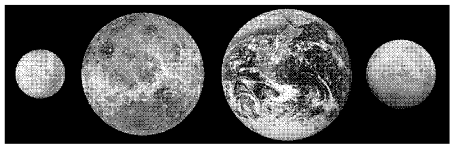
# Wednesday, October 27
# Terrestrial Planets



**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.

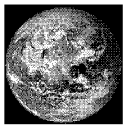
## Terrestrial Planets
## Key Concepts

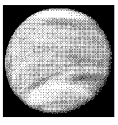
1) Terrestrial planets all started out with thick atmospheres, but evolved differently.

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

3) **Large** terrestial planets have young surfaces and hot interiors.

## Terrestrial planets





**Large:**

Earth (radius = 1 $R_E$, mass = 1 $M_E$)

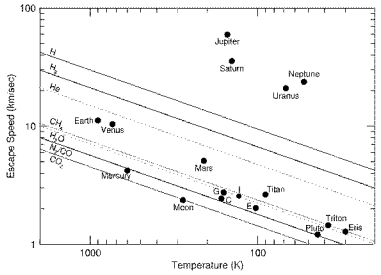
Venus (0.95 $R_E$, 0.82 $M_E$)

**Small:**

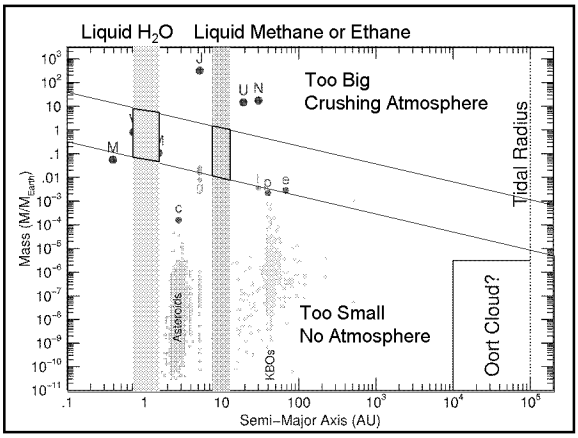
Mars (0.53 $R_E$, 0.11 $M_E$)

Mercury (0.38 $R_E$, 0.055 $M_E$)

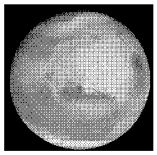
The ability of a planet to retain an atmosphere depends on its **mass** and **temperature**.




**Massive** planets have a high escape speed; **cold** planets have slow-moving atmospheric molecules.

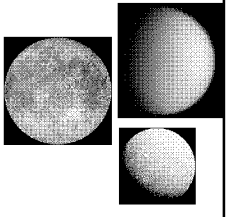



Where should we look for life in the Solar System?



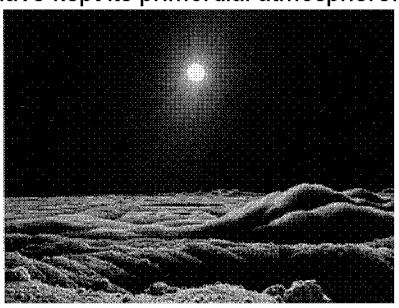
**Mars** may have had liquid water & a thicker atmosphere in the past.

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



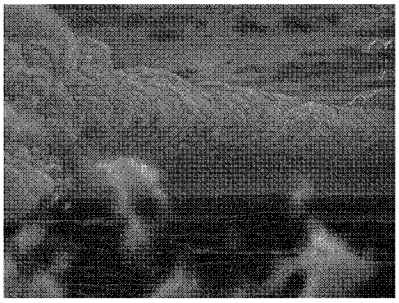
Wild cards:
**Europa** (moon of Jupiter) and **Enceladus** (moon of Saturn) may have liquid water under icy surfaces.

**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**

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



**Average temperature = 470°C**

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

Volcanoes belched out $H_2O$, $CO_2$, $SO_2$ (all greenhouse gases).

↓

Air temperature rose.

↓

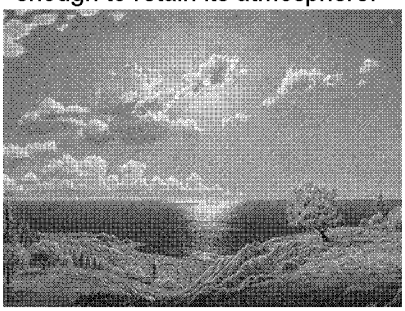
$H_2O$ evaporated from seas;
$CO_2$, $SO_2$ released from seas & rocks.

↓

Air temperature rose more.

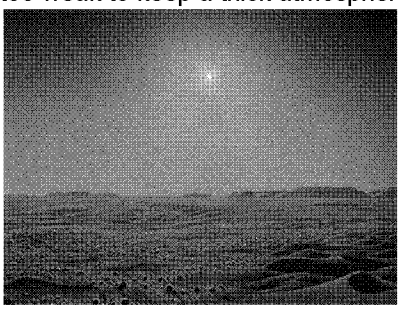
↻

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



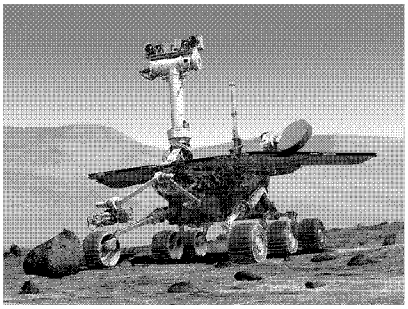
**Average temperature = 15°C**

**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.



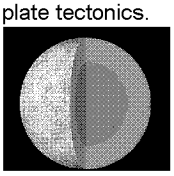
**Mars has a cold, dry, thin $CO_2$ atmosphere today – but it might have been habitable in the past.**

**Present-day** atmospheres are very diverse, despite similar **primordial** atmospheres.

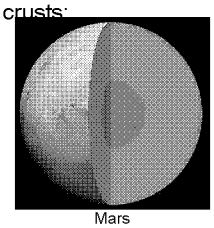
| | Earth | Venus | Mars |
|---|---|---|---|
| $CO_2$ | 0.035% | 96% | 95% |
| $N_2$ | 77% | 3.5% | 2.7% |
| $H_2O$ | 1% | 0.01% | 0.007% |
| Ar | 0.93% | 0.007% | 1.6% |
| $O_2$ | 21% | trace | trace |
| | Habitable | Inhospitable today | |

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

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



Mercury

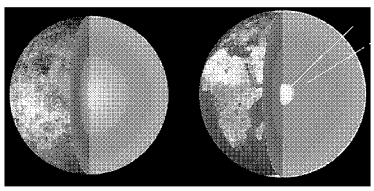


Mars

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

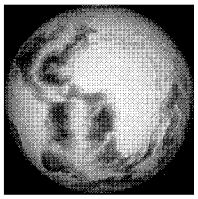
The interiors of the **large** terrestrial planets cool more slowly, and are still partially liquid.

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

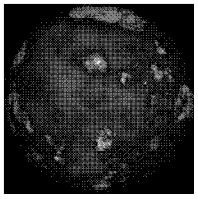


The surfaces of the **large** terrestrial planets are **young**.

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

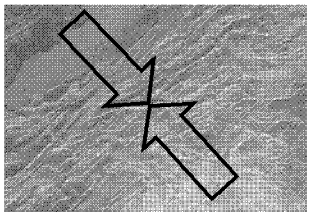


Earth:
plate tectonics,
driving $CO_2$ cycle

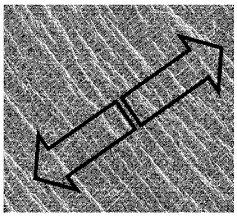


Venus:
lithosphere too soft
to fracture into plates

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



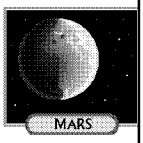
**Wrinkled mountains** are seen where the crust is compressed.



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

Tomorrow's Lecture:

More about Mars




This Week's Reading:

Chapters 7 & 8