

Welcome to Class 12:
Water & Mars Geology

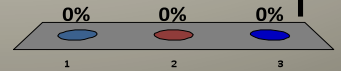
The search for life is
the search for water

Could humans live on Mars?



Which of today's learning objectives
are most difficult?

- 3 unique properties of H_2O make it most likely liquid for life.
- Contrast/Compare Earth/Mars weather and atmosphere.
- History of Mars Volcanism.



Which below is NOT a reason for
life to need a 'liquid'?

- To move in
- Transport nutrients
- Dissolving molecules
- For chemical reactions



Of all liquids: WATER is the best

Among 'astronomically significant'* molecules:

Substance	Freezing Temp	Boiling Temp	Liquid Range
Water (H_2O)	0°C	100°C	100°C
Ammonia (NH_3)	-78°C	-33°C	45°C
Methane (CH_4)	-182°C	-164°C	18°C
Ethane (C_2H_6)	-183°C	-89°C	94°C

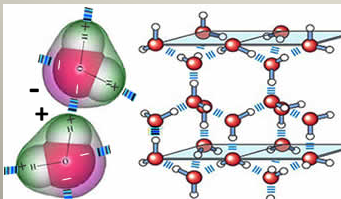
Now consider two important points about life:

- Life is better protected if it doesn't easily boil or freeze.
- Biological metabolism **STRONGLY** increases with temperature

*Astronomically Significant: simple molecules made of elements abundant in the universe

Another critical and unique property
of Water: It's polar nature

Nearly all molecules have a more dense structure when solid over when liquid.



The water molecule is 'polar'.
One side '+', the other side '-'

Because of its charge imbalance, water:

- Forces the molecules **FURTHER** from each other in the solid phase making the density lower as a solid (simply stated: **ICE FLOATS**).
- Dissolves charged molecules (salts, etc.) but not 'oils' (no charge).

What would happen if ice sunk?

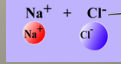
- As the temperature above the water dropped below freezing, the surface would start to solidify.
- The frozen portions would start to sink, revealing underlying liquid water.
- The new liquid water at top would be exposed to freezing temperatures and begin to freeze.
- The frozen portion at top would sink, revealing underlying liquid water....

The entire lake/ocean would freeze top to bottom solid!
All life in the oceans and lakes would be dead.

But water ice floats at top, insulating the liquid below.

List the unique properties of water that make it the most likely liquid for life in the universe.

- 1) It is in a liquid state over a very WIDE range of temperatures.
- 2) The liquid state of water is at much higher temperatures than other molecules.
- 3) Because of its overall charge structure, it is less dense as a solid than a liquid (ice floats).
- 4) It dissolves charged molecules well (like salts, Na^+Cl^- , good for chem rxns) but NOT cell walls ('oil' based).



BUT WHAT ARE THE BIOLOGICAL IMPLICATIONS OF THESE PROPERTIES?

- 1) It is in a liquid state over a very WIDE range of temperatures. **LIFE CAN'T SO EASILY FREEZE OR BOIL AWAY!**
- 2) The liquid state of water is at much higher temperatures than other molecules. **METABOLISM INCREASES WITH HIGHER TEMPERATURE**
- 3) Because of its overall charge structure, it is less dense as a solid than a liquid (ice floats). **OCEANS WON'T FREEZE SOLID KILLING ALL LIFE**
- 4) It dissolves charged molecules well (like salts, Na^+Cl^- , good for chem rxns) but NOT cell walls ('oil' based) **CRITICAL FOR EARTH-BASED LIFE**

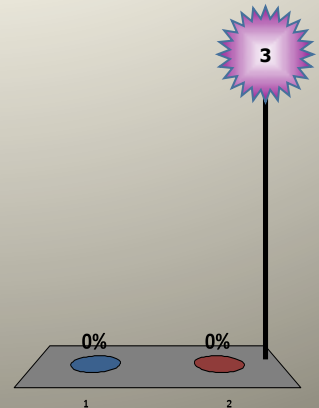
Which is NOT one of the three requirements for life?

1. Source of energy.
2. Source of motion.
3. A liquid medium.
4. A source of molecules (raw materials) to build cells.

If given the opportunity (and you might not return alive) would you want to visit Mars?

1. YES
2. NO

Remember to set your channel to 80!

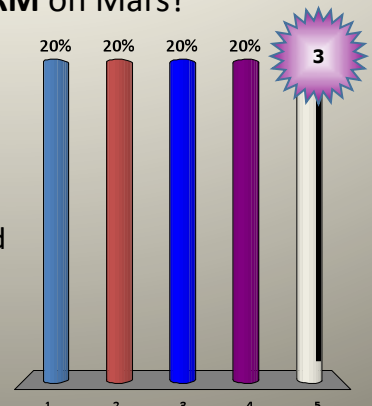


Let's compare Mars to Earth

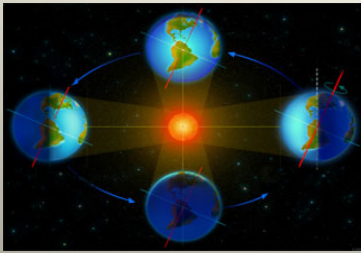
	Mars	Earth	Significance for human life?
Average Distance from Sun	142 million miles	93 million miles	→ $< \frac{1}{2}$ the solar radiation
Radiation Levels	VERY HIGH	Moderate	→ You'll need a space suit
Diameter	4,220 miles	7,926 miles	→ $\frac{1}{2}$ Diameter, $\frac{1}{4}$ Volume
Tilt of Axis	25 degrees	23.5 degrees	→ Similar seasons
Length of Year	687 Earth Days	365.25 Days	→ Longer seasons
Length of Day	24 hours 37 minutes	23 hours 56 minutes	→ Nice for humans
Gravity	.375 that of Earth	2.66 times that of Mars	→ You can <i>walk</i> with that heavy space suite
Temperature	Average -81 degrees F	Average 57 degrees F	→ You'll need a space suit
Atmosphere	mostly CO_2 , some water vapor, $1/100^{\text{th}}$ pressure of Earth	nitrogen, oxygen, argon, water vapor, others	→ You'll need a space suit
# of Moons	2	1	→ 2x more romantic nights

What is the greatest challenge to humans living safely **LONG TERM** on Mars?

1. Cold temperatures.
2. Lack of Oxygen.
3. Low Pressure.
4. Lack of Magnetic field
5. UV radiation.



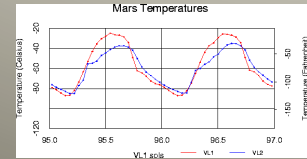
The 'seasons' on Mars and Earth



Earth's seasons are caused by the tilt of its rotational axis – (almost) ONLY
 On Mars, there is a similar tilt, but the orbit is not very circular or even.

Mars is closer to sun during Northern Winter.

The Northern seasons are milder while Southern seasons are more extreme.

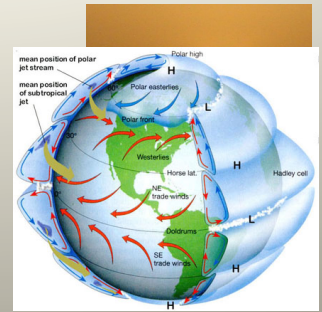


Daily temperature changes are extreme (here changing 100F from day to night) because of the thin atmosphere (weak greenhouse effect). The atmosphere on Mars is 1/100th that of Earth!

What drives Earth's Weather?

The same thing that drives Mars' weather: The Sun!

Equatorial regions on Earth heat up, driving hot expanding air up word. But meanwhile, the Earth rotates. This moves global flows depending on the latitude. At our latitude, our 'weather' comes from the West (westerlies).



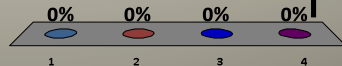
On MARS, the long summers melt ONE polar CO₂ caps. This INCREASES pressure overhead as more air enters the atmosphere.

At the same time, the other polar cap is so cold, the atmosphere above it is freezing out!

This sets up a huge **pressure difference** pole to pole, driving strong winds and dust storms back and forth, responding to the freeze/thaw of Mars' polar ice caps each year.

What color is the Martian sky (as seen from its surface)?

1. Black
2. Blue
3. Green
4. Orange



Like on Earth, the color of Mars's sky depends on weather and time of day

Normally, the dusty air casts a brown-orange color. If dust content is low, the sky may appear blue or even greenish, particularly when the sun is low. Yes, those are clouds of water vapor.



On the web you will find many sites who claim NASA has deliberately set the colors to make the sky look red-pink (and that its true color is blue).

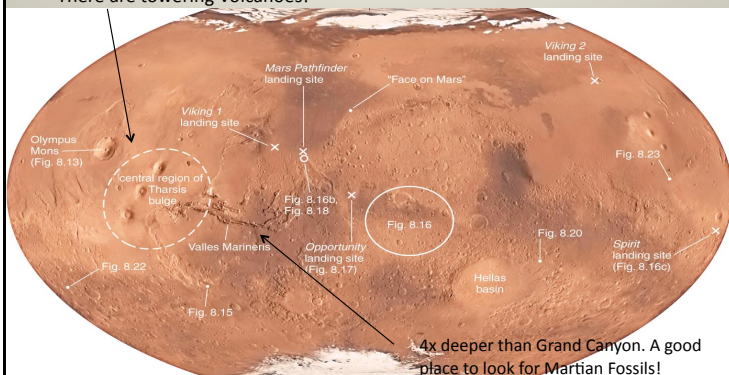
NASA does this, presumably, to hide that the images were taken in Arizona (standard conspiracy theory).

In truth: the sky is typically brown-orange, but can take on a bluish tinge at sunset.

Is Mars Geologically Active?

Mars is small, but there is evidence for activity:

- The N. hemisphere is clear of large impact craters.
- There are features characteristic of lava flows.
- There are towering Volcanoes!



Recall the Hawaiian Island chain. How would that hotspot look if the upper plate never moved?

1. It would plug up and stop producing lava
2. It would simply form a single normal island.
3. It would form a single island that was very large.

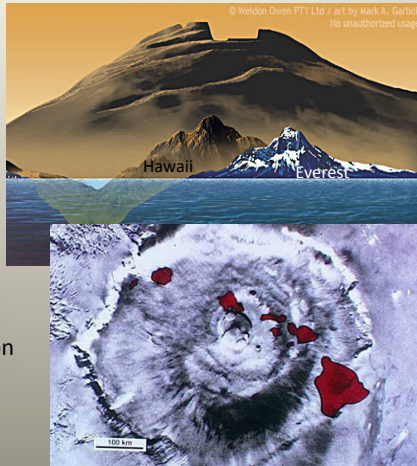
Behold! Olympus Mons!

- A 26 km high Volcano
- Hawaii, 9 km to seafloor
- Mt Everest, 8.9 km

WHY SO BIG?

- 1) No plate tectonics.
- 2) Gravity on Mars surface is 1/3 that on Earth.

Here is a top view comparison of Olympus Mons vs. the Hawaiian Islands.

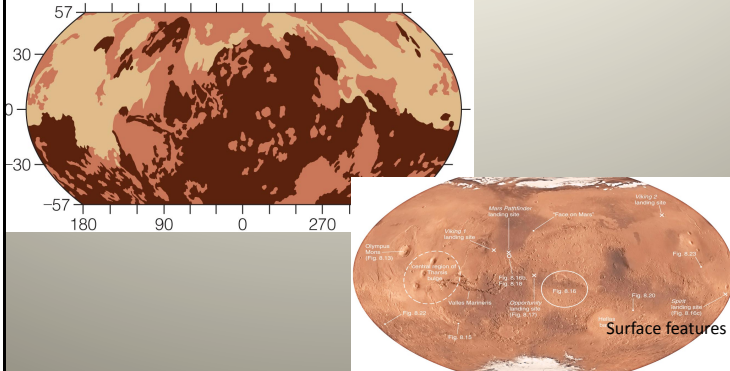


When you look at Mars's surface features what can you already tell?

1. Life can live there.
2. Its geological activity has declined.
3. There was once running water on its surface
4. Liquid water may exist below the surface

What happened to the Volcanism?

Dark areas: 4.6-3.8 B.Y.O. Pink areas: 3.8-1.0 B.Y.O. Tan areas: < 1.0 B.Y.O.



Surface geology indicates evidence of a decrease in volcanism dating already by 3.5 B.Y.O. However, Martian meteorites indicate molten lava ~ 180 M.Y.A. Maybe not dead yet.

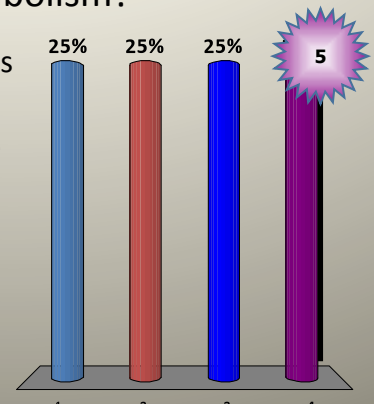
Why did Mars' overall geological activity decline with time?

1. It lost its magnetic field.
2. Collisions with early small planets released Mars' internal heat.
3. Mars' small size allowed it to cool more quickly.

End of class Quiz

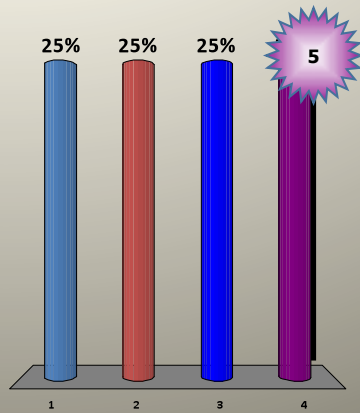
1. Which of water's unique properties increases bio-metabolism?

1. The broad range for its liquid state
2. The high temperature range for liquid state.
3. Its ability to dissolve salts.
4. Solid ice floats on liquid ice.



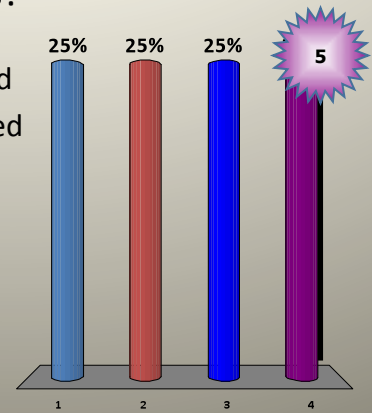
2. In which way are Mars and Earth similar?

1. Number of moons
2. Diameter
3. Chemistry of atmosphere
4. Tilt of axis



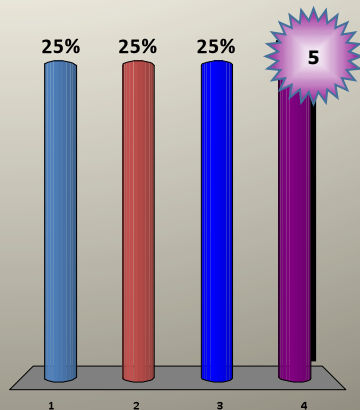
3. What does it mean if a surface region lacks impact craters?

1. The surface is very old
2. Fewer impact occurred there
3. The region has been resurfaced with lava
4. The impacts are too small to measure



4. Which is NOT evidence of Mars PAST geological activity?

1. Volcanoes
2. A magnetic field
3. Lava flows
4. Large regions lacking impact craters



5. Why does Mars have the largest volcanoes in the Solar System?

1. It is a small planet
2. It has two moons
3. The surface gravity is very low
4. It has no magnetic field.

