Mercury

- Mass: $3.3 \times 10^{24} \text{ g}$
  - $0.055 M_{\text{Earth}}$
- Radius: $2439 \text{ km}$
  - $0.38 R_{\text{Earth}}$
- Density: $5.4 \text{ g/cm}^3$
  - (Earth $5.5 \text{ g/cm}^3$)
- Gravity: $0.38$ that of Earth
- Semimajor axis: $0.39 \text{ AU}$

Venus

- Mass: $0.82 M_{\text{Earth}}$
- Radius: $0.95 R_{\text{Earth}}$
- Density: $5.2 \text{ g/cm}^3$
- Average distance from Sun: $0.72 \text{ AU}$
- Orbital period: $225 \text{ days}$
- Rotation period: $243 \text{ days}$ (longer than orbital period, and retrograde?)

General Features

- Mass: $M_{\text{Earth}} = 6 \times 10^{27} \text{ g}$
- Radius: $R_{\text{Earth}} = 6378 \text{ km}$
- Density: $\rho = 5.5 \text{ g/cm}^3$
- Age: $4.6$ billion years
- Orbital period: $365 \text{ days}$
- Rotation period: $1 \text{ day}$

Mars

- Mass: $0.11 M_{\text{Earth}}$
- Radius: $0.53 R_{\text{Earth}}$
- Density: $3.9 \text{ g/cm}^3$
- Average distance from Sun: $1.52 \text{ AU}$
- Eccentricity: $0.093$
- Range in distance from Sun: $1.38 - 1.66 \text{ AU}$
- Rotation Period: $24.6$ hours
- Orbital Period: $687 \text{ days}$

Terrestrial Planets' Spin

Clicker Question:

Venus and the Earth are very similar (within 10%) in their:

A: Amount of carbon dioxide in their atmospheres.
B: Distance from the Sun.
C: Surface gravity.
D: Length of a day.
E: All of the above.
Clicker Question:

Large scale motions of the crust (plate tectonics) are seen on which planets:
A: Mercury and Venus
B: Earth, Venus and Mars
C: Only the Earth
D: Mars and Venus
E: All terrestrial planets - Mercury, Venus, Earth and Mars.

Clicker Question:

It takes 8 minutes for light to travel 1 AU, how long does it take for a radar signal to travel from Earth to Mercury and back at its closest point to Earth in its orbit?
A: 1 minute
B: 10 minutes
C: 2 hours
D: 2 days
E: 1 year

The Martian Atmosphere

- 95% CO$_2$
- Surface Pressure 0.006 that of Earth's atmosphere (thin air!)
- Surface Temperature 250 K.
- Dust storms sometimes envelop most of Mars, can last months.
  A "Reverse Runaway Greenhouse Effect" may have happened: during volcanic phase (first two billion years), thicker atmosphere, warmer surface, possibly oceans. But gradually most CO$_2$ dissolved into surface water and combined with rocks, then atmospheric and surface water froze (creating ice caps and possible permafrost layer).
  Or: most atmosphere lost due to low gravity
  Or: most atmosphere lost due to heating by early impacts

Demo - The Atmosphere of Mars or Fun with Carbon Dioxide

The Martian Surface

- Southern Hemisphere -5 km higher elevation than Northern, and more heavily cratered.
- South is like lunar highlands, surface ~4 billion years old, North like maria, ~3 billion years old.
- Valles Marineris - 4000 km long, up to 7 km deep. Ancient crack in crust.
- Reasons not clear.
- Tharsis Ridge - highest (10 km) and youngest (2-3 billion years) region.
- Olympus Mons - shield volcano, highest in Solar System, 3x Everest in height, 100 km across.
- Hellas Basin - large impact crater, ~4 billion years old.

The View From the Surface

Dry, desert-like. Red => high iron content. Mars didn't differentiate as completely as Earth. Sky has butterscotch hue due to dust.
Pathfinder site was an outflow channel

Red arrows: rounded boulders indicating water erosion?
White arrows: "conglomerate" rock, like in Earth's riverbeds?
Blue arrows: sharp-edged boulders, volcanic rock?

Spirit and Opportunity Rovers
Scenes from "Roving Mars" (start at 20:27)

Opportunity’s first pictures from Victoria Crater

Deepest crater explored by far (230 feet, 10 times deeper than Endurance Crater) => more layers of geologic history. Will it go in? Will it ever get out?

Mars Reconnaissance Orbiter view of Victoria Crater

Evidence for Past Surface Water

"runoff channels" or dry rivers

"outflow channels" of standing water erosion in craters

teadrop "islands" in outflow channels

Did Mars once have a huge ocean?

Long stretches along border are very even in elevation, like a coastline

Ocean fed by outflow channels from higher elevation southern hemisphere?
Clicker Question:

From Mars, Deimos has an angular diameter of 140 arcseconds. Would colonists on Mars ever see Deimos produce a total solar eclipse?

A: Yes, every day on Mars
B: Yes, every new moon
C: Yes, but rarely
D: Never

Clicker Question:

The largest mountain in our solar system is:

A: Caloris Basin range on Mercury
B: Gula Mons on Venus
C: Mt. Everest on Earth
D: Olympus Mons on Mars

Clicker Question:

Where is the water that once flowed on the surface of Mars?

A: In the atmosphere
B: In the polar caps only
C: In a layer of permafrost below the surface and in the polar caps
D: It was diverted to Los Angeles

Evidence for "Permafrost" layer beneath surface

"Splosh" craters suggesting liquefied ejecta.

Valles Marineris flyover movie

Mars' History

Smaller than Earth, Mars cooled faster.
Most volcanic activity ended two billion years ago.
Differentiation less complete than on Earth.
No evidence for plate tectonics.
Atmosphere mostly froze out into subsurface ice, polar ice caps and surface rocks.
Mars' Moons Phobos and Deimos

Phobos: 28 x 20 km

Deimos: 16 x 10 km

Properties similar to asteroids. They are probably asteroids captured into orbit by Mars' gravity.