Wednesday, October 27
Terrestrial Planets

Announcement: The question that was garbled on last Friday’s quiz was also garbled in grading. The correct answer is “Each sequence of 3 base pairs in DNA molecules consists of a genetic word that codes for an amino acid.” As a result of the erroneous grading, one additional point will be added to the score of everyone who took the quiz last Friday.

Terrestrial Planets
Key Concepts
1) Terrestrial planets all started out with thick atmospheres, but evolved differently.

2) Small terrestrial planets have old surfaces and cold interiors.

3) Large terrestrial planets have young surfaces and hot interiors.

Terrestrial planets

Large:
Earth (radius = 1 R\textsubscript{E}, mass = 1 M\textsubscript{E})
Venus (0.95 R\textsubscript{E}, 0.82 M\textsubscript{E})

Small:
Mars (0.53 R\textsubscript{E}, 0.11 M\textsubscript{E})
Mercury (0.38 R\textsubscript{E}, 0.055 M\textsubscript{E})
The ability of a planet to retain an atmosphere depends on its mass and temperature. Massive planets have a high escape speed; cold planets have slow-moving atmospheric molecules.

Where should we look for life in the Solar System?

Mars may have had liquid water & a thicker atmosphere in the past.

Titan (moon of Saturn) may have organic compounds in lakes of methane & ethane.

Wild cards:

Europa (moon of Jupiter) and Enceladus (moon of Saturn) may have liquid water under icy surfaces.
**Mercury** is too hot for liquid water: it’s too hot (and its gravity too weak) to have kept its primordial atmosphere.

*Daytime highs = 425°C, nighttime lows = -175°C*

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**Venus** is too hot for liquid water: but its gravity is strong enough to retain its atmosphere.

*Average temperature = 470°C*

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Venus was once cooler, and may have had seas, but its temperature rose due to a **runaway greenhouse effect**.

Volcanoes belched out H₂O, CO₂, SO₂
(all greenhouse gases).

↓ ↓ ↓

Air temperature rose.

H₂O evaporated from seas;
CO₂, SO₂ released from seas & rocks.

↓

Air temperature rose more.
**Earth** has the right temperature for liquid water: its gravity is strong enough to retain its atmosphere.

Average temperature = 15°C

**Mars** may have been warm enough for liquid water during its first Gyr, but its gravity is too weak to keep a thick atmosphere.

Average temperature = -50°C

Mars rovers have revealed evidence of past liquid water; as Mars cooled, the water froze.

Mars has a cold, dry, thin CO₂ atmosphere today – but it might have been habitable in the past.
Present-day atmospheres are very diverse, despite similar primordial atmospheres.

<table>
<thead>
<tr>
<th></th>
<th>Earth</th>
<th>Venus</th>
<th>Mars</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>0.035%</td>
<td>96%</td>
<td>95%</td>
</tr>
<tr>
<td>N₂</td>
<td>77%</td>
<td>3.5%</td>
<td>2.7%</td>
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<tr>
<td>H₂O</td>
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<td>0.01%</td>
<td>0.007%</td>
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<tr>
<td>Ar</td>
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<td>0.007%</td>
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<tr>
<td>O₂</td>
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<td>trace</td>
<td>trace</td>
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</table>

Habitable

Inhospitable today

The interiors of the small terrestrial planets cooled rapidly, and have solidified.

Mercury & Mars have thick, rigid crusts; no plate tectonics.

Mercury has signs of ancient volcanic vents. Mars has large, extinct shield volcanoes.

The interiors of the large terrestrial planets cool more slowly, and are still partially liquid.

Venus & Earth are kept warm longer by energy release from radioactive decay.

Solid inner core

Liquid outer core
The surfaces of the large terrestrial planets are young.

Average crust age:
Earth: 200 Myr
Venus: 500 Myr

Earth:
plate tectonics, driving CO$_2$ cycle

Venus:
lithosphere too soft to fracture into plates

There's evidence for convection in the mantle of Venus.

Wrinkled mountains are seen where the crust is compressed.

Fractures ("stretch marks") are seen where the crust is stretched.

Tomorrow's Lecture:
More about Mars

This Week's Reading:
Chapters 7 & 8