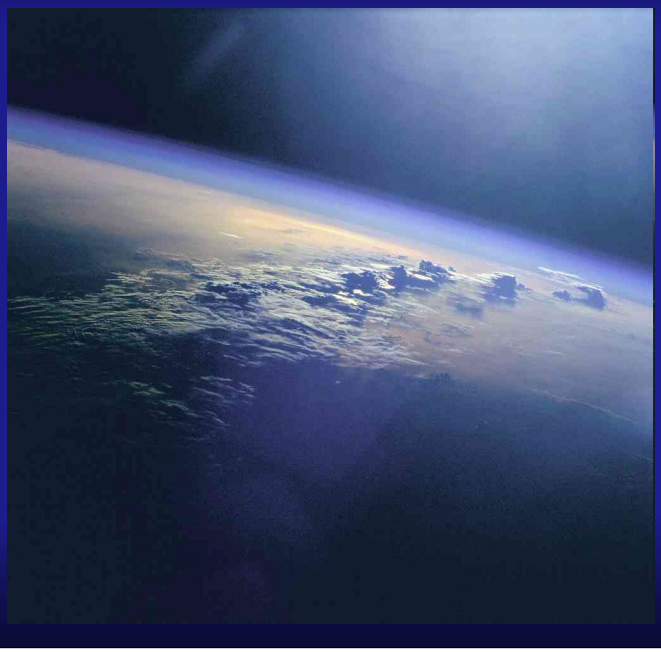
# Planetary Atmospheres



# Terrestrial Planets

# Venus

Completely cloud shrouded

Surface atmospheric pressure 100 times Earth's

Surface temp: 870° F

The PRIMARY reason for the extremely high surface temperature of Venus the accumulation of greenhouse gasses in the atmosphere.

Venus for some reason has an extremely thick $CO_2$ atmosphere that drives a runaway greenhouse effect.

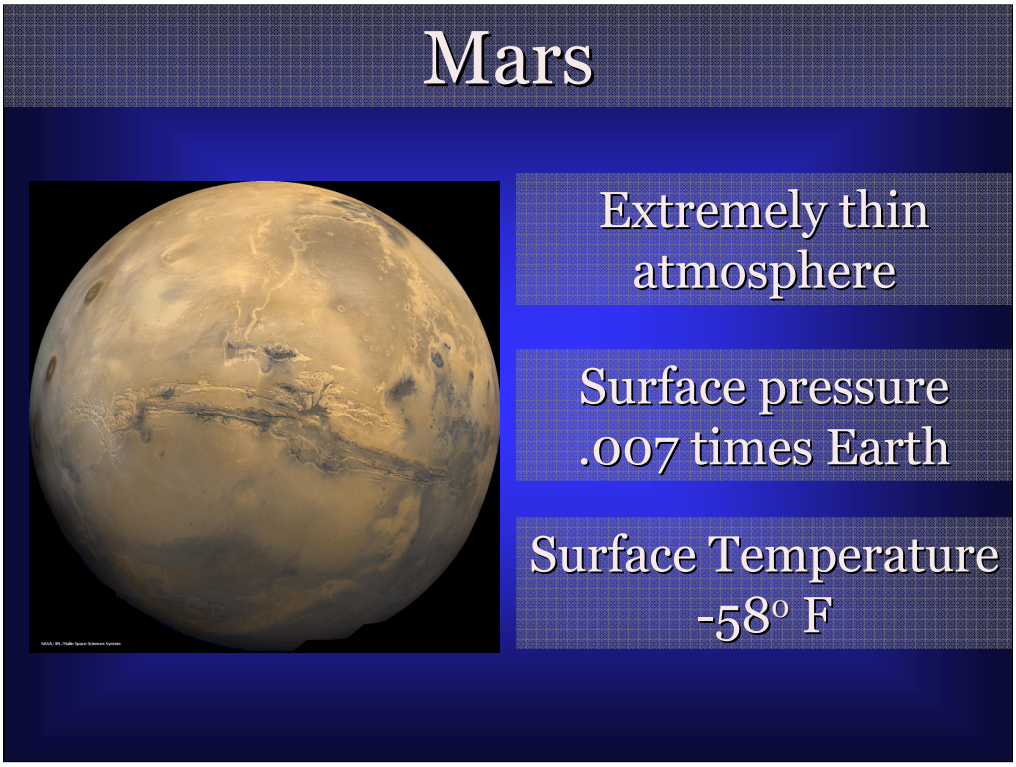
Venus was slightly warmer than Earth because it is slightly closer to the Sun.

This probably drove more $CO_2$ out of the rocks and into the atmosphere.

The extra $CO_2$ caused the temperature to increase driving more $CO_2$ out of the rocks.

And so on and so on and so on…

Could this happen to the Earth? YES! It could!




Mars has a very thin atmosphere, which is also primarily $CO_2$

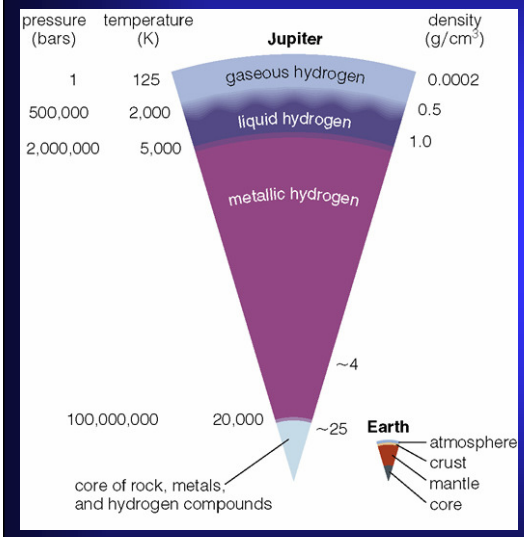
Where the atmosphere of Mars went is something of a mystery.

It must have HAD and atmosphere at some point in the past because there is ample evidence for liquid water.

It must be at least partially due to the small size of the planet so that it has a difficult time holding an atmosphere.

A leading hypothesis has impacts in the early solar system driving the atmosphere off.

# Jupiter




**No real 'surface'**

**Gaseous atmosphere**

**Liquid and metallic hydrogen interior**

**Earth sized core**

Temperature, density, and pressure all increase with depth

Jupiter's core is slightly larger than the Earth, but 10 times as massive and 5 times as dense due to the intense pressure from the material stacked on top of it

Metallic Hydrogen

Hydrogen molecules share the same electrons

Only one probe has been dropped into Jovian atmospheres

# Holding an Atmosphere

A bunch of Hydrogen gas (very light) and a bunch of Carbon Dioxide gas (very massive) are at the same **temperature**. Which has the greatest **velocity**?

A. Hydrogen

B. Carbon Dioxide

C. They have the same velocity.

A. Hydrogen

Temperature measures average Kinetic Energy.

So.. The kinetic energy of each gas is the same.

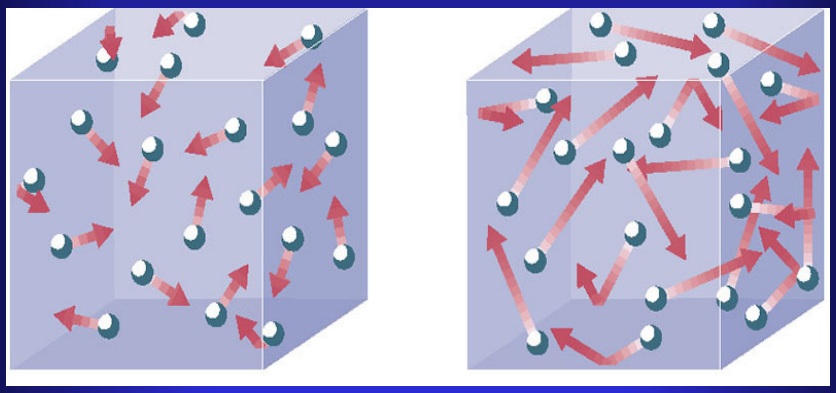
So, the velocity of the less massive gas must be higher.

# Kinetic Energy

Which has more Kinetic Energy?

A) Bowling Ball
B) Baseball
C) They have the same amount
D) Can't tell

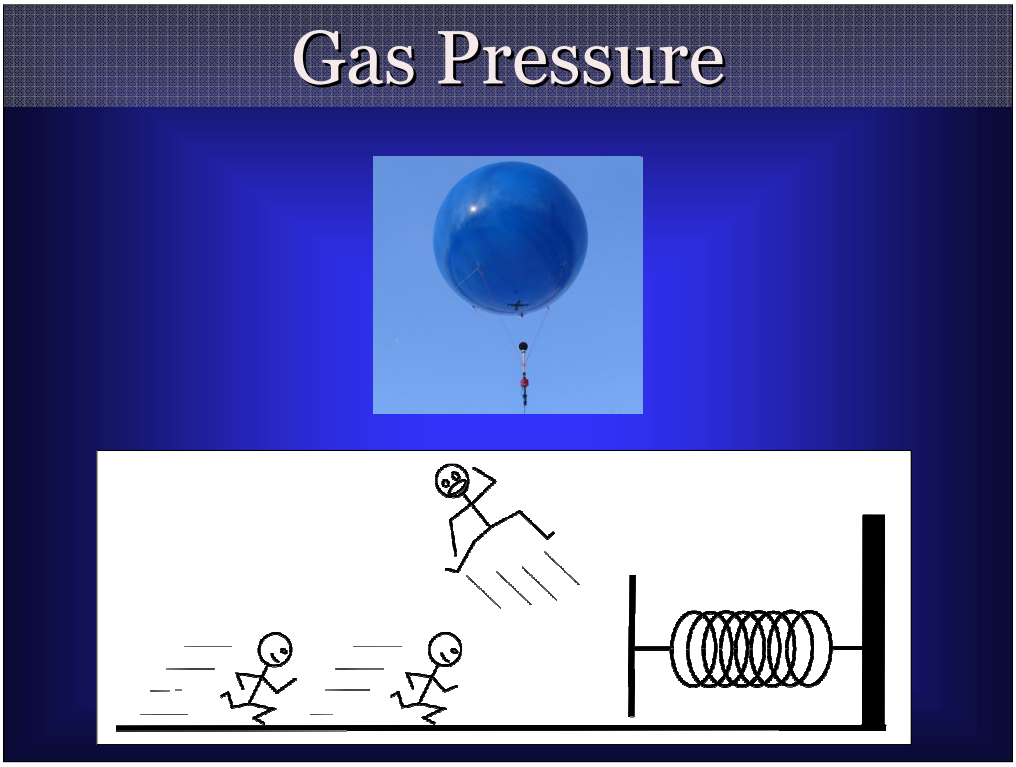
# Thermal Energy



**Temperature**:

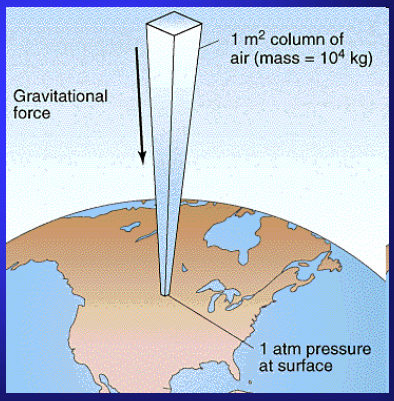
The average **kinetic energy** of a collection of particles

# Gas Pressure



Gas pressure is caused by collisions among the “particles” of gas.

# Atmospheric pressure




Air has mass.

Massive things in a gravitational field have weight, so the air presses down on us with some amount of force.

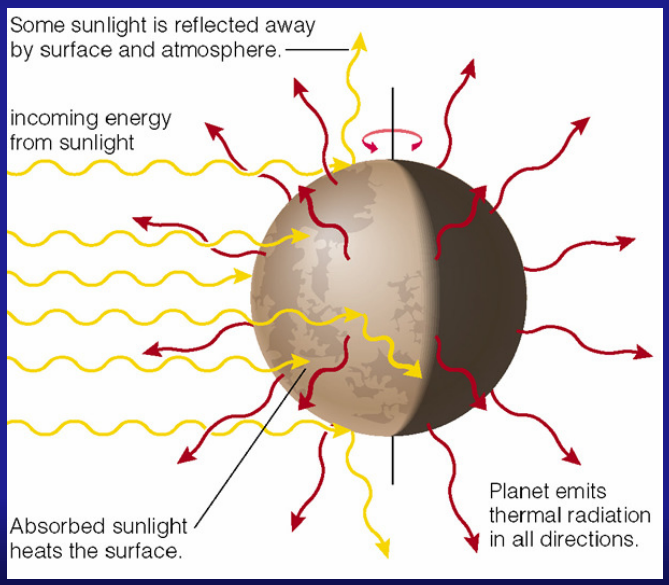
Something must be holding it up, or it would all collapse. That something is Pressure.

Pressure comes from the molecules in the air knocking into each other.

If I cool a balloon down, the internal pressure decreases and the balloon deflates.

The atmospheric pressure decreases with increasing altitude.

# Planetary Temperature




Incident solar radiation is absorbed and the planet heats up.

Everything that has a temperature emits *radiative energy*.

The hotter it is, the more energy it radiates.

Total incoming energy must equal total outgoing energy.

so the planet will heat up to an **equilibrium** temperature. This is called **thermal balance**.

Terrestrial planets emit **infrared** radiation.

Without an atmosphere, Earth would be about 50 degrees Fahrenheit (7 degrees Kelvin).
Venus should be about 145 F and Mars should be about -50 F

Actually, taking albedo (amount of solar radiation that is reflected back into space) into account, the Earth should be about -1 degrees F (-18 C)

# Planetary Temperature

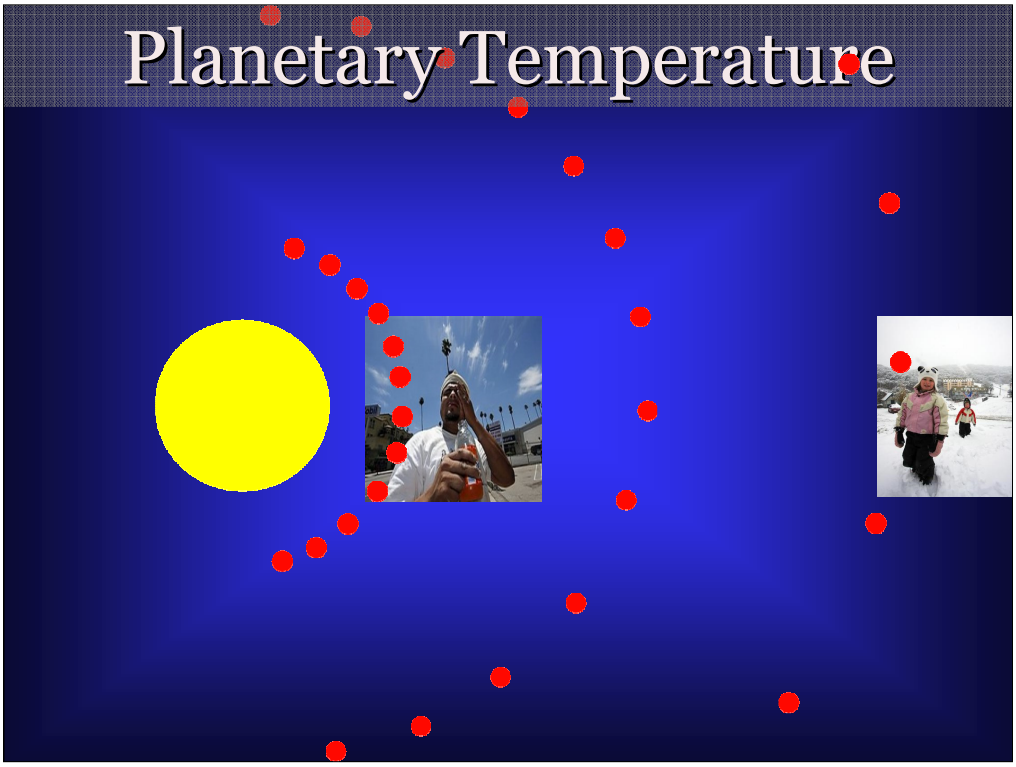
Imagine standing very close to the firehose versus standing far away from it.

If you are very close, you will get very wet because all of the water will hit you.

If you stand very far away, a lot of water will miss you and you won't get as wet.

For you to maintain the same "wetness" while the firehose is still on you, you have to evaporate

as much water as you are absorbing.

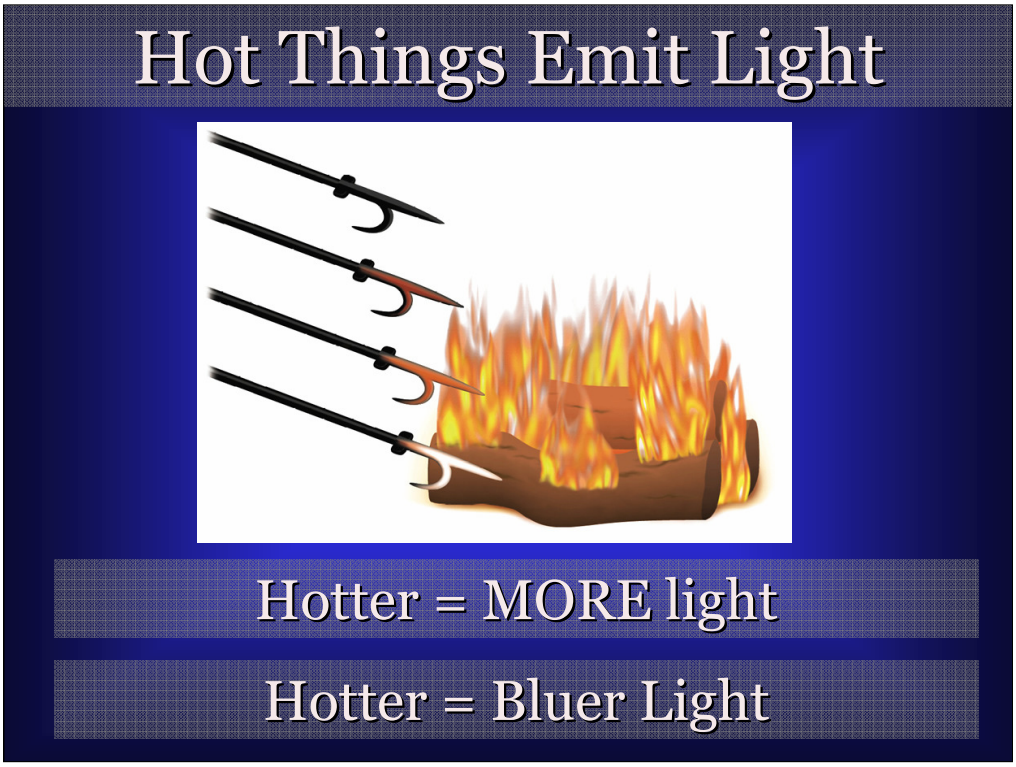



Light works much like the firehose.

Imagine the light particles are little ping pong balls called “photons.”

The Sun spits photons in all directions. If you are standing very close, you will intercept many photons

If you are far away, you will intercept fewer photons.

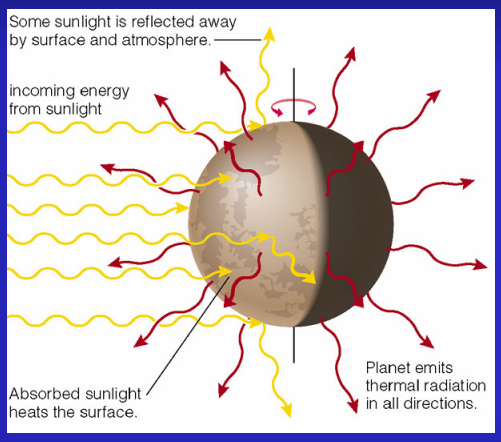



As things heat up, they emit MORE light
They also emit BLUER light.

Objects that are too cold to emit visible light emit other colors of light that are invisible to our eyes.

HOT is relative.  Anything with a temperature emits light.

# Planetary Temperature




Energy in = Energy out

Energy in equals energy out.

If we move a planet closer to the sun, it intercepts more energy.
It heats up until it's emitting as much energy as it recieves.

This is called Thermal Balance.

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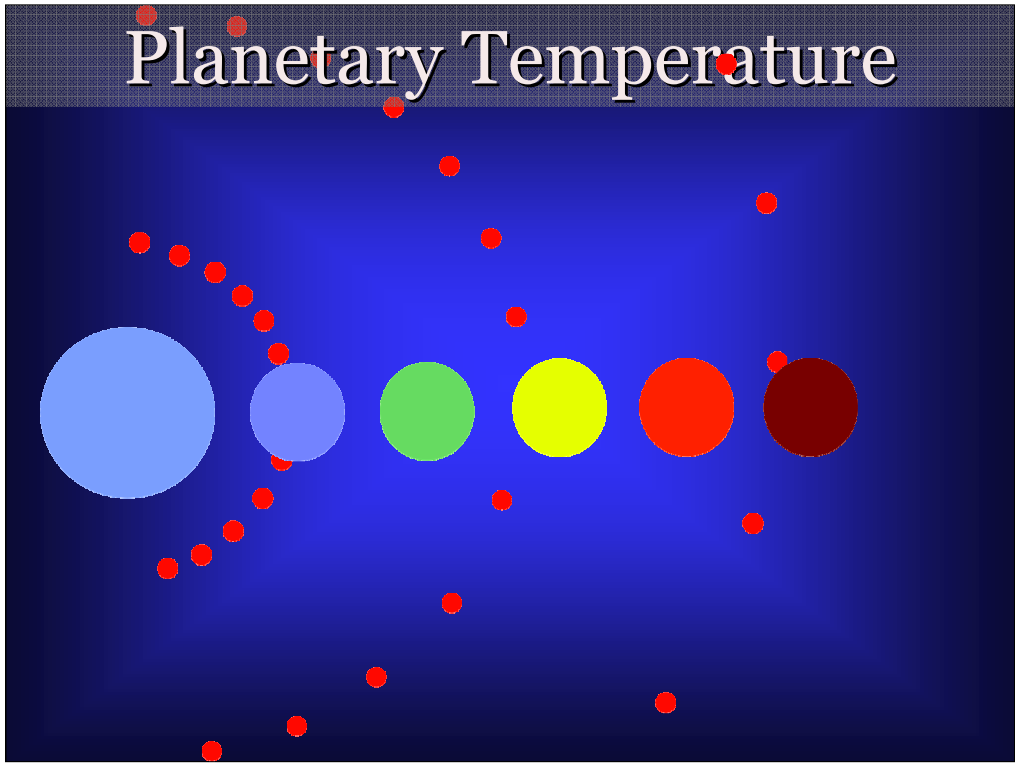
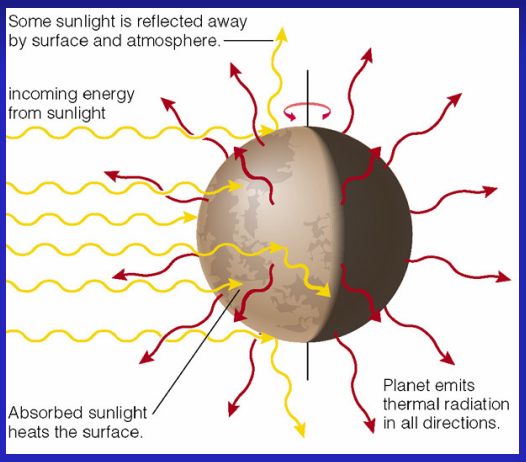



Planets close to the sun are hotter than planets far away.

They heat up so that they are radiating as much energy as they are receiving.

# Planetary Temperature

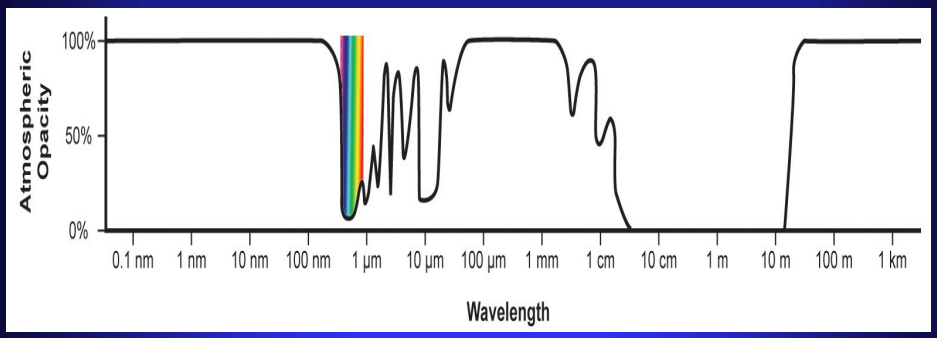



## Terrestrial Planets emit PRIMARILY Infrared light

The Sun emits PRIMARILY in the visible.

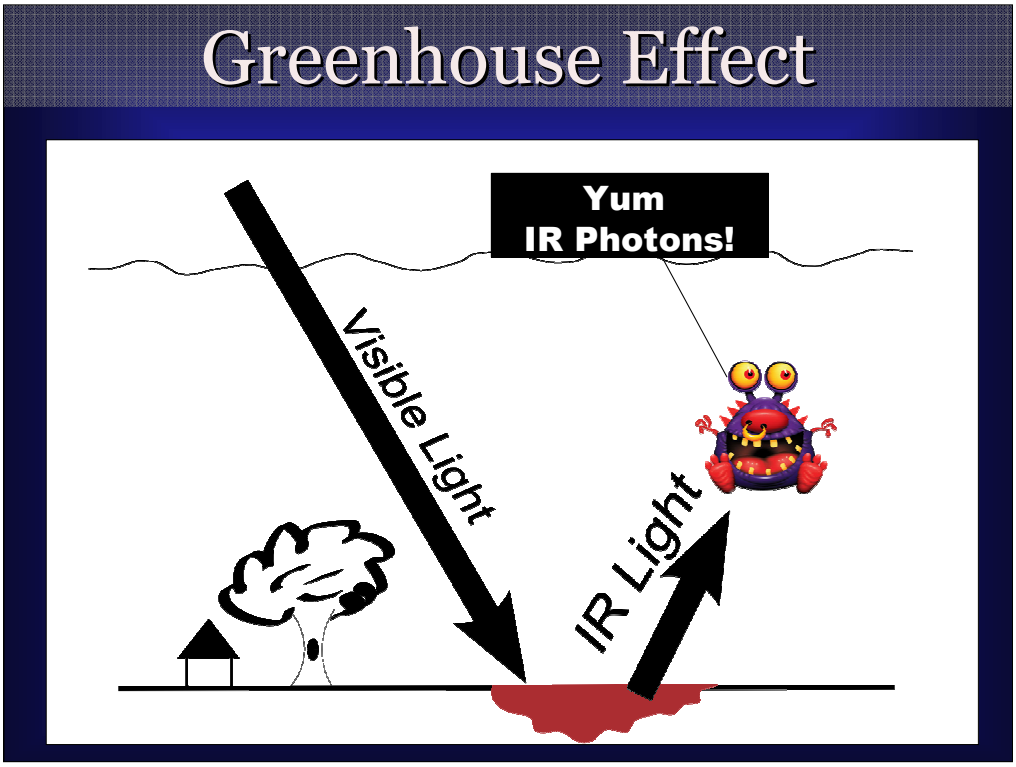
Terrestrial planets primarily emit **infrared** radiation.

# The Atmosphere




The atmosphere passes visible light

And absorbs infrared light




The greenhouse effect is, in general, a GOOD thing. Remember, without it the average global temperature would be -1 degrees.

Visible light passes through the atmosphere and is absorbed by the planet.

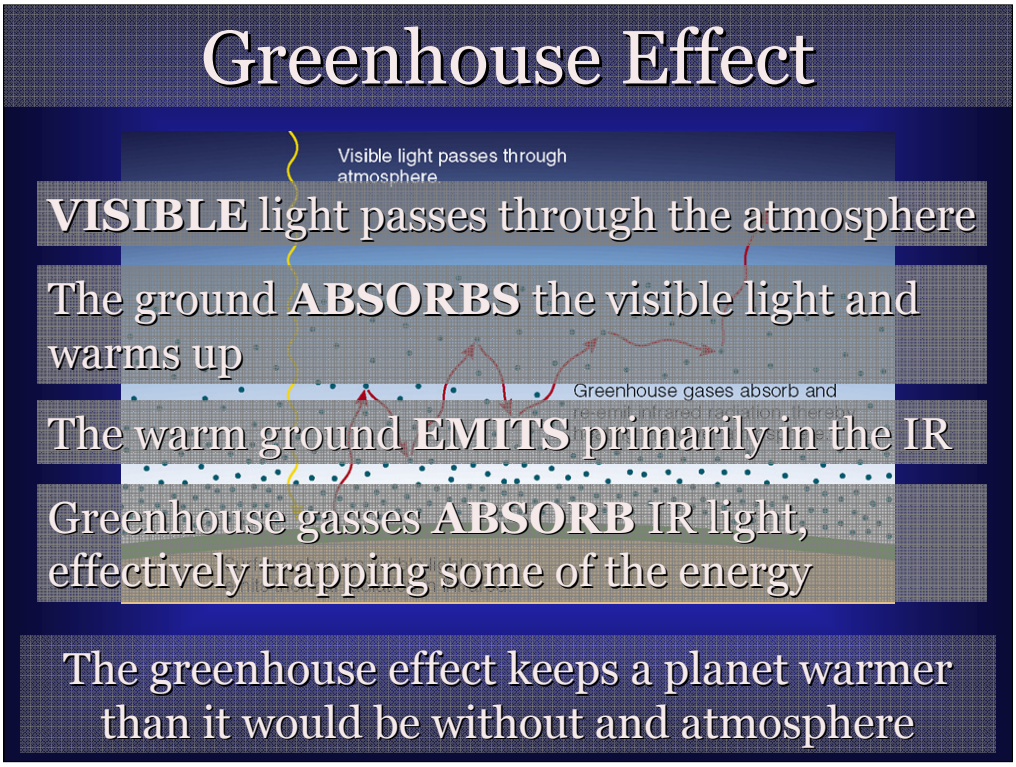
The planet responds by warming up.

The peak of the planet's blackbody (at 281 K) is in the infrared (around 10 microns)

Greenhouse gasses (such as $CO_2$ and water vapor) absorb infrared radiation raising the atmospheric temperature.

The atmosphere causes the planet to radiate less efficiently so it has to get hotter to stay in thermal balance.

The Greenhouse effect on Venus is whacky out of control. The surface temperature is nearly 900 degrees F.

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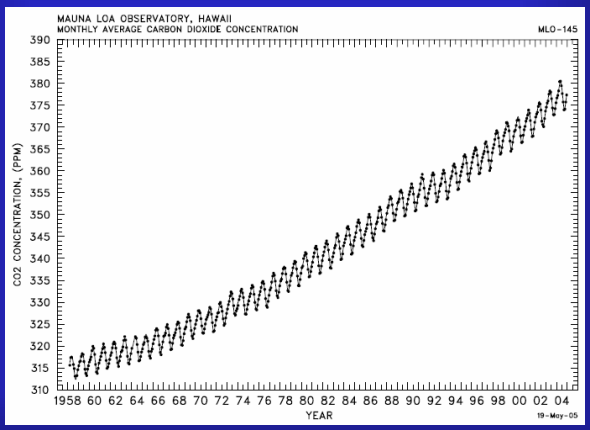
# Atmospheric $CO_2$




Rising carbon dioxide levels are not under dispute.

Nor is the fact that global temperature rises with increasing levels of carbon dioxide.

The average global temperature IS rising. That's a fact.

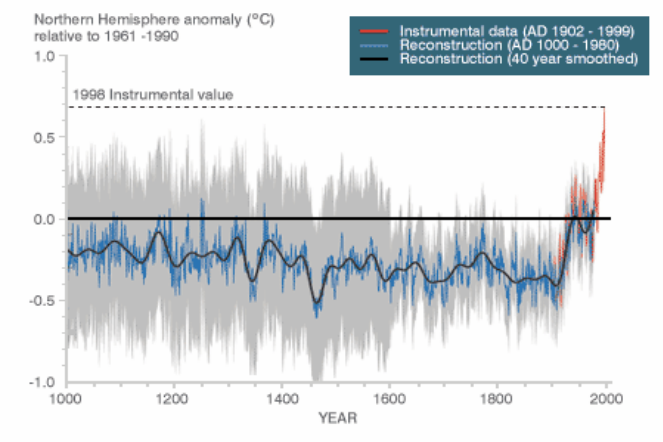
The question is why are co2 levels rising?

The ice shelf pictured above is the Larson B shelf in Antarctica.

The area that has shattered is several times the size of Rhode Island. (2700 square kilometers)

# Global Warming

## The 'Hockey Stick'



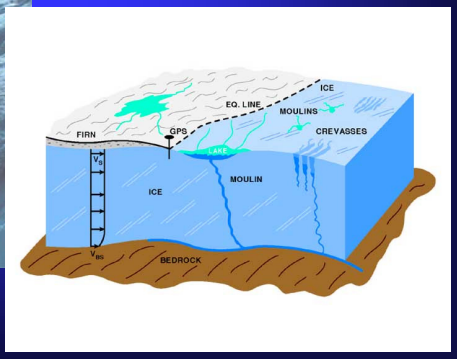

Past climate data (pre late 1800's) is reconstructed from tree ring growth and ice cores.

There is a lot of potential room for error in this type of analysis.

Shows a sharp increase in global average temperature since the industrial revolution.

This plot is somewhat controversial due to uncertainty of data based on tree rings and ice cores.

# Moulin




This is a moulin in Greenland.

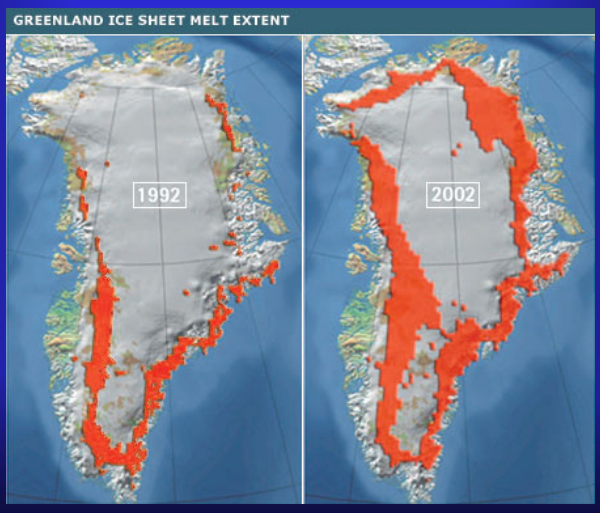
Moulin's are lakes of melt water that form on the surface of a Glacier.

The warm water works its way through the ice to the bedrock below lubricating the ice sheet.

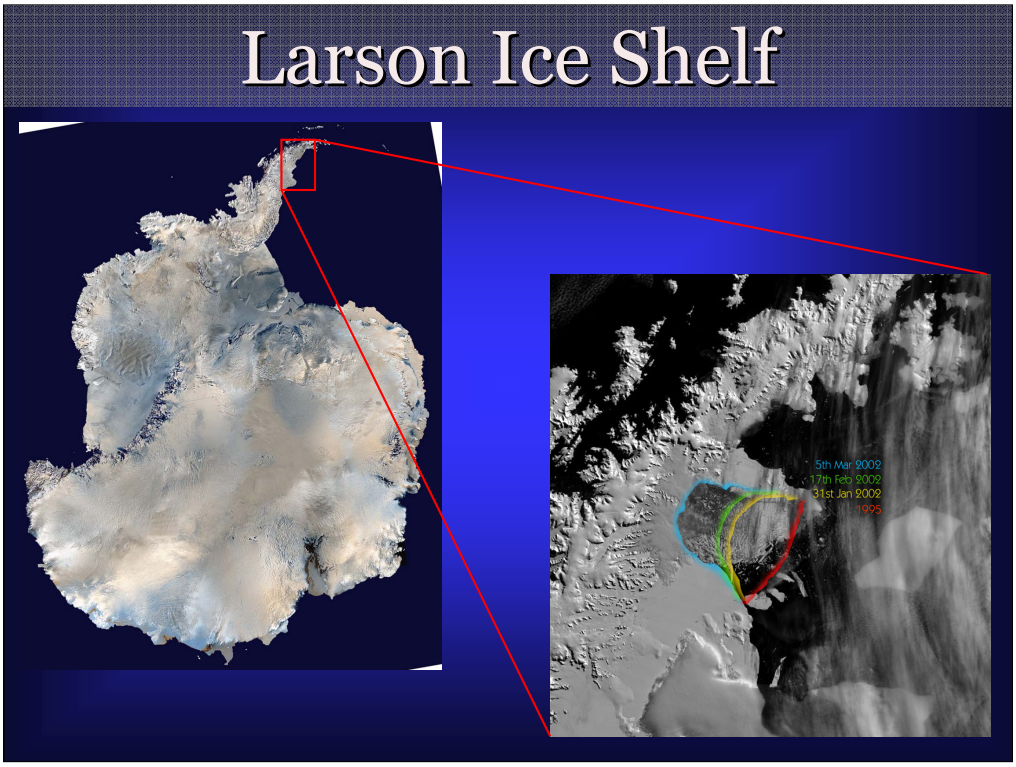
The ice sheet is then free to slide down and into the ocean.

# Greenland

## Greenland's ice would raise ocean levels 20 feet




Greenland's Ice sheets are melting.




The larson B ice shelf in Antarctica

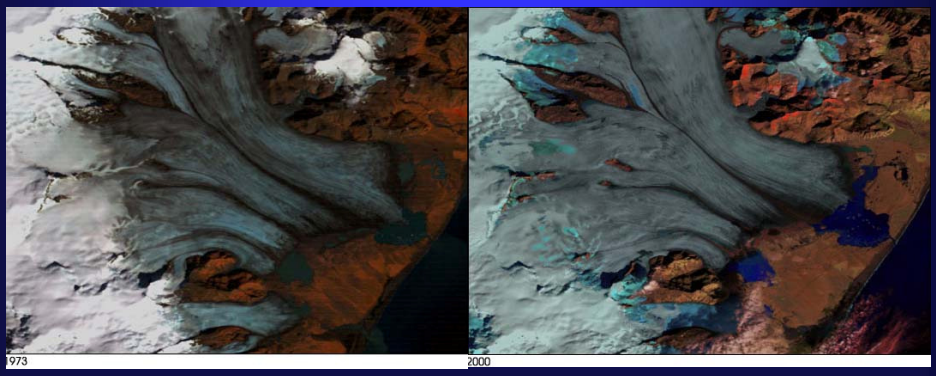
The ice shelf pictured above is the Larson B shelf in Antarctica.

A chunk about the size of Rhode Island disintegrated in 2002

# Breidamerkurjökull

This glacier in Iceland has receded 2km since 1973

1973 2000



# Pasterze Glacier


1875

2004

# Permafrost

Permafrost is melting in several areas.
The resulting bogs produce methane.

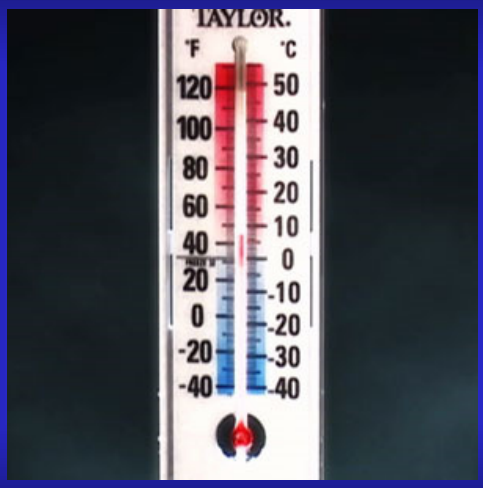

Denali Park, Alaska


Abisko National Park, Sweden

In the picture on the left, the gentleman is pointing to where the ground level used to be.
As the permafrost melts and the peat thaws, methane gas and carbon dioxide are produced.
The ground sinks eroding riverbanks and ruining roads and buildings.

In Abisko National Park, wetlands have increased by 50% since 1970.
The resulting mires have increased methane emissions by 2/3.

# Temperature




Measures average KINETIC energy