



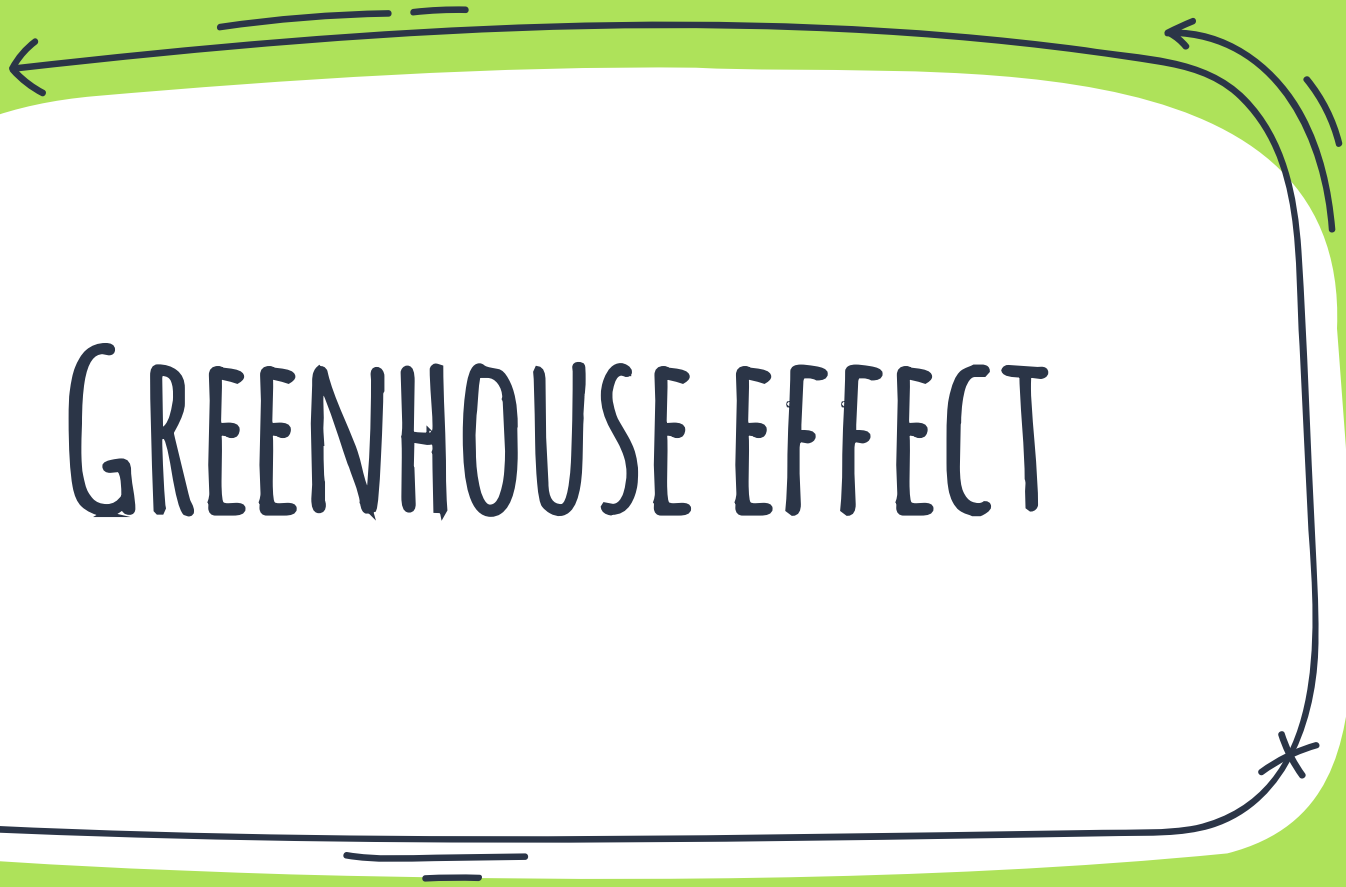
You're here!

Welcome to Croatia!





# GREENHOUSE EFFECT



# ROADMAP

Energy transfer

1

Reflection, transmission,  
absorption

3

Greenhouse gases

5

Experiment:  
Spectrometry

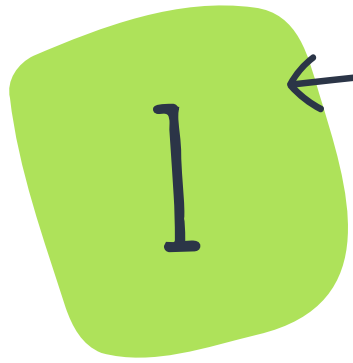
2

Application to the  
Greenhouse effect

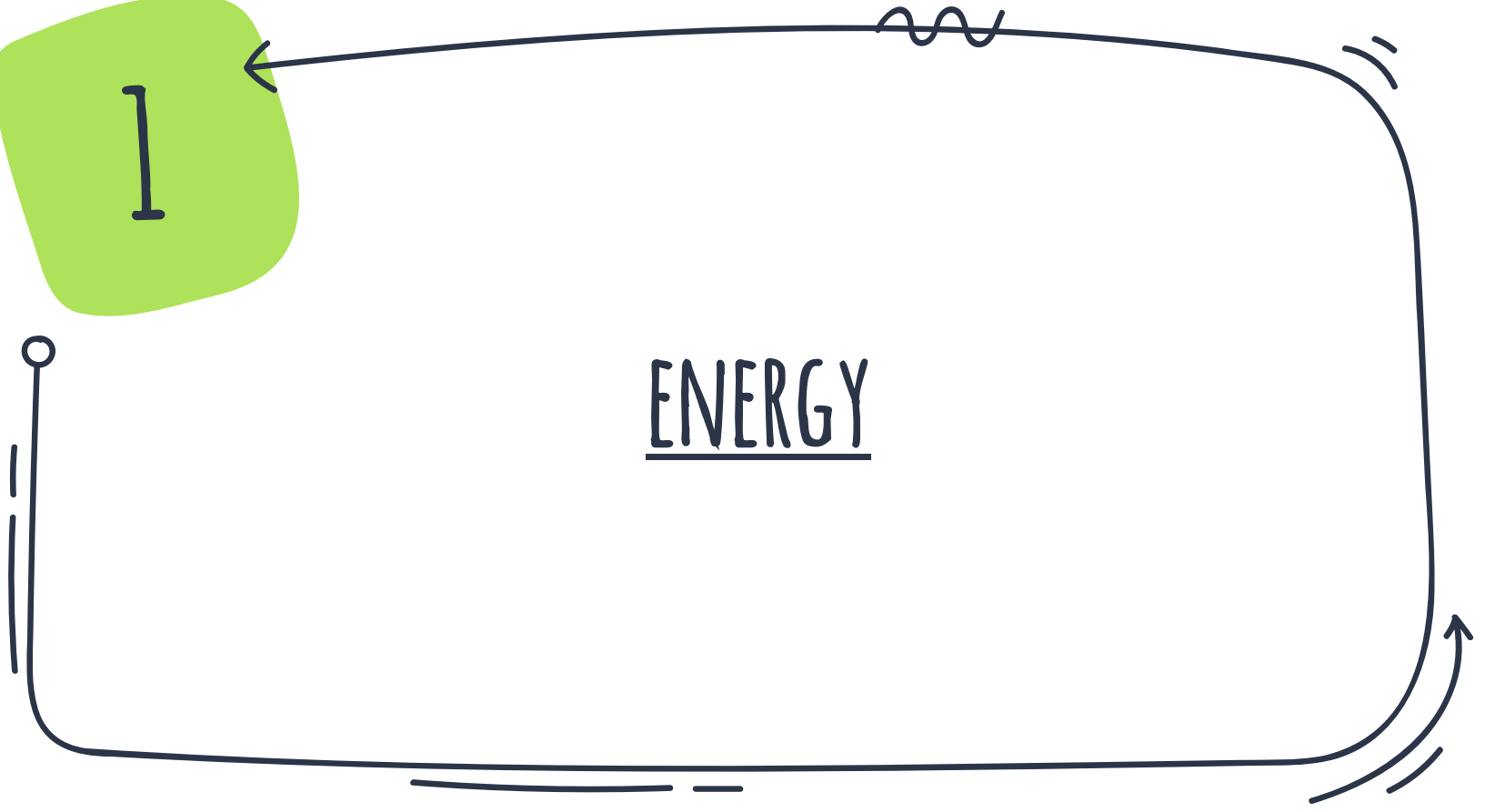
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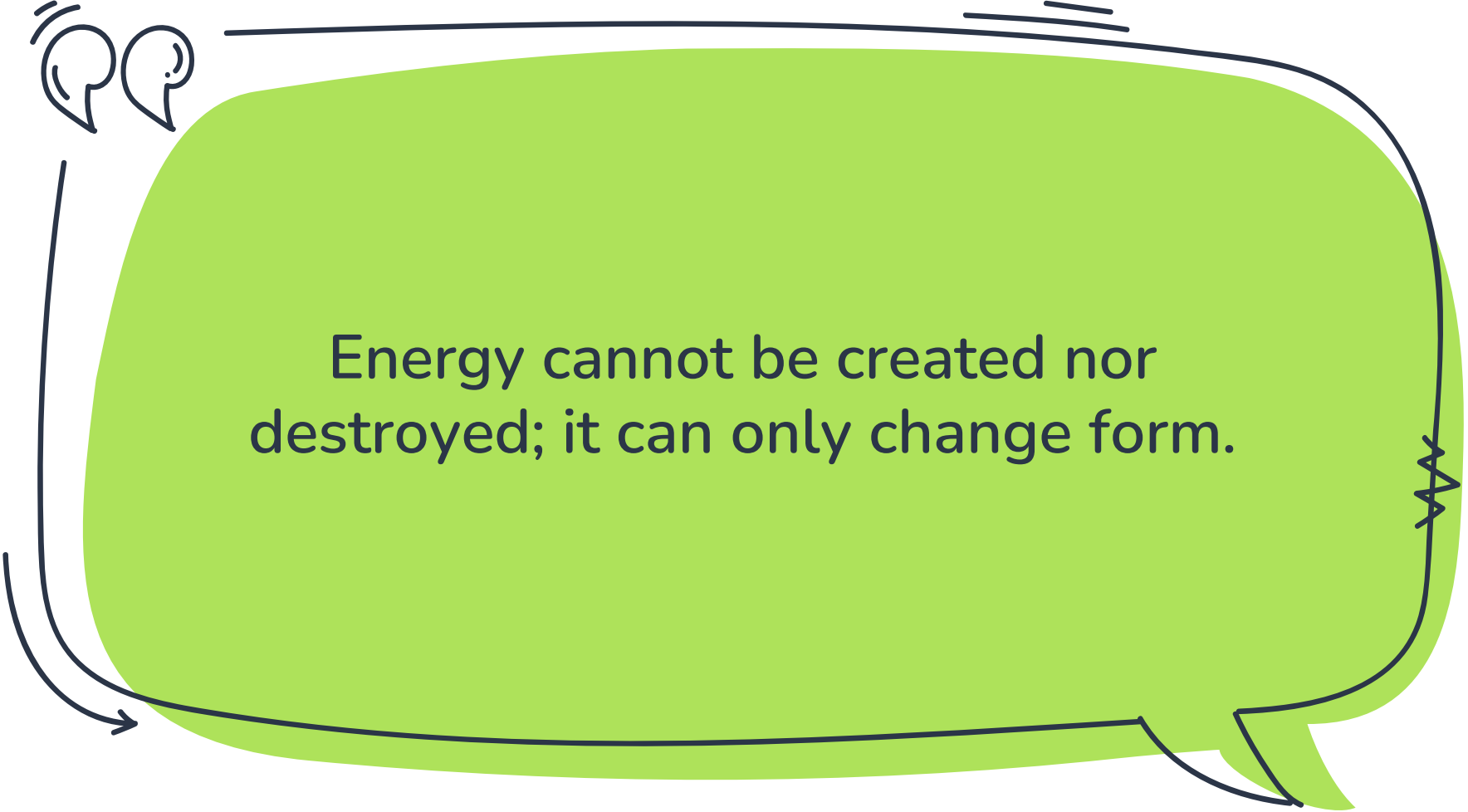
Experiment:  
Plastic bottle

6



ENERGY





Energy cannot be created nor  
destroyed; it can only change form.

# HOW TO TRANSMIT ENERGY?

## Convection

- through the movement of a fluid



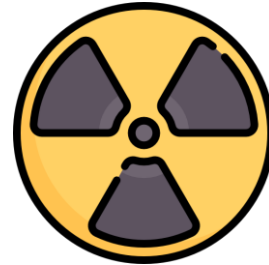
## Conduction

- through direct contact

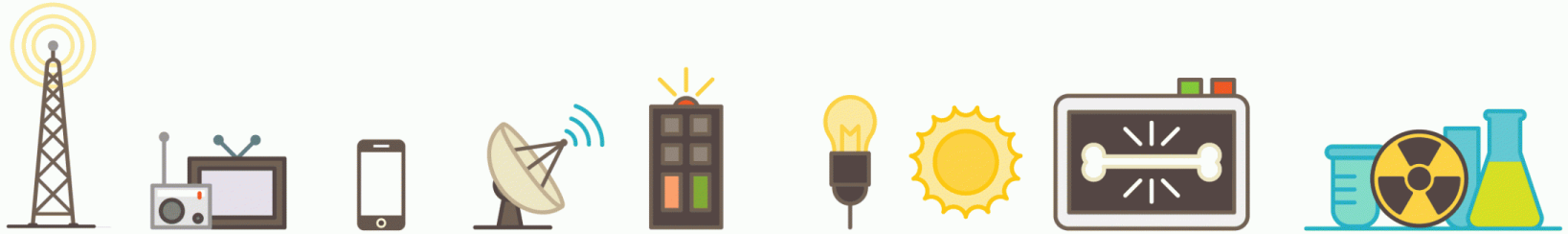


## Radiation

- by electromagnetic waves



# Electromagnetic Spectrum



AM

FM TV

Cell Phones

Radar

TV Remote

Light Bulb

Sun

X-ray machine

Radioactive Elements

Extremely Low Frequency

Radio waves

Microwaves

Infrared

Visible Light

Ultraviolet

X-rays

Gamma rays

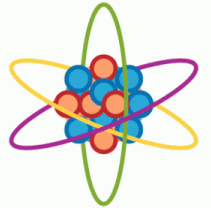
NON-IONIZING

IONIZING

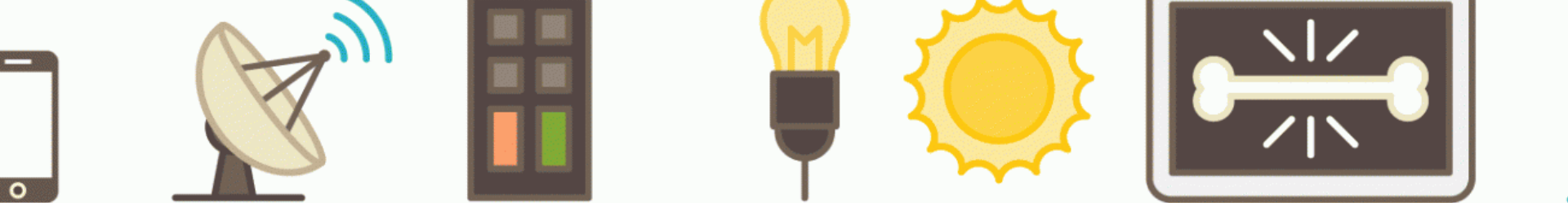


Building Size

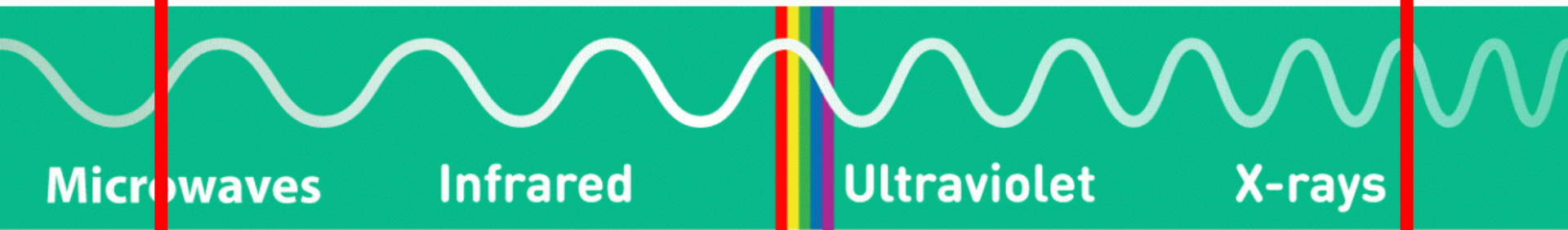
VISIBLE SPECTRUM



Atom Size



Phones Radar TV Remote Light Bulb Sun X-ray machine

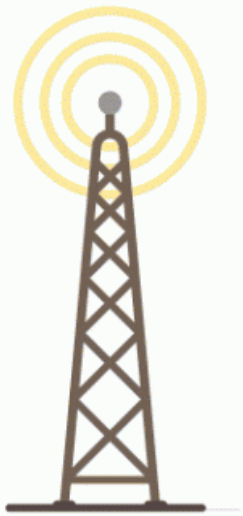


NON-IONIZING

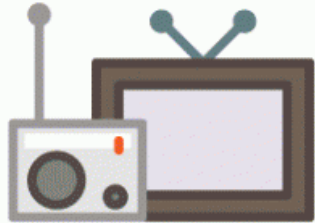
IONIZING







**AM**



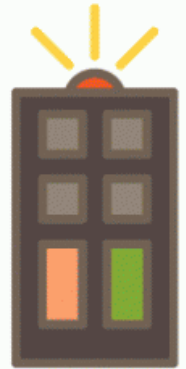
**FM TV**



**Cell Phones**



**Radar**



**TV Remote**



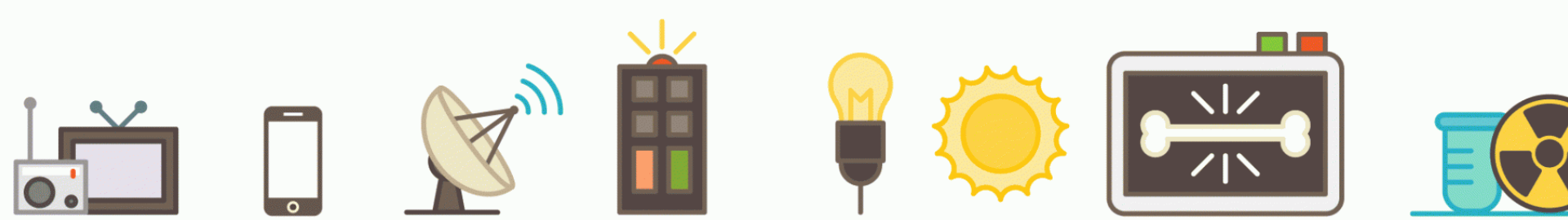
**Extremely Low  
Frequency**

**Radio waves**

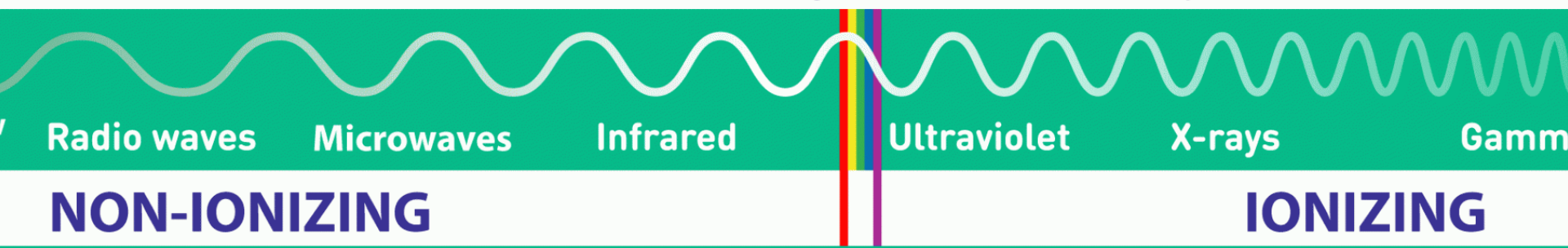
**Microwaves**

**Infrared**

**NON IONIZING**



FM TV    Cell Phones    Radar    TV Remote    Light Bulb    Sun    X-ray machine    Radioactive



Radio waves    Microwaves    Infrared    Visible light    Ultraviolet    X-rays    Gamma rays

**NON-IONIZING**

**IONIZING**

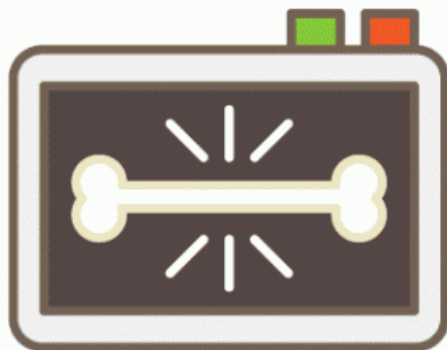
# VISIBLE SPECTRUM



Light Bulb



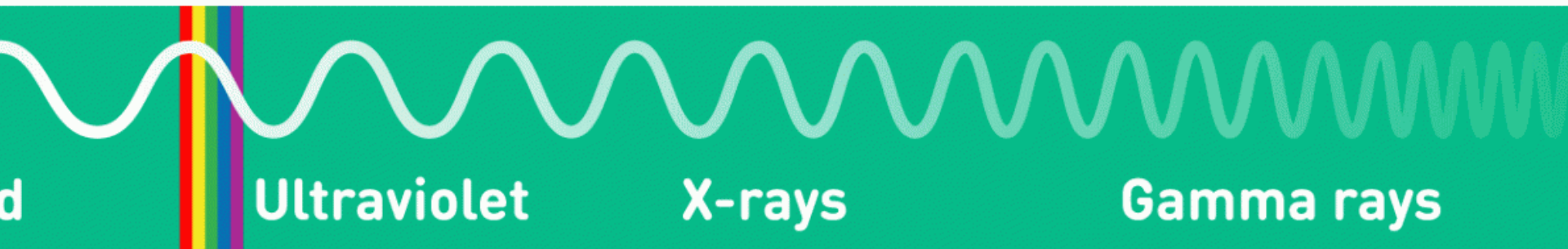
Sun



X-ray machine



Radioactive Elements



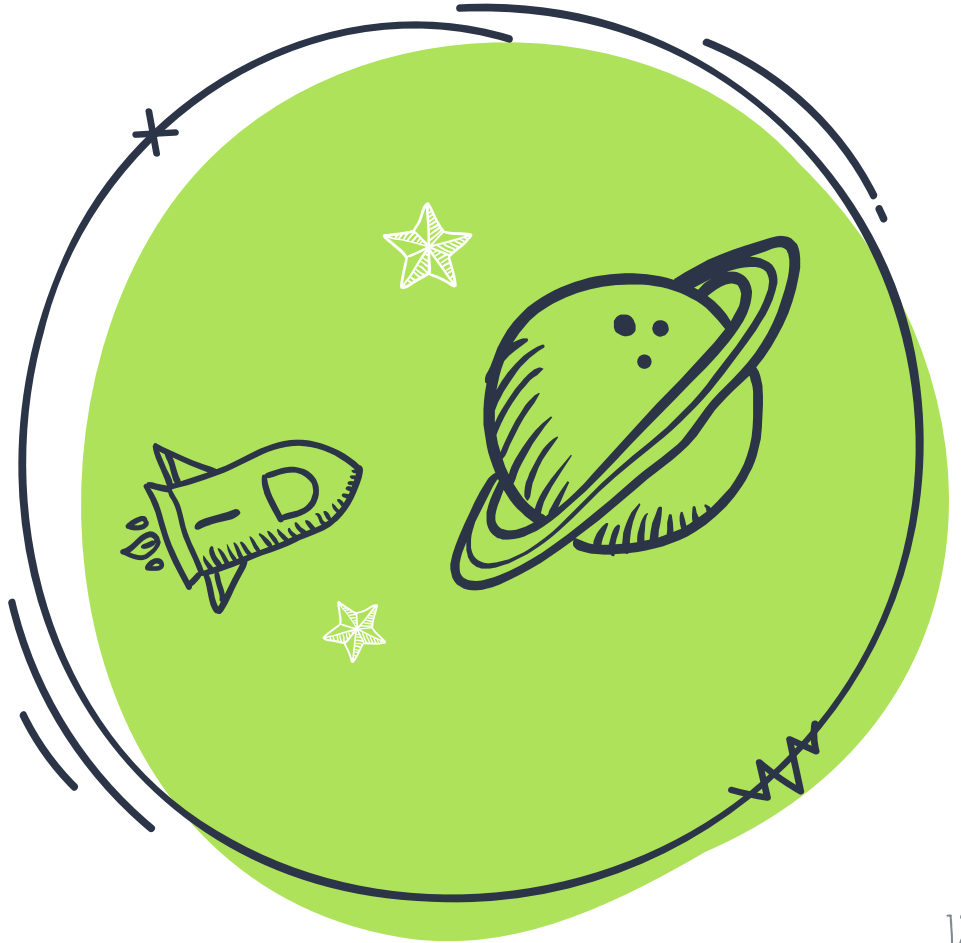
Ultraviolet

X-rays

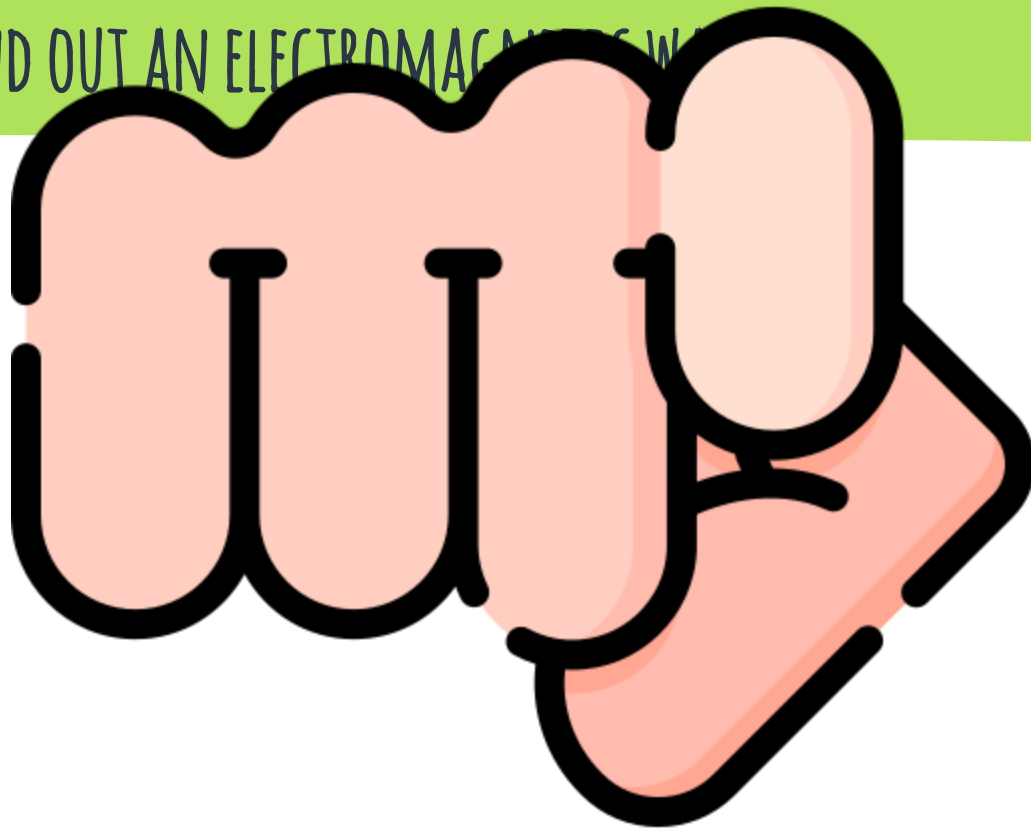
Gamma rays

**IONIZING**

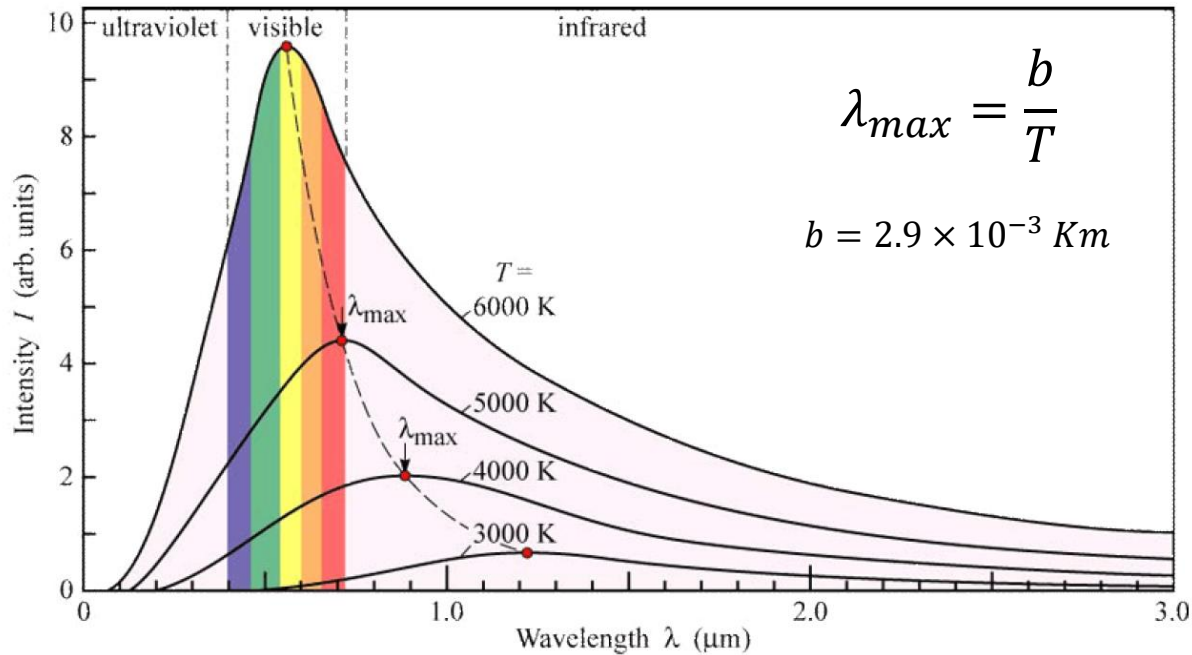
EM waves greatly differ depending on their wavelength.



# HOW TO SEND OUT AN ELECTROMAGNETIC WAVE



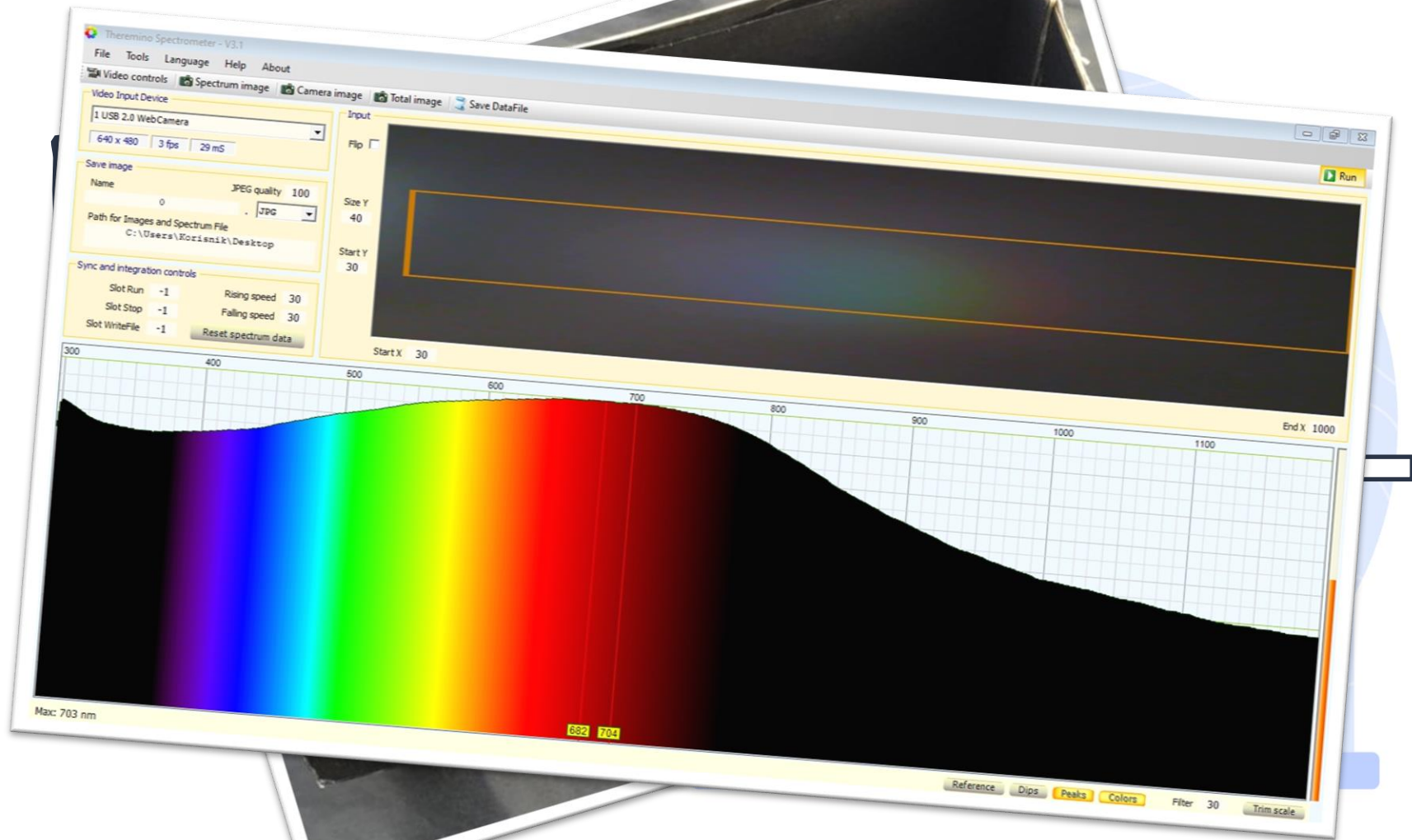
# WIEN'S DISPLACEMENT LAW



$$\lambda_{\text{max}} = \frac{b}{T}$$

$$b = 2.9 \times 10^{-3} \text{ Km}$$







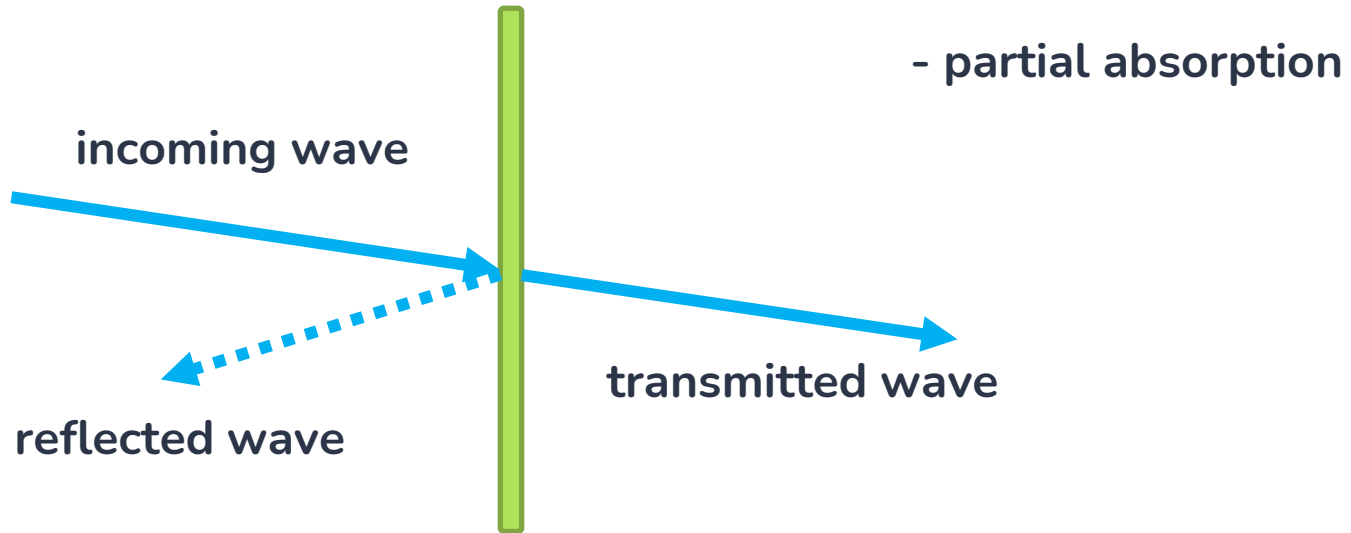
2

# WAVE BEHAVIOUR

Reflection, transmission, absorption



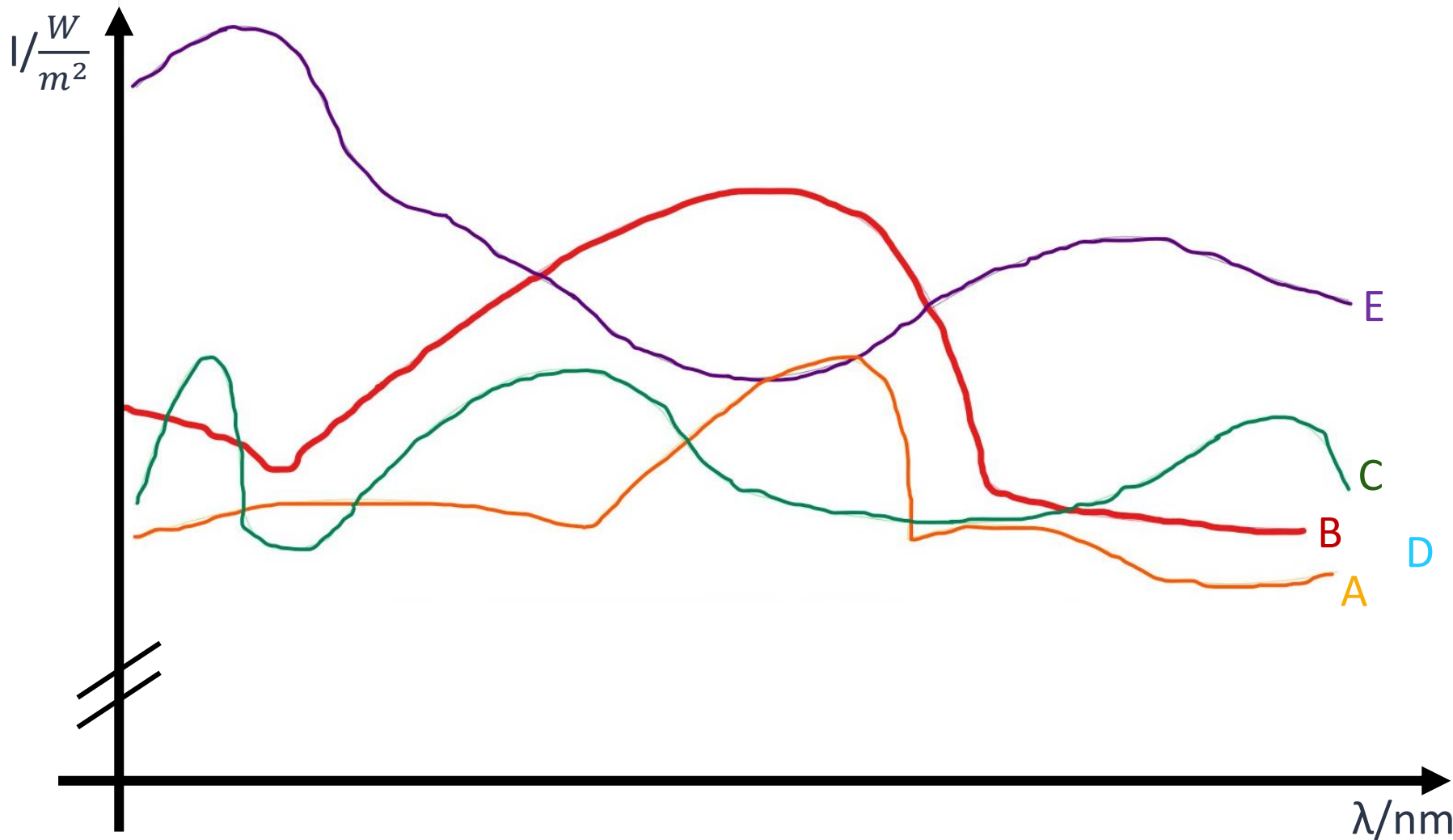
# WAVE BEHAVIOUR



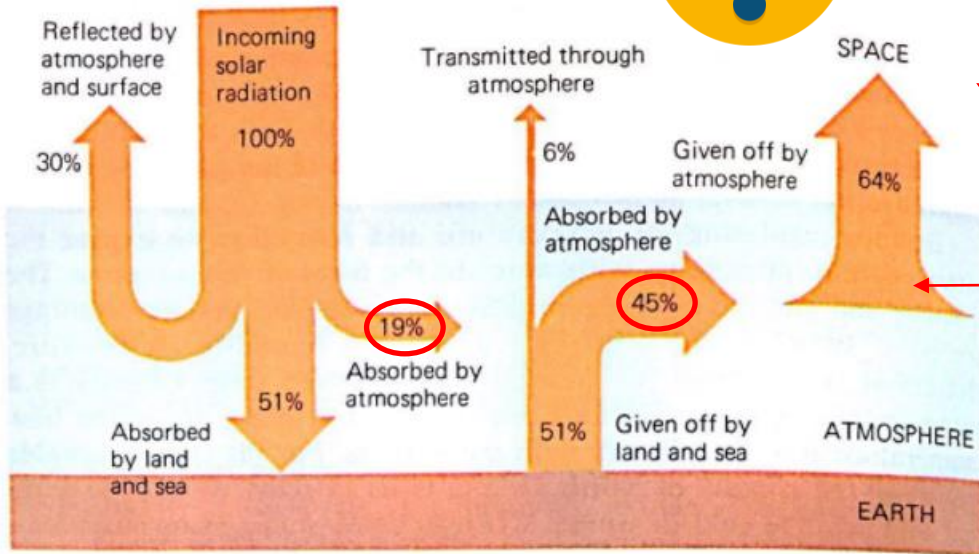


# GRAPH ANALYSIS QUESTION

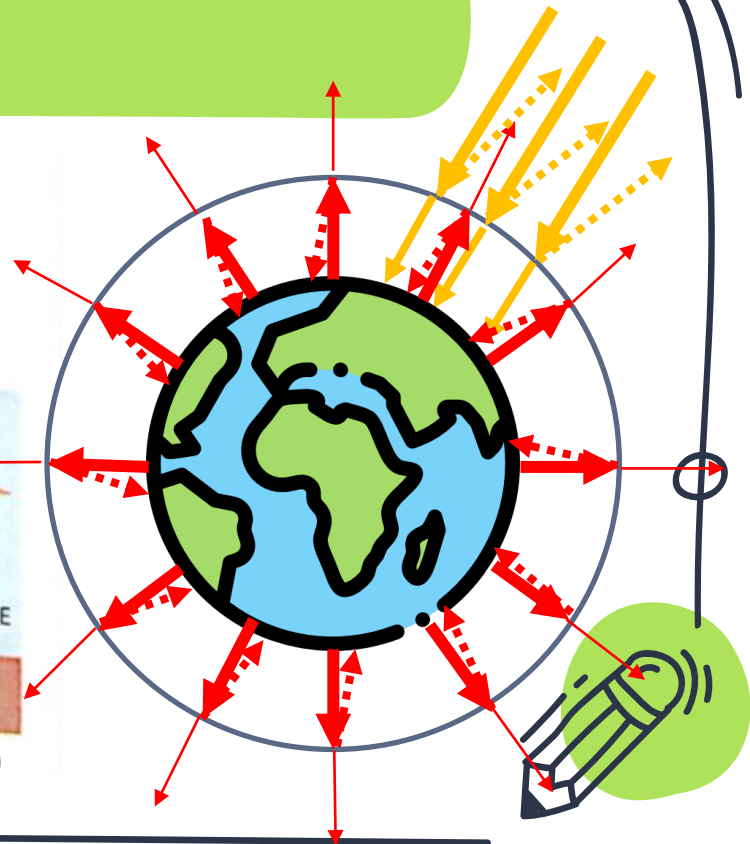
Transmission through  
glass plate



# THE GREENHOUSE EFFECT



(Krauskopf, fig. 13-11, p. 466)

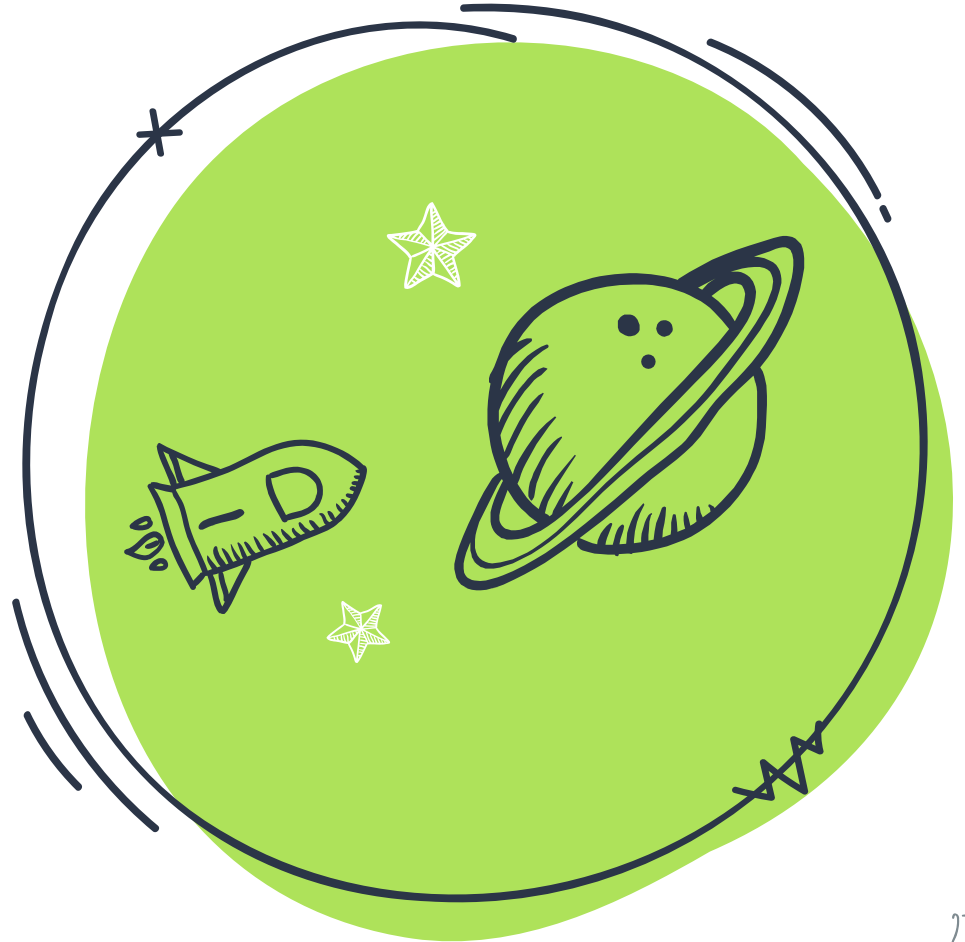


- Without the greenhouse effect, the average surface temperature of Earth would be  $-18^{\circ}\text{C}$ .
- The last decade was the hottest in 2500 years.

1. transmission, absorption and reflection depend on the material of the barrier and the wavelength of the EM wave

2. the Earth mostly radiates in the infrared part of the EM spectrum

3. the Sun mostly radiates in the visible part of the EM spectrum



# QUESTION

How do we know that the Earth doesn't radiate greatly within the visible part of the spectrum?

Hint: No math! Rely on your everyday experience and what you can('t) see!



# ANSWER

If Earth did in fact radiate with high intensity within the visible spectrum, we would see it glow at night!



# (MATH) QUESTION

At what wavelength (in nm and mm) does the Earth's intensity of radiation peak?

Instructions: We're doing a rough estimate! Take the temperature of the Earth to be  $20^{\circ}\text{C} \approx 300\text{ K}$ , and the Wien's displacement constant  $b \approx 3 \times 10^{-3}\text{ Km}$ .





# ANSWER

$$\lambda_{max} = \frac{b}{T} = \frac{3 \times 10^{-3} \text{ Km}}{300 \text{ K}} = 10^{-5} \text{ m} =$$
$$= 0,01 \text{ mm} = 10\,000 \text{ nm}$$



# GREENHOUSE GASES

FLUORINATED

Name	Chemical formula	Global Warming Potential after ...		
		... 20 years	... 100 years	... 500 years
Carbon dioxide	CO <sub>2</sub>	1	1	1
Methane	CH <sub>4</sub>	25	72	7,6
Nitrous oxide	N <sub>2</sub> O	289	298	153
Carbon tetrafluoride	CF <sub>4</sub>	5 210	7 390	11 200
Sulfur hexafluoride	SF <sub>6</sub>	16 300	22 800	32 600
Nitrogen trifluoride	NF <sub>3</sub>	12 300	17 200	20 700

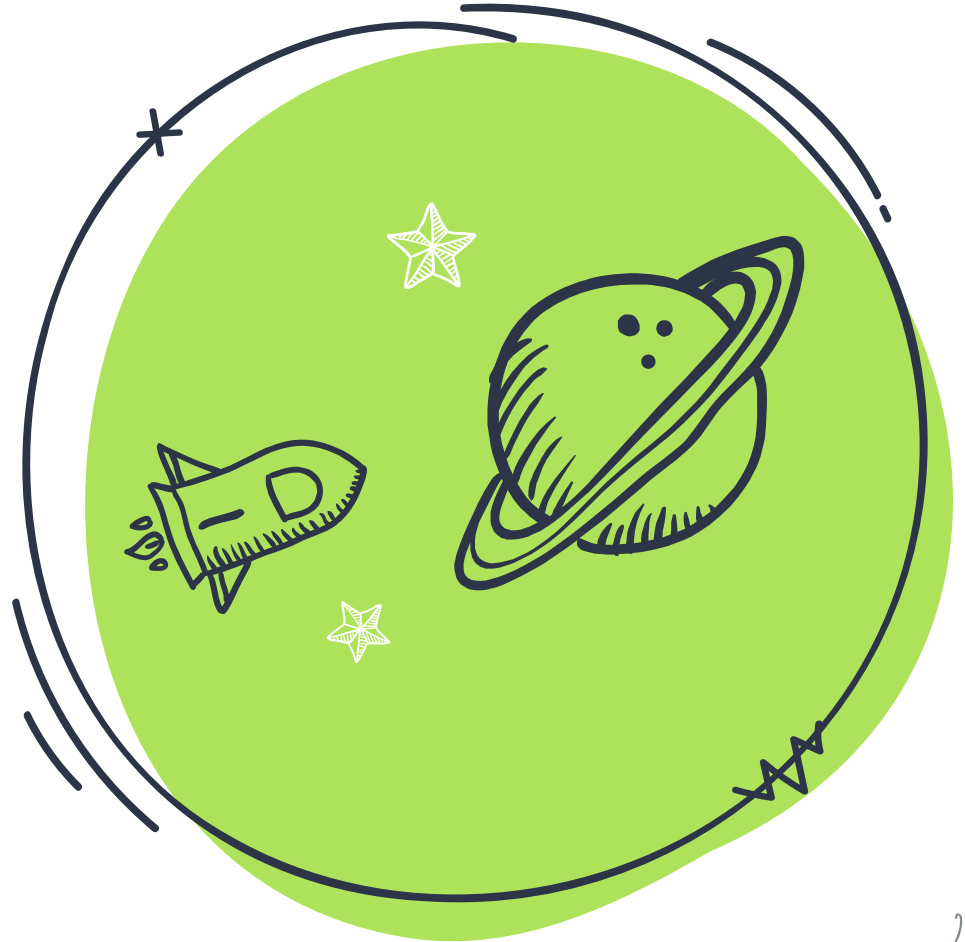


What is the most widespread greenhouse gas?

Answer: H<sub>2</sub>O



Greenhouse gases have a different Global Warming Potential (GWP).



## CARBON 'FUN' FACTS

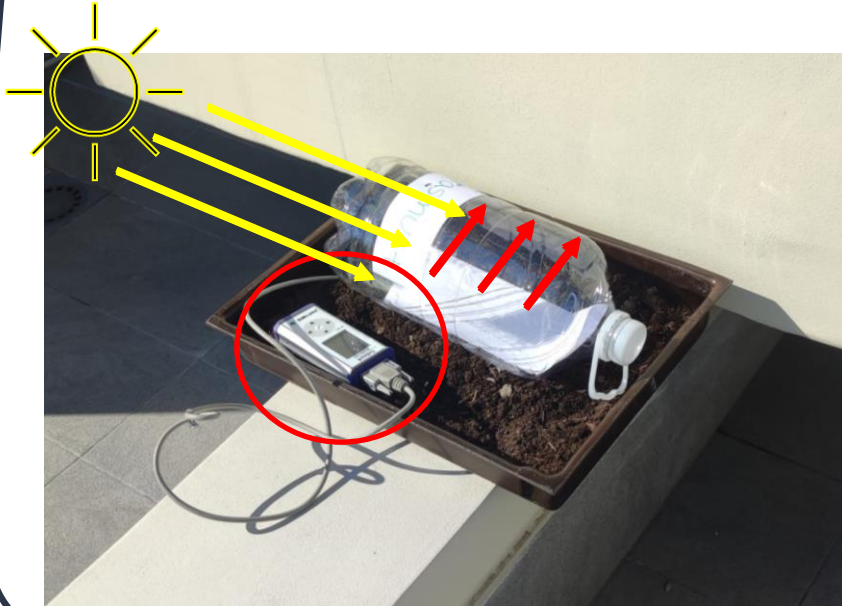
- X A Big Mac's carbon footprint is equal to driving a car around 12.5 km.
- X Permafrost contains 65% more carbon than the atmosphere. If it melts the released carbon can worsen climate change.
- X Food production produces 19 times more carbon than the commercial aviation industry.

# EXPERIMENT TIME

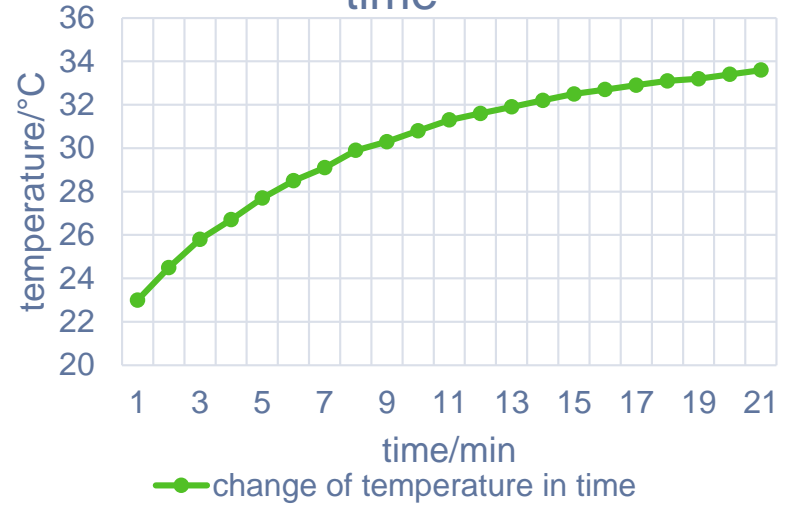
Greenhouse effect in a  
plastic bottle

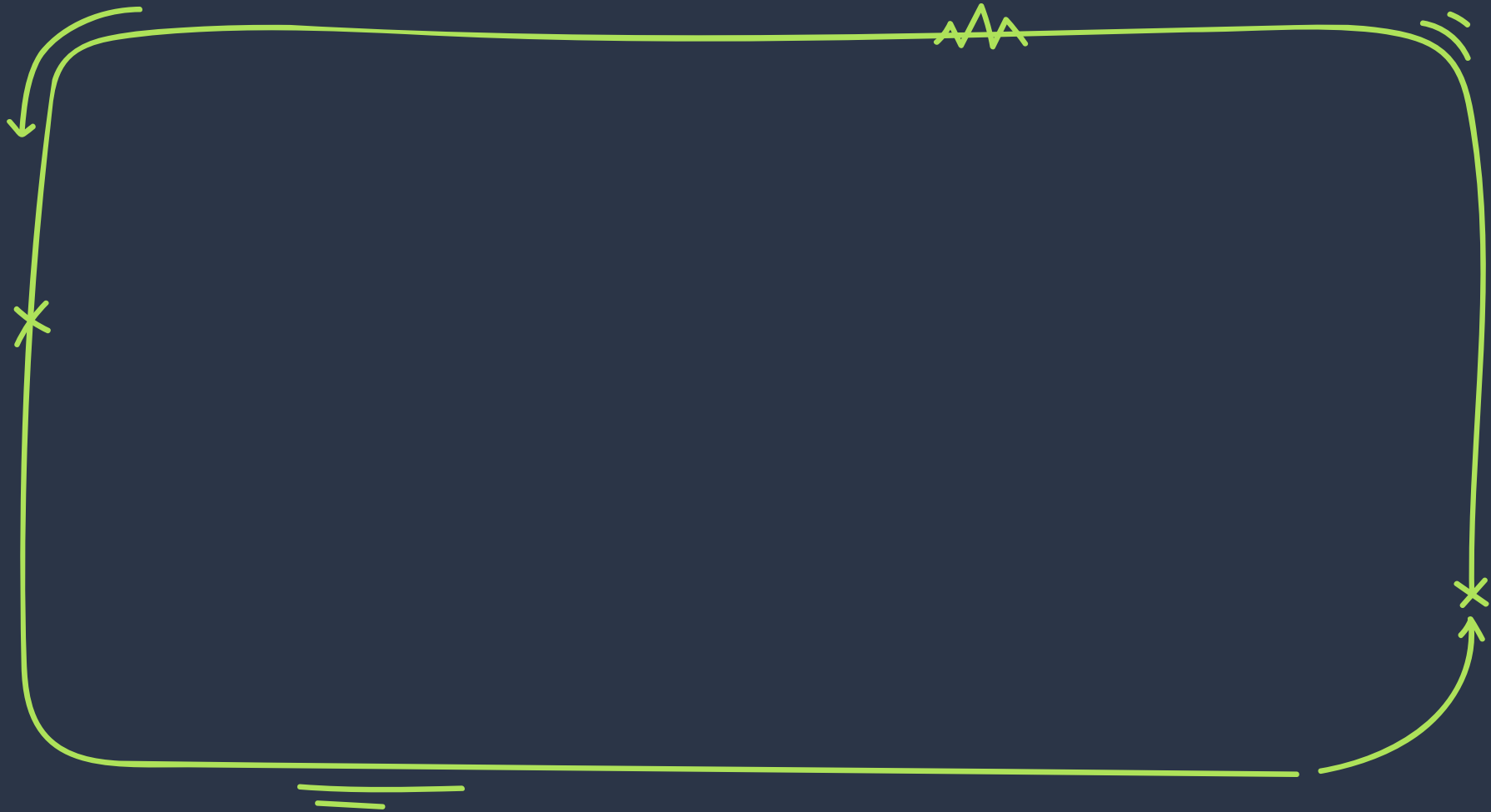


# EXPERIMENT TIME



Temperature dependency on time





# THANKS!

Any questions?





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