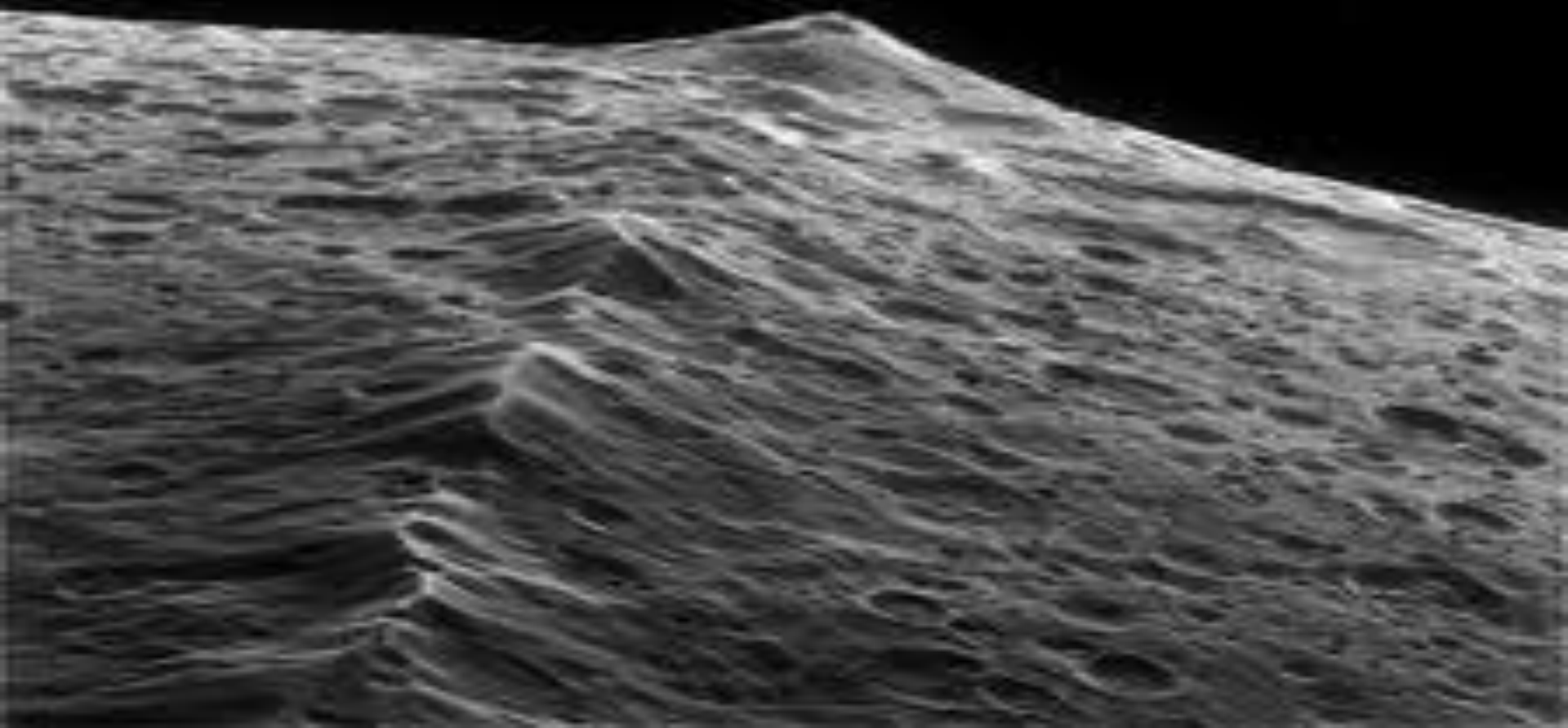
Iapetus

- Scientists were amazed to find a giant ridge girdling at least one-third of the moon's circumference giving it the appearance of being a giant walnut.



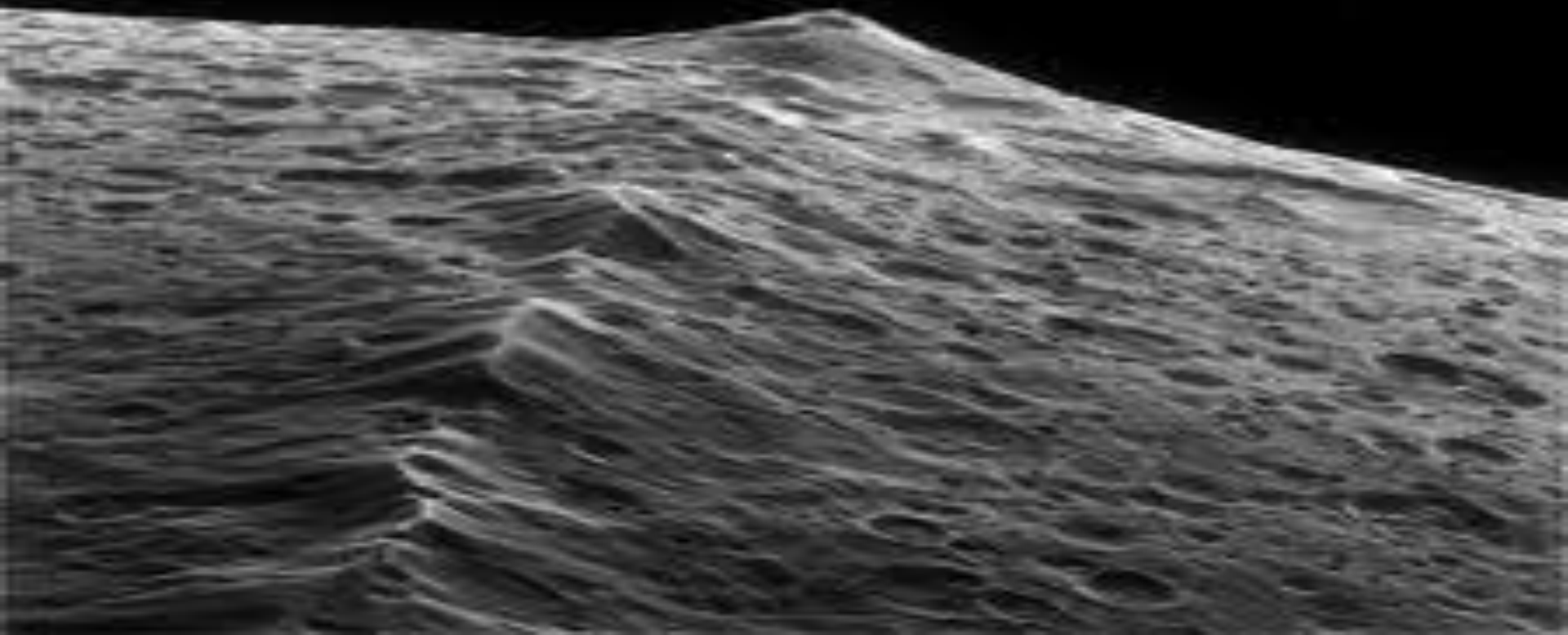
Iapetus

- The huge ridge that stretches over 1,300km (808 miles) around its equator. The tallest mountains in the ridge reach up to 20km high (12 miles), which is well over twice as high as Mount Everest. The ridge is so large that it reaches up to 100km wide (62 miles).



Iapetus

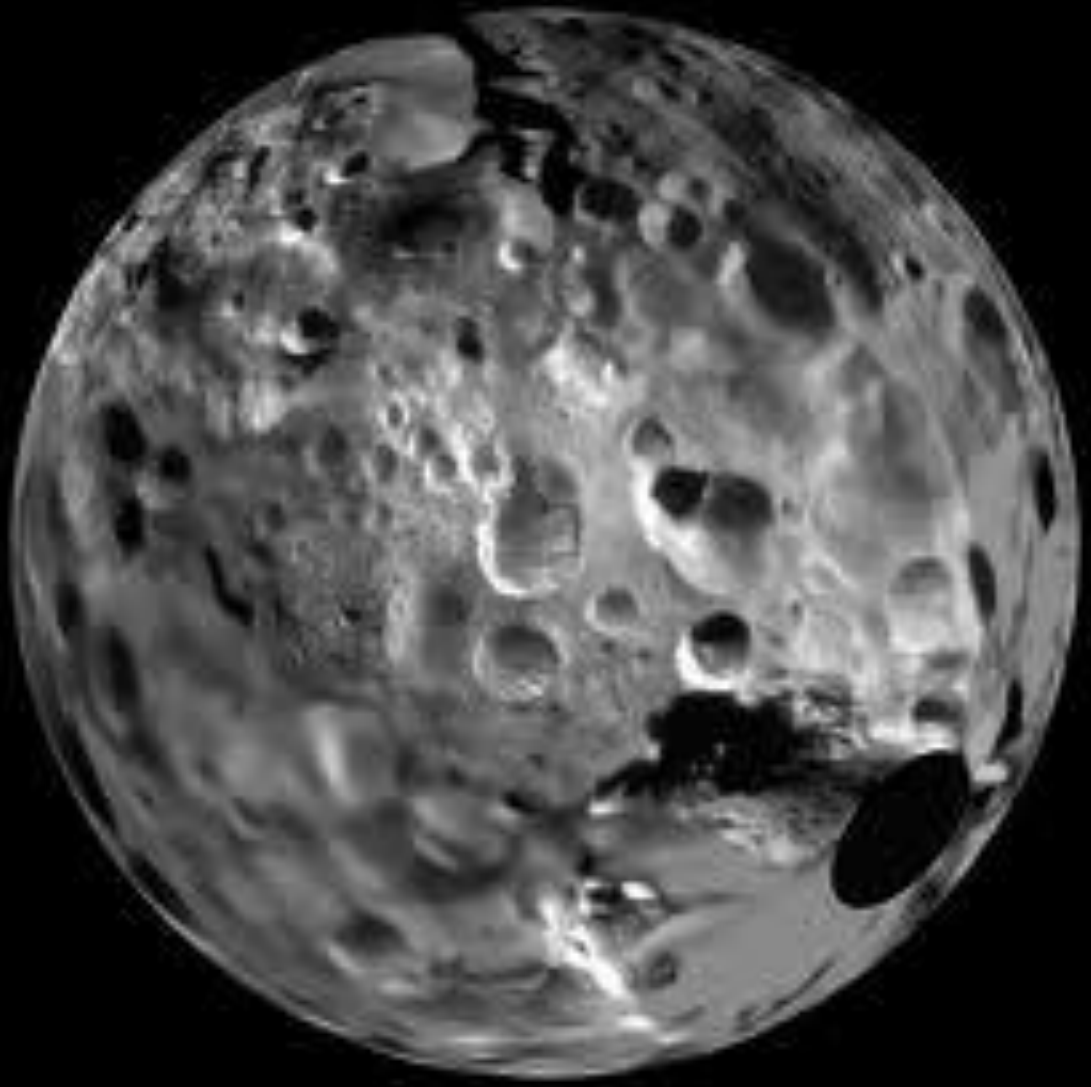
- Now researchers working with the Cassini spacecraft believe they have found an explanation for why Saturn's moon Iapetus has this strange distinctive ridge



Iapetus

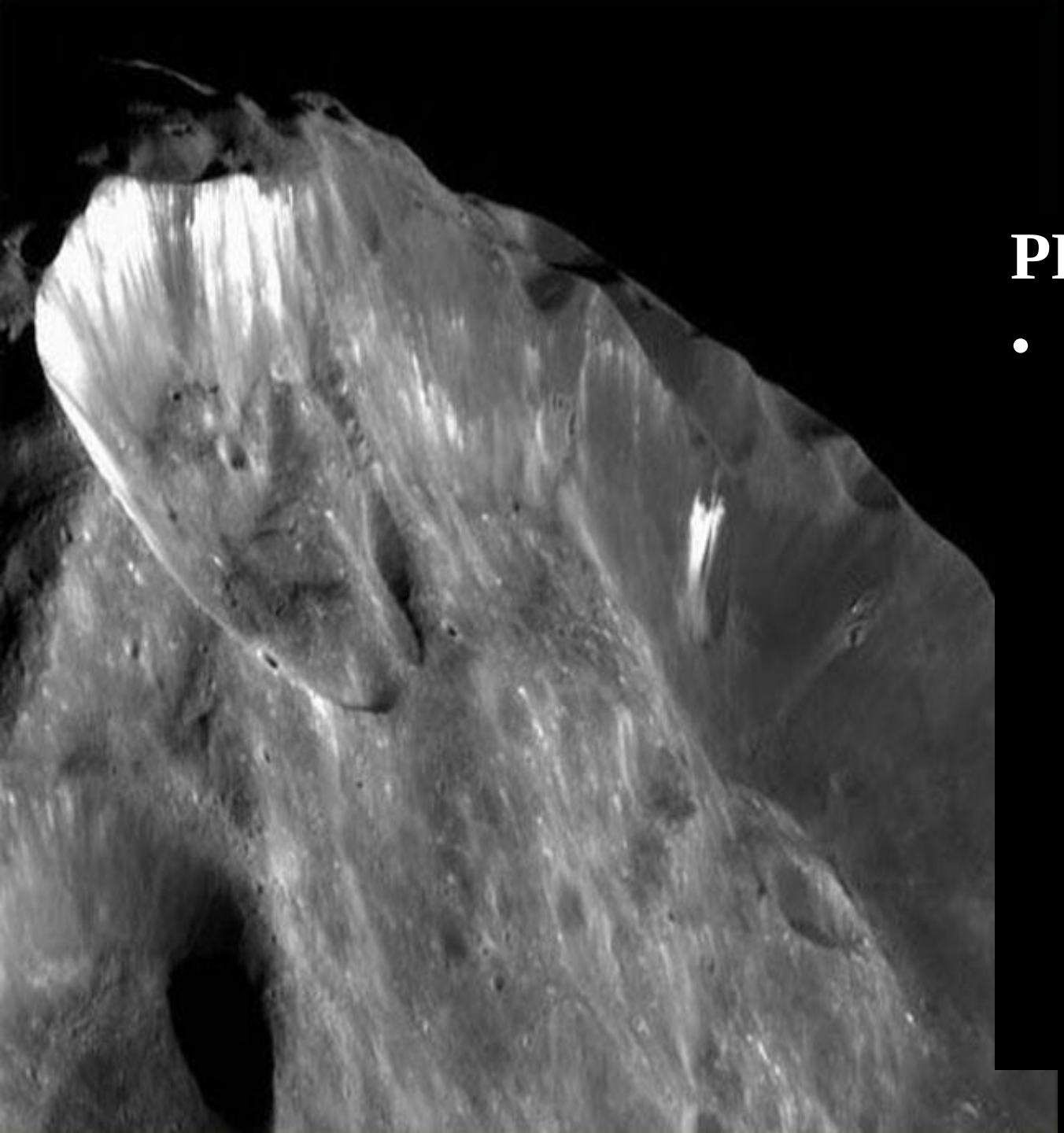
Saturn's Moon

- Most theories for how the mountains got there revolve around volcanoes or shifting ground on Iapetus.
- Now, scientists say that Iapetus could have had its own moon, which was eventually broken apart by the pull of Iapetus' gravity. Then it would have formed a ring of material over Iapetus, which would then have slammed down onto the equator like frozen baseballs, according to the researchers.



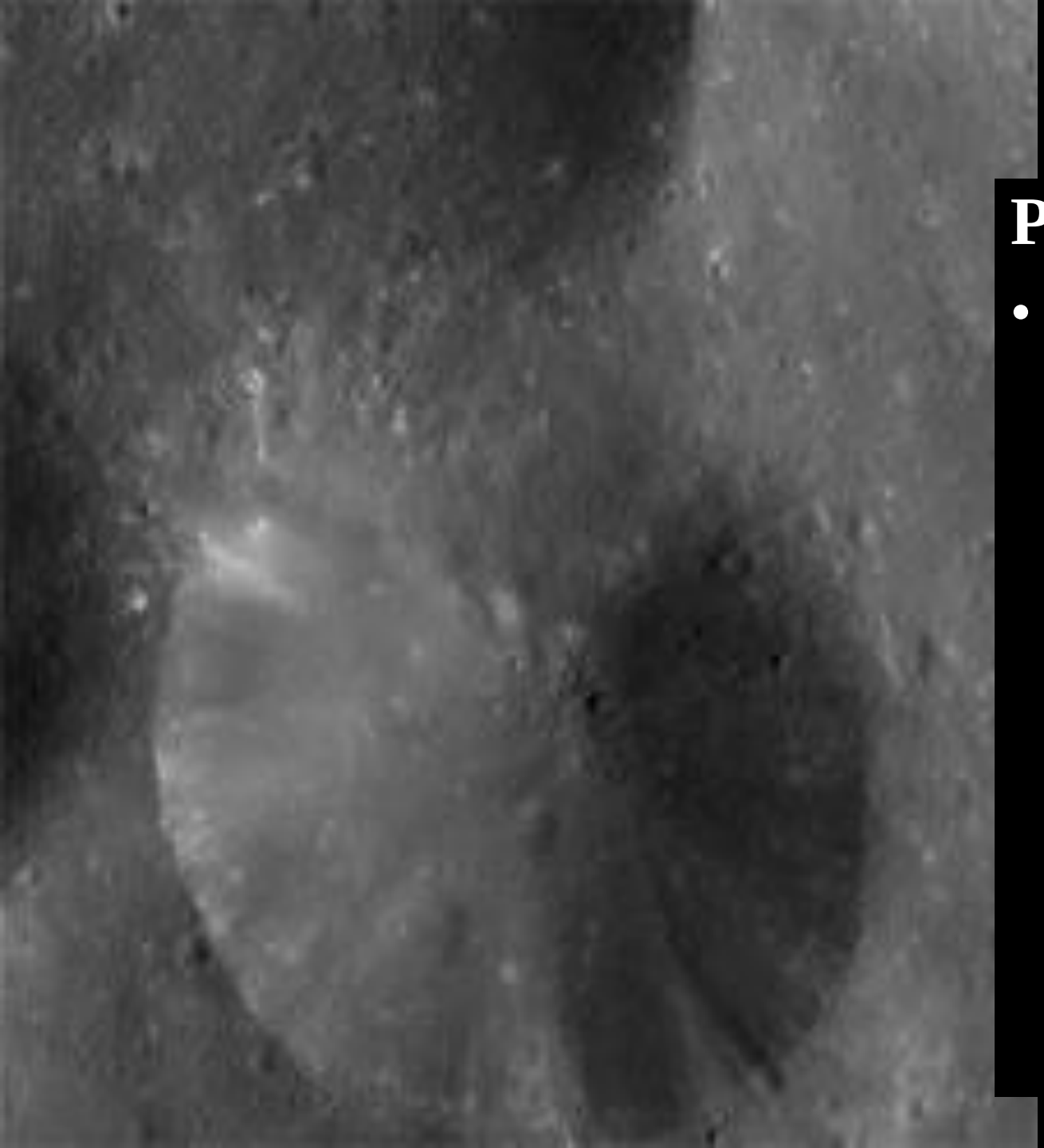
PHOEBE

- **Rotates: 9 hours**
- **Revolves: 550.3 days**
  - **RETROGRADE**
- **Phoebe is as black as coal, making it one of the darkest objects in the solar system.**



PHOEBE

- **A closer examination** casts doubt on the notion that the largest crater could have been created by an object smashing into Phoebe.



PHOEBE

- **The alternative - formation by plasma discharge - is well supported. The most obvious evidence is the *spiral-shaped crater rim* and the *steeply carved cliffs*.**

PHOEBE

- **These are not features expected under *the impact hypothesis.***

Satellites of Saturn

82 moons **A Visual Tour of the Moons of Saturn**

THE END