THE PLANETS AND THE SOLAR SYSTEM

Chapter 27

SECTION 27.1: THE INNER PLANETS

Objectives:

1. Describe the characteristics of the four inner planets.
2. Compare the positions of the inner planets in orbit.

Key Vocabulary:

- inner planets
- outer planets

TWO PLANETARY NEIGHBORHOODS

The planets in our solar system are divided into two groups.

The **inner planets** are those found closest to the Sun: **Mercury, Venus, Earth, and Mars**.

The inner planets are sometimes called the **terrestrial** (Earth-like) planets. This is because all the inner planets have **rocky crusts**, **dense mantle layers**, and **very dense cores**.**

TWO PLANETARY NEIGHBORHOODS

The **outer planets** are those found beyond the asteroid belt (located between Mars and Jupiter): **Jupiter, Saturn, Uranus, and Neptune**.

The outer planets are known as the **Jovian** (Jupiter-like) planets. The first four of the outer planets are considerably **larger** than Earth, and are **gaseous** planets with an outer layer that is mostly hydrogen gas, with compressed hydrogen (making a hot liquid) near the center. These planets are **less dense** than Earth, and all have **ring systems**.**

PLANETARY DATA

Table 1 Planetary Data

Planet	Average Distance from Sun AU	Average Distance from Sun Millions of km	Period of Revolution	Orbital Velocity km/s	Period of Rotation	Diameter (km)	Relative Mass (Earth = 1)	Average Density (g/cm^3)	Number of Known Satellites*
Mercury	0.39	58	88^d	47.5	59^d	4878	0.06	5.4	0
Venus	0.72	108	225^d	35.0	244^d	12,104	0.82	5.2	0
Earth	1.00	150	365.25^d	29.8	$23^h\ 56^m\ 04^s$	12,756	1.00	5.5	1
Mars	1.52	228	687^d	24.1	$24^h\ 37^m\ 23^s$	6794	0.11	3.9	2
Jupiter	5.20	778	12^{yr}	13.1	$9^h\ 50^m$	143,884	317.87	1.3	63
Saturn	9.54	1427	29.5^{yr}	9.6	$10^h\ 14^m$	120,536	95.14	0.7	31
Uranus	19.18	2870	84^{yr}	6.8	$17^h\ 14^m$	51,118	14.56	1.2	25
Neptune	30.06	4497	165^{yr}	5.3	$16^h\ 03^m$	50,530	17.21	1.7	13
Pluto	39.44	5900	248^{yr}	4.7	6.4^d	approx. 2300	0.002	1.8	1

*Includes all satellites discovered as of March 2004.

THE INNER PLANETS

(ALSO KNOWN AS TERRESTRIAL PLANETS)

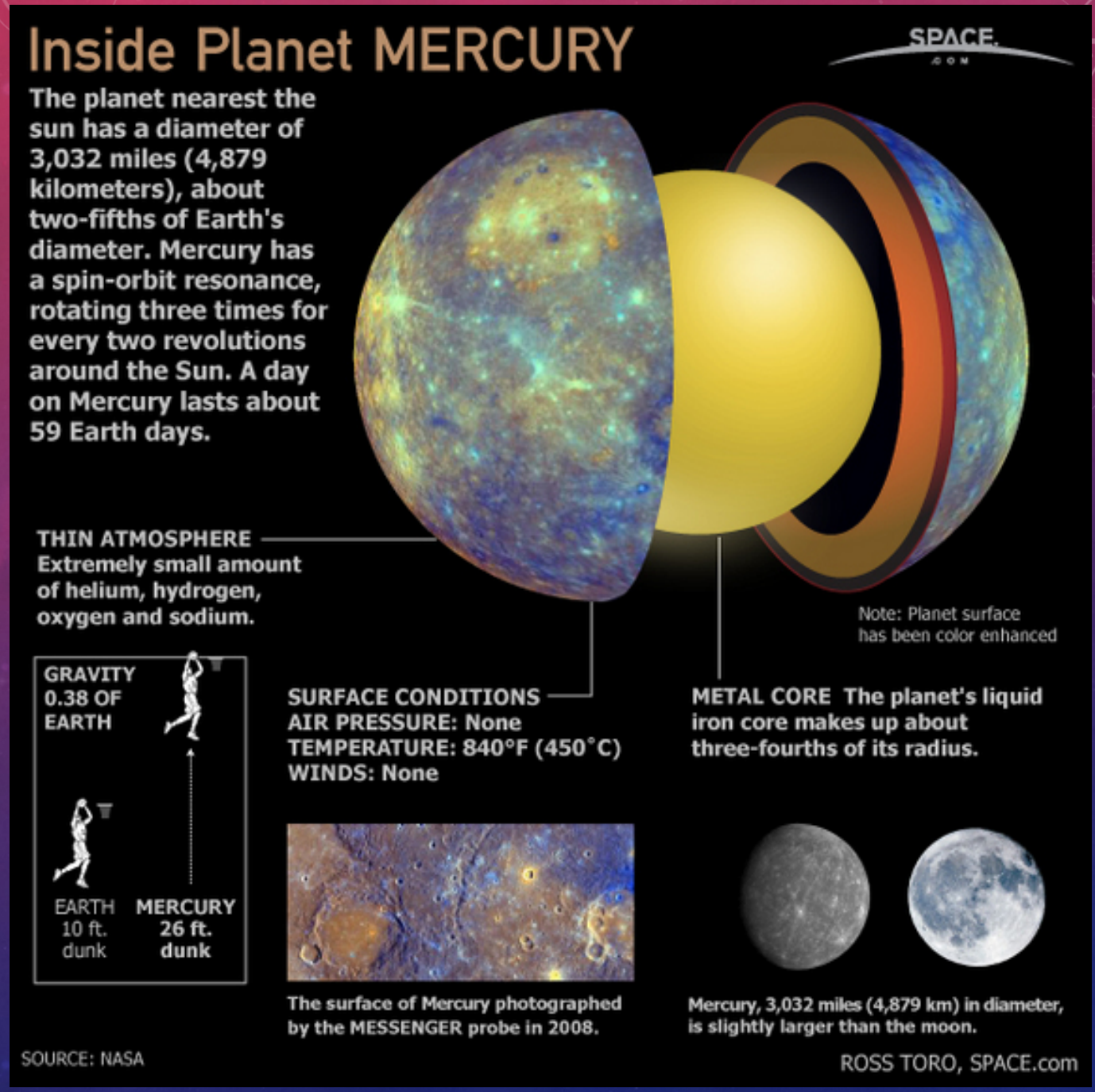
Mercury – Roman name, probably named for the winged messenger because the planet moves so quickly across the sky.

Venus – Roman name, the goddess of love and beauty.

Earth – Greek name, Gaia was Mother Earth.

Mars – Roman name, the god of war.

MERCURY


Inside Planet MERCURY
SPACE.COM
The planet nearest the sun has a diameter of 3,032 miles (4,879 kilometers), about two-fifths of Earth's diameter. Mercury has a spin-orbit resonance, rotating three times for every two revolutions around the Sun. A day on Mercury lasts about 59 Earth days.
THIN ATMOSPHERE
Extremely small amount of helium, hydrogen, oxygen and sodium.
Note: Planet surface has been color enhanced
GRAVITY 0.38 OF EARTH
EARTH 10 ft. dunk
MERCURY 26 ft. dunk
SURFACE CONDITIONS
AIR PRESSURE: None
TEMPERATURE: 840°F (450°C)
WINDS: None
METAL CORE The planet's liquid iron core makes up about three-fourths of its radius.
The surface of Mercury photographed by the MESSENGER probe in 2008.
Mercury, 3,032 miles (4,879 km) in diameter, is slightly larger than the moon.
SOURCE: NASA
ROSS TORO, SPACE.com

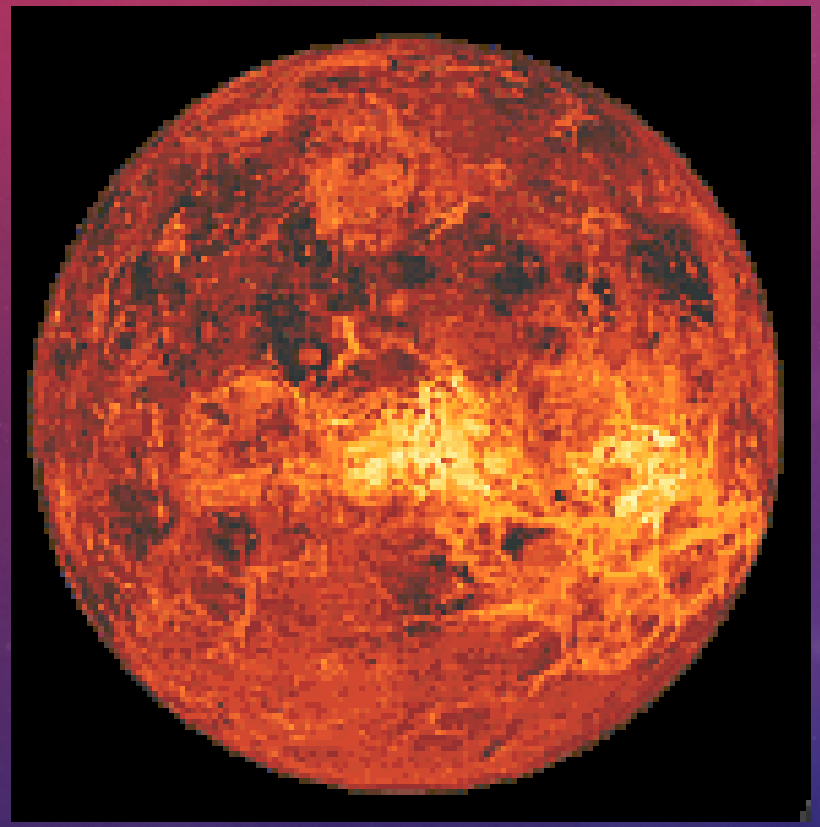
MERCURY

- Planet located **nearest the Sun**.
- **Orbits** the Sun in only **88** Earth days.
- Rotates once every 59 Earth days.
- Smallest of the terrestrial planets.
- Very **weak magnetic field**.
- **Weak gravity – no atmosphere** – results in **surface being heavily cratered****. [Note: Earth has an atmosphere, which prevents heavy cratering].

MERCURY

- Daytime temperatures of more than 400° C, and nighttime temperatures of nearly –200° C.
- Has **no moons**.

VENUS



VENUS

- Earth's "sister" planet, because it is **similar to Earth** in **diameter, mass, and gravity**.
- **Orbits** the Sun once every **224.7** Earth days.
- Rotates once every 243 Earth days.
- Unlike the other planets, it **rotates east to west**.
- Very weak or non-existent magnetic field.

VENUS

- Surface landscape is dominated by volcanic features, faulting, and impact craters.
- About **80%** of the surface appears to be **covered by lava**.
- Fault and fracture systems shows past tectonic activity.
- Has a **dense atmosphere** made up of mostly carbon dioxide with about 3% nitrogen.

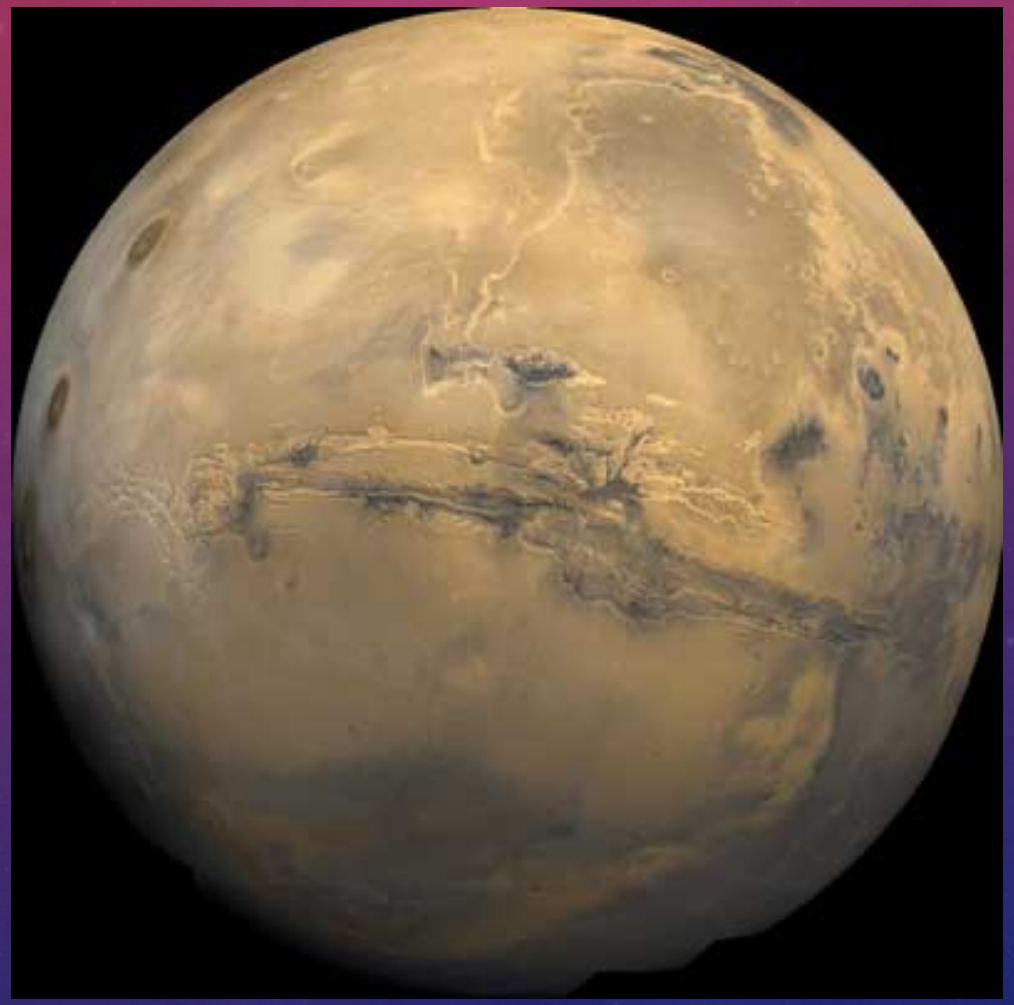
VENUS

- Yellow clouds contain droplets of concentrated sulfuric acid.
- Surface pressure is about 90 times greater than it is on Earth.
- **Greenhouse effect** (carbon dioxide in atmosphere) **traps heat** making a surface temperature of 475° C.**

VENUS

- When Venus is behind Earth in its orbit, the sun sets first and Venus is seen in the evening twilight of the western sky. Venus is called an "**evening star**."
- When Venus is ahead of Earth in its orbit, it rises before the sun and is seen in the eastern sky. Venus is called a "**morning star**."

MARS



MARS

- Orbits the Sun in 687 Earth days.
- Rotates once in just over 24 Earth hours.
- About one-half the diameter of Earth.
- Gravity is only about 2/5 that of Earth.
- Has a very weak or non-existent magnetic field.
- Has a **tilt similar to Earth** (almost the same angle and in the same direction), **giving Mars seasons similar to Earth**.

MARS

- Summer days may be as warm as 27° C, while winter temperatures drop to –125° C.
- Has a **thin atmosphere** made up of 95% carbon dioxide and 5% nitrogen and argon, with traces of other gases.
- Atmospheric pressure is less than 1% that of Earth.

MARS

- **Has polar ice caps**. The north cap is probably water ice, while the south cap may contain frozen carbon dioxide.
- Temperature differences between the polar caps and the warmer soil in spring leads to strong winds and swirling dust storms that often cover the entire planet.

MARS

- The northern hemisphere is a smooth lowland plain of volcanic material, with few craters.
- On a northern plain is the **largest known volcano in the solar system**, **Olympus Mons**.** It is more than 500 kilometers across and about 26 kilometers high. That is about 3 times higher than Mauna Loa (Earth's largest volcano).

MARS

- The southern hemisphere is a highland fractured by many large craters and cut by small channels.
- Cutting across the craters of the southern hemisphere is the **Valles Marineris**, a **canyon system** as long as the United States is wide.
- At present, water cannot exist on the surface of Mars, because it would quickly boil, evaporate, and freeze – all at the same time.
- Water may be trapped as ice beneath the surface.

SECTION 27.1: WRAP-UP

1. Into what two groups are the planets divided? What are the main characteristics of each group?
2. Why does Mercury have no atmosphere?
3. Why is the surface of Venus so hot?
4. Why does Mars have seasons?

SECTION 27.2: THE OUTER PLANETS

Objectives:

1. Describe the characteristics of each of the outer planets.
2. Explain the orbiting pattern of Neptune, Pluto and Charon.

THE OUTER PLANETS

(ALSO KNOWN AS JOVIAN PLANETS, EXCEPT FOR PLUTO)

Jupiter – Roman name, the King of the gods (ruler of Olympus).

Saturn – Roman name, the god of agriculture. (In Greek mythology, this was the son of Uranus and Gaia, and the father of Jupiter.)

Uranus – Greek name, earliest supreme god, father of Saturn.

Neptune – Roman name, the god of the sea.

Pluto – Roman name, the god of the underworld.

THE JOVIAN PLANETS

- **Very large planets** (Uranus, smallest of the giants is nearly 15 times larger than Earth).
- These planets **do not have solid surfaces** (their “surface” is the uppermost gas layer).
- Planets are **composed** mainly of the **light elements** hydrogen and helium.

THE JOVIAN PLANETS

- These planets have a three-layered structure (dense hot core, **metallic hydrogen**, molecular hydrogen).
- **Metallic hydrogen** is a state similar to liquid metal. It is caused by the pressure exerted by the outer layer of the planet.
- **Each have ring systems**** orbiting over the planet's equator.
- Saturn's rings are highly visible, the others are faint ring systems.

JUPITER

JUPITER

- Takes 11.9 Earth years to orbit the Sun.
- **Rotates faster than any other planet**, once in just under 10 hours.
- **Largest planet** in our solar system.
- Has at least **60 moons**.
- Has more than twice the mass of all other planets combined.
- Has the **strongest** known **magnetic field**.

JUPITER

- We have observed auroras on Jupiter.
- Radiates about twice as much heat back into space as it receives from the Sun. The extra heat is thought to come from Jupiter's original heat of formation and from contraction due to gravity.
- High velocity winds blow parallel to equator.
- **Great Red Spot – giant storm**.
- Has the **largest moon in our solar system**** (Ganymede).

JUPITER

- Dark bands are areas of sinking gases.
- Bright bands are areas of rising gases.
- Rings are made from dust that was kicked off small moons surrounding Jupiter when these moons were struck by comets or asteroids (very hard to see).

SATURN

SATURN

- Takes nearly 30 years to complete one orbit.
- Rotates once about every 10 hours.
- Has at least 31 moons.
- Also has bands of rising and sinking gases.
- **Lowest density of all planets**, actually lower than water (Saturn would float in water!)**

SATURN

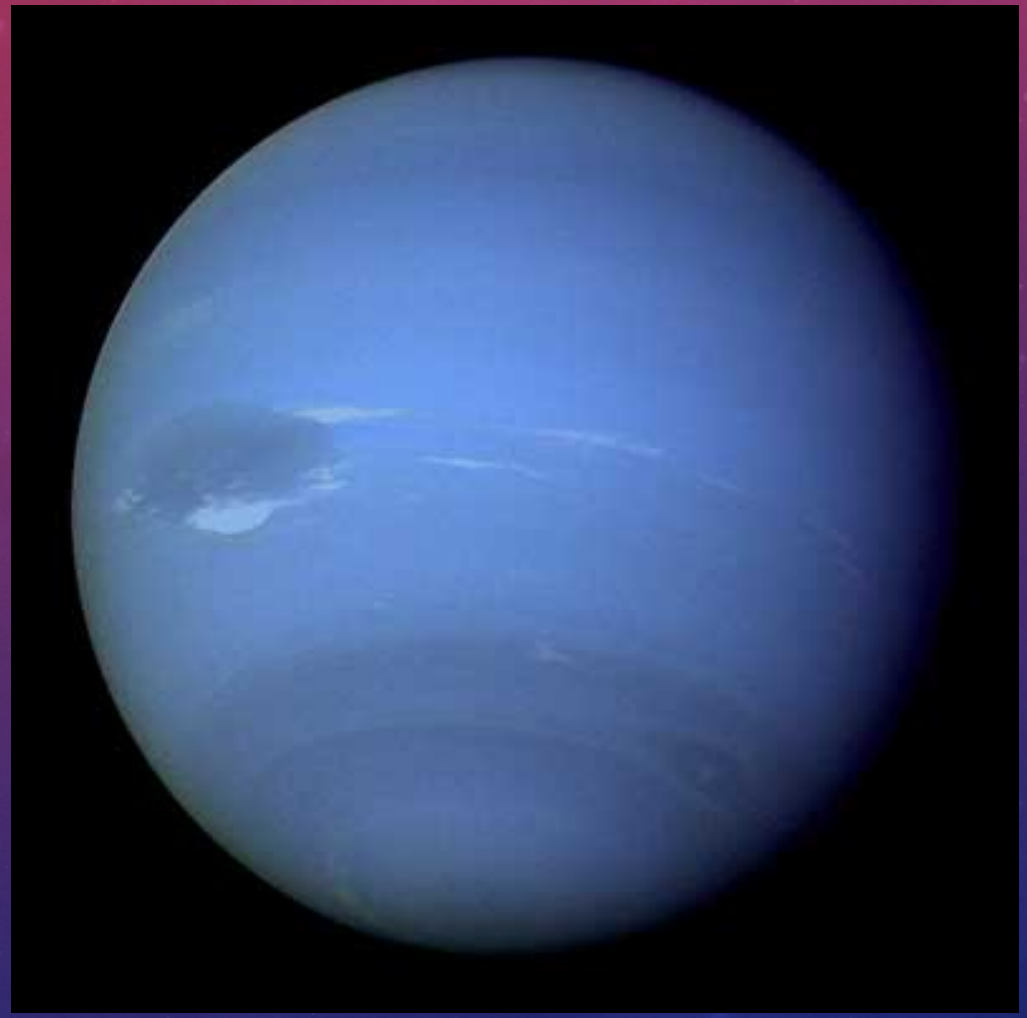
- Radiates **more heat** than it receives from the Sun.
- Strong magnetic field.
- **Most visible ring system** of the Jovian planets.
- Rings are made mostly of ice and rock pieces.

URANUS

URANUS

- Takes 84 years to complete one orbit.
- Rotates once every 17.2 Earth hours.
- Has 21 moons.
- Average surface temperature is about –200°C.
- Axis is almost tipped over, so it **orbits on its "side"**.**
- Magnetic field is not tipped over.
- Has a faint ring system that includes a partial ring, or ring arc.
- Need a telescope to see this planet from Earth.

NEPTUNE



NEPTUNE

- Takes about 165 years to orbit the Sun.
- Rotates once every 16.1 Earth hours.
- Has 11 moons.
- Has a magnetic field. The magnetic axis is tipped about 45°.
- Has winds of 2000 km per hour.
- Average temperature is about –225° C.

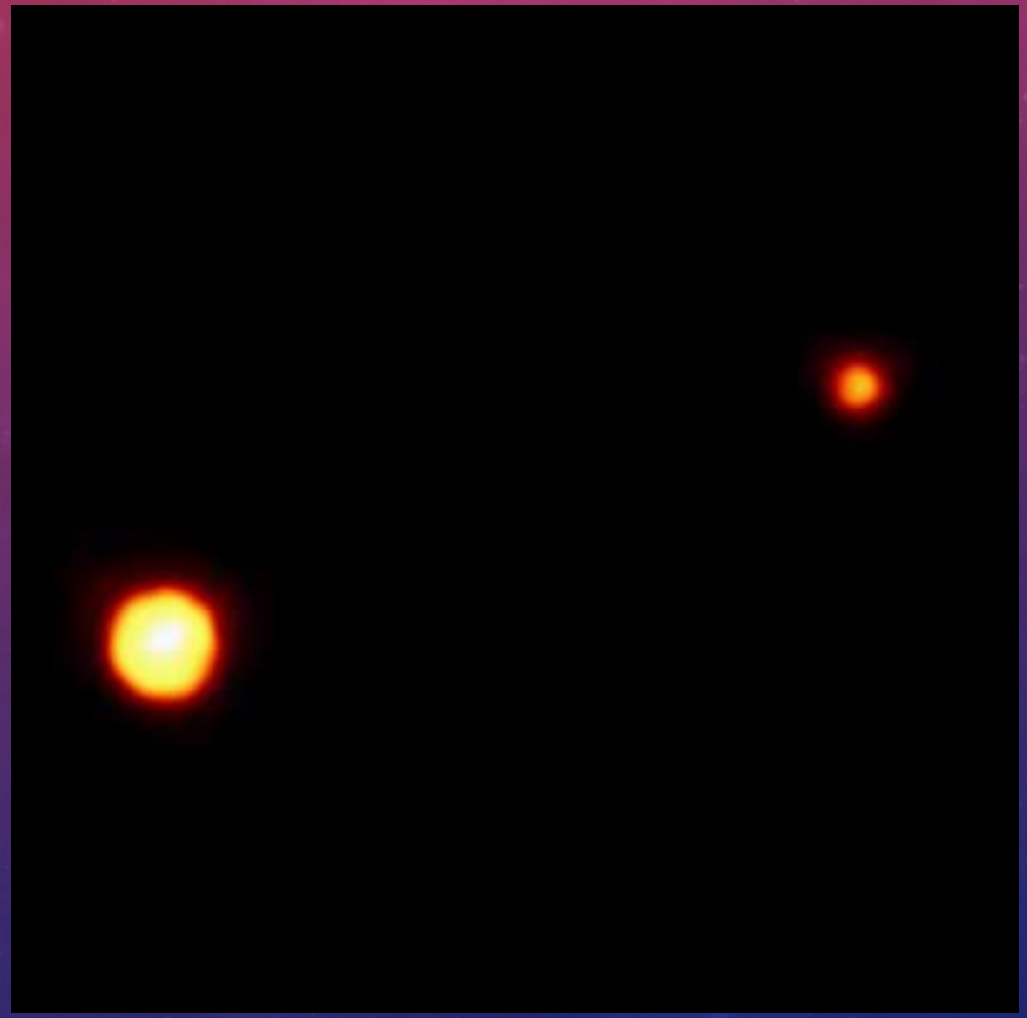
NEPTUNE

- Atmosphere is 74% hydrogen, 25% helium, and 1% methane.
- **Existence** had been **predicted mathematically**.
- Need a telescope to see this planet from Earth.
- Has a faint ring system.

NEPTUNE/PLUTO

- Neptune is the eighth planet from the Sun, but occasionally Pluto (dwarf planet) is closer to the sun.
- Every 248 years Pluto’s orbit brings it closer to the Sun than Neptune.
- Pluto stays nearer to the Sun for about 20 years.

PLUTO



PLUTO

- **Dwarf planet as of 2006**. It is large enough for its gravity to pull it into the shape of a ball but it is too small to clear other objects and debris out of its path around the sun.
- Diameter of 2,274 km; Smaller than seven of our solar systems moons (including our Moon).
- Orbits the Sun once every 247.7 Earth years. Pluto orbits in a region called the Kuiper (KY-per) Belt
- Rotates once every 6.4 Earth hours.

PLUTO

- Surface temperatures are probably between –210 and –235° C.
- Most of its atmosphere is frozen, **thawing out slightly** when the planet is **nearest the Sun**.
- Unknown density, however, scientists believe Pluto consists of 70% rock and 30% water.
- Averages 39.5 AU from the Sun.
- Need a telescope to see this planet from Earth.

SECTION 27.2: REVIEW

1. What are some of the main differences between the Jovian and terrestrial planets?
2. Why do Jupiter and Saturn give off more eat than they receive from the sun?
3. What is unusual about Uranus's axis of rotation?

SECTION 27.3: PLANETARY SATELLITES

Objectives:

1. Describe the satellites of the planets.
2. Compare and contrast the Galilean satellites of Jupiter.

PLANETARY SATELLITES

Bodies that revolve around planets are called **satellites**, or moons. Except for Mercury and Venus, each planet in our solar system has at least one natural satellite.

SATELLITES OF EARTH AND MARS

- Earth has one natural satellite, the Moon.
- **Mars** has **two** tiny natural **satellites**, Phobos and Deimos.
  - Phobos and Deimos both have irregular shapes.
  - Phobos is closer to Mars and it circles Mars more than three times each day.

DEIMOS AND PHOBOS

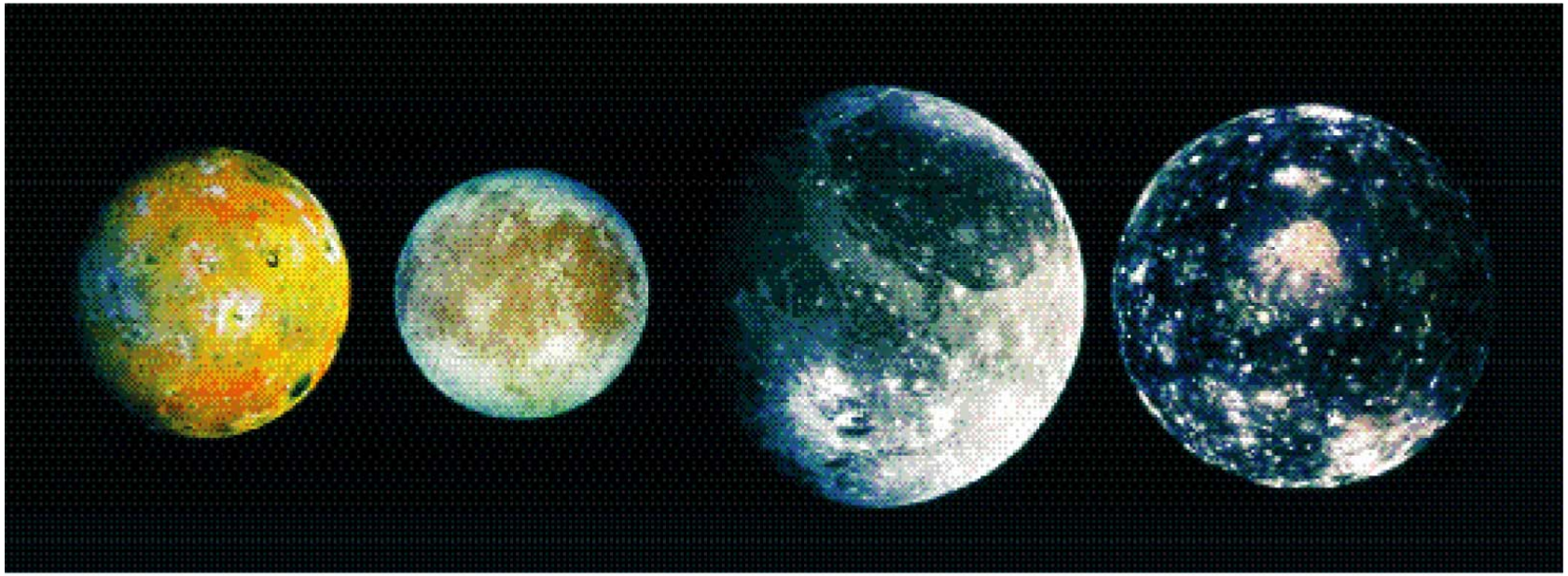
Deimos

Phobos

JUPITER'S MOONS

- Jupiter has **at least 60 moons**.
- The **four largest moons** (Io, Europa, Ganymede, and Callisto) are known as the **Galilean moons** – in honor of their discoverer, Galileo Galilei.

JUPITER’S LARGEST MOONS



A. Io B. Europa C. Ganymede D. Callisto

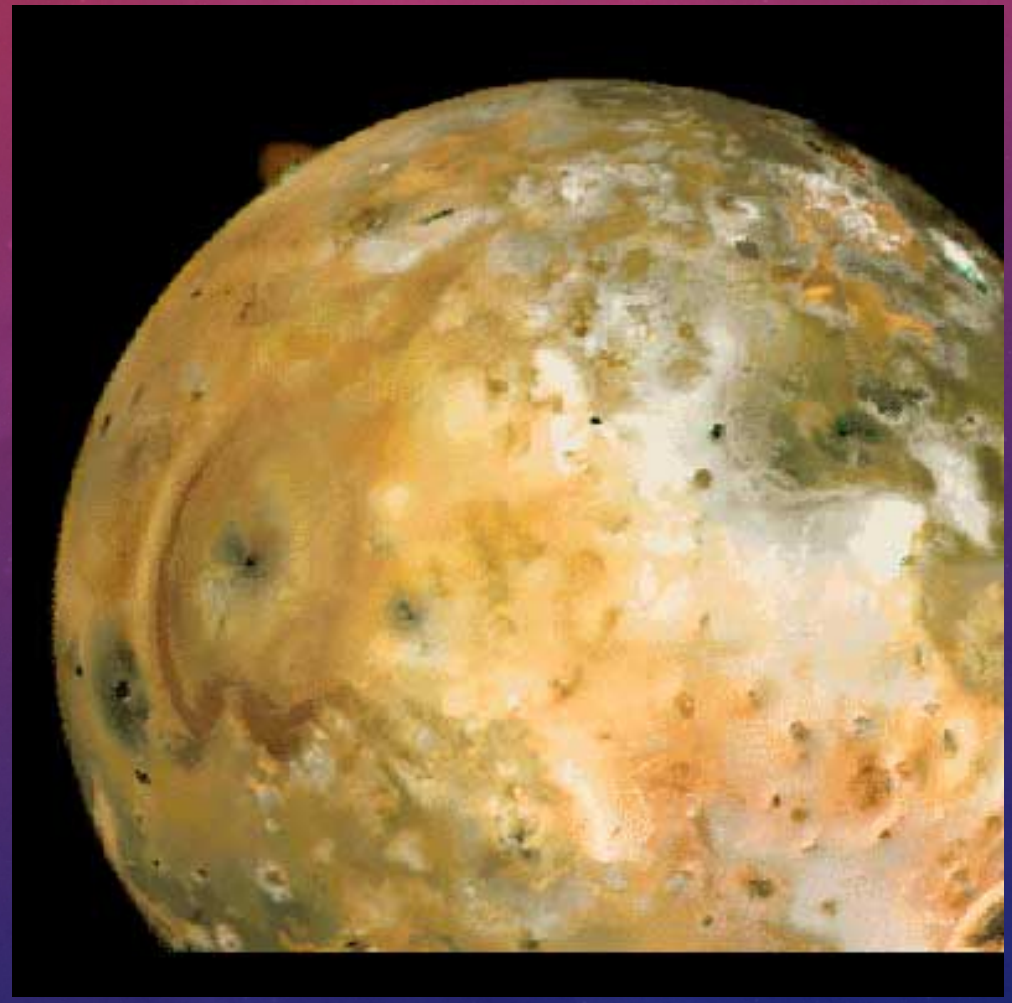
JUPITER'S MOONS - IO

- Io is located closest to Jupiter, and is **geologically active**. At least nine active volcanoes have been observed.
- Io volcanoes contain sulfur, sulfur dioxide, and other sulfur compounds. These cause Io's distinctive surface color. It varies from yellow-orange to red to black.

JUPITER'S MOONS - IO

- Io has a density close to our Moon.
- Appears to have a thin sulfur dioxide atmosphere.
- A layer of molten rock surrounds an iron core.
- Its surface is covered with layers of sulfur and frozen sulfur dioxide.
- No signs of surface impact craters.

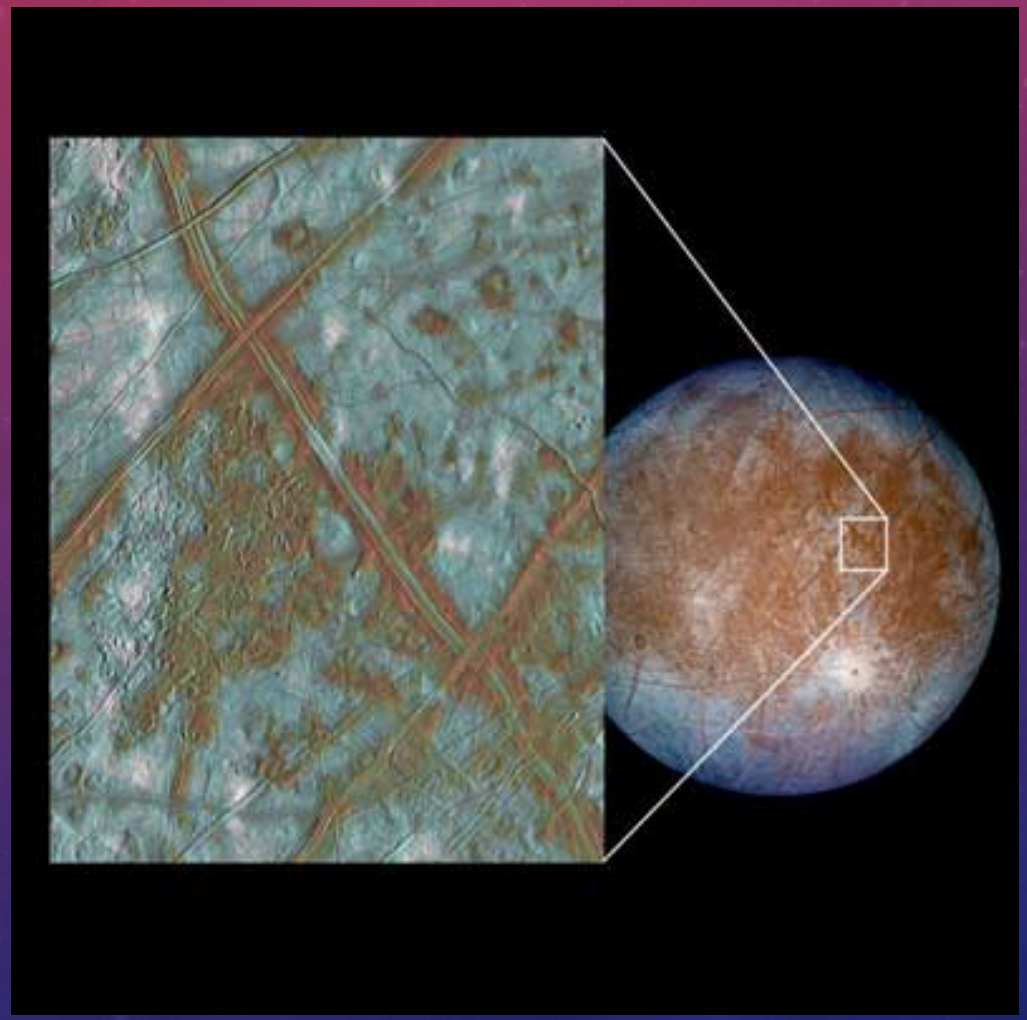
IO



JUPITER'S MOONS - EUROPA

- Appears to have an atmosphere.
- Appears to have a smooth and shiny white surface with a shell of water ice up to 100 km thick.
- Evidence suggests a liquid ocean 100 km deep below the frozen surface.
- Few surface craters.
- Surface is marked by a crisscross pattern of bright and dark lines.

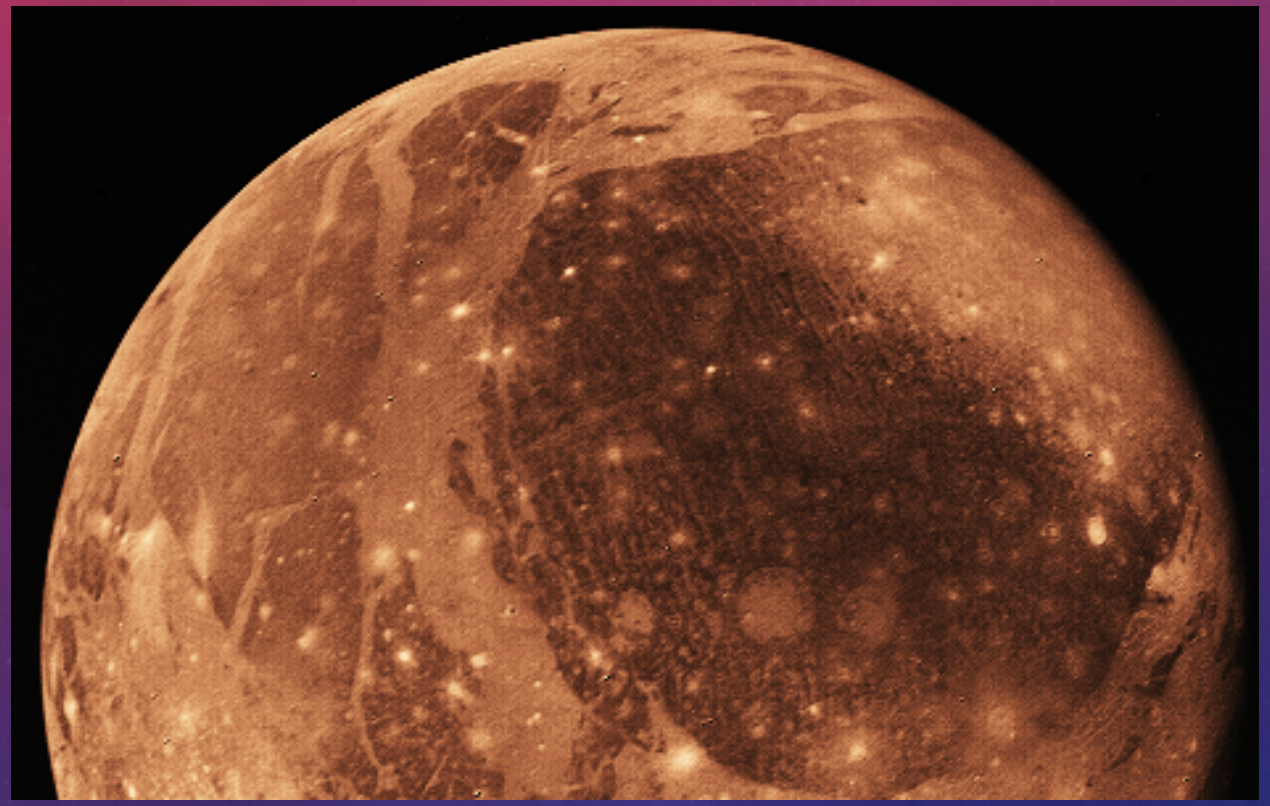
EUROPA



JUPITER'S MOONS - GANYMEDE

- **Largest moon in the solar system**,** larger than Mercury and Pluto. If Ganymede orbited the Sun, it would probably be considered a planet.
- Has a **low density**; probably made up of a lot of ice around a rocky core.
- Crust is believed to be a layer of water ice.
- Only Jupiter moon that **has a magnetic field**.
- Might have a subsurface ocean of salty liquid water several km deep.

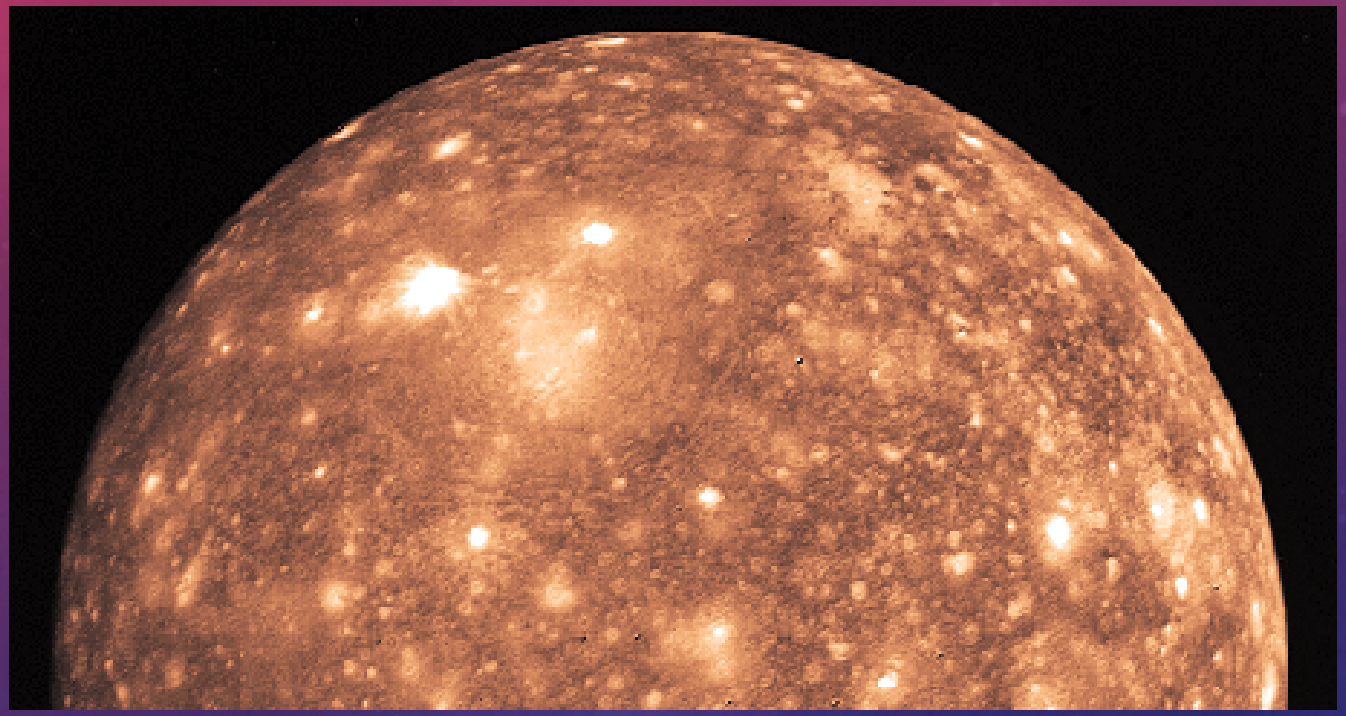
GANYMEDE



JUPITER'S MOONS - CALLISTO

- **Most heavily cratered moon** in our solar system.
- **Least dense** of the Galilean satellites.
- Oxygen detected, probably released by sunlight striking its icy surface.
- Interior may be a mixture of ice and rock, with a rocky core.
- Might have a subsurface ocean of salty liquid water several kilometers deep.

CALLISTO



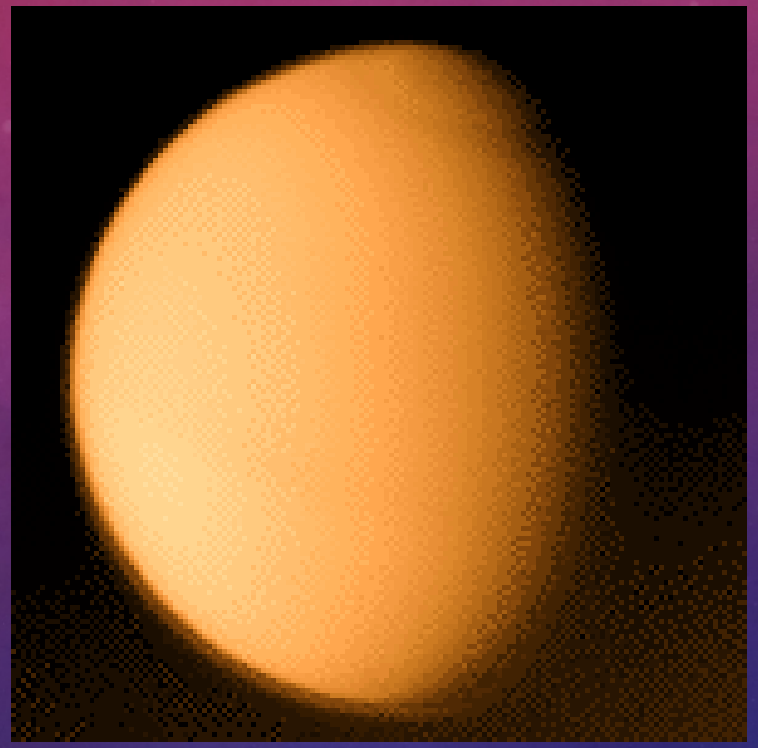
SATURN'S MOONS

- Has at least 31 moons.
- First nine moons were discovered before 1900.
- Some of the "newest" moons still have to be confirmed.

SATURN'S MOONS - TITAN

- The second largest moon in our solar system.
- Seems to be about half rock and half frozen water.
- **Only moon known to have a substantial atmosphere**.** Nitrogen makes up 90-95%. Most of the remaining atmosphere is methane with traces of hydrogen cyanide and acetylene. Atmospheric pressure is about 1.5 times Earth's.
- Surface temperature is about –180° C.
- Atmospheric gases turn to liquid, and the droplets form a dense orange smog that hides the surface.

TITAN



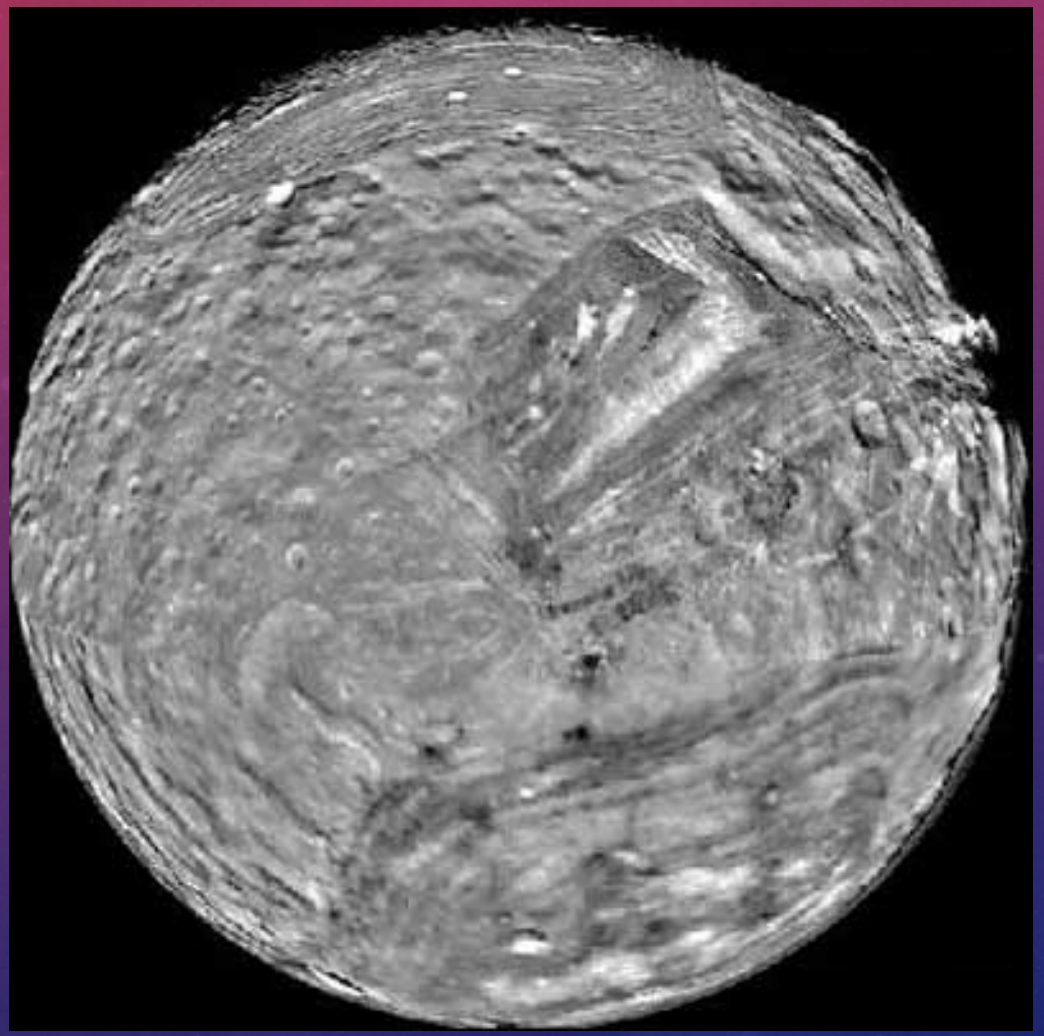
MOONS OF URANUS

- Known to have 21 moons.
- **Five major moons** (Titania, **Oberon**, Umbriel, **Ariel**, and **Miranda**).**
- They all lack atmospheres and have many impact craters.
- Oberon's impact craters are partly flooded with dark material.
- Umbriel has an unusual dark surface.
- Ariel's cratered surface is crisscrossed by valleys and faults.

MOONS OF URANUS - MIRANDA

- Miranda is deeply scarred with V-shaped grooves and parallel ridges.
- Some scientists theorize that Miranda has been shattered as many as five times during its existence.
- Other scientists believe the surface features resulted from upwelling of partly melted ice.

MIRANDA



NEPTUNE'S MOONS - TRITON

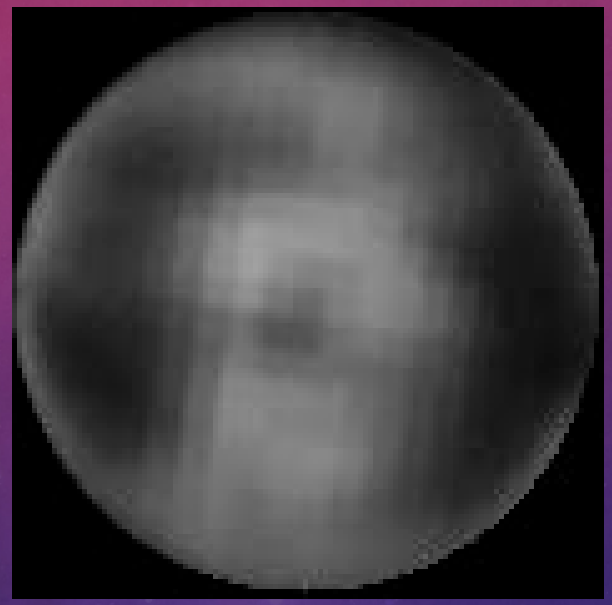
- Triton is one of the 11 moons of Neptune.
- About 4/5 the size of Earth's Moon.
- The southern ice cap is made of methane and ammonia.
- Ice volcanoes of nitrogen have been seen erupting.
- Has a very thin atmosphere.

TRITON

PLUTO'S MOON - CHARON

- About one half the size of Pluto.
- Because it is close in size to Pluto, some scientists consider Pluto-Charon to be a double planet.

CHARON



SECTION 27.3: REVIEW

1. What are the moons of the inner planets?
2. What makes Titan an interesting moon?
3. Why are small moons, like Deimos, potato-shaped, while larger moons are spherical?
4. Hypothesize why the Jovian planets have so many moons. Where do you think the moons came from?

SECTION 27.4: SOLAR-SYSTEM DEBRIS

Objectives:

1. Identify smaller components of the solar system.
2. Explain the effects of objects colliding with Earth.

Key Vocabulary:

- Comet
- Asteroid
- Meteor
- Meteorite
- Meteor shower

SOLAR SYSTEM DEBRIS

In addition to the Sun, the planets, and the moons of the planets, additional smaller objects are found in our solar system.

Some of these objects have collided with the Earth in the past, while some objects continue to reach our planet.

COMETS

- Often described as “dirty snowballs.”
- Made of dust particles trapped in a mixture of water, carbon dioxide, methane, and ammonia.
- **Spend most of their time far out beyond Neptune’s orbit** ** where they consist only of a solid main body called a nucleus.
- Vast numbers of comets orbit in a cold region beyond Neptune called the **Edgeworth-Kuiper Belt** and in the much more distant **Oort Cloud**.

COMETS

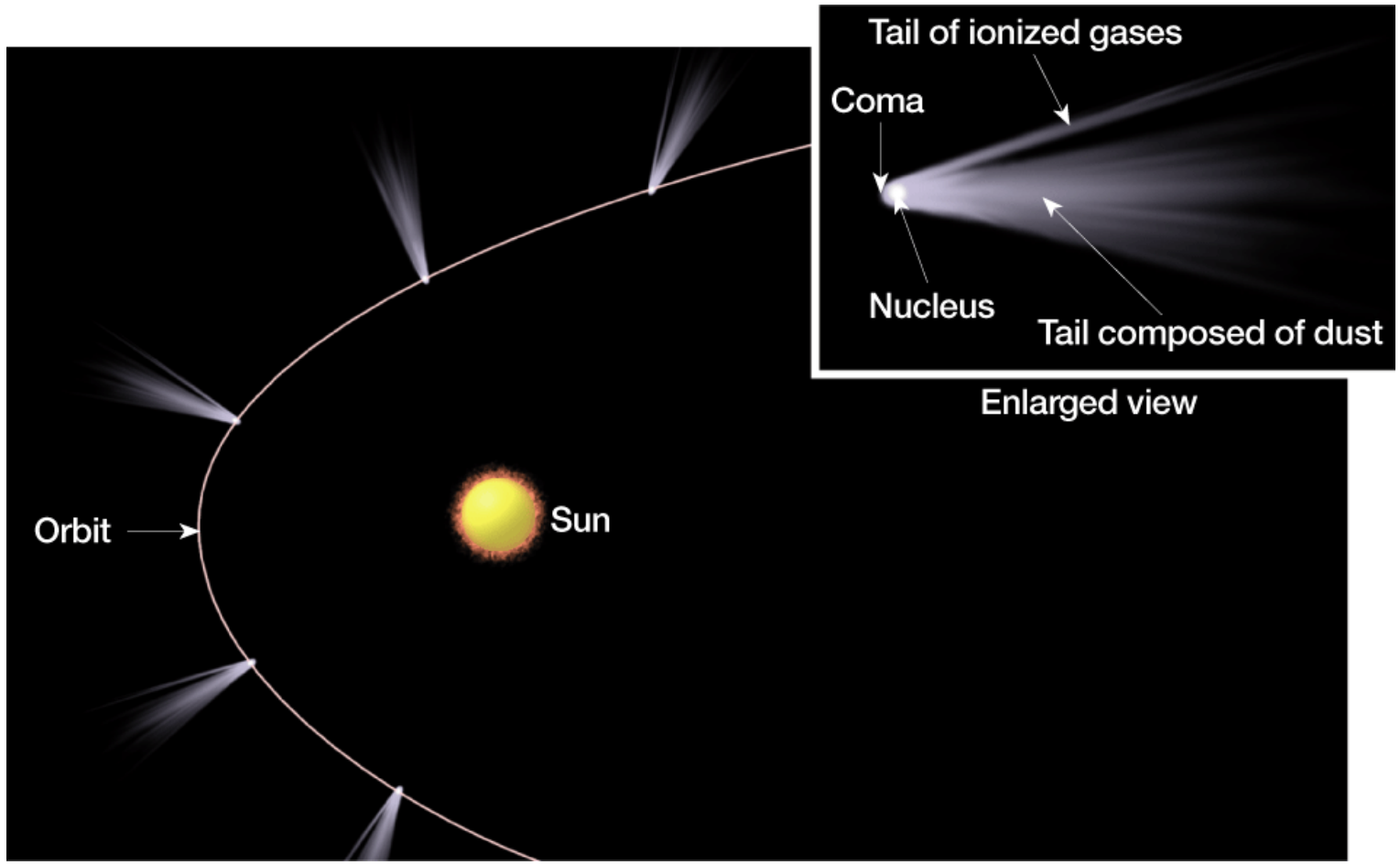
COMETS

- Some comets have **highly elliptical orbits** that take them closer to the Sun.
- Energy from the Sun heats the comet's icy surface, causing it to form a **coma**.
- **Coma** – a cloud of gas and dust that expands into space.
- Solar wind pushes the coma material far out into space, forming a tail.
- A comet has two tails, one composed of gases, the other of dust particles.

COMETS

- Since the solar wind is forming the tail, the **tail of a comet always points away** from the Sun.
- As a comet moves away from the Sun back into the outer solar system, the tail actually precedes it.
- Halley's Comet returns to the inner solar system every 76 years. It last returned in 1986.

COMET'S TAIL POINTS AWAY FROM SUN



TRANS NEPTUNIAN OBJECTS (TNOS)

More than 375 large bodies (up to several hundred kilometers in diameter) have been detected in the Edgeworth-Kuiper Belt.

These are known as **Trans Neptunian Objects**.

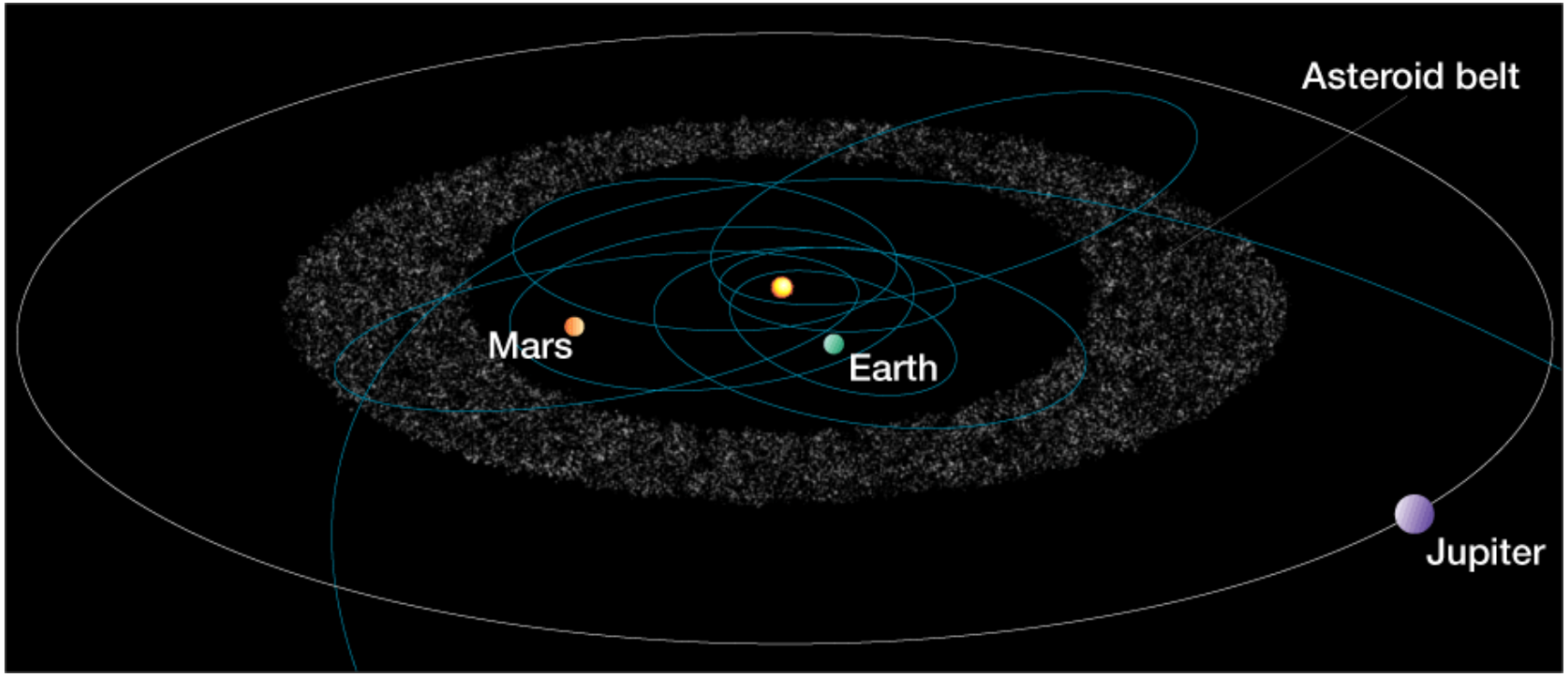
ASTEROIDS

- **Asteroids** are solid, rock-like masses. Most seem to have **irregular shapes**.
- There are thousands of asteroids in the solar system, but **only the two largest** (Ceres and Pallas), **are spherical**.
- Ceres has a diameter of about 1000 km, however, most asteroids are less than 1 km long.
- Possibly left over material from the formation of the solar system.

ASTEROIDS

- **Revolve** around the Sun in the **same direction** as the planets.
- Most asteroid **orbits are nearly circular**, and lie between Mars and Jupiter.
- Asteroids can, and have collided with Earth in the past.
- Today we are looking to prevent future collisions by diverting objects before they reach Earth.

IRREGULAR ORBITS OF ASTEROIDS



METEORS AND METEOROIDS

- **Meteoroid** – a rock or icy fragment traveling in space. They are smaller than asteroids, from less than 100 meters in diameter down to the size of a sand grain.
- **Meteor** – (also called a shooting star) is the light made by a meteoroid as it passes through Earth's atmosphere. The light is caused by friction between the meteoroid and our atmosphere.

METEORS AND METEOROIDS

- On a clear, dark night about 5-15 meteors can be seen every hour.
- Scientists estimate that anywhere from a million to a billion meteoroids enter our atmosphere daily.
- Most meteoroids are tiny and burn or vaporize in the atmosphere.

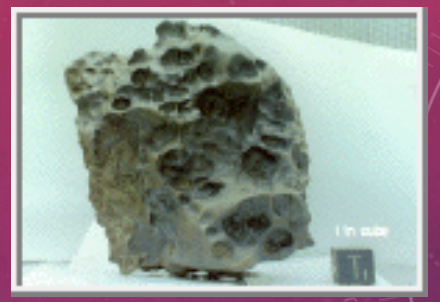
METEORS AND METEOROIDS

- **Meteor shower** – when a large number of meteors streak across the sky within a few hours of one another.
- Meteor showers **occur when Earth passes through the tail of a comet**,** and particles from the tail plunge through the atmosphere as meteors.
- Because Earth's orbit crosses the paths of comets around the same time each year, many meteor showers occur at predictable times.

METEORITES

- **Meteorite** – part of a large meteoroid that survives its trip through the atmosphere and strikes Earth's surface.
- Statistically, every million years Earth can expect 3 meteorites large enough to make impact craters 10 km or larger.
- An impact the size that may have affected the dinosaurs may occur once every 100,000,000 years.

METEORITES



- There are **3 basic types** of meteorites:
- 94% of meteorites are classified as "**Stony**" meteorites. These resemble Earth's dark igneous rocks. They are composed primarily of silicates.
- 5% of meteorites are classified as "**Iron**" meteorites. These consist of large crystals made mostly of iron with a small amount of nickel. The crystals may have formed in large asteroids that later broke apart.

METEORITES

- 1% of meteorites are classified as "**Stony-iron**" meteorites. They appear to have formed when molten silicates came into contact with molten metal.
- The **most abundant source** of meteorites is the **Antarctic ice cap**. Thousands of meteorites have been found there.

IMPACT CRATERS

- **Impact craters** are bowl-shaped depressions that remain after a meteor or other object strikes Earth, another planet, or a moon.
- These are rare finds on Earth. Only about 150 impact craters are known to exist. Why so few? (Burn up ; Geologically active)
- Impacts change Earth geologically. They leave rings, they provide reservoirs for oil and gas deposits, and they may even provide mineral deposits.

IMPACT CRATER

Barringer Crater in Arizona – 1200 m in diameter, about 200 m deep. (49,000 years old.)

SECTION 27.4: REVIEW

1. What happens to comets as they approach the sun?
2. Where are most asteroids found?
3. Explain the difference between meteoroid, meteor, and meteorite.
4. Most meteorites formed between 4.55 billion and 4.65 billion years ago, making them a little older than the oldest moon rocks. Infer why moon rocks are younger than most meteorites.