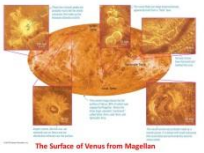
Mars & Venus: Just Down the Street

Of course, Mars & Venus are our nearest planetary neighbors and are more similar to Earth than any other bodies in the Solar System.



Your author does an excellent job covering the geology and surface features of both planets. In today's class, I want to concentrate on our explorations of these two planets and their very different atmospheres.

Our Exploration of Venus: there have been 38* space missions to Venus that have been fully or partially successful

(**LC:** in what year was the first spacecraft sent to Venus?)

(**LC**: If Venus is covered by clouds, how was Magellan able to map the surface of Venus?)

Our Exploration of Mars: there have been 43* missions to Mars that have been at least partially successful

(**LC**: in what year was the first spacecraft landed on the surface of Mars?)

(**LC**: what is humanity's success rate for Mars Missions?)

The most ambitious missions to date is the **Mars Perseverance Rover, landed 2021.**

How do you land such a large rover on Mars?

(Man, you really have to be in awe of those engineers!)

Perseverance Rover Overview and progress report.

Perseverance

New from Perseverance

Ingenuity

Sample Return

**Don't trust these numbers.*

The Atmospheres of Mars and Venus

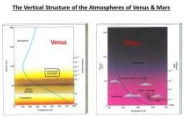
The Present Atmospheres of Mars and Venus:

	Venus	Mars
Composition	96% CO_2; < 4% N_2	95% CO_2; < 3% N_2
Average Surface Temperature	745 K (882°F)* (very little fluctuation)	223 K (-58°F)* (-220°F to 68°F)
Average Surface Pressure **(Earth at surface = 1 atmosphere)**	90 atmospheres*	0.01 atmospheres*

What would it feel like to stand on the surface of Venus or Mars?

- 882°F is almost 400°F hotter than a household oven
- *90 atm would be like being 3000 feet below the surface of Earth's ocean!*
- 68°F is about the temperature outside in Oxford right now.
  -220°F is colder than anywhere on Earth..
- *0.01 atm would be like being 125,000 feet above sea-level on Earth.*
  (Mt. Everest is ~29,000 feet; airliners typically fly at ~35,000 feet)

The above gives the conditions at the surface, like Earth, pressure and temperature depend on altitude too.

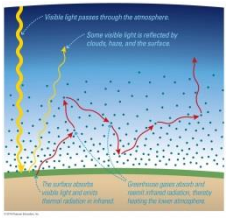


The most important question to ask is **"Why is Venus so Hot?"**

The Greenhouse Effect

Sunlight, mostly at visible wavelengths, warms the surface of a planet, but the planet cools by emitting infrared.

- The atmospheres of the terrestrial planets are fairly transparent for light at visible wavelengths.
- However, infrared is readily absorbed by certain molecules like CO_2, H_20, and CH_4 (methane)– Greenhouse gases
- Thus, the IR has a difficult time escaping to space, and this warms the planet further.



LC, what's significant about this temperature

The GHE raises the temperature of Earth above the freezing point of H_20

TABLE 7.1 The Greenhouse Effect on Venus, Earth, and Mars

World	Calculated "No Greenhouse" Average Surface Temperature	Actual Average Surface Temperature*	Greenhouse Warming
Venus	–40°C	470°C	510°C
Earth	–16°C	15°C	31°C
Mars	–56°C	–50°C	6°C

*The "no greenhouse" temperature is calculated by assuming no change to the atmosphere other than lack of greenhouse warming. For example, Venus has a lower "no greenhouse" temperature than Earth even though it is closer to the Sun, because the high reflectivity of its bright clouds means that it absorbs less sunlight than Earth.

Venus, Strong GHE

Earth, Modest GHE

Mars, Weak GHE

(GHE on Earth)

The Evolution of the Terrestrial Planets' Atmospheres

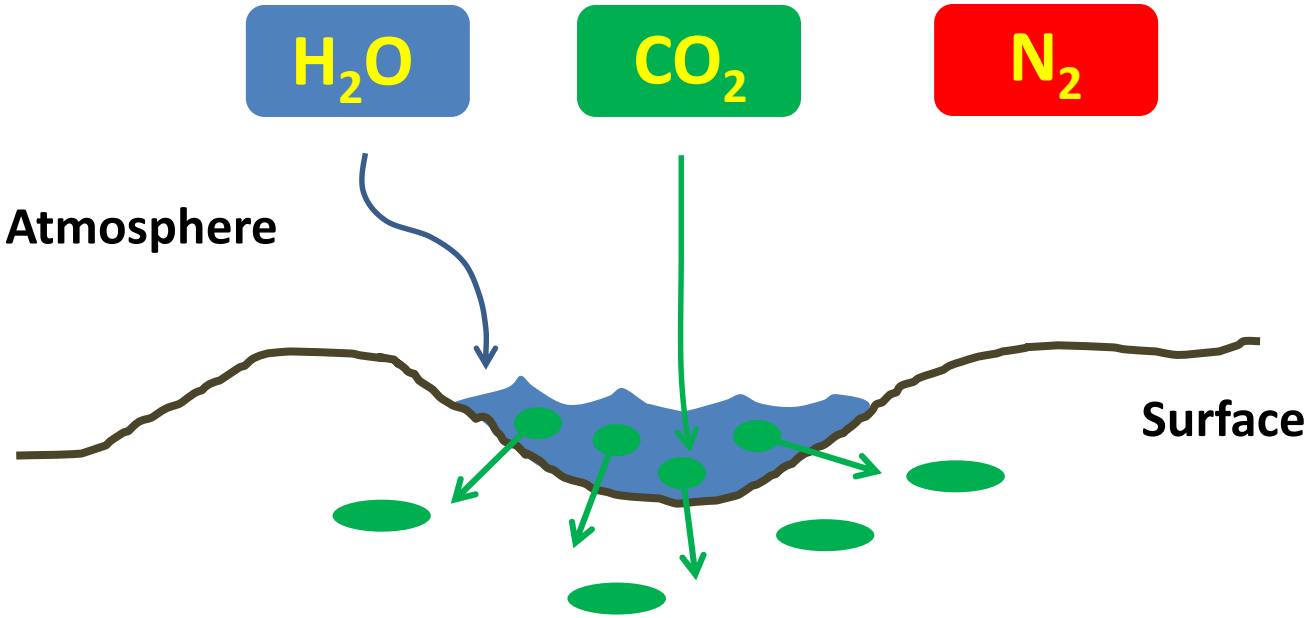
- **Now, we can perhaps understand why the atmospheres of Mars and Venus are as they are today.**

- **No matter how the terrestrial planets acquired their atmospheres, it is likely that they all started with the same gases (H_2O, CO_2, and N_2) in about the same amounts.**

- **But, they evolved into very different atmospheres – why?**

- **First, let's review what we did for the Earth's atmosphere, then we'll look at Venus and Mars.**

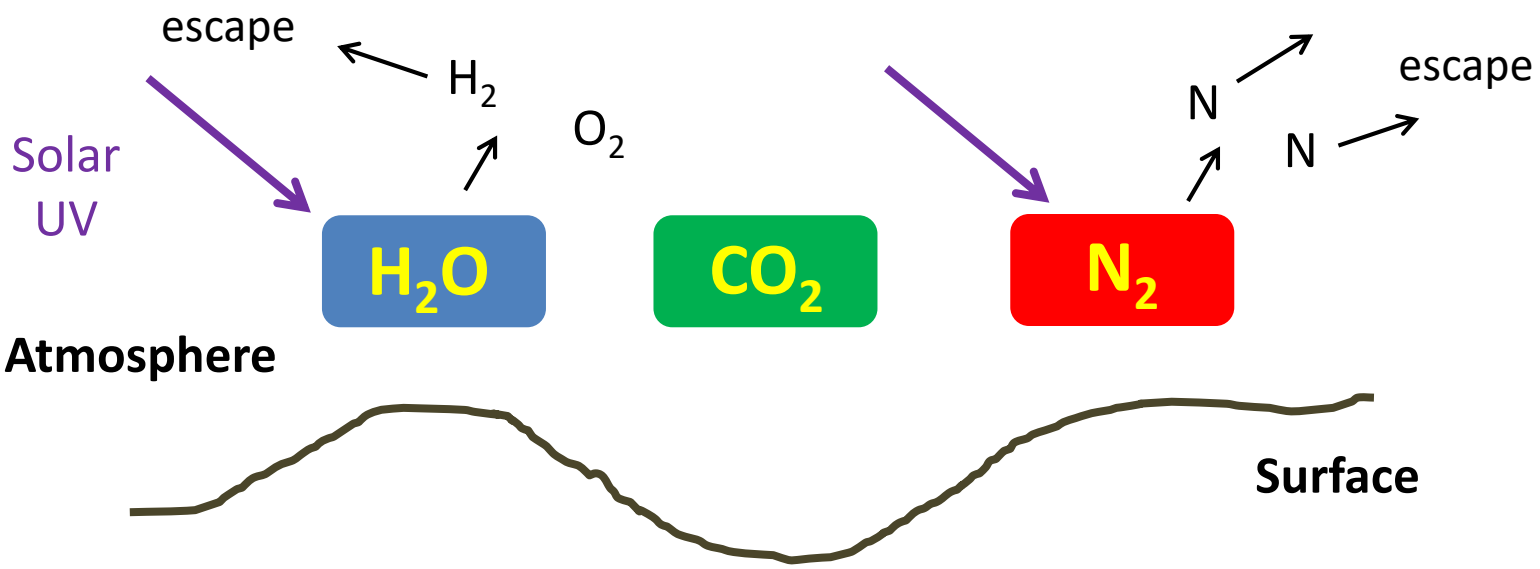
The Evolution of the Earth's Atmosphere



1. As the atmosphere cooled, H_2O condensed to liquid – most of the Earth's water is trapped in liquid and ice form.
2. Liquid H_2O dissolves CO_2. The CO_2 then precipitates into the surface forming carbonaceous rocks. Most of Earth's CO_2 is trapped in rocks below the surface.
3. We are left with an atmosphere of N_2, **but where did the free oxygen come from?**

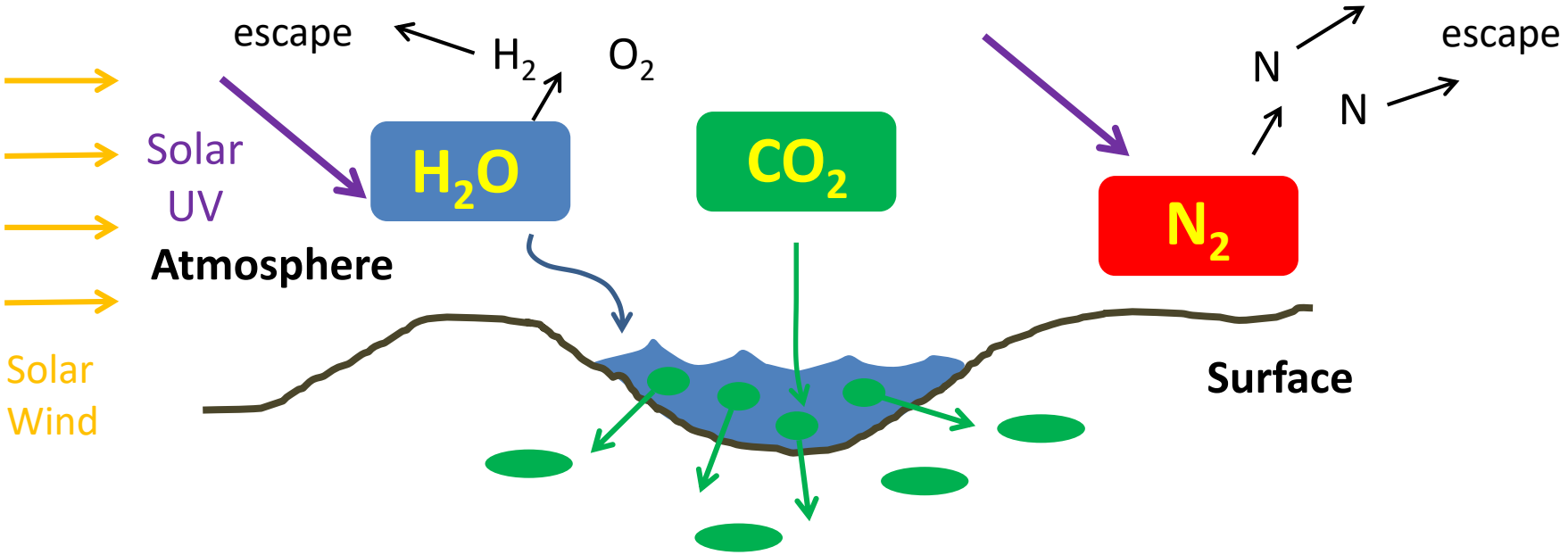
The O_2 is the product of 2 to 3 billion years of plant photosynthesis. This also provides an ozone (O_3) shield that absorbs solar UV.

The Evolution of the Venus' Atmosphere



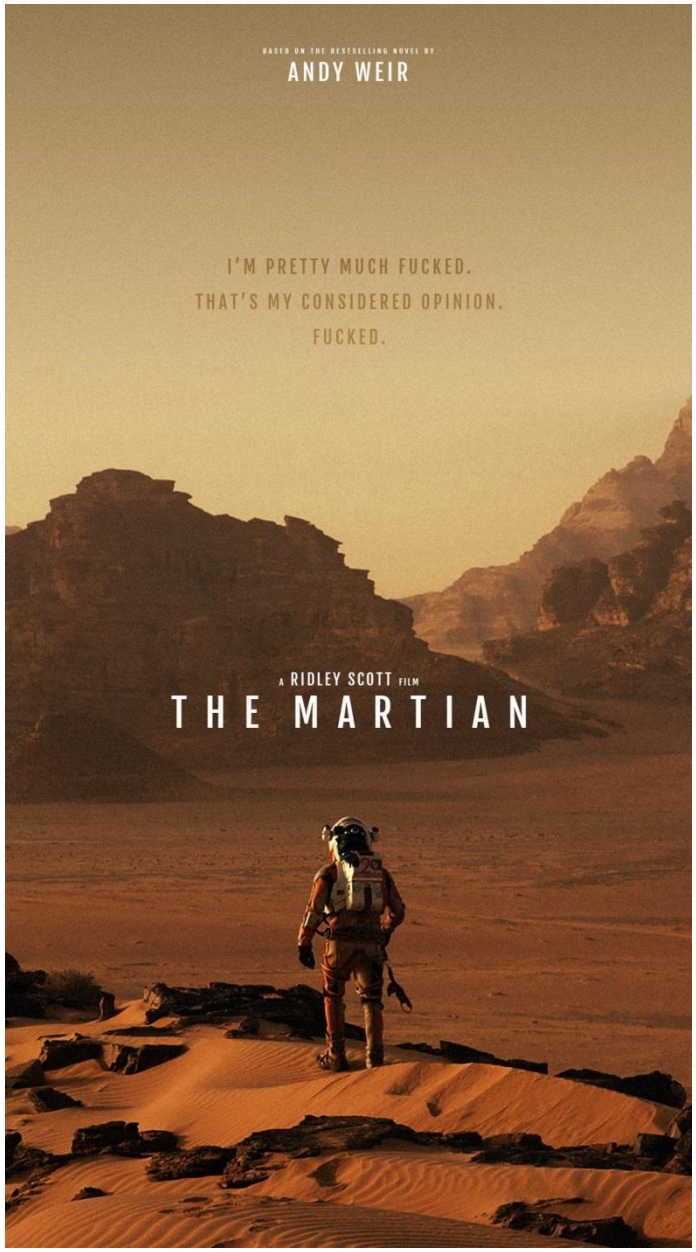
1. The atmosphere cooled, but it never cooled enough for lots of H_2O to condense.
2. Without liquid H_2O, the CO_2 stays in the atmosphere.
3. Solar Ultraviolet dissociates the H_2O and N_2; the Hydrogen and Nitrogen escape to space; the O_2 chemically combines with something else.
4. We are left with a very dense atmosphere (high pressure) of CO_2 and the resulting strong GHE that gives very high temperatures.

The Evolution of the Mars's Atmosphere



1. As the atmosphere cooled, H_2O condensed to liquid.
2. Liquid H_2O dissolves CO_2. The CO_2 then precipitates into the surface forming carbonaceous rocks *(this last part is controversial)*.
3. The loss of the GHE from the H_2O and CO_2 cools the planet below the freezing point of water. Solar UV dissociates H_2O and N_2
4. The weakening of Mars' magnetic field would allow the Solar Wind to slowly strip away most of the remaining gas *(this is controversial).*
5. We are left with a low density (low pressure) CO_2 atmosphere where the GHE is insufficient to raise the temperature significantly.

The Martian – Hollywood Style



For anyone with even a mild interest in Mars or Space Exploration, Hollywood has made a remarkable movie from Andy Weir's excellent book.

Just about everything in the movie is scientifically accurate, and it's a hell of a story . . . A bit like Apollo 13.

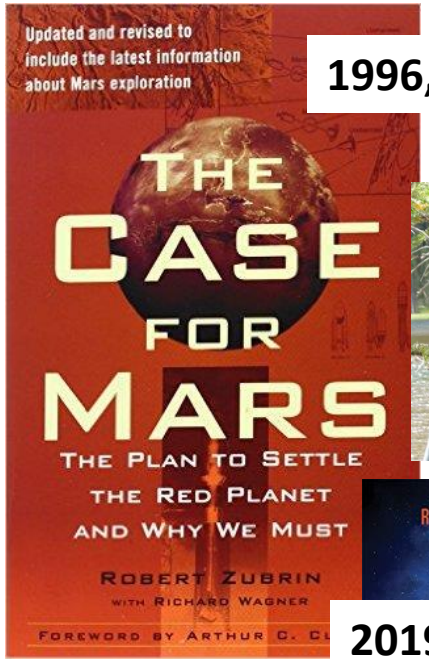
This is an excellent movie. If you've never seen it, I highly recommend it. It's available online for streaming.

Here's the Trailer

(they didn't put in what would be my favorite scene)

The Martian – Real World Style

Is anyone proposing sending people to Mars?



1996, 2011

2019

In the past, a manned mission to Mars has been proposed and abandoned several times. For the last 30 years, the leading advocate (and architect) for such a mission is **Robert Zubrin**. Unlike some of the newer proposals, Zubrin's mission could be achieved with existing technology. The video, **The Mars Underground,** describes his proposed mission, and is a summary of his excellent book. Many of the ideas in **The Martian** can be attributed to Zubrin.

Zubrin and the Mars Society have a video about their plans; here's the trailer:

Mars Underground

Currently, several private companies are in the early stages of planning. The best known is **SpaceX**, but it's quite unclear if this will work.

But, hey who knows, SpaceX has actual working rockets (that land) and spacecraft that carry people!

Space X's Starship