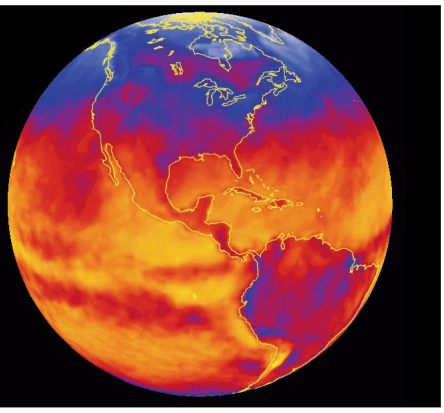
A Warm Planet in a Cold Universe

How the Earth stays warm and why it's getting warmer



Questions from Teacher Workshops (week 4)

Atmospheric Science
- What exactly do we mean by stability in the atmosphere and how does it relate to thunderstorms?
- What is a temperature inversion and how does that relate to what we are learning?
- How exactly are climate change and worsening storms related?
- Can people and other living things really change the temperature and pressure of the entire world?

Simple Climate Model
- Was a bit difficult to follow over zoom. Lots of moving tokens, but many folks lost the big picture.
- A video would be helpful to show the process and summarize the results.
- How do we make this relatable for younger elementary students?
- How does radiation absorption and emission relate to weather and climate?

Simulation
- Where exactly are temperatures calculated and recorded?

Space Fridge
- The space refrigerator is super cool. How does it relate to weather and climate again?

Cloud in a bottle
- Is there a way to emulate the cloud in a bottle activity without needing to use matches? Why does this activity not work when you add too much water?
- I want to know more about why dust/smoke is needed to make cloud particles condense. When I teach about the water cycle, I never make a point of discussing this....I just talked about evaporation, condensation, precipitation, etc. Should I be adding information about needed particulate matter to my instruction (for third graders)? Also, does the fact that there is more pollution in our world then lead to more clouds?
- Why does the air temperature increase with altitude in the stratosphere?
- What would adding food coloring do to the cloud?

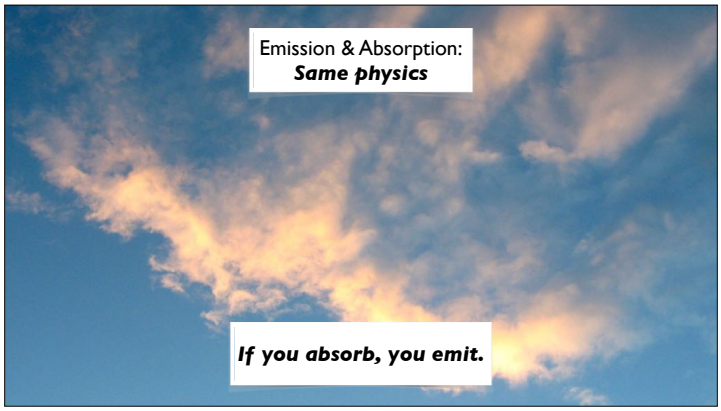
Frequencies

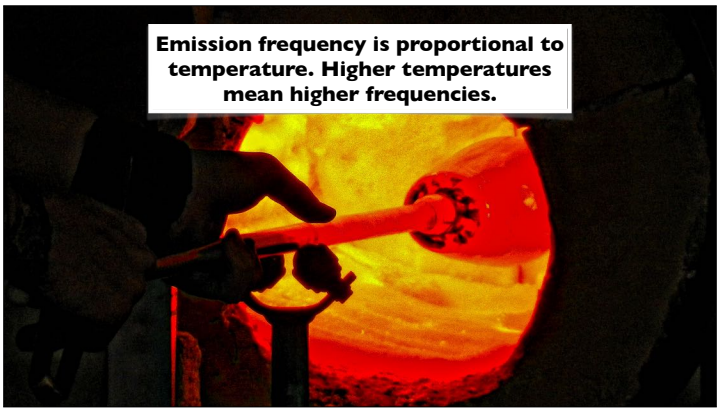
Description	Frequency (THZ)
Ultraviolet	1,000
Visible light	550
Near infrared	350
Thermal infrared	30

T = tera = 10^{12}

$$\frac{Q}{\Delta t} = e\sigma A T^4$$

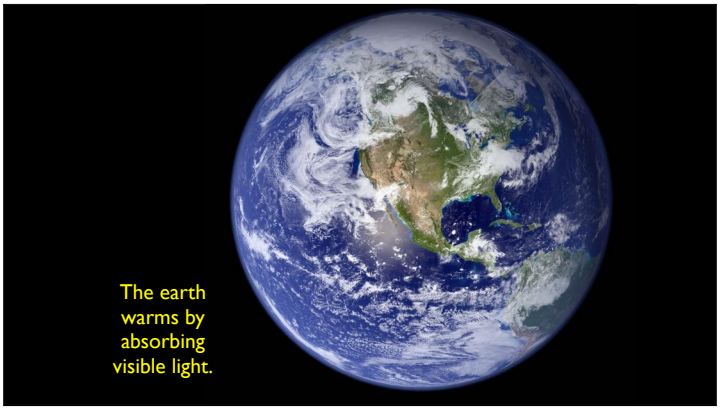
Rate of heat transfer by radiation at temperature T (Stefan's Law)

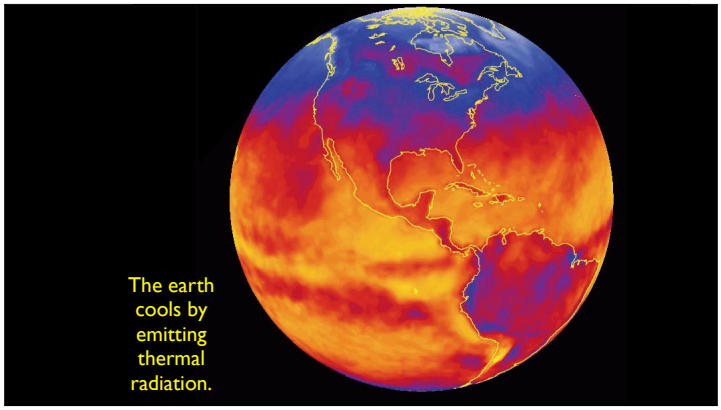


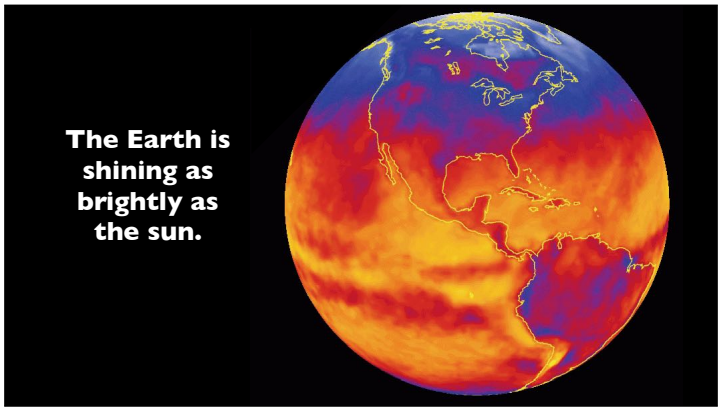


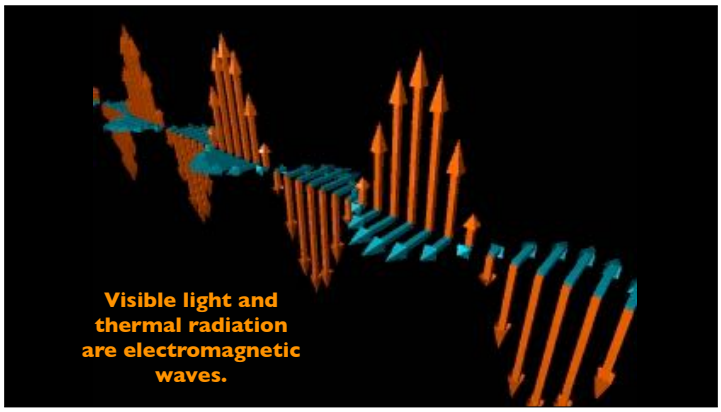
Frequencies

Description	Frequency (THz)	Temperature (K)	Object
Ultraviolet	1,000	10,000	Arc welding
Visible light	550	5,300	Surface of the sun
Near infrared	350	3,400	Light bulb filament
Thermal infrared	30	290	Surface of the earth









Electromagnetic waves interact with matter.

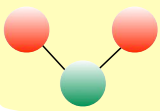
Does an electromagnetic wave interact with gas molecules?

Red=positive
Green=negative
Blue=neutral

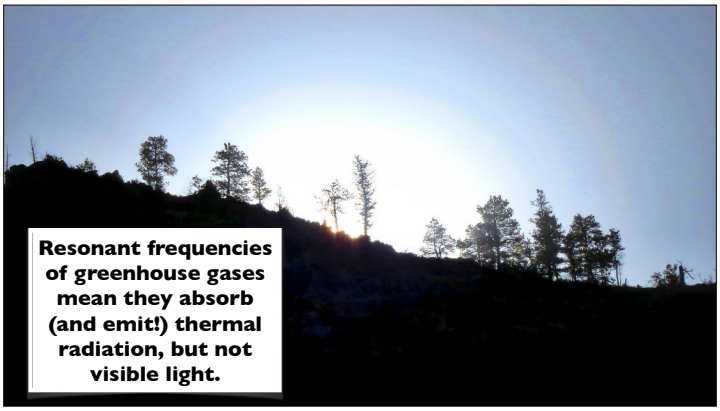
Nitrogen/Oxygen:
Nope.

Carbon Dioxide:
Yes.

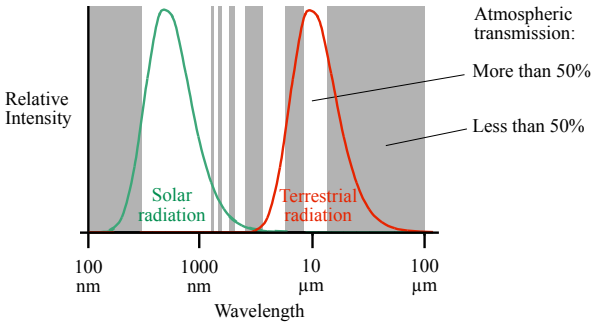
Water Vapor:
Oh Yeah.

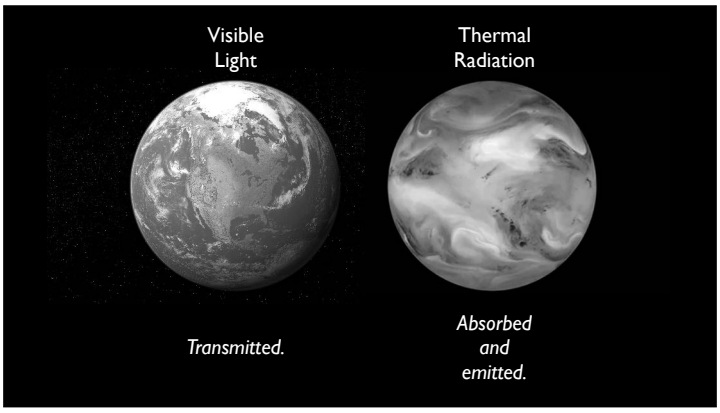


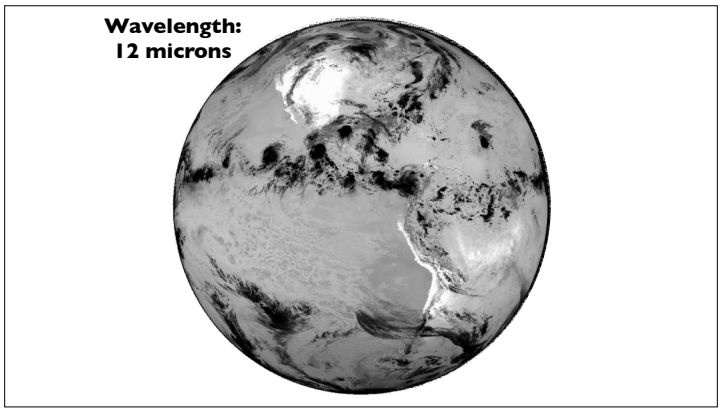
Greenhouse gases

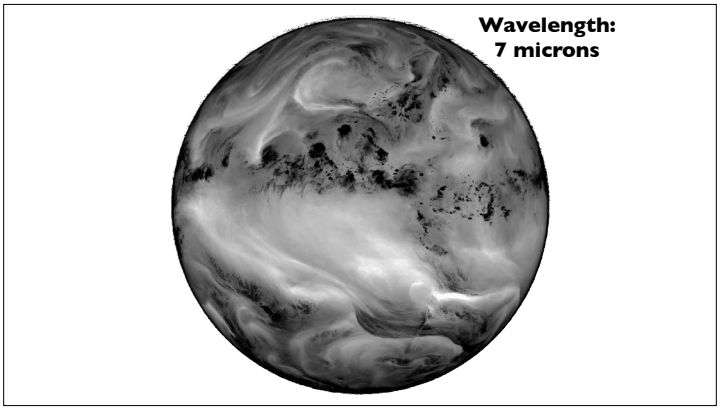


Atmospheric Transmission

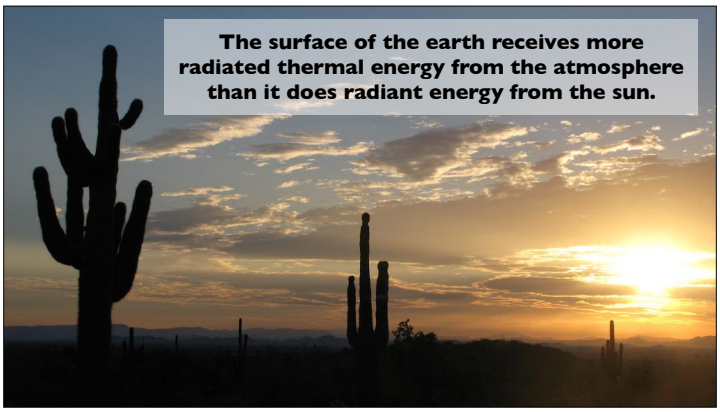



Visible
Light
Thermal
Radiation
Transmitted.
Absorbed
and
emitted.


Wavelength:
12 microns

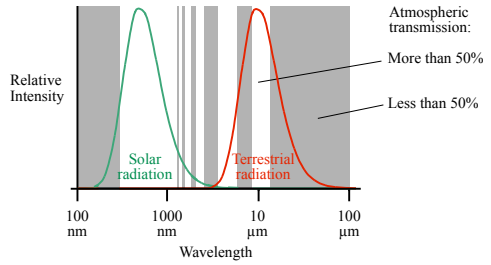

Wavelength:
7 microns


The sky is shining on you.

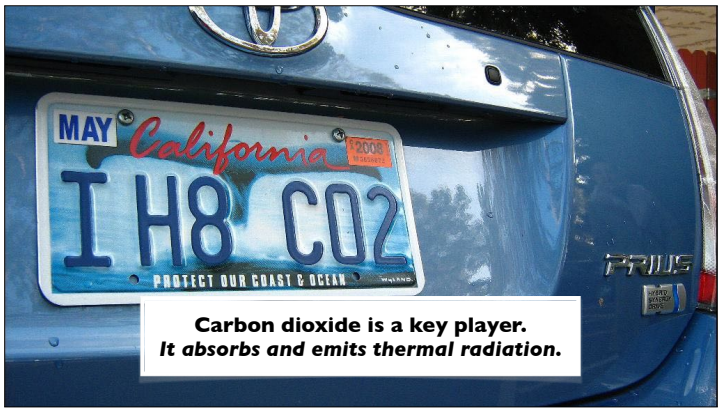

The surface of the earth receives more
radiated thermal energy from the atmosphere
than it does radiant energy from the sun.


The sun shines during the day.
The sky shines 24/7.

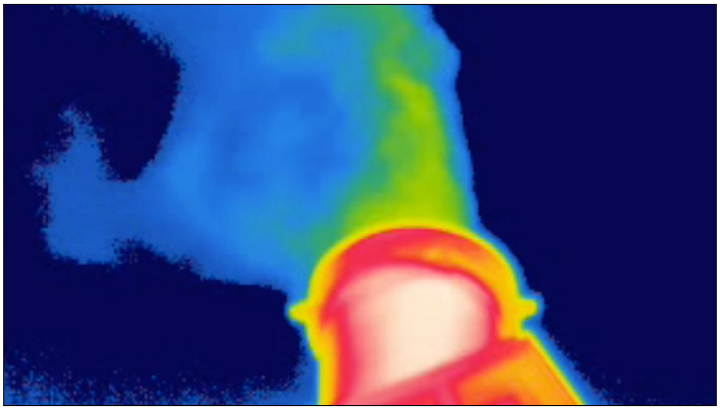
The Greenhouse Effect

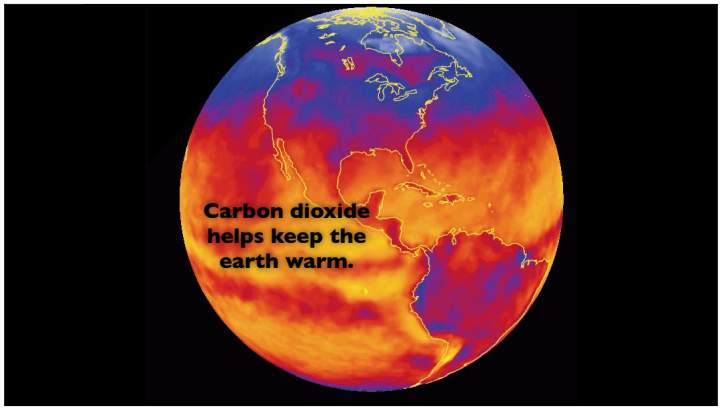


No atmosphere: -18°C (0°F)
With atmosphere: +15°C (59°F)

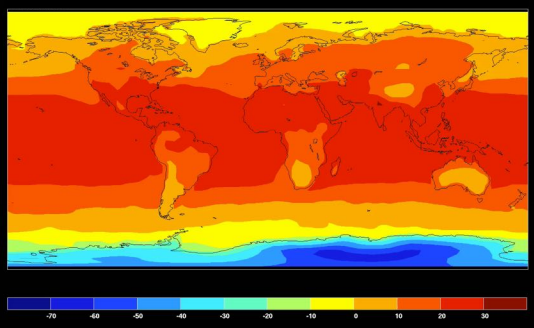


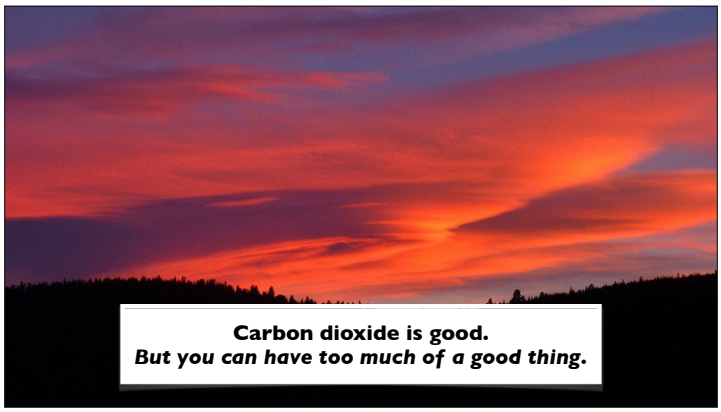
Carbon dioxide is a key player.
It absorbs and emits thermal radiation.





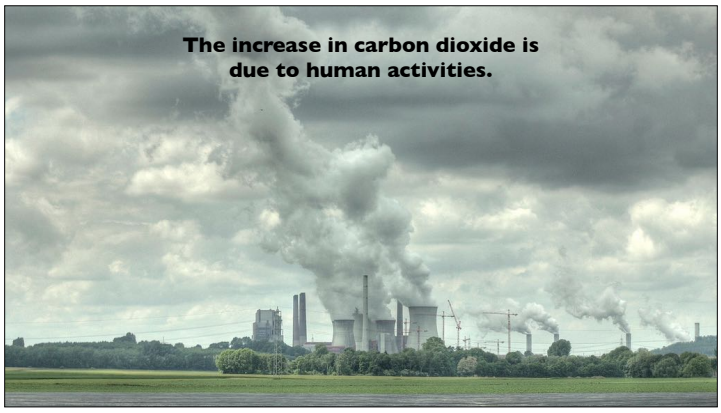
A no carbon dioxide future.





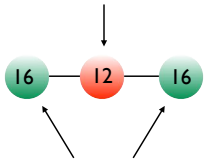
Carbon dioxide is good.
But you can have too much of a good thing.

Carbon dioxide in the atmosphere is increasing.



Burning 1 gallon of gas (6 pounds) produces 20 pounds of carbon dioxide.

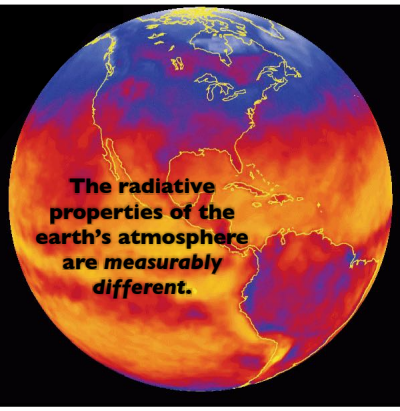
From the fuel

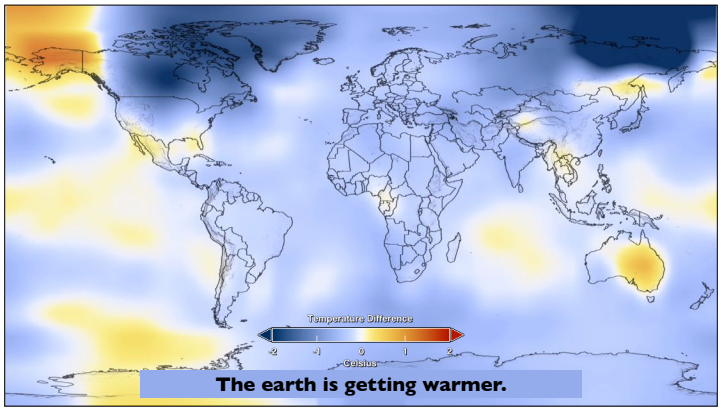


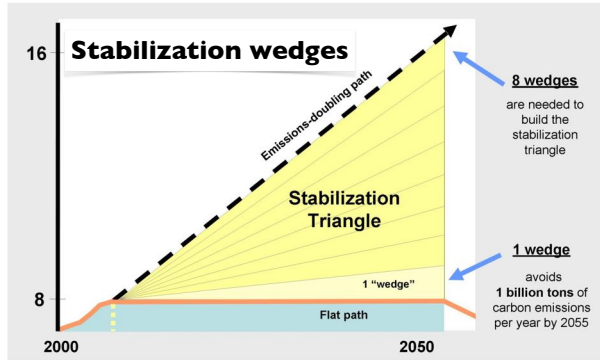
From the air

120 gallons per year

2,400 pounds of CO_2







Reducing Humanity's Carbon Footprint

Individuals can make changes, but significant reductions in greenhouse gases will mean making some changes, worldwide, of how energy is created, how land is managed.

To put the planet on a path of stable emissions, we need to, over the next 30 years, implement 8 of the following strategies. Each strategy involves tradeoffs. Which strategies do you pick?

Efficiency & Conservation

1. *Increased efficiency of cars*

GOAL

All cars in the world by must have a minimum fuel efficiency of 60 miles per gallon.

COSTS

This will require much more efficient engines and lighter weight vehicles.

Reducing Your Carbon Footprint

Each year, every person in the United States adds about 36,000 pounds of carbon dioxide equivalents to the atmosphere. Suppose you want to shrink your carbon footprint by 10%, a reasonable goal. To accomplish this, you'll need to make changes that remove 3,600 pounds of carbon dioxide equivalents from your carbon footprint annually.

So, what changes do you make? The following activities or products each contribute about 1 pound of carbon dioxide equivalents to the atmosphere. What can *you* do?

One pound of carbon dioxide corresponds to:

Electricity — one pound of carbon dioxide corresponds to approximately 1.1 kW-hr of electricity, enough for:

- 12 minutes of electric clothes dryer use
- 11 hours of TV use (HDTV)
- 18 hours of running a 60 W incandescent bulb
- 120 hours of running a 60 W-equivalent LED bulb (typically ~9 W)
- 340 hours of laptop use

Travel — one pound of carbon dioxide will get you:

This is the perfect capstone activity for a class on this topic.

Doing the activity

Before you open your bottle and pour your beverage, notice the engraving at the bottom of the glass.

Now, open the bottle, but pay attention as you do so, and explain the following observations

- Why is there a hiss when you open the cap?
- Why does a cloud form when you open the cap?

Now, pour your beverage into the glass. Pour slowly down the side to make as little foam as possible. Once things have settled, set your glass down and explain the following observations:

- Where are the bubbles forming? Why do they form here?
- As the bubbles rise, they get bigger. Why? (Note: There are 2 reasons.)
- As the bubbles rise, they get farther apart. Why?
- The glass "sweats". Where does this water come from?
- As the glass "sweats", does this tend to warm up the glass or cool it down?

Once you have completed your observations, please dispose of the contents of your glass in a responsible manner.

For those looking for further experimentation, here are a couple of ideas:

- If you have a dark beer, the beer is dark, but the foam is light. Why?
- If you have a nitro beer, you'll notice that, right after pouring, the bubbles on the outside of the glass move downward. What's that about?

Summing up

Necessary materials:

- Glass, ideally with nucleation sites etched into the bottom.
- Beer or soda, ideally in a glass bottle. If the beer or soda is too dark, some of the phenomena will be hard to see.