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2025/26

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TEACHER NOTE - This is an example of what a 7th grade student's Table of Contents *might* look like. Because each student's individual work habits are unique, however, the dates, titles, and page numbers may vary.

CRYSTALLIZATION LAB

BACKGROUND

We learned that when magma cools it can form different types of igneous rock. We also learned that what determines the type of igneous rock formed when magma cools is BOTH the mix of elements in the magma AND how quickly it cools.

What if we take tiny samples of magma and put it on glass slides kept at different temperatures (e.g., -18°C, 25°C, 60°C)? Can we then form different types of igneous rock? Because real magma is hotter than 1000°C, we will use an imitation magma called “salol” which turns from a solid to a liquid--just like magma--but at a much lower temperature (50°C).

CONCLUSION

How this lab relates to our Driving Question...

Our Research Question (RQ) for this investigation was: What is the effect of the temp at which magma is allowed to cool on the size of the magma crystals formed? Our data (our drawings, our photos) shows a CLEAR relationship between our two variables. **As the temperature at which our magma was allowed to cool INCREASED (from -18° to 25° to 60° C) the size of the crystals formed INCREASED.**

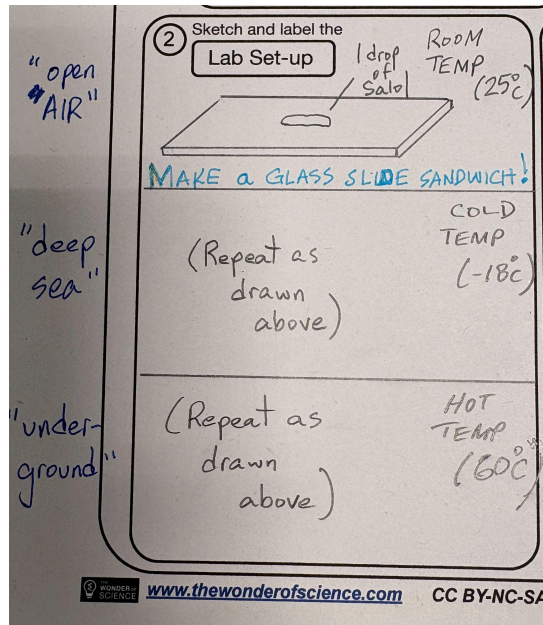
- This means that magma which comes out of the Earth’s crust and cools in the deep ocean (where it’s quite cool/cold) will form SMALLER sized crystals.
- In the air outside of a volcano...BIGGER sized crystals than the deep ocean.
- Deep underground near a magma chamber...EVEN BIGGER sized crystals than the air outside of a volcano.

PLANNING and CARRYING OUT INVESTIGATIONS (Handout)

1. RESEARCH QUESTION

- What is the effect of **the temperature (°C) at which magma is allowed to cool** on **the size of the magma crystals formed**?

2. LAB SET-UP



3. INDEPENDENT VARIABLE (IV)

- The temperature (°C) at which magma is allowed to cool**

4. DEPENDENT VARIABLE (DV)

- The size of the magma crystals formed**

5. CONSTANTS (aka. CONTROLLED VARIABLES)

- The amount of magma added to each glass slide = THE SAME (1 drop)
- The thickness of the glass slides = THE SAME
- The position of the magma drop on the slide = THE SAME (in the middle)
- The size of the dropper = THE SAME
- The length/width of the glass slide = THE SAME
- The same power (magnification) of the hand lens = THE SAME
- The length of time the magma is allowed to cool before viewing = THE SAME

6. DATA

Figure 6.1: Crystallization results drawings provided by Student 2B

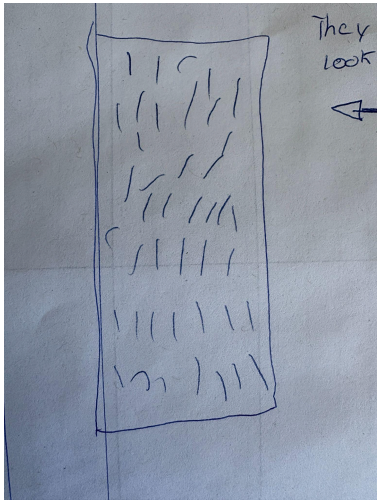
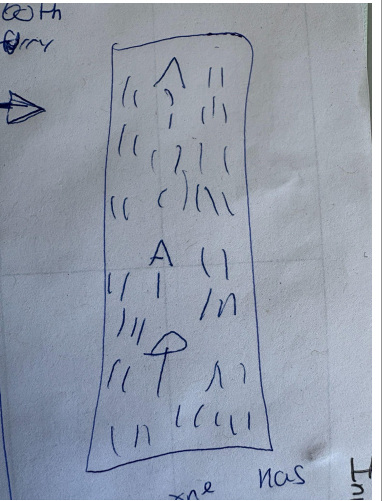
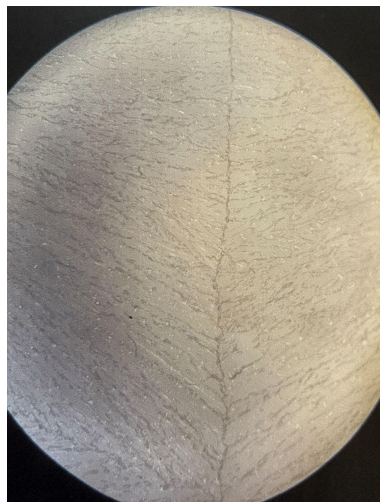
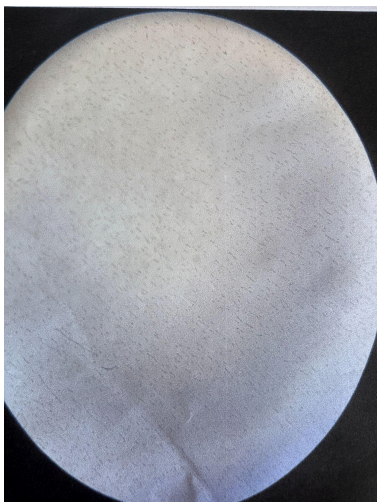
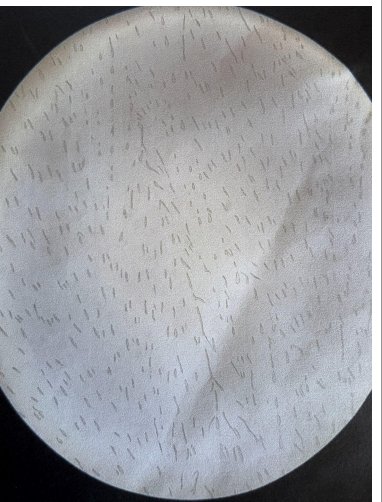
Cold (-18°C)	Room temp (-25°C)	Hot (-18°C)
		
Magnification: 20x or 40x?	Magnification: 20x or 40x?	Magnification: 0x, 20x, 40x?

Figure 6.2: Crystallization results photos provided by Student 8B

Cold (-18°C)	Room temp (-25°C)	Hot (-18°C)
		
Magnification: 20x or 40x?	Magnification: 20x or 40x?	Magnification: 20x or 40x?

Magma (salol) crystallization results provided by [Coda Science](#)

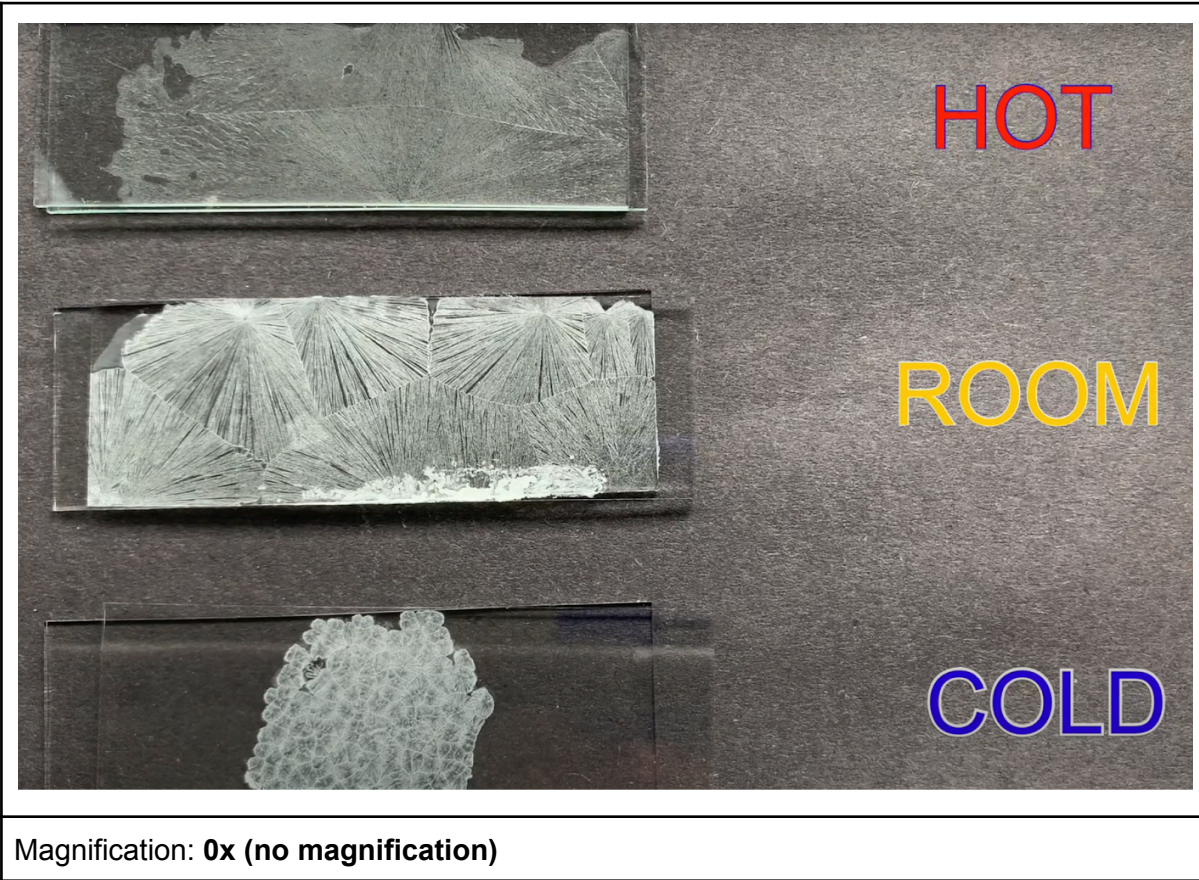
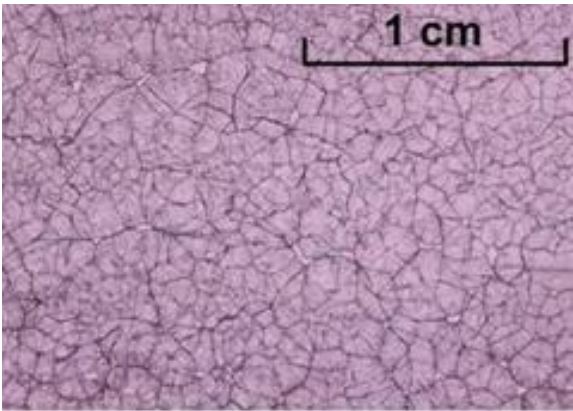
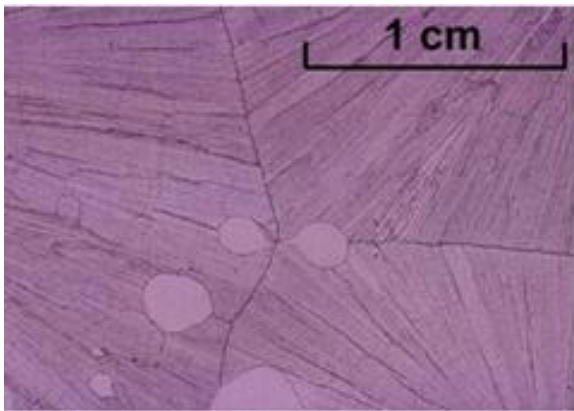


Figure 6.4: Crystallization results provided by [Geoff Pignotta](#)

Cooler temperature	Hotter temperature
	
Magnification: 20x or 40x? (But a “scale factor” is provided so that you can compare the images and thus compare	Magnification: 20x or 40x? (But a “scale factor” is provided so that you can compare the images and thus compare

the size of the crystals!)

the size of the crystals!)

Figure 6.5: Crystallization results provided by [Coda Science](#)

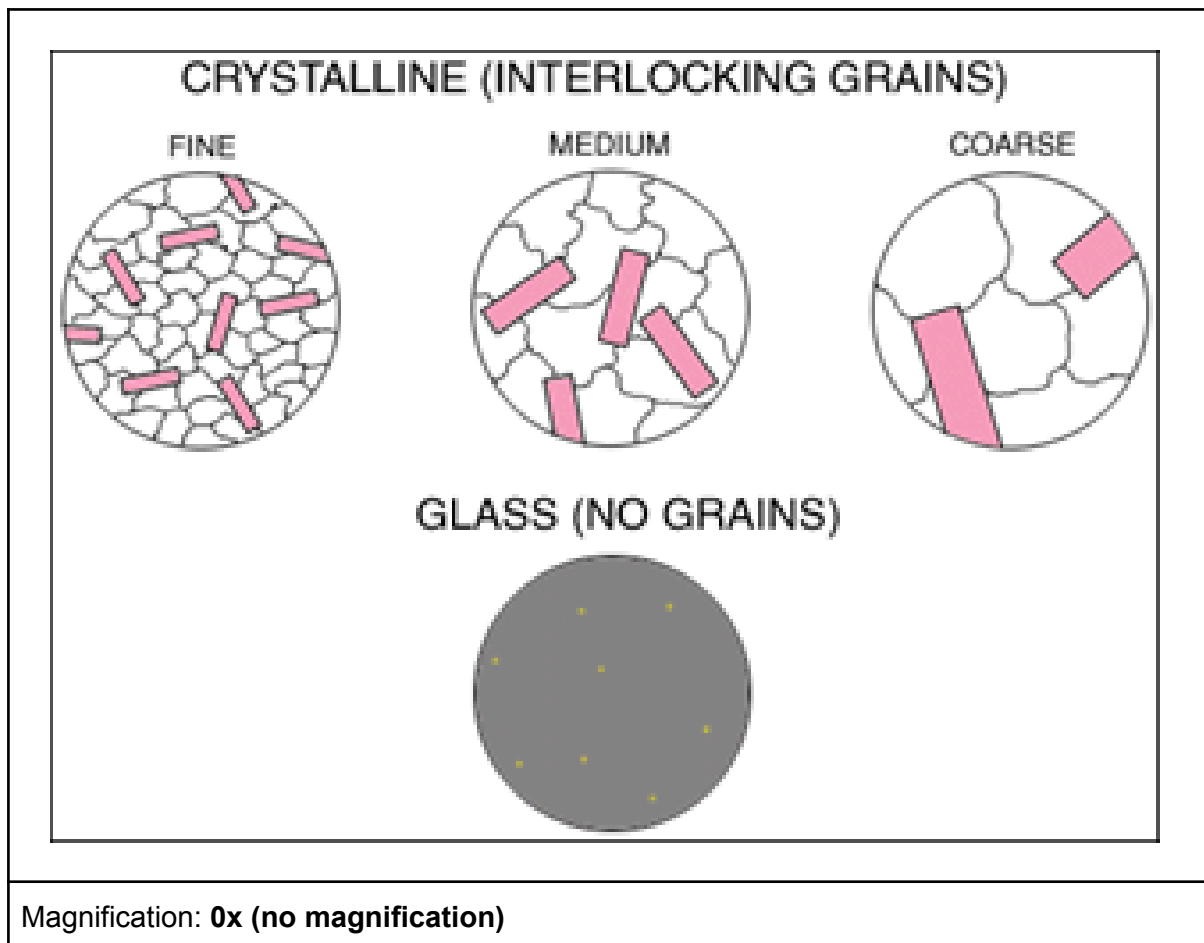


Figure 6.6: Crystallization habits - A diagrammatic overview
(Source: ScienceDirect)

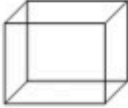
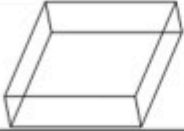
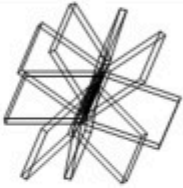
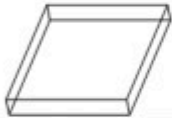
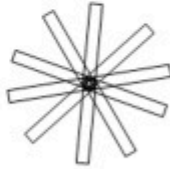
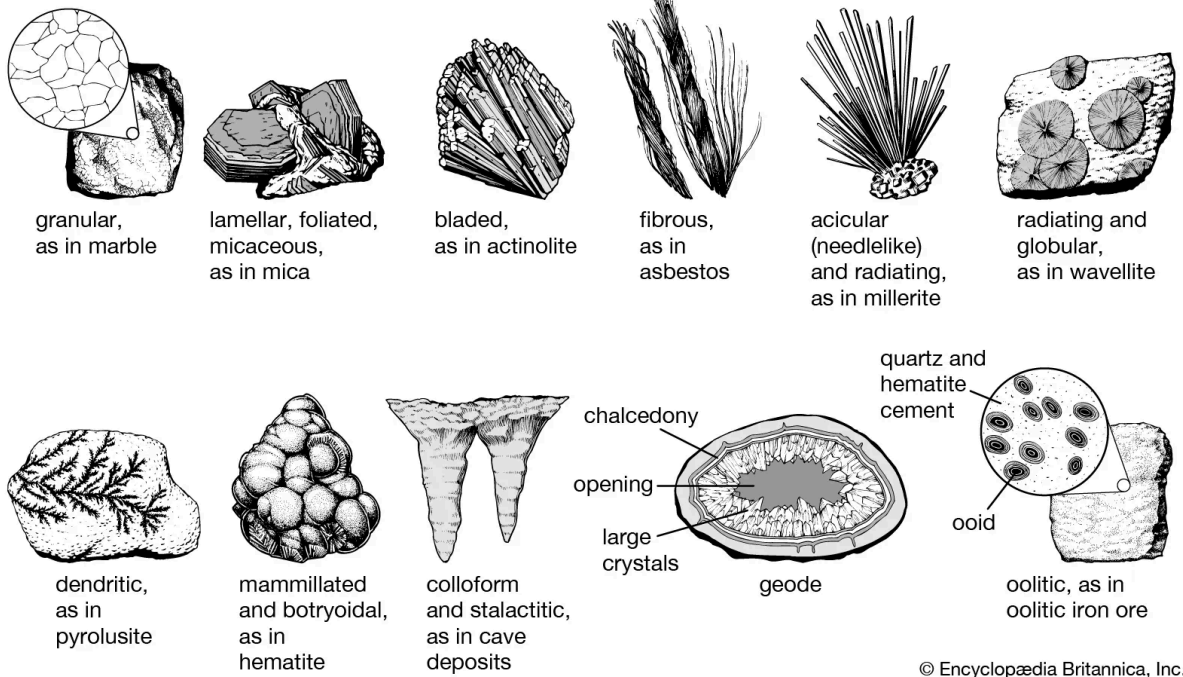
Habit	Schematic	Habit	Schematic
cuboid		dendrite	
tabular		spherulite plate	
plate		spherulite blade	
sheet		spherulite needle	
blade			
rod			
needle			
fibre			

Figure 6.7: Crystallization habits - A photographic overview
(Source: [GeologyIn](http://GeologyIn.com))



Figure 6.8: Common crystallization aggregations and habits
(Source: [Britannica](#))

Common crystal aggregations and habits



MODELLING the EARTH

PHENOMENON

At mid-ocean ridges such as the Atlantic mid-ocean ridge, as you move farther away from the ridge the age of the rocks get older, while the rocks next to the center of the ridge are younger.

QUESTION

How do scientists explain this phenomenon?

ANSWER

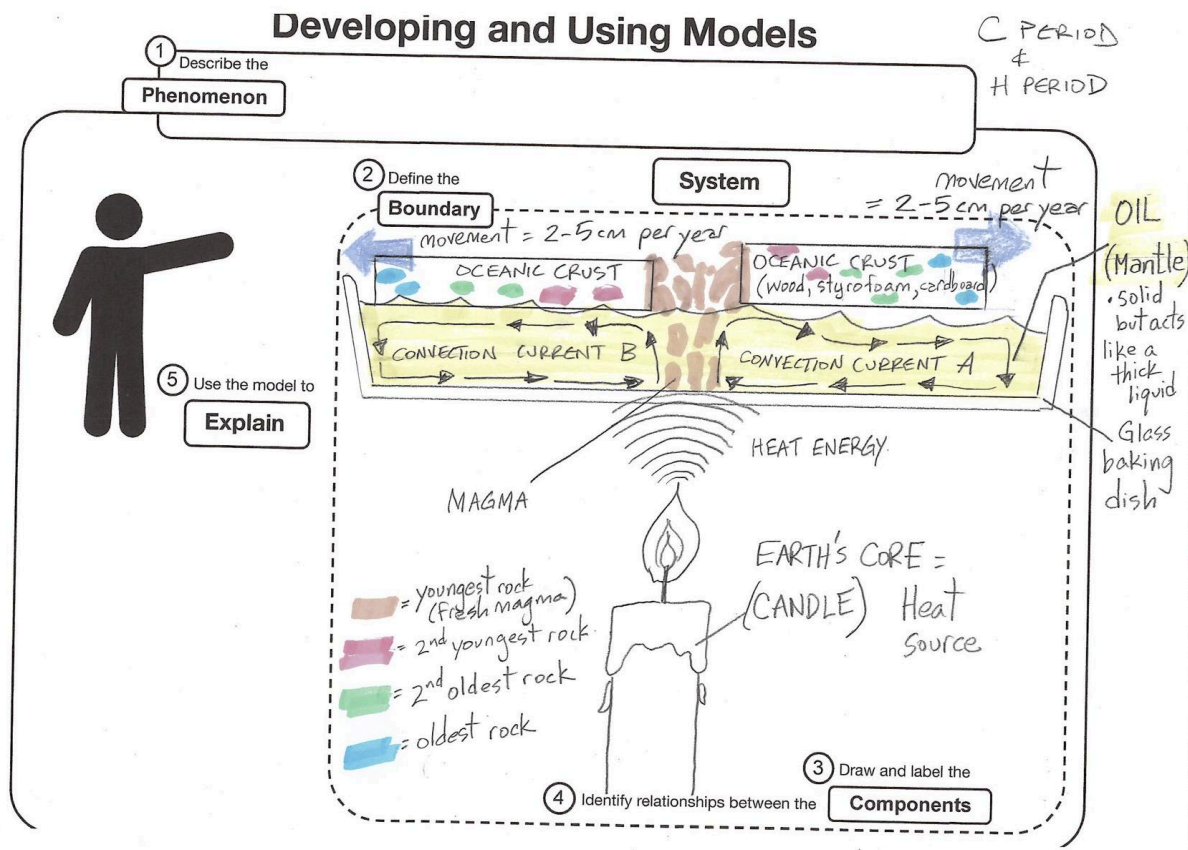
Your answer should be in a well-written paragraph form...

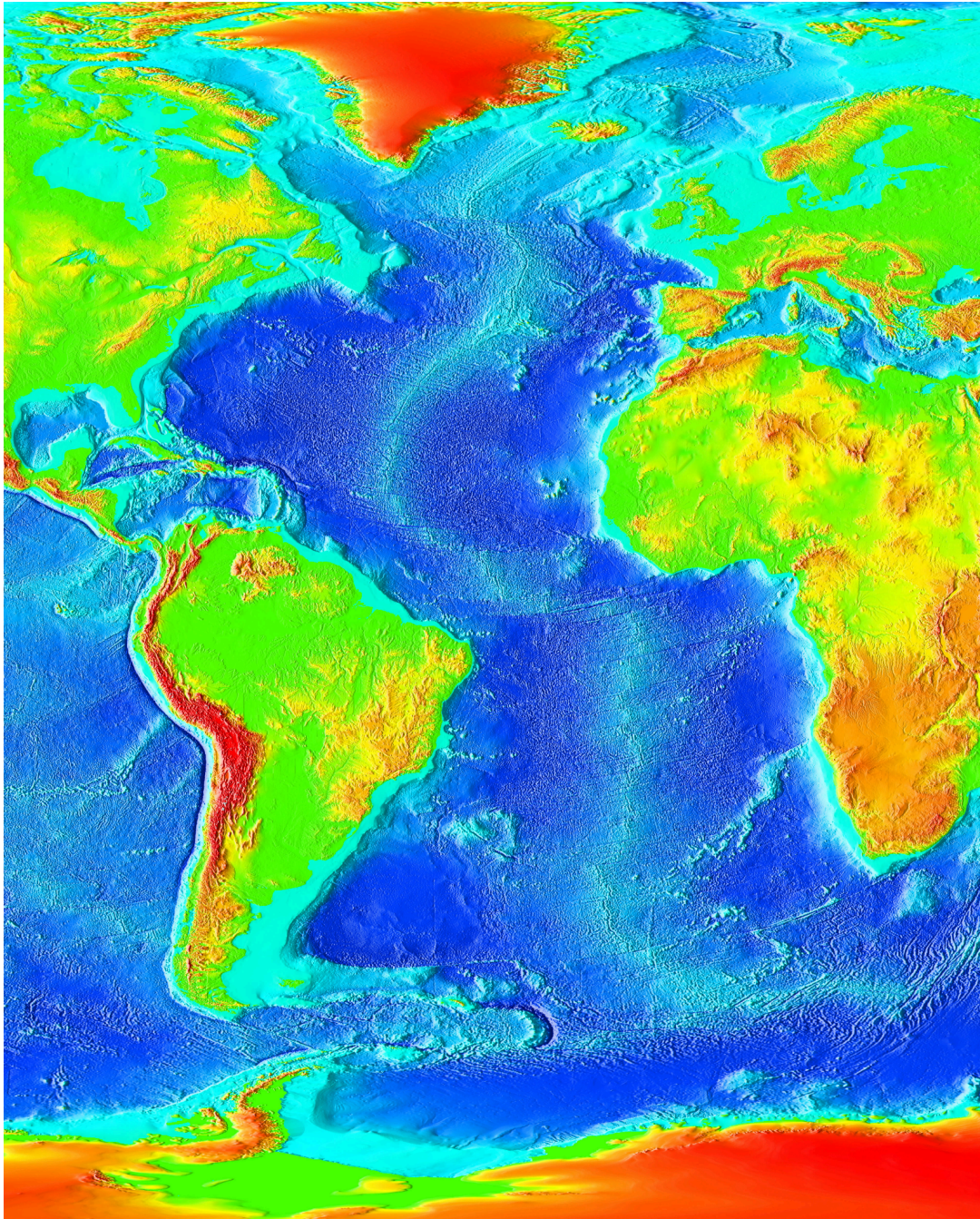
- Forbidden words: ~~candle~~, oil, ~~wood~~, ~~styrofoam~~, ~~card~~
- You must need **Earth objects** such as *magma*, *core*, *mantle*, *(oceanic) crust*, *rocks*, *crystals*, and *convection currents* BUT ALSO **Earth processes** such as *heating*, *cooling*, *rising*, and *moving*.

Example...

"It all begins deep in the Earth, in the part known as the Earth's core. The core is a source of immense heat energy. This heat energy radiates (moves) outward from the core towards the mantle

Figure. An scan of the model we developed in B & H period after completing Demos 1 & 2





WATERY ROCKS

BACKGROUND

The rocks atop Monte Generoso receive regular exposure to water in the form of rain, snow, sleet (a form of water between rain and snow), hail (*grandine*), fog (*nebbia*), and dew (*rugiada* - moisture in air condenses into drops on a solid surface). What happens when water comes into contact with the rocks? Can water help 'break' larger rocks into smaller pieces?

RESEARCH QUESTION

What happens when rain falls upon the exposed rocks atop Monte Generoso?

PROCEDURE

- ~~1. Find a dry rock outdoors.~~
- ~~2. Measure and record its dry mass.~~
- ~~3. Put the rock into labelled (Stu#) a plastic cup filled 3/4 full with water and leave overnight.~~
4. After 24+ hours, remove rock from water, dry it off completely, and measure and record its wet mass. *Report the new mass to Dr. M.*
5. Use a formula to calculate the % of mass gained due to water absorbed by the rock.

DATA COLLECTION

- [Link to the ALL PERIODS Data Table \(with embedded formulae\)](#)

Figure 2.1b - A data table showing the change in mass for B period

STU#	DRY MASS (g)	WET MASS (g)	DIFFERENCE (g) (Wet - Dry)	% change
1B	24.1	24.2		
2B	35.6	35.5		
3B	22.8	23.3		
4B	19.4			
5B	31.7	32.0		
6B	19.1	19.0		
7B	59.4	60.4		
8B	66.7	66.8		
9B	52.3	52.4		
AVG	36.8			

Figure 2.2b - A data table showing the change in mass for the three main rock types selected in B period

DEMOS	DRY MASS (g)	WET MASS (g)	DIFFERENCE (g) (Wet - Dry)	% change
Igneous (Obsidian)	5.1	5.1	+0.0	
Metamorphic (Amphibolite)	5.5	5.5	+0.0	
Sedimentary (Sandstone)	7.7	8.1	+0.4	

Figure 2.1h - A data table showing the change in mass for H period

STU#	DRY MASS (g)	WET MASS (g)	DIFFERENCE (g) (Wet - Dry)	% change
1H	26.7		-	
2H	18.1			
3H	20.0			
4H	30.0			
5H	50.7	51.15		
6H	25.6			
7H	16.7			
8H	42.3			
9H	27.1			
10H	20.0			
11H	22.2			
12H	39.6			
AVG	28.3			

Figure 2.2 - A data table showing the change in mass for the three main rock types selected in H period

DEMOs	DRY MASS (g)	WET MASS (g)	DIFFERENCE (g) (Wet - Dry)	% change
Igneous (<i>Porphyry</i>)	3.6			
Metamorphic (<i>Marble</i>)	7.9			
Sedimentary A (<i>Coal</i>)	3.4			
Sedimentary B (<i>Arkose</i>)	14.5			

PERCENT CHANGE FORMULA...

WET MASS

$$\frac{\text{Wet Mass}}{\text{(divided by)}} \times \text{Dry Mass} \times 100 = \% \text{ CHANGE}$$

DRY MASS

RESULTS

1. **Noa:** Most rocks we tested (7 out of 9 rocks) GAINED mass, which means the rocks absorbed water. The *smallest* amount of water absorbed by a rock was 0.1 g; the largest amount of water absorbed was 1.0 g. On average, the 7 rocks that gained mass gained 0.3 g.
 - **CONCLUSION** - If the exposed rocks atop Monte Generoso are similar types of rocks to the 7 rocks that gained mass (i.e., *absorbed* water) in our investigation, then we might claim that they will absorb water after a rain and gain mass.
2. **Dr. M:** A couple of rocks we tested (2 out of 9 rocks) LOST mass, which means the rocks did not absorb water. On average, the 2 rocks that lost mass lost 0.1 g. *What happened to this lost mass?*
 - **CONCLUSION** - If the exposed rocks atop Monte Generoso are similar types of rocks to the 2 rocks that lost mass (i.e., did not absorb water) in our investigation, then we might claim that they might not absorb water after a rain and instead might lose mass! *What happens to this lost mass atop Monte Generoso?*

ALL-PERIOD (B, C, & H) CONCLUSIONS

1. **21** out of **33** rocks tested *gained* mass, which means **63.6%** of rocks tested must have *absorbed* water.
2. **7** out of **33** rocks tested *gained NO* mass, which means **21.2%** of rocks tested must have *absorbed* NO water.
3. **5** out of **33** rocks tested *lost* mass, which means **15.2%** of rocks tested must have *lost more rock mass than they gained from water absorption*.

Look at us, we've created our own [Campus Rock Predictor Model!!!](#)

DISCUSSION

Dr. Merritt: "Do you think our new **Campus Rock Predictor Model**, most of which was created by selecting rocks found in front of the P.E. office or the Campo Science Lab, can predict how ALL of the rocks found on the TASIS Campus will respond to being soaked in water?"

B period: "Can we test it by going on and collecting rocks from all over the TASIS Campus?"

Dr. Merritt: "Sure, why not."

WATERY ROCKS (MODEL TEST)

BACKGROUND

The rocks atop Monte Generoso receive regular exposure to water in the form of rain, snow, sleet (a form of water between rain and snow), hail (*grandine*), fog (*nebbia*), and dew (*rugiada* - when moisture in the air condenses into drops on a solid surface). What happens when water comes into contact with the rocks? Can water help 'break' larger rocks into smaller pieces?

In INV#2, we discovered that when rocks taken from the landscaped area in front of the Campo Science building are submerged in water for approx. 24 hours...

- **63.6%** of them increased in mass (i.e., they *absorbed* water)
- **21.2%** of them showed NO mass increase or decrease (i.e., they retained NO water)
- **15.2%** of them decreased in mass (i.e., they lost more rock mass *compared to* the mass of any water they may have absorbed).

We think that IF the rocks on the TASIS Campus are similar to the rocks found atop Monte Generoso, THEN this means there is a **63.6%** chance that the rocks atop Monte Generoso will absorb water when exposed to it; a **21.2%** chance they will not absorb water when exposed to it; and a **15.2%** chance they might lose mass when exposed to it.

After completing INV#2, however, we realized the rocks we tested were from a very small part of the TASIS campus, i.e., from the landscaped beds in front of the Campo Science building. We then wondered if the rocks found around the ENTIRE TASIS Campus would fit our INV#2 model!!!!

RESEARCH QUESTION

Can our INV#2 [Campus Rock Predictor Model](#) accurately predict the proportion(s) of rocks that can a) absorb water, b) absorb no water, and c) lose rock mass?

RESULTS

RESULTS

B period

STU#	DRY mass (g)	WET mass (g)	DIFFERENCE (g) (Wet - Dry)	% CHANGE	RESULTS	CONCLUSION	LOCATION
					A statement about the relationship between the ROCK and the MASS	A statement of a relationship between the ROCK and the WATER	
1	22.8	29.3	6.5	28.5	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	De Nobili forest
2	8.6	9.1	0.5	5.8	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	Mr. Laurent's rock collection
3	65.3	68.8	3.5	5.4	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	Next to the gazebo
4a	6.2	6.3	0.1	1.6	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	Mr. Laurent's rock collection
4b	11.9	12.0	0.1	0.8	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	ES Science Lab garden
4c	14.0	14.1	0.1	0.7	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	ES Science Lab garden
5a	5.4	5.4	0.0	0.0	The mass of the rock <i>stayed the same</i> .	The rock <i>absorbed</i> no water.	Near basketball court
5b	38.8	53.6	14.8	38.1	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	De Nobili forest
6	4.5	4.5	0.0	0.0	The mass of the rock <i>stayed the same</i> .	The rock <i>absorbed</i> no water.	Casa Fleming
7a	5.4	7.4	2.0	37.0	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	De Nobili forest
7b	12.8	13.1	0.3	2.3	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	De Nobili forest
8	18.4	18.5	0.1	0.5	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	Base of stairs near football pitch
9a	31.7	31.8	0.1	0.3	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	Mr. Laurent's rock collection
9b	49.2	49.9	0.7	1.4	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.	ES Science Lab garden
AVG	21.1	23.1	1.3	8.8			
					The mass of MOST of the rocks <i>increased</i> (12).	MOST of the rocks <i>absorbed</i> some water (12).	86% of our rocks tested gained mass
					The mass of A COUPLE of the rocks <i>stayed the same</i> (2).	A COUPLE of the rocks <i>absorbed</i> NO water (2).	14% of our rocks gained no mass
					The mass of NONE of the rocks <i>decreased</i> (0).	NONE of the rocks...did they <i>lose</i> rock? Did they <i>absorb</i> water? (0)	0% of our rocks lost mass

H period

STU#	DRY mass (g)	WET mass (g) - Day 3	WET mass (g) - Day 6	DIFFERENCE (g) (Wet - Dry)	% CHANGE	RESULTS	CONCLUSION
						A statement about the relationship between the ROCK and the MASS	A statement of a relationship between the ROCK and the WATER
1a*	32.7			-32.7	-100.0	The plastic cup was cracked and all the water drained away over the weekend (on Monday there was no water in the cup; the rock was dry!).	
1b*	50.1	50.2		0.1	0.2	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
2a	63.3	63.6		0.3	0.5	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
2b	17.5	17.6		0.1	0.6	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
3a*	31.0	31.1		0.1	0.3	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
3b*	32.1	32.2		0.1	0.3	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
4a	16.2	16.3		0.1	0.6	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
4b	32.1	32.6		0.5	1.6	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
5a	43.8	43.9		0.1	0.2	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
5b	0.8	1.0		0.2	25.0	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
6a	17.9	18.0		0.1	0.6	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
6b	28.8	25.7		-3.1	-10.8	The mass of the rock <i>decreased</i> .	The rock <i>lost</i> more of its own mass than it <i>absorbed</i> water!
7	14.3	14.4		0.1	0.7	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
8a	12.5	12.6		0.1	0.8	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
8b	1.4	1.5		0.1	7.1	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
9a	1.6	1.8		0.2	12.5	The mass of the ANIMAL WASTE(?) <i>increased</i> .	The ANIMAL WASTE(?) <i>absorbed</i> some water, but also started visibly disintegrating
9b	34.2	34.4		0.2	0.6	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
10a	16.0	16.3		0.3	1.9	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
10b	47.5	48.0		0.5	1.1	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
11*	33.6			-33.6	-100.0	This student was absent when we collected and weighed our rocks.	
12	31.7	32.0		0.3	0.9	The mass of the rock <i>increased</i> .	The rock <i>absorbed</i> some water.
AVG	26.3	26.0	#DIV/0!	-3.1	-2.7		
						The mass of ??? of the rocks <i>increased</i> (?).	??? of the rocks <i>absorbed</i> some water (?)
						The mass of ??? of the rocks <i>stayed the same</i> (?).	??? of the rocks did NOT <i>absorb</i> water (?)
						The mass of ??? of the rocks <i>decreased</i> (?).	NONE of the rocks...did they <i>lose</i> rock? Did bits of the rock <i>dissolve</i> ? (?)

Results (only B period)

86% of our rocks tested gained mass

14% of our rocks gained no mass

0% of our rocks lost mass

Results (only C period)

89% of our rocks tested gained mass

11% of our rocks tested gained no mass

0% of our rocks tested lost mass

Results (only H period)
94% of our rocks tested gained mass
0% of our rocks tested gained no mass
6% of our rocks tested lost mass

CONCLUSION

Based on the Results of INV#3, which included 50 rocks taken from all over the TESIS Campus, our Rock Predictor Model (version 2.0) leads us to believe that IF the rocks atop Monte Generoso are similar to those found on the TESIS Campus, THEN...

- There is a **90%** chance (or probability) the exposed rocks atop Monte Generoso WILL absorb water.
- There is an **8%** chance (or probability) the exposed rocks atop Monte Generoso will NOT absorb water.
- There is a **2%** chance (or probability) the exposed rocks atop Monte Generoso will lose more rock mass than they gain from absorbing any water.

DISCUSSION

B period: Some *limitations* of our Rock Predictor Model (v2.0)...

- We soaked our campus rocks in water for 3 days--Mt. Generoso rocks would likely not experience the same conditions, that is, continuous rain for 3 days without stopping.
- Our campus is lower altitude and has very few (if any) large exposed rocks--Mt. Generoso is higher altitude and has large exposed rocks.
- Our campus rocks included some brought to the campus by workers (so they're not really 'campus' rocks)--Mt. Generoso probably has no worker-delivered rocks on it.

H period: Some *limitations* of our Rock Predictor Model (v2.0)...

- When rain falls from the sky it hits rocks with a force. That same force is absent when rocks are just soaked in water instead. Maybe this falling force can affect the rocks somehow?

At the conclusion of INVs #2 & #3, we **STILL** have some key questions to answer:

- *What happens to rocks when they absorb water?*
- *How does absorbing water help us explain how an exposed rock atop Monte Generoso will eventually get into the Earth's mantle?*

Student ideas...

Ellie: Rocks absorb water. They get heavier. Heavier objects are more affected by gravity. Gravity pulls heavier rocks downhill, which brings them (a little) closer to the core...

Eliza/Sara: When it rains, rocks absorb water. Water puts more pressure on the rocks to bring them down the mountain in an event called "a landslide," which is a sort of collapse of a large portion of a mountain. Landslides bring rocks found on top of a mountain farther down towards the bottom of the mountain. That's closer to the core...

Ali: When it rains, rocks absorb water. When rocks freeze with water inside of them, they might crack. Cracked rocks...(to be continued)

FREEZE-THAW

BACKGROUND

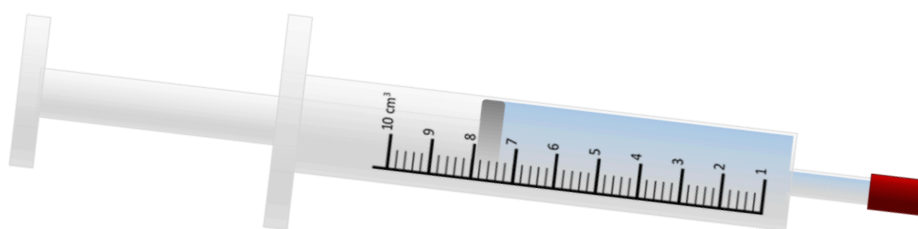
In INVs 2 & 3, we collected evidence predicting that there is a **90% chance** the exposed rocks atop Monte Generoso will absorb water, but we're still wondering, so what? So what if rocks absorb water? How will this small, seemingly insignificant action help them get closer to the Earth's mantle?

RESEARCH QUESTION

What happens when the water-absorbing, water-containing exposed rocks atop Monte Generoso experience water-freezing temperatures of 0°C (or below)?

PROCEDURE

1. Fill a syringe with a known quantity of water ($7.4 \text{ cm}^3 = 7.4 \text{ mL}$)
2. Block the end of the syringe with a cap.
3. Put the syringe into a freezer and leave overnight.



PREDICTION

What will happen to the total volume of the water (7.4 mL) when it freezes?

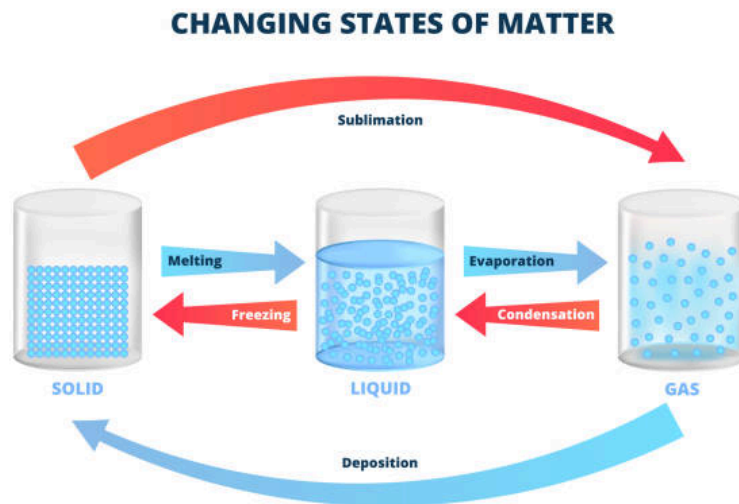
- *Increases? Decreases? Stay the same?*

EXPLANATION

Explain why you think this will happen.

- *Why increase? Why decrease? Why stay the same?*

- **B period student:** “I think the water volume is going to **decrease**. Why? Well, last year we learned about the states of matter: solid water (ice), liquid water (water), gas water (vapor), so when liquid water changes state into solid water, the water molecules get more compact (come closer together). Therefore, when the water in the syringe freezes the water molecules will get more compact and the volume will **DECREASE!**”



- **Another B period student:** “I know that my sister once put a water bottle in the freezer...and the volume of water seemed to **increase**...how do you explain this volume increase...pressure? closed system? open system?”
- **Yet another B period student:** “I think that since there are no water molecules either added to the syringe or taken away, then the volume of the water **MUST** stay the same!”

RESULTS

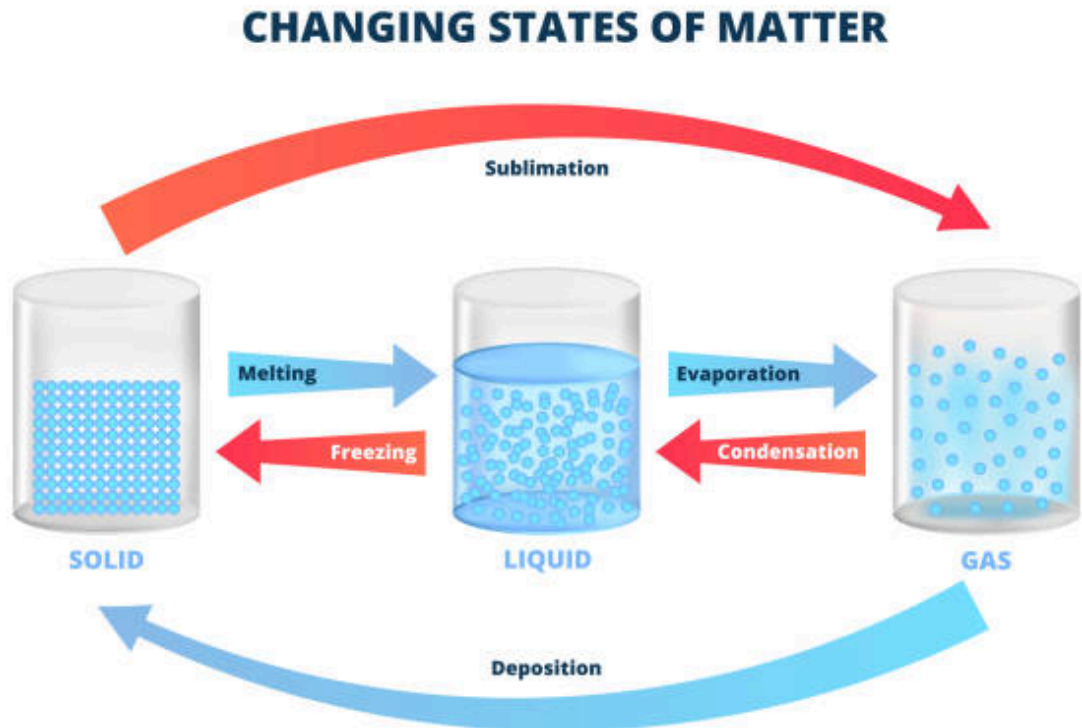
What happened to the volume of water in the syringe...

- Initial volume: **7.4 mL**
- Final volume, Syringe #1: **8.1 mL = the volume increased!**
- Final volume, Syringe #2: **8.0 mL = the volume increased!**
- Final volume, Syringe #3: **8.2 mL = the volume increased!**

CONCLUSIONS

The initial (beginning) volume of water in a syringe **INCREASED** by approximately 0.6-0.8 mL in every syringe tested. However, since the number of water molecules present in the initial volume of water did not change, the **AMOUNT of SPACE** between the water molecules must have **INCREASED**! That's the only way for the same number of water molecules to increase in volume.

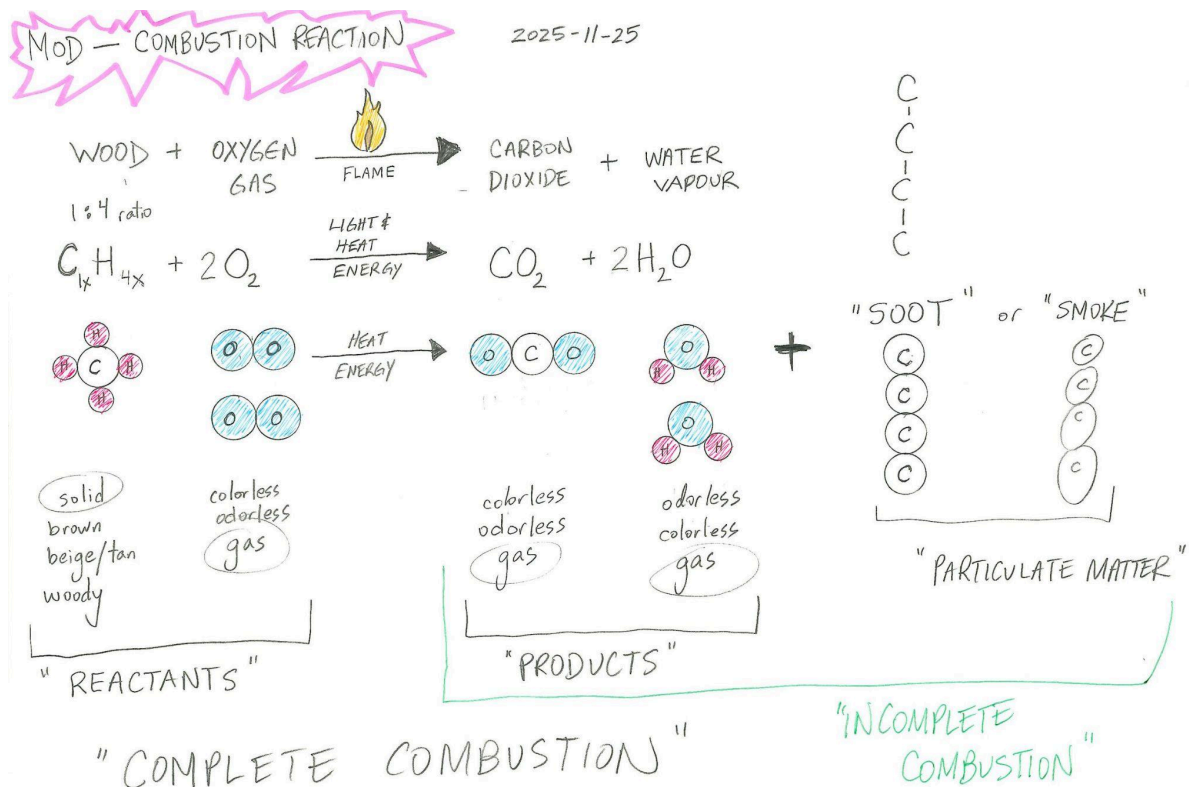
- This is the exact opposite of what our states of matter model taught by our Grade 6 Science teachers. Does that mean our teacher lied to us last year?

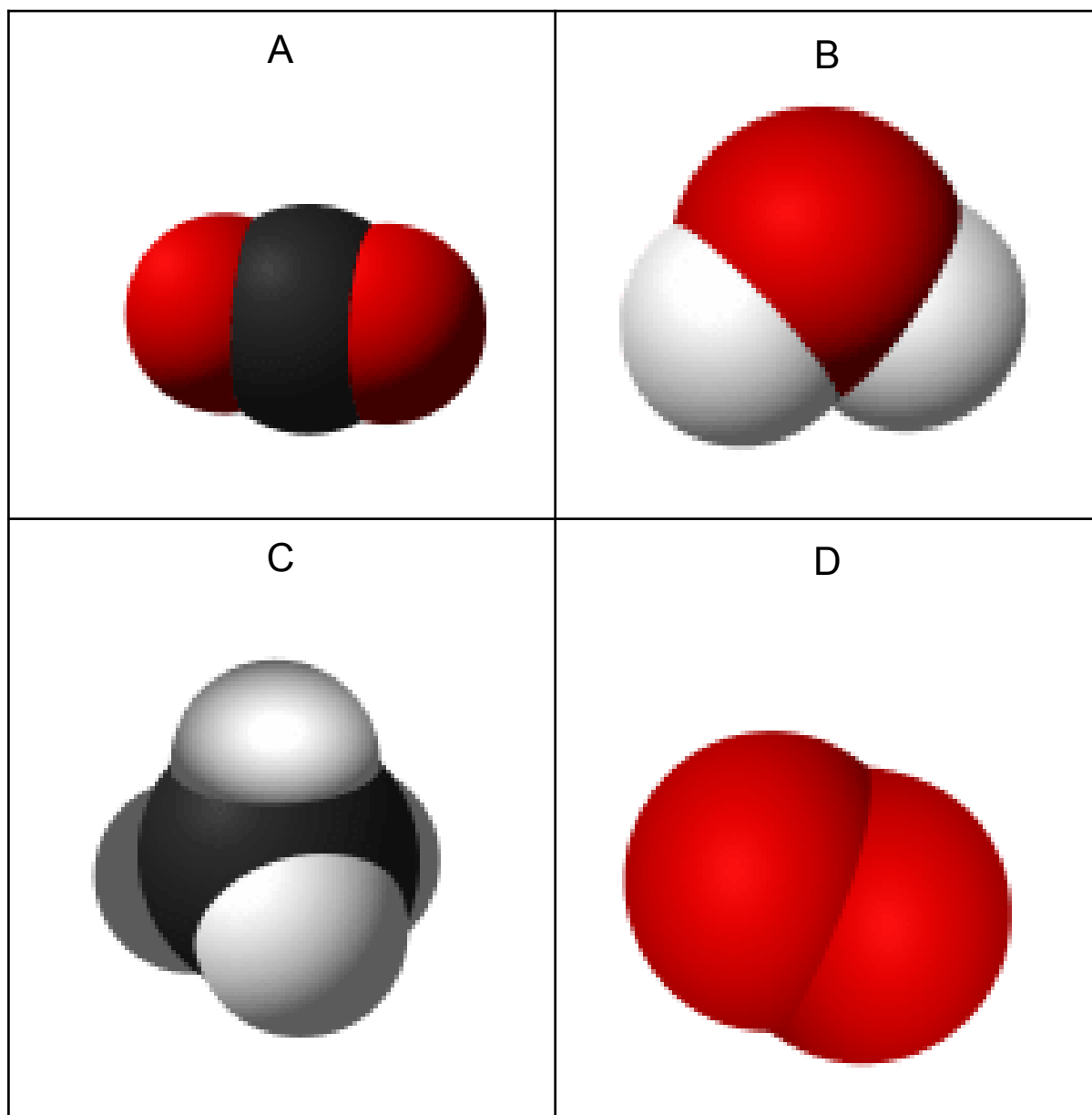


Well...

COMBUSTION REACTION

BACKGROUND





GREENHOUSE GASES

BACKGROUND

CO₂ (carbon dioxide) gas is found *naturally* in the troposphere and stratosphere (0.042% = not a lot).

CH₄ (methane gas) is found *naturally* in the troposphere and stratosphere (0.00017% = not a lot).

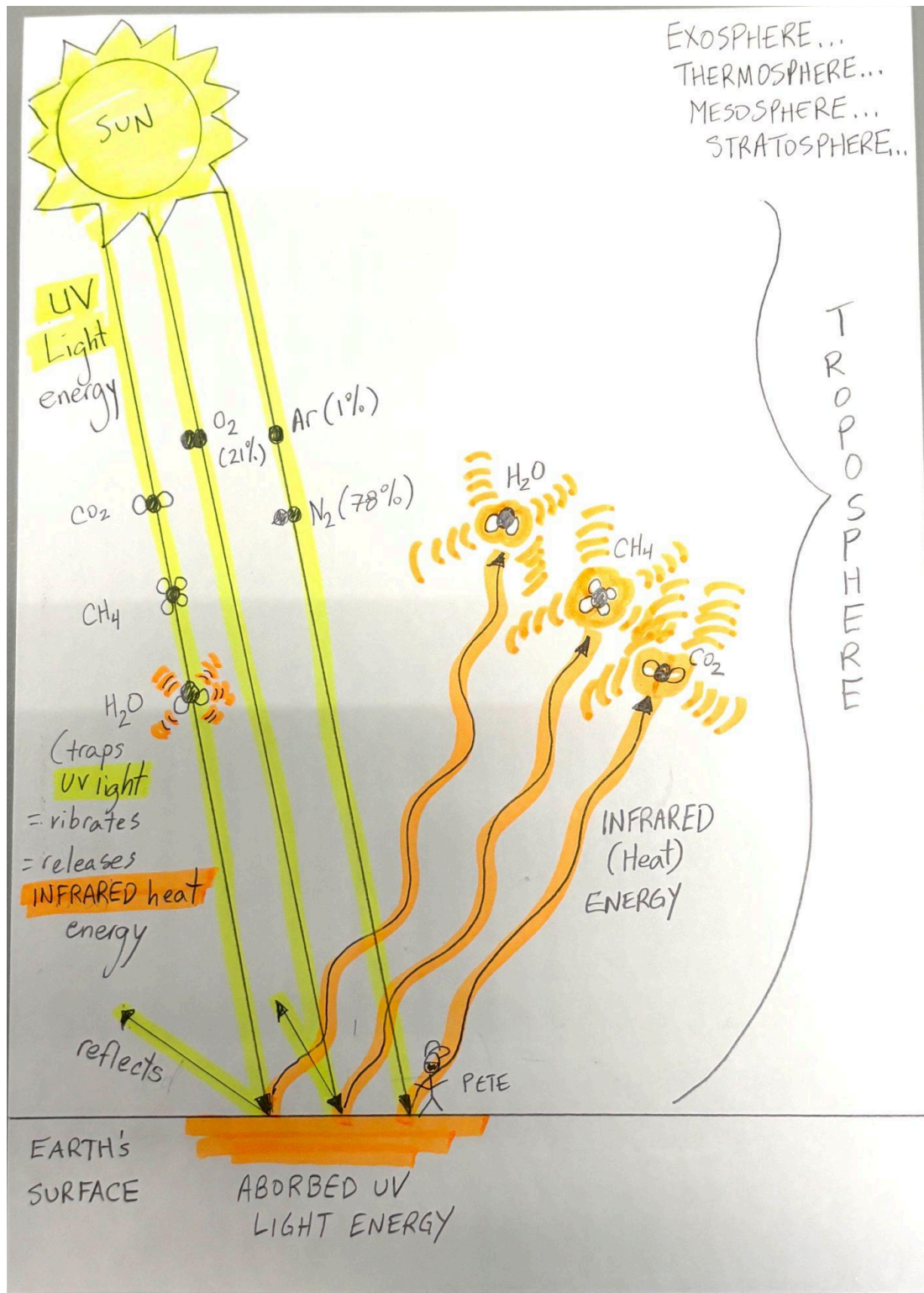
H₂O (water vapor) is found *naturally* in the troposphere and stratosphere (0-4% = a bit).

But...

- **CO₂, CH₄, and H₂O gas** have a special property.
- They can **absorb** and **hold (or 'trap')** INFRARED (radiated) HEAT ENERGY more effectively than other gas molecules in the atmosphere.

What does this look like in a diagram?

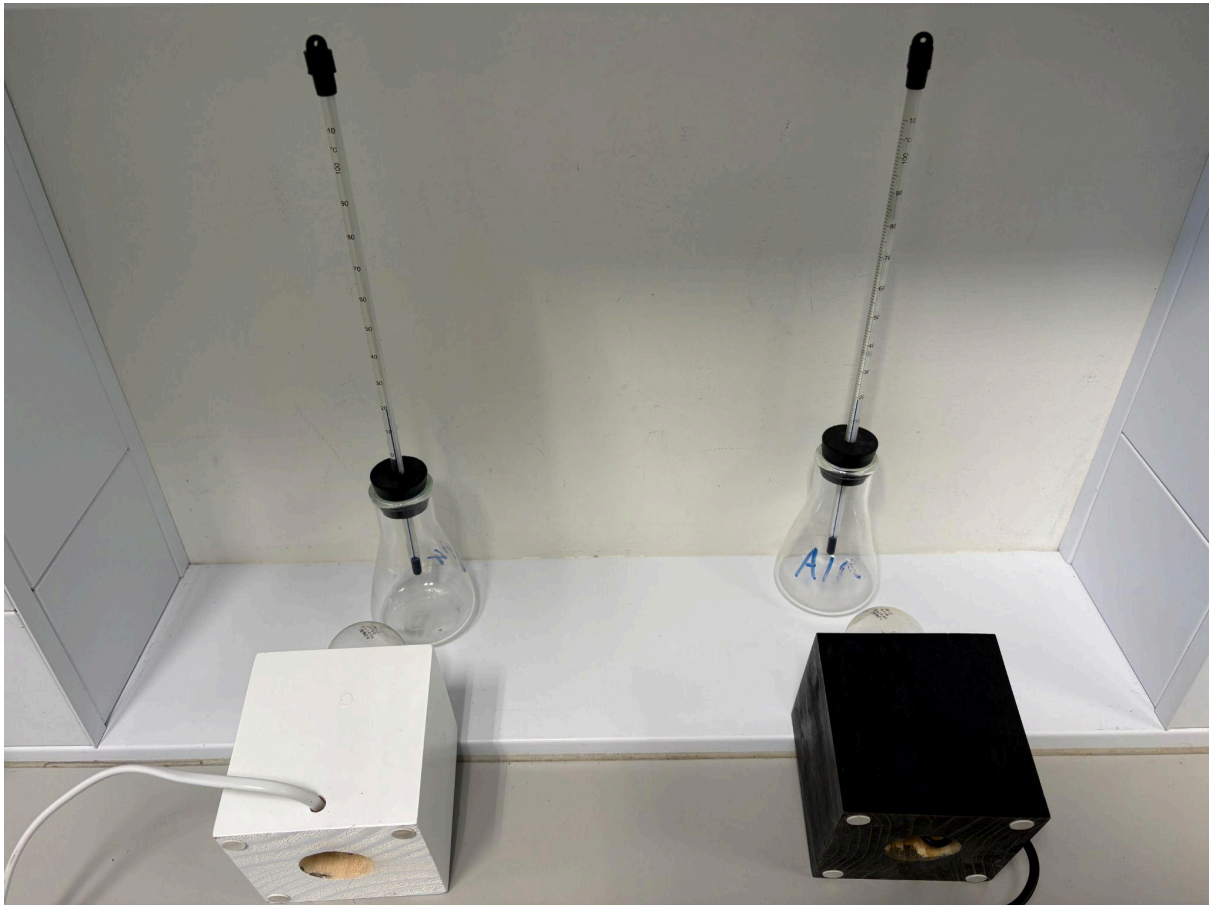
Our greenhouse gases model...



Our greenhouse gases story...

1. Most air molecules absorb very little UV light (energy) coming into the atmosphere from the sun.
2. UV light hits Earth's surface and is 1) reflected, and 2) absorbed. When absorbed UV light energy is TRANSFORMED into infrared (HEAT) energy.
3. Greenhouse gases such as CH_4 , CO_2 and H_2O vapor absorb the infrared (HEAT) energy and prevent it from traveling into outer space.
4. The more greenhouse gases, the more infrared (heat) energy trapped in the Troposphere, and thus the higher the Earth's average temperature = "GLOBAL WARMING."

Our greenhouse gas apparatus...



DATA COLLECTION

B period (4 Dec 15:00-16:00)

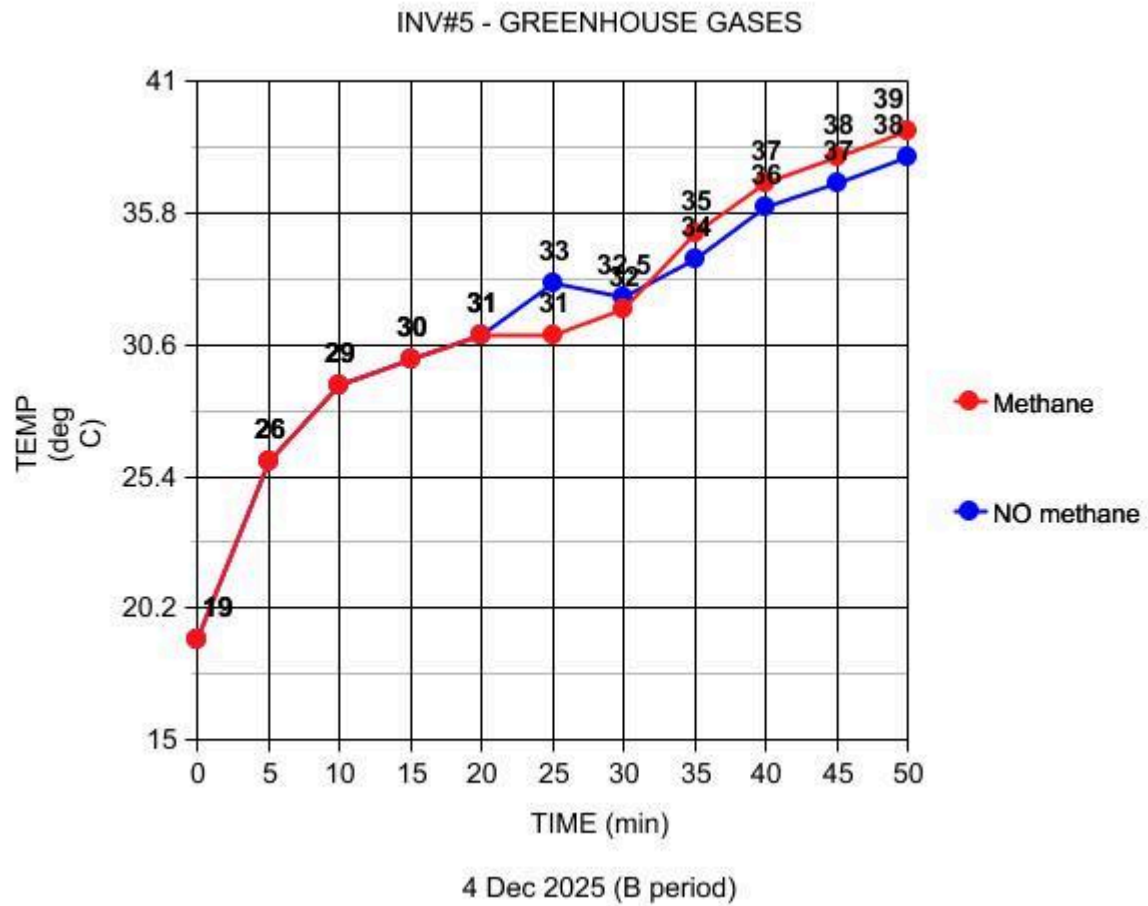
- Room (air) temperature - 19°C
-

A table comparing the change in temperature over time of 'atmospheres' (Flask A - 100% methane vs. Flask B - 0.00017% methane)

TIME (min)	FLASK A (°C)	FLASK B (°C)	OBSERVATIONS
0	19	19	Methane gas smells like car gasoline/fuel (but a little worse).
5	26	26	
10	29	29	
15	30	30	
20	31	31	
25	31	33	The methane gas temperature is 2 degrees lower; we did not expect this result. 😞 (We noticed the light boxes were not equal distance from the two flasks. Hmmm.)
30	32	32.5	
35	35	34	
40	37	36	
45	38	37	
50	39	38	VAR review needed 😊
CHANGE			

DATA ANALYSIS

- B period (Create A Graph - Kids' Zone)



B period (9 Dec 08:00-09:00)

- Room (air) temperature - ??°C
-

A table comparing the change in temperature over time of 'atmospheres' (Flask A - 100% methane vs. Flask B - 0.00017% methane)

TIME (min)	FLASK A (°C)	FLASK B (°C)	OBSERVATIONS
0	24	26	The two thermometers started at slightly different temperatures 24.5° C & 25° C
5	26	27	
10	27	28	
15	28	28.5	
20	28.5	29	
25	29	29.5	
30	29	30	
35	29	30	
40	29	30	
45	29	30	
50	29	30	
CHANGE	+5	+4	

H period (5 Dec 14:00-15:00)

- Room (air) temperature -

A table comparing the change in temperature over time of 'atmospheres' (Flask A - 100% methane vs. Flask B - 0.00017% methane)

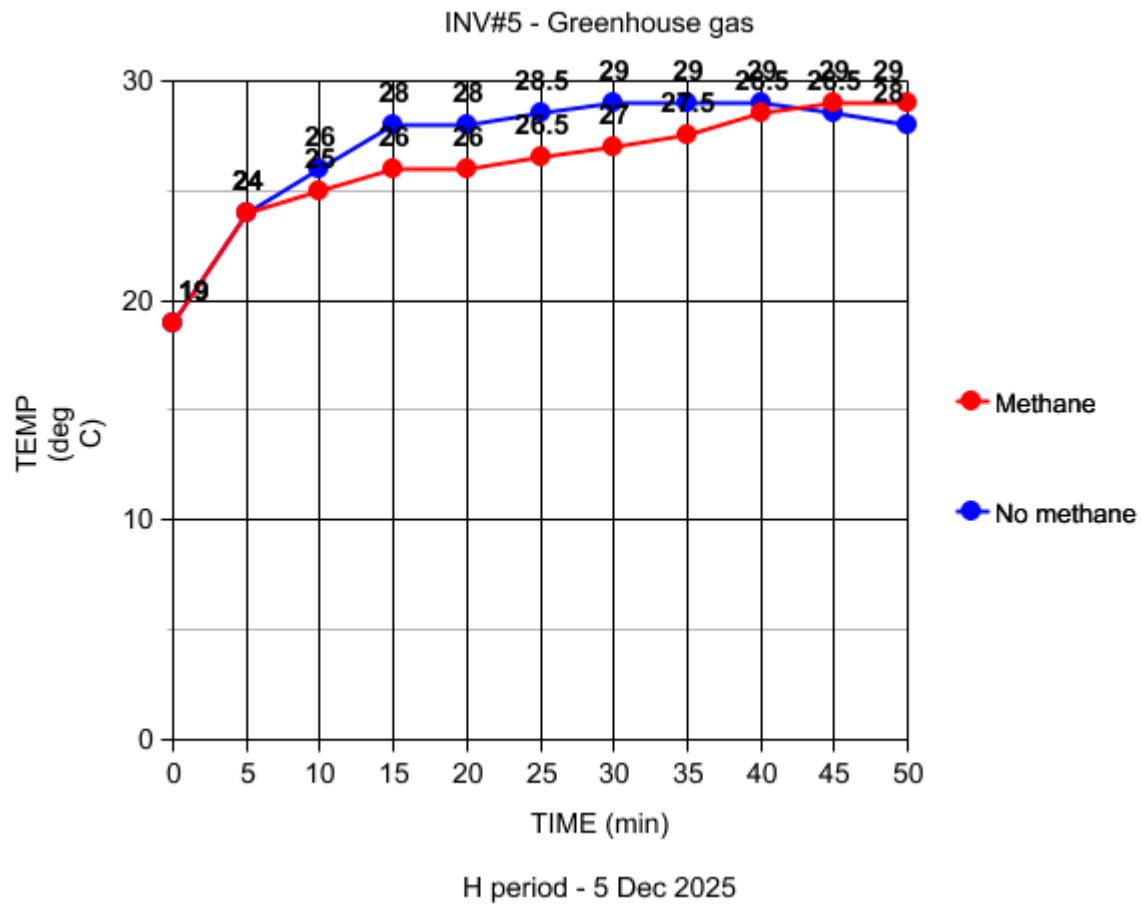
TIME (min)	FLASK A Methane (°C)	FLASK B No methane (°C)	OBSERVATIONS
0	19	19	Methane smells like car petrol or BBQ fuel.
5	24	24	
10	25	26	This is not quite what we expected; the methane is 1 deg lower than the NO methane.
15	26	28	This is not what we expected; the methane is 2 deg lower than the NO methane.
20	26	28	
25	26.5	28.5	
30	27	29	Andrea noticed that the light boxes were not the same distance from the flasks.
35	27.5	29	Lights were made equal distance from flasks.
40	28.5	29	Light color on the methane flask: <i>yellowish</i> Light color on the no methane flask: <i>whiteish</i>
45	29	28.5	
50	--	--	
CHANGE			

**A table comparing the change in temperature over time of
'atmospheres' (Flask A - 100% methane vs. Flask B -
0.00017% methane)**

TIME (min)	FLASK A (°C)	FLASK B (°C)	OBSERVATIONS
0	24	26	
5	26	28	
10	27.5	28.5	
15	28	28.5	
20	28	29	
25	28	29	
30	28.5	29	
35	29	29	
40	29	29	
45	29	29	
50	29	29	
CHANGE	+5	+3	

DATA ANALYSIS

- H period (Create A Graph - Kids' Zone)

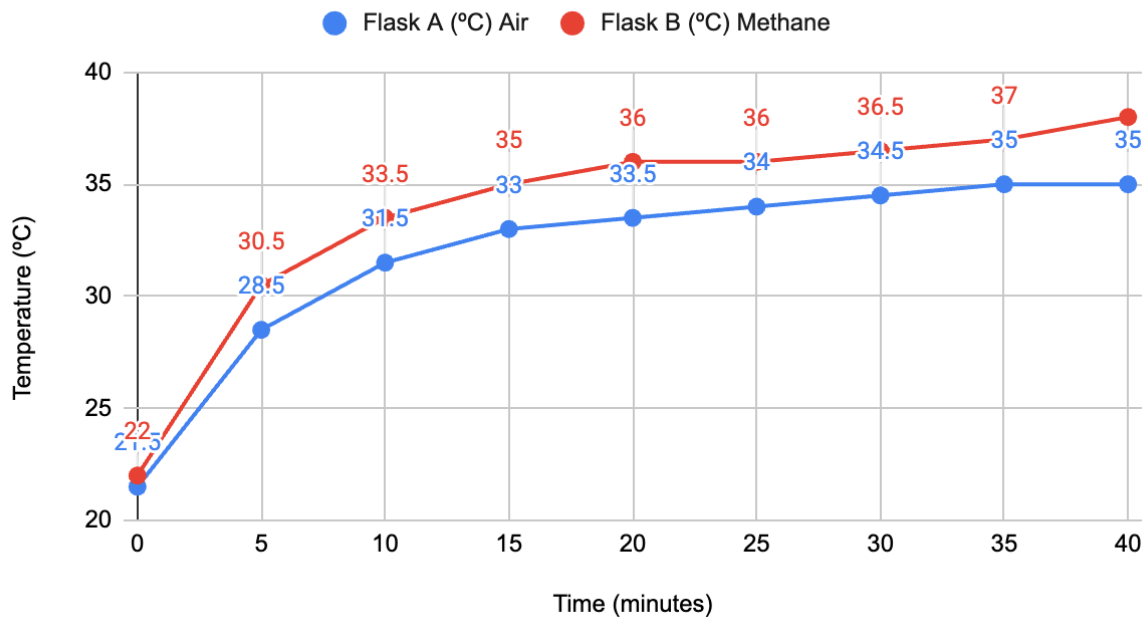


DATA ANALYSIS

C period - Sinnathamby (5 Dec 08:00-09:00)

- Room (air) temperature - ?
-

Flask A (°C) Air and Flask B (°C) Methane



SEASONAL LIGHT INTENSITY

(Students do not have to write what is in blue.)

INTRODUCTION / BACKGROUND

Can a (“slight”) tilt of 23-24° either toward or away from the Sun *really* cause a change in the intensity of light hitting the Earth’s surface, to the point that the Earth’s surface can experience a temperature difference large enough to create, for example, two of the four seasons (Summer & Winter)?

Some KEY IDEAS in this investigation...

- Light rays travel in **STRAIGHT** lines.
- When light hits a surface, it can be 1) **SCATTERED**, 2) **REFLECTED**, and/or 3) **ABSORBED**.
- Light rays are reflected according to the Law of Reflection: **The angle of REFLECTION (“out”, “way”) always equals the angle of INCIDENCE (“in”).**
- Light intensity is a measure of **the amount of light hitting** a surface (you can also think of light intensity as ***brightness***).
- Light intensity and surface temperature can be **related**...
 - The *greater* the light intensity, the GREATER/WARMER the surface temperature.
 - The *lower* the light intensity, the LOWER/COLDER the surface temperature.

- The behavior of light when hitting a particular surface is affected by properties such as...
 - **Texture** (e.g., smooth vs. rough)
 - **Color** (e.g., white vs. black vs. silver)
 - **Surface angle** (e.g., 90° vs 30°)
 - **Porosity (openings)** (spongy vs. solid wood)

RESEARCH QUESTION (RQ)

How does changing the **tilt angle of a sphere** affect the **incoming light intensity** at different points (as measured by a light meter)?

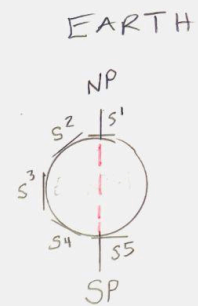
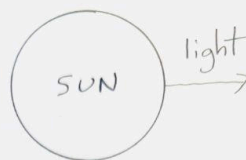
IDENTIFICATION OF THE VARIABLES

- Independent (Manipulated) variable:
- Dependent (Observable/Measurable) variable:
- Controlling variables (Controls or Constants):
 -
 -
 - ...

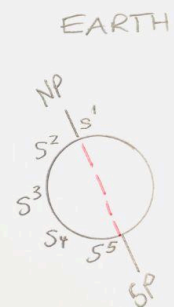
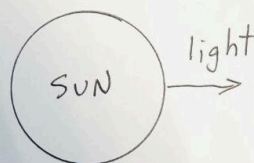
METHOD (PLAN)

EXP 1 0° EARTH TILT

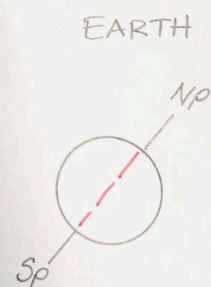
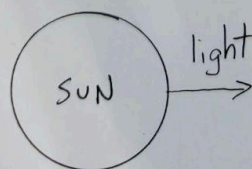
Not
to
scale



EXP 2 $+23.5^\circ$ EARTH TILT



EXP 3 -23.5° EARTH TILT



METHOD (APPARATUS)

Photo 6.1. A Tilted Earth (+23.5°)

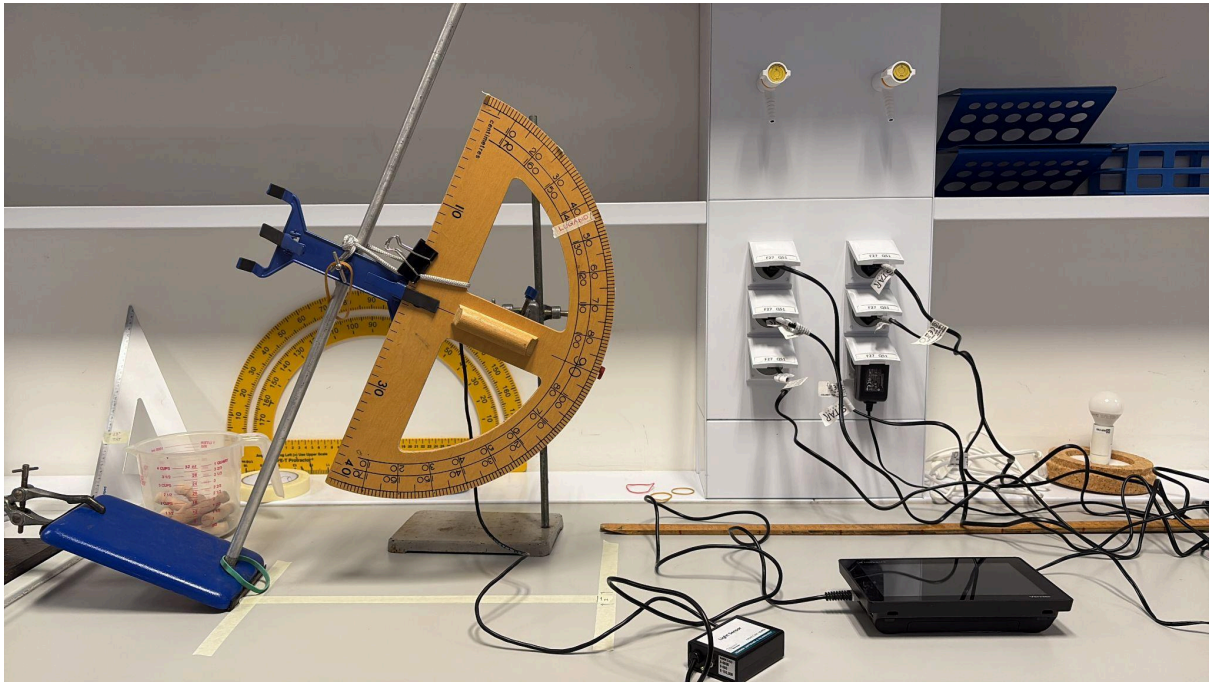
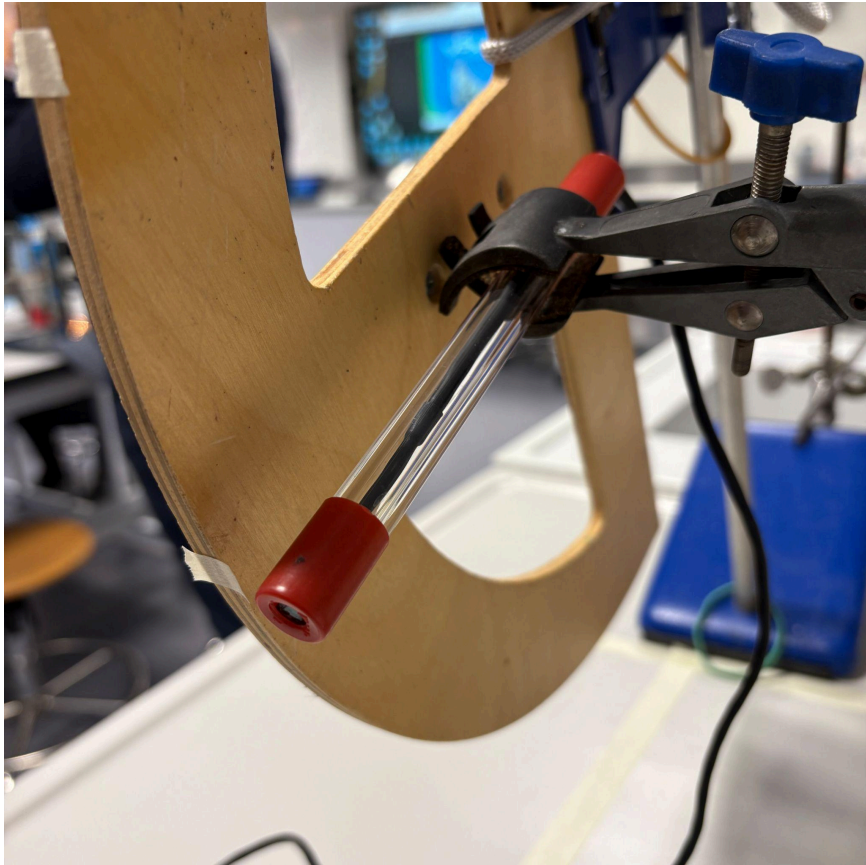


Photo 6.2. The Sun



Photo 6.3. The Light Intensity Sensor



RESULTS (DATA COLLECTION)

- Dr. M has created (digital) data tables for this multi-part investigation in Google Sheets and put them into the Google Science Classroom.

Table 6.1. The light intensity as measured by changing the surface angle of the light sensor when positioned on an **UNTILTED Earth model** (Earth's vertical axis tilted 0° towards the Sun model)

Surface Angle (degrees)	Corrected Angle (degrees)	Light Intensity	Simulated Earth location
90			North Pole (90° North latitude)
66.5			Arctic Circle (66.5° North latitude)
45			45th Parallel North (45° North latitude)
23.5			Tropic of Cancer (23.5° North latitude)
0			Equator (0° latitude)
-23.5			Tropic of Capricorn (23.5° South latitude)
-45			45th Parallel South (45° South latitude)
-66.5			Antarctic Circle (66.5° South latitude)
-90			South Pole (90° South latitude)

Table 6.2. The light intensity as measured by changing the surface angle of the light sensor when positioned on an **TILTED Earth model** (Earth's vertical axis tilted +23.5° towards the Sun model)

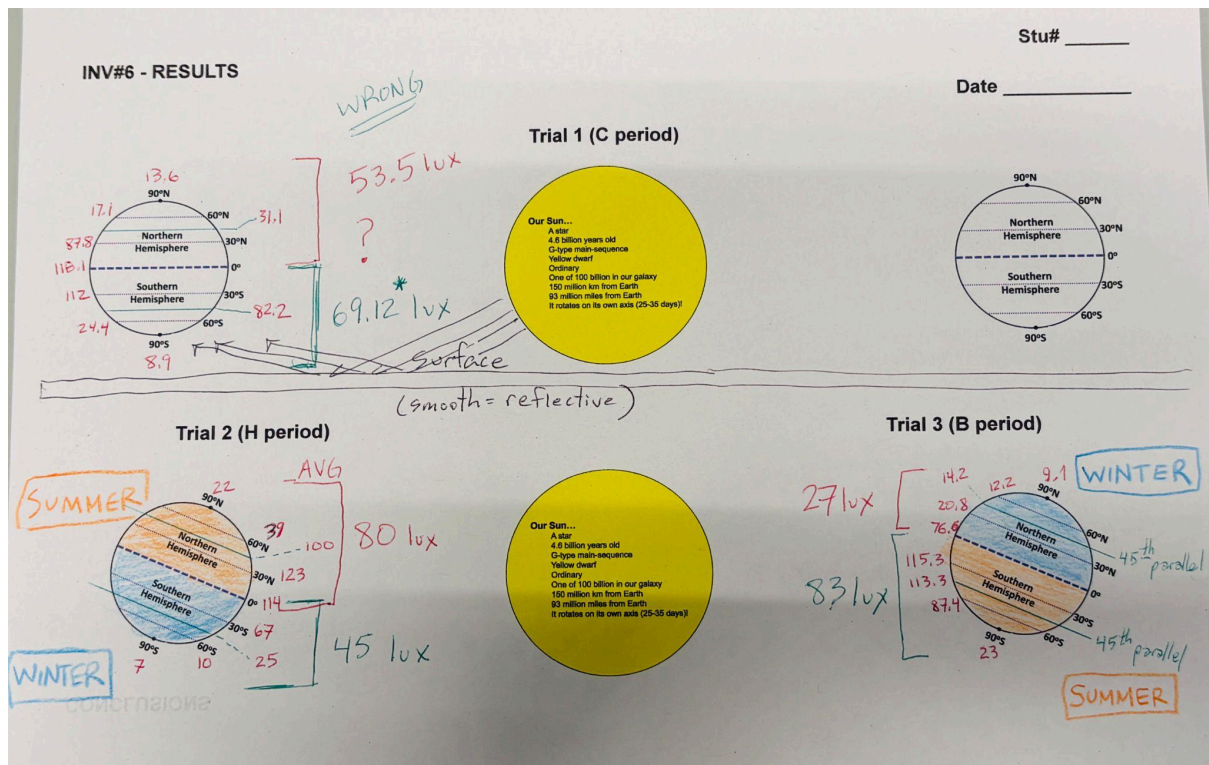
Surface Angle (degrees)	Corrected Angle (degrees)	Light Intensity	Simulated Earth location
90			North Pole (90° North latitude)
66.5			Arctic Circle (66.5° North latitude)
45			45th Parallel North (45° North latitude)
23.5			Tropic of Cancer (23.5° North latitude)
0			Equator (0° latitude)
-23.5			Tropic of Capricorn (23.5° South latitude)
-45			45th Parallel South (45° South latitude)
-66.5			Antarctic Circle (66.5° South latitude)
-90			South Pole (90° South latitude)

Table 6.3. The light intensity as measured by changing the surface angle of the light sensor when positioned on an **TILTED Earth model** (Earth's vertical axis tilted 23.5° away from the Sun model)

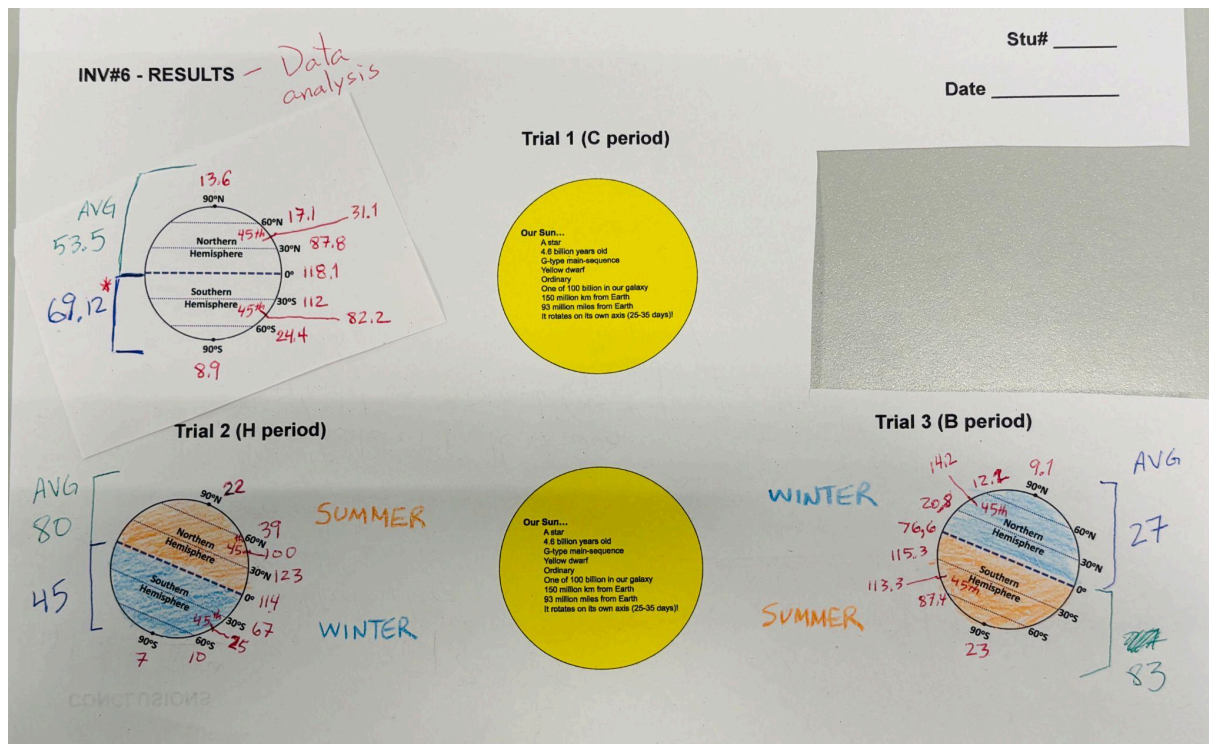
Surface Angle (degrees)	Corrected Angle (degrees)	Light Intensity	Simulated Earth location
90			North Pole (90° North latitude)
66.5			Arctic Circle (66.5° North latitude)
45			45th Parallel North (45° North latitude)
23.5			Tropic of Cancer (23.5° North latitude)
0			Equator (0° latitude)
-23.5			Tropic of Capricorn (23.5° South latitude)
-45			45th Parallel South (45° South latitude)
-66.5			Antarctic Circle (66.5° South latitude)
-90			South Pole (90° South latitude)

RESULTS (DATA ANALYSIS)

C period



H period



Our data tables can be found here:

- iPad > Google Science Classroom > Classwork TAB > Unit 7.3 - Earth in Space > INV#6 - Seasonal Light Intensity (Google Sheet)

CONCLUSIONS

- 1. Our results show that a tilted Earth (approx. 23°) orbiting the Sun can produce an Earth on which the Northern and Southern Hemispheres can experience something similar to a “winter” and a “summer” season at the same time.**
- 2. Our results also show that a non-tilted Earth (0°) orbiting the Sun cannot produce the seasonal differentiation that we experience on Earth.**
- 3. Furthermore, our results also show that we made some errors when constructing our Earth-Sun model...**

a. SUN

- i. Our Sun was *smaller* in its scale than the Earth = this created *less* light intensity.
- ii. Our Sun was *not* centered with respect to the Earth's position = this probably created *greater* light intensity in the Southern Hemisphere and *less* in the Northern.

b. EARTH

- i. Our Earth was *not* 3D; it was more 2D - flat (how might this have affected the light intensity measurements? higher? lower?).

c. SURROUNDING FEATURES

- i. Our Earth received reflected light from the lab bench and the wall and the cabinets surrounding it.

“THE END”

The 'Official' Structure of a Scientific Investigation Report...

Introduction

- Why?

Method

- How?

Results

- What?

Discussion

- So what?

SEED DESCRIPTION (*Castanea sativa*)

INTRODUCTION

Our DQ for Unit 7.4 is, “How does a small chestnut seed become a giant chestnut tree?”

Our first task is to describe a chestnut seed *scientifically*.

- Mass (g):
- Dimensions (cm or mm): *width x height x depth (thickness)*
- Volume (cm³ or mm³ or mL): ???
- Texture(s):
- Color(s):
- Shape(s):
 - *“It reminds me of...”*
- Typical (regular) features:
- Atypical (irregular, unique) features:
- Sounds? Smells? ~~Tastes?~~
- 6 sketches (“to scale” = actual/real size): top/bottom, front/back, left/right side

CHESTNUT DISSECTION

What makes a scientific dissection?

1. Have a **purpose/goal** (see below).
2. Go *slow*, take your time.
3. The goal is not to *destroy*, but to *dismantle*.
4. Take specimens apart soooooo carefully that you can eventually put them back together as they once were.
5. See-saw ('bounce') between **dissecting** (*taking apart*) AND **describing** (*writing and drawing*, but also additional *measuring*).
6. Find out how the object is organized: Look for *order*; look for *structure(s)*; look for distinctive *parts* which look like they might have a purpose or function.

Our goal today: to find something inside of the chestnut (a seed) that we might consider to be **living (alive)** OR **capable of life**.

SOME IMPORTANT SAFETY CONSIDERATIONS...

- Be careful with the sharp instruments (scissors, probes, forceps).
- Go *slow*.
- Always cut and poke AWAY from your fingers, hands, and body.
- Always cut and poke GENTLY--when you meet resistance, don't push harder, back off/away.
- Use the desktop (or lab bench) as your '3rd hand'.
- Stay near your specimen; don't carry instruments away from your designated area.
- Ask for help/advice (*Dr. M, how can I...? Dr. M, do you have a...?*)

SEED DISSECTION (*Phaseolus vulgaris*)

PURPOSE

1. To dissect bean seeds and locate AND photograph (or sketch) the three main structures: **seed coat** (the outer 'skin'), **the embryo** (the baby plant), and the **two halves of the cotyledon** (the embryo's food source).

A whole (undissected) bean seed

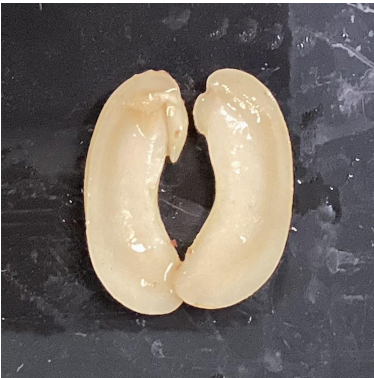


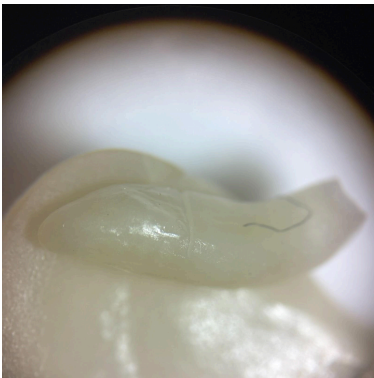
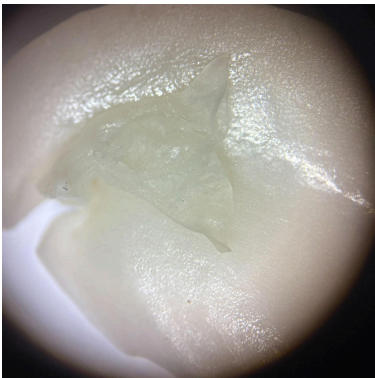
Bean types we have available for this investigation...

Pinto bean	White bean	Kidney bean
		

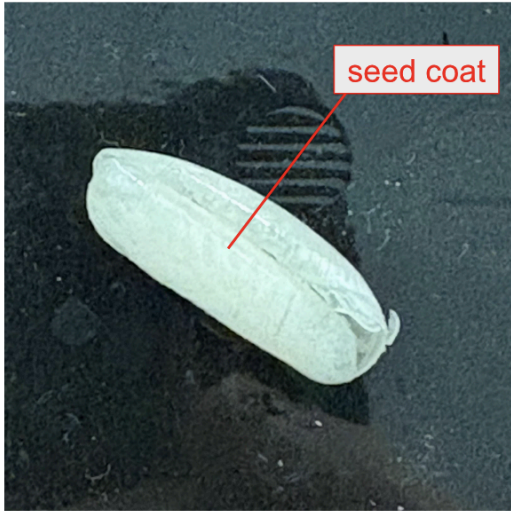
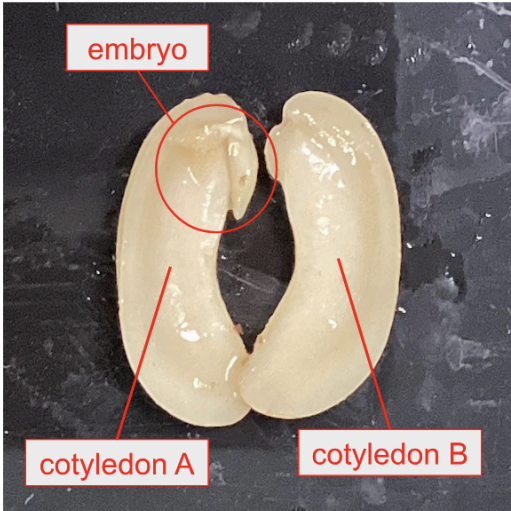
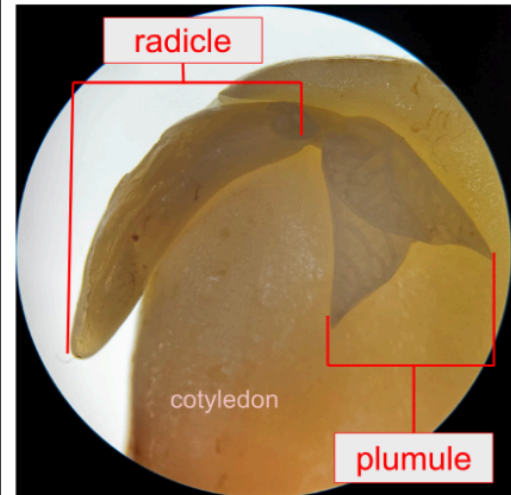
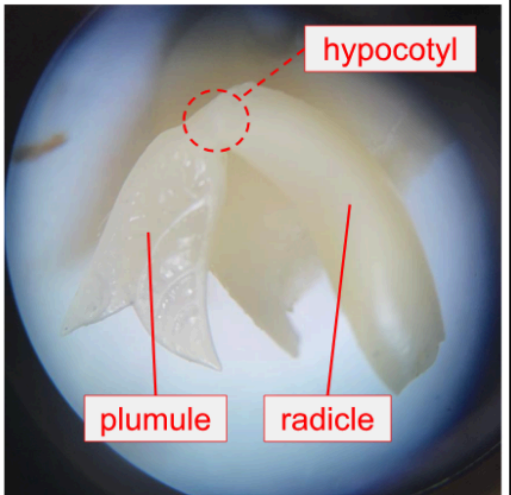
Please use the images below to guide you during your dissection...

- You may sketch or photograph the results of your dissection.
- All sketches/photos must be accurately labelled.
- Students are responsible for printing their own photos (photos must not be bigger than 1/4 (25% of the page)
- Consider using the dissecting (stereo, binocular) microscopes when searching for the embryo.

Seed coat	Cotyledons A & B (unseparated)	Cotyledons A & B (splayed)
		

Radicle (seed root) attached to Cotyledon A	Plumule (seed leaves) attached to Cotyledon B	Embryo (separated)
		

Examples of labelled seed diagrams...

Seed coat	Cotyledons (splayed)
	
This seed coat is from a white bean. The two inner cotyledons have been removed. <i>[Image credit: Dr. M]</i>	This white bean seed has been splayed to show the two halves of the cotyledon. The embryo is visible, still attached, near the top of cotyledon A.
Embryo (attached)	Embryo (extracted)
	
The attached embryo consists of two parts: the <i>radicle</i> (seed root) and <i>plumule</i> (seed leaves). <i>Image credit: Bea - 7B</i>	The extracted embryo visible here is the young plant. Its <i>radicle</i> will become the root, absorb water and minerals, and anchor the plant into the ground. Its <i>plumule</i> will become the shoot system (stem, leaves, flowers). <i>Image credit: Bianca - 3B</i>

CONCLUSION

What did you learn by dissecting three different bean seeds?

What new knowledge do you now have about the **structure** of the bean seeds and how they are assembled/arranged?

* Note: You do NOT need to say anything in your Conclusions section about the *functions* of the bean seed structures.

SEED GERMINATION (*B. rapa*)

PURPOSE

1. To figure out what a **mustard** seed needs in order to germinate successfully.
 - Why? Because germination is the first stage of life for a flowering plant and our Driving Question (DQ) is, “How does a small seed become a larger plant?”
2. To figure out if the scene in the Lorax (movie) in which a kid spills water onto a bare seed (i.e., not surrounded by soil) and it germinates is scientifically true. Could *that* actually happen?

What do we already know about *seeds* from INV#8?

- In every seed there is an embryo.
- It has a specific *structure* and each structure has a main *function*. It has three main parts: seed coat (*protection*), cotyledons (*food source*), and embryo (develop into an adult plant).
- The embryo has two parts: radicle (absorbs water and minerals and anchors the plant into the soil) and plumule (becomes the leaves and stem).
- **Gio**: the embryo in the seed is made of cells and cells need nutrients (food) to live

PREDICTION

So if Dr. M gives you 10 radish seeds, what **should** you provide them so that they can germinate successfully?

- Adequate sunlight? *Not needed, but it will help.*
- Adequate water (both quantity and timing)?
- Healthy soil? *Not needed, but it will help.*
- Oxygen gas (O₂)?
- Ideal temperature?
- Protection from parasites, bacteria, viruses, fungi, insects...?
- A source of energy?
- Food?
- Nutrients?
- Space?

H PERIOD

PROCEDURE

Trial A (Andrea, Ruhaan, Vlada)

10 radish seeds (w/O₂ + water + ad. temp) in SOIL.

10 radish seeds (w/O₂ + water + ad. temp) in NO SOIL.

- RQ: What is the effect of soil on seed germination?

Trial B (Sara, Violetta, Tima)

10 radish seeds (w/O₂ + water + ad. temp) with SUNLIGHT.

10 radish seeds (w/O₂ + water + ad. temp) with NO SUNLIGHT.

- RQ: What is the effect of sunlight on seed germination?

Trial C (Grisha, Ali)

5 radish seeds (w/O₂ + water + ad. temp) with MORE SPACE.

10 radish seeds (w/O₂ + water + ad. temp) with LESS SPACE.

- RQ: What is the effect of space on seed germination?

Trial D (Nicole, Eliza, Nico, Misha)

10 radish seeds (w/O₂ + water + ad. temp) with UV PROTECTION.

10 radish seeds (w/O₂ + water + ad. temp) with NO UV PROTECTION.

- RQ: What is the effect of UV light protection on seed germination?

B PERIOD

PROCEDURE

Trial B (Light) - Soil Creep x 2

10 seeds in **dark** (water + oxygen gas + adequate temperature)

10 seeds in **light** (water + oxygen gas + adequate temperature)

Trial A (Soil) - Bea/Noa, G³

10 seeds in **nutrient-containing soil** (water + oxygen gas + adequate temperature)

10 seeds in **no nutrient-containing soil** (water + oxygen gas + adequate temperature)

RESULTS

B PERIOD

Day 0 - Wed, Feb 25

TRIAL	DAY (% germinated successfully)						
	0	1	2	3	4	5	6
3B/4B: Light A	0	--	--	--	--	70	80
3B/4B: Light B	0	--	--	--	--	60	60
1B/5B: No light A	0	--	--	--	--	70	80
1B/5B: No light B	0	--	--	--	--	90	100
6B/7B: Soil	0	--	--	--	--	50	50
6B/7B: No soil	0	--	--	--	--	70	70
2B/8B/9B: Soil	0	--	--	--	--	70/80	70/80
2B/8B/9B: No soil	0	--	--	--	--	70	70

Day 0 observation: The highlighter I traced bled and the blue ink contacted the radish seeds. We are worried this might affect the seed's ability to germinate because the ink might be toxic to them.

Day 5 observations:

- Describe your seeds. What do you see? Structures? Leaves? Stem? Empty seed coat? Roots? Colors?
- Make a sketch AND label the names of the structures.
- Is there anything that can be *measured*?

RESULTS

H PERIOD

Day 0 - Friday, Feb 27

TRIAL	DAY (% germinated successfully)					
	0	1	2	3	4	5
5H/8H/10H: Soil	0	--	--	30	--	30
5H/8H/10H: No soil	0	--	--	30	--	50
4H/6H/7H: Light	0	--	--	80	--	100
4H/6H/7H: No light	0	--	--	100	--	100
3H/11H: More Space	0	--	--	80	--	80
3H/11H: Less Space	0	--	--	90	--	100
1H/2H/9H/12H: UV light	0	--	--	10	--	10
1H/2H/9H/12H: No UV light	0	--	--	40	--	70
5H: More space (5 seeds)	0	--	--	60	--	60

Day 3 Observations:

- Describe your plants. Name the structures you seed (empty seed coat? roots? stem? leaves?).
- Color? Measurement? Length?
- Make drawings. Label them.

FLOWER DISSECTION #1 (*Prunus avium*)

PURPOSE

1. To practice identifying the structures that constitute a flower of a wild, sweet cherry tree.
2. To compare and contrast the structures of a cherry flower (*P. avium*) with those of a fast-growing mustard flower (*B. rapa*).

PROCEDURE

1. Draw the **CHERRY FLOWER** before dissecting it.
 - **Top view + Side view** - place these two drawings in two boxes side-by-side.
 - Try drawing “to scale” = same size as the actual flower (If you want to increase the size of your drawings, consider using 2x and no bigger)
2. Photograph the **CHERRY FLOWER** before dissecting it.
 - **Top view + Side view** - save room to print the two photos and glue them directly underneath their corresponding drawings.
 - We want to see how accurate your drawings can be.
3. Carefully remove the (whole) **SEPALS** without damaging them.
 - Use clear tape to mount them--side-by-side and all pointing in the same direction--onto a well organized part of your science notebook.
 - Give them a TITLE and write a caption (below) explaining the *function*.
4. Carefully remove the (whole) **PETALS** without damaging them.
 - Use clear tape to mount them--side-by-side and all pointing in the same direction--onto a well organized part of your science notebook.
 - Give them a TITLE and write a caption (below) explaining the *function*.
5. Carefully remove the (whole) **STAMENS** without damaging them.
 - Use clear tape to mount them--side-by-side and all pointing in the same direction--onto a well organized part of your science notebook.
 - Using a ruler, label the two stamen parts: *anther* and *filament*.
 - TITLE this section and write a caption (below) explaining the **functions** of the stamen AND both of its parts.
6. What remains we will call the **PISTIL COMPLEX**, because there is more than just the pistil present.
 - Use clear tape to mount it onto a well organized part of your science notebook.
 - Using ruled lines, label the following parts: *stigma*, *style*, *ovary*, *receptacle*, and *petiole*.
 - TITLE this section and write a caption (below) explaining the **functions** of the pistil, but also the *stigma*, *style*, and *ovary* AND the two other remaining parts.

INV#12

2026-03-23^H

2026-03-25^B

FLOWER DISSECTION #2 (*Tulipa gesneriana*)

PURPOSE

1. See INV#11: Similar purposes

PROCEDURE

1. Draw the **TULIP FLOWER** before dissecting it.
 - **Top view + Side view** - place these two drawings in two boxes side-by-side.
 - Try drawing “to scale” = same size as the actual flower.
 - i. If you want to increase the size of your drawings, consider using 2x and no bigger.
2. Photograph the **TULIP FLOWER** before dissecting it.
 - **Top view + Side view** - save room to print the two photos and glue them directly underneath their corresponding drawings.
 - We want to see how accurate your drawings can be.
3. Carefully remove the (whole) **SEPALS** without damaging them.
 - Insert your photo into the correctly labelled box in the Google Doc provided for you in the Google Science Classroom.
 - Write a caption (below) explaining the *function*.
4. Carefully remove the (whole) **PETALS** without damaging them.
 - Insert your photo into the correctly labelled box in the Google Doc provided for you in the Google Science Classroom.
 - Write a caption (below) explaining the *function*.
5. Carefully remove the (whole) **STAMENS** without damaging them.
 - Insert your photo into the correctly labelled box in the Google Doc provided for you in the Google Science Classroom.
 - Using the “Insert Drawing” feature, label the two stamen parts: *anther* and *filament*.
 - Write a caption (below) explaining the **functions** of the *anther* and *filament*.
6. What remains we will call the **PISTIL COMPLEX**, because there is more than just the pistil present.
 - Insert your photo into the correctly labelled box in the Google Doc provided for you in the Google Science Classroom.
 - Using the “Insert Drawing” feature, label the *stigma*, *style*, *ovary*, *receptacle*, and *petiole*.
 - Write a caption (below) explaining the **functions** of the *stigma*, *style*, *ovary*, *receptacle*, and *petiole*.

7. Now it's time to **DISSECT THE PISTIL** and try locating the ovules. Remove the pistil from the pistil complex and use a blade/scalpel (provided by your teacher) to open the pistil with a longitudinal (i.e., vertical) incision. Photograph the ovules without removing them from the ovary--you may use a microscope if needed.
- Insert your photo into the correctly labelled box in the Google Doc provided for you in the Google Science Classroom.
 - Using the "Insert Drawing" feature, label all of the visible *ovules* in the photo.
 - Write a caption (below) explaining the **function** of the *ovules*.
8. If there is still time remaining in the lesson, see your teacher for one final dissection challenge.

PISTIL DISSECTION (*Phaseolus vulgaris*)

PURPOSE

1. To practice naming the structures found in the pistil and learning their functions.
2. To locate an embryo (a fertilized egg cell!) inside of one of the ovules.

HARVESTING SEEDS (*Brassica rapa*)

PURPOSE

To practice naming the structures found in the pistil and learning their function

PROCEDURE

1. Photograph the **PISTIL (GREEN BEAN)** before dissecting it.
 - Lay the pistil flat on one of the white cutting boards. Photograph it and insert the image into the Google Doc provided for you in the Google Science Classroom.
2. Carefully **SPLAY** (slice) the **PISTIL** open along one of the 'seams' while trying not to damage any of the round ovules (bean seeds) inside.
 - Lay the splayed pistil flat on one of the white cutting boards. Photograph it and insert the image into the Google Doc provided for you in the Google Science Classroom.
3. Zoom in on some of the **OVULES** still attached to the walls of the **OVARY**. See if you can get at least two attached ovules in your photo while still showing both halves of the splayed pistil.
 - Photograph the attached ovules (including both halves of the splayed pistil) and insert the image into the Google Doc provided for you in the Google Science Classroom.
4. Carefully remove one of the **FERTILIZED OVULES** without damaging it (the larger the ovule the greater the chance it has already been successfully fertilized).
 - Photograph the fertilized ovule against a proper background color and insert the image into the Google Doc provided for you in the Google Science Classroom.
5. Dissect the **FERTILIZED OVULE** similar to how you dissected your bean seeds, that is: 1) try to remove the seed coat, 2) find where the two halves of the **COTYLEDON** want to naturally separate, and 3) pry the two halves of the cotyledon open so as not to damage the **EMBRYO** inside.
 - Photograph the embryo (it's OK to leave it attached to the cotyledon--if you try to remove it you might damage it) and insert the image into the Google Doc provided for you in the Google Science Classroom.
 - Photograph one of the two cotyledons (preferably the one without the embryo attached to it) and insert the image into the Google Doc provided for you in the Google Science Classroom.
6. If you have any other interesting images you took during your dissection please create some new boxes--with both **TITLES** and **CAPTIONS**--and add them to your Google Doc.
 - Seed coat?

- The solid connection between the fertilized ovule and the wall of the ovary?
 - The *hilum* of the ovule seed?
 - An undestroyed embryo separated from its cotyledon (20x and 40x)?
 - A starch-tested cotyledon (using Iodine solution) to see if there are complex carbohydrates present?
7. Once all of the required (and optional) images are added to your Google Doc, be sure to go back and write **FUNCTION**-based captions for each image with the help of the [SCIENCEsEDiment Word Glossary](#).
- Don't forget that to add proper labels to your photos, you should use the **Insert > Drawing > New** feature in Google Docs so that you can add LABEL LINES (straight lines without arrows) and LABELS (text boxes) that look professional.