

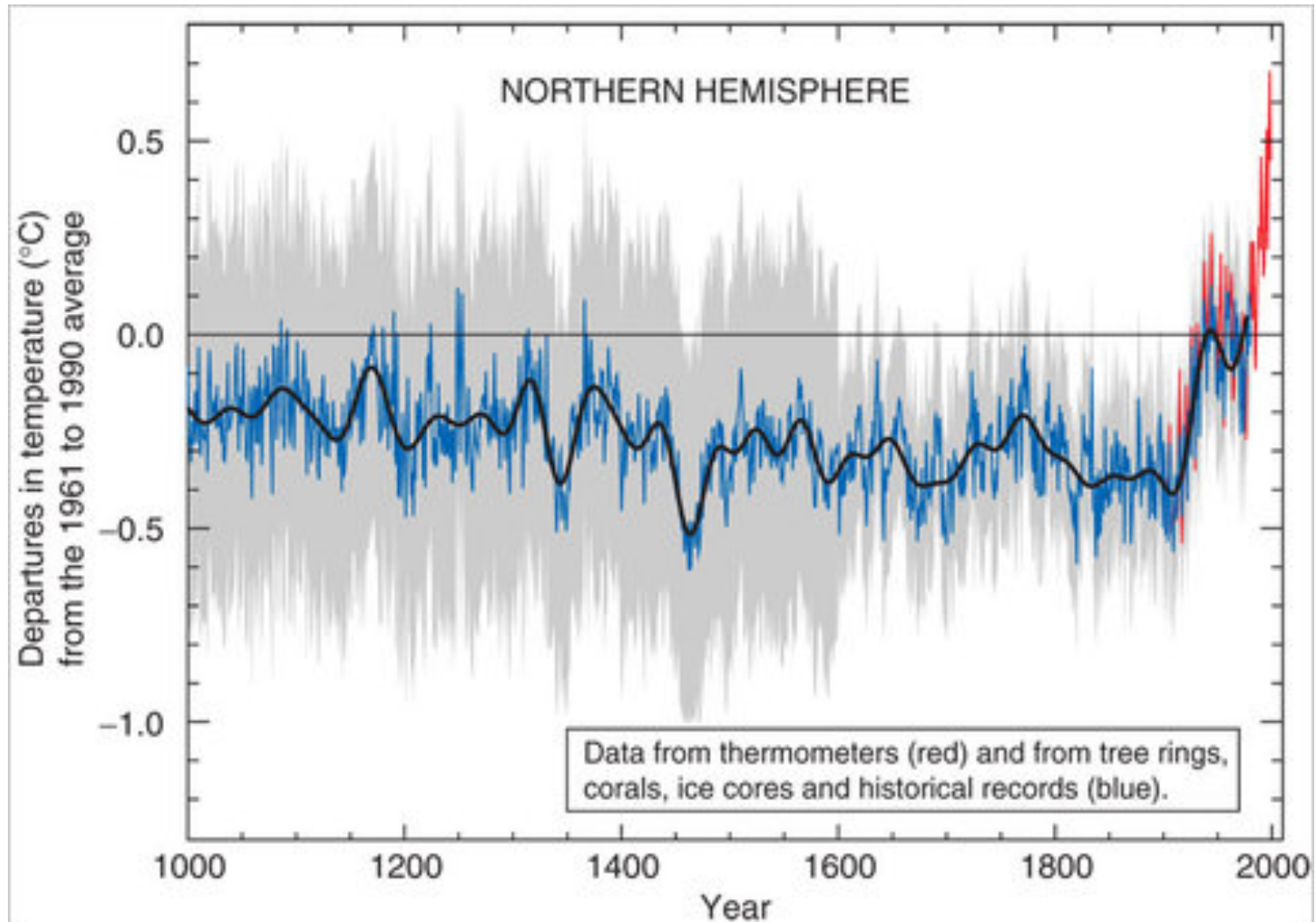
Climate Change & Greenhouse Gases



Communicating
Ocean Sciences
to
Informal Audiences



Think-Pair-Share

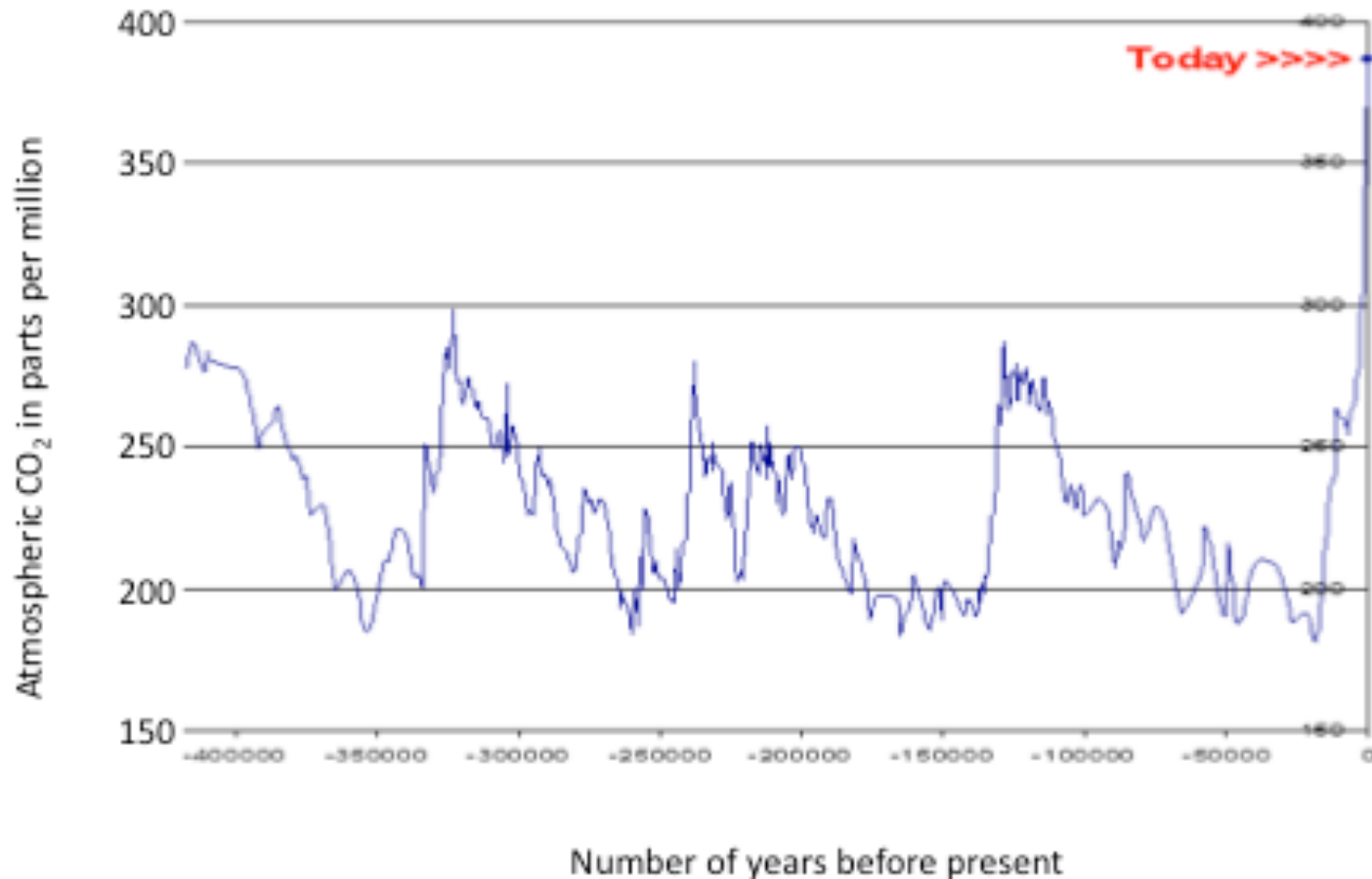


Earth's temperature has increased
over the past 50 years.
What is the main cause?

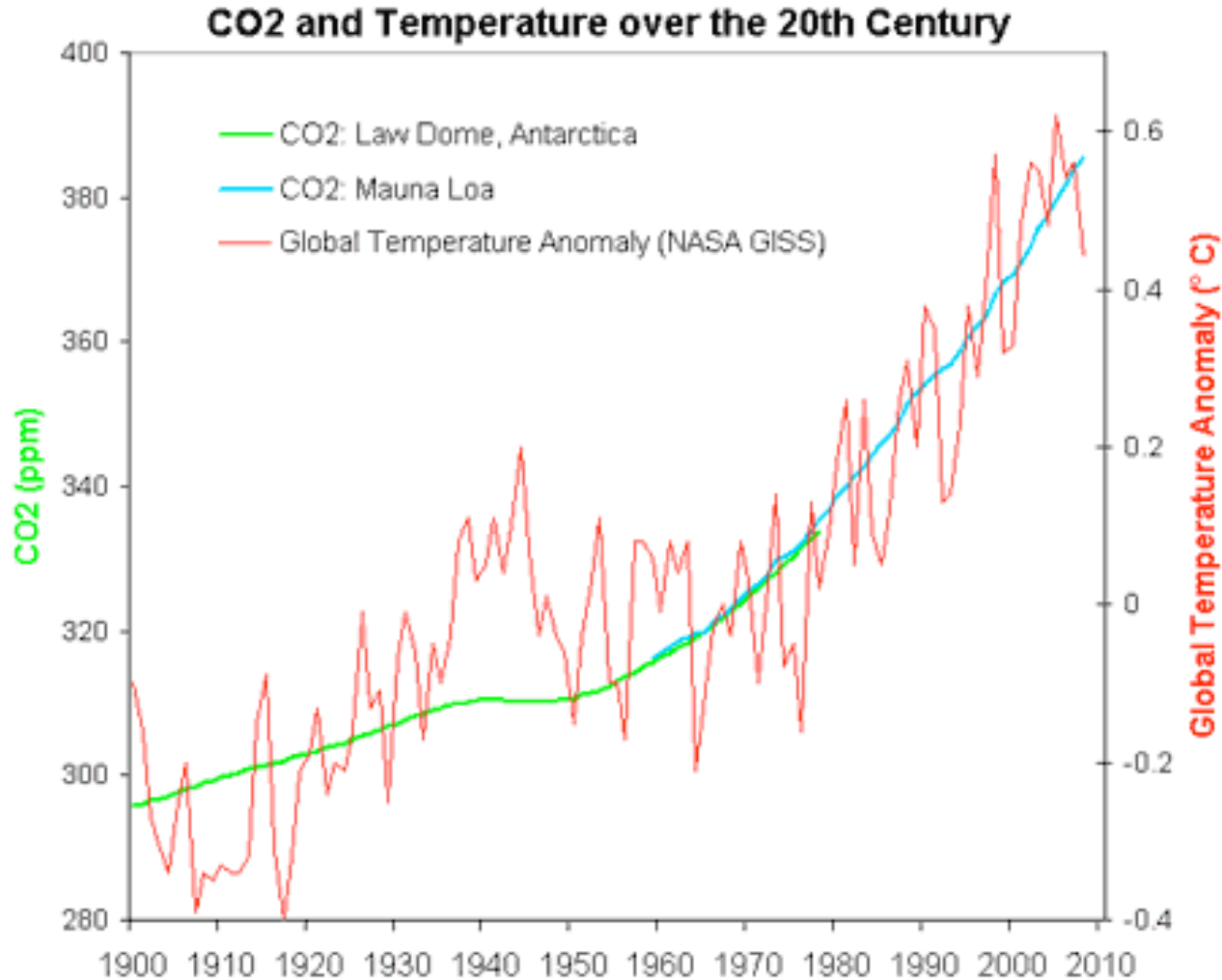
- A. The number of active volcanoes on Earth has increased.
- B. The burning of fossil fuels like coal and gasoline releases greenhouse gases.
- C. Human population has increased from about 3 billion in 1960 to 6.93 billion today.
- D. Earth's orbit has changed, and we are now closer to the sun than we were before.

Since 1960, CO₂ levels in the atmosphere have increased faster than at any other time in Earth's history

Atmospheric CO₂ from 400,000 Years Ago - present



As atmospheric CO₂ levels have increased, so has Earth's temperature



Why do greenhouse gases have such a big impact on Earth's temperature?

- A. They remain in the atmosphere for a long time.
- B. They trap heat from the Sun.
- C. Humans produce a lot of them.
- D. They are part of feedback loops, which compound the greenhouse effect.

Greenhouse Effect

- Draw a diagram depicting your understanding of the greenhouse effect.
- Label the parts of your diagram.
- Record any questions you have about the greenhouse effect.

Greenhouse in a Bottle



After the activity...take a few moments to

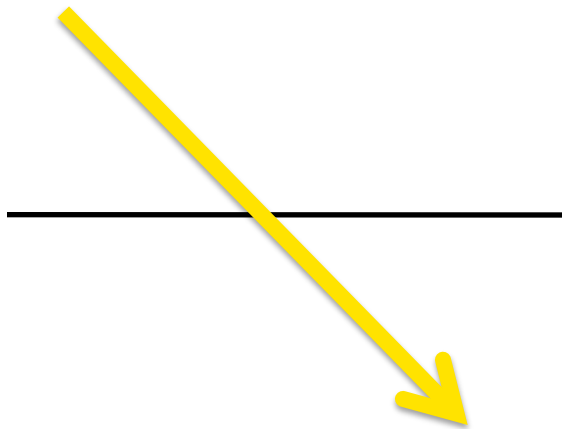
- Add to &/or revise your original diagram with additional details.
- Record additional questions that came up for you as you did the activity.
- Discuss your ideas, drawing and questions with a partner/small group.
- How would you explain your findings if you were going to “publish” right now?

Simulation

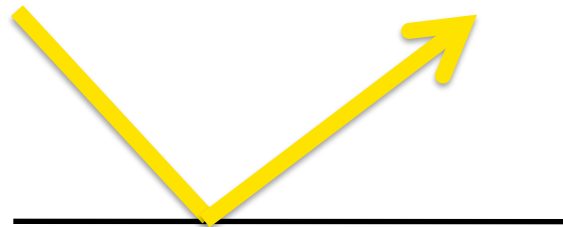
- Your challenge is to figure out why atmospheric temperatures rise when greenhouse gases are present in the atmosphere.
- This simulates how gases respond to:
 - Visible Photons — light
 - Infrared Photons — heat

When a photon hits a molecule,
there are three options:

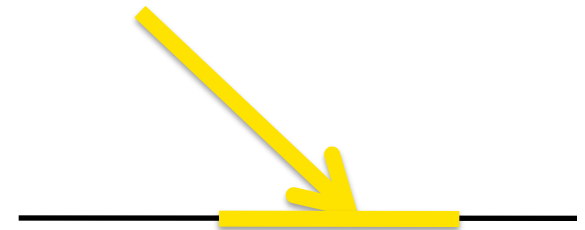
Transmit



Reflect



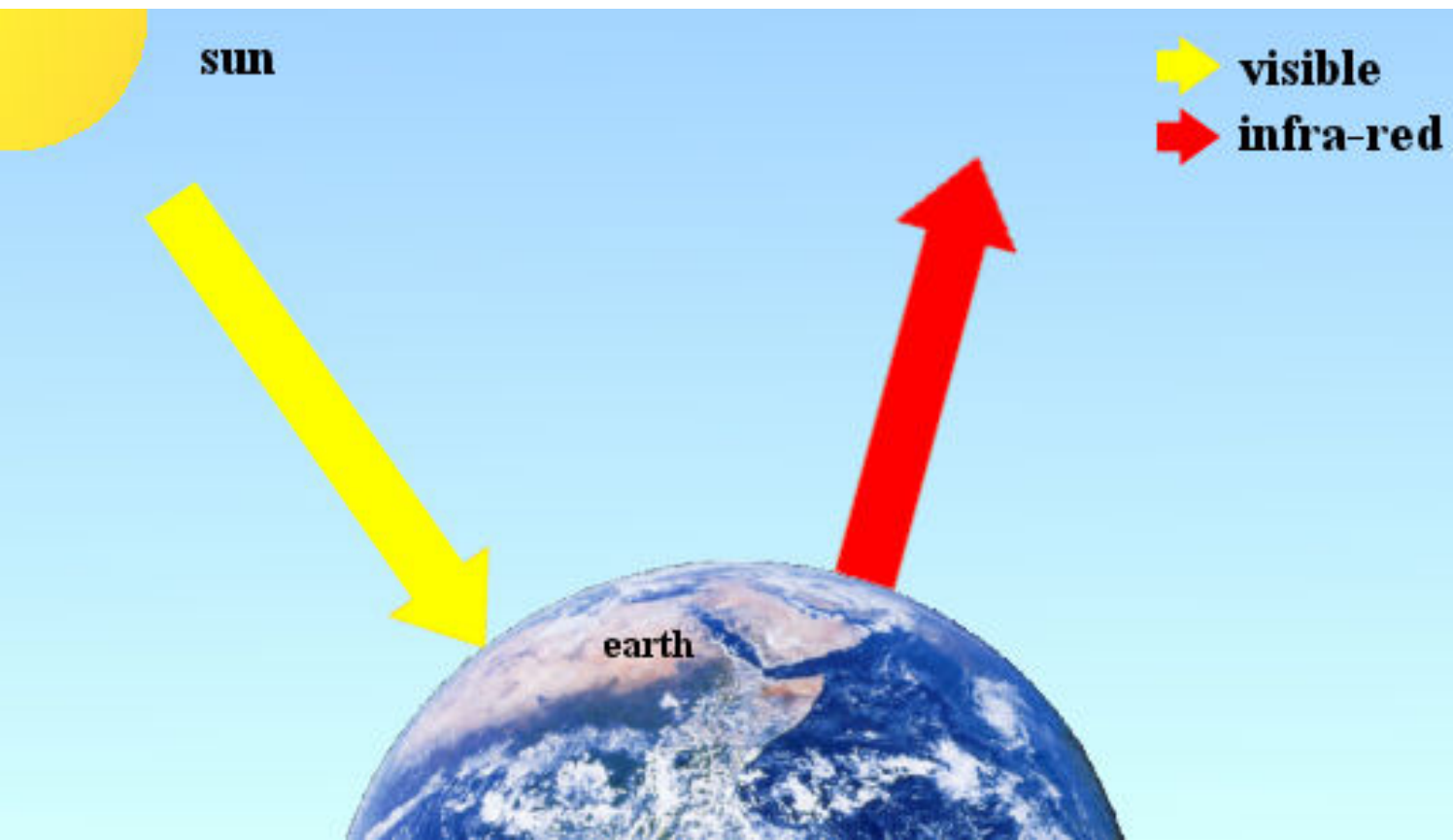
Absorb



Solar energy enters Earth's atmosphere.

Earth radiates heat.

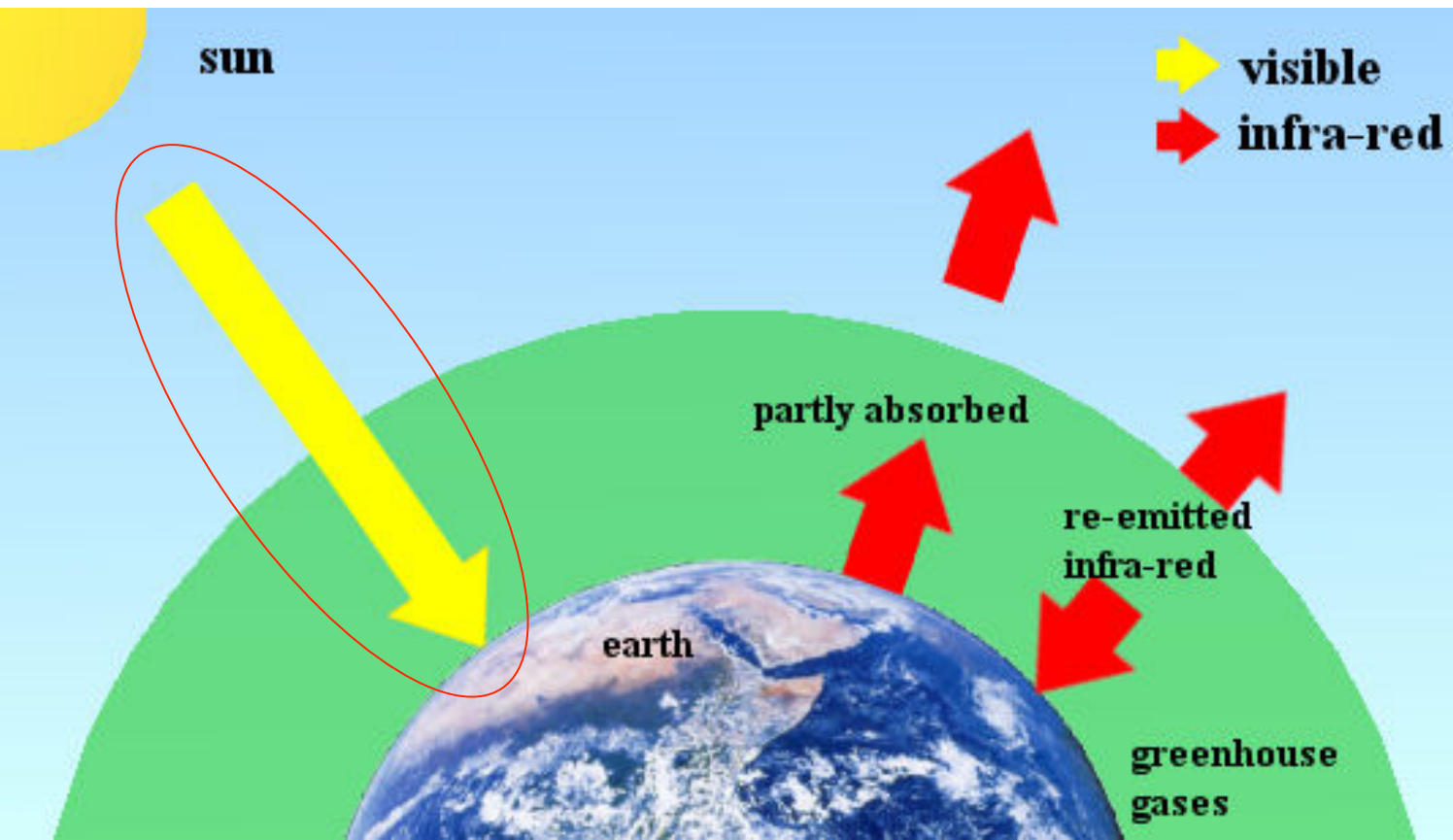
What happens to that heat when it hits the atmosphere?



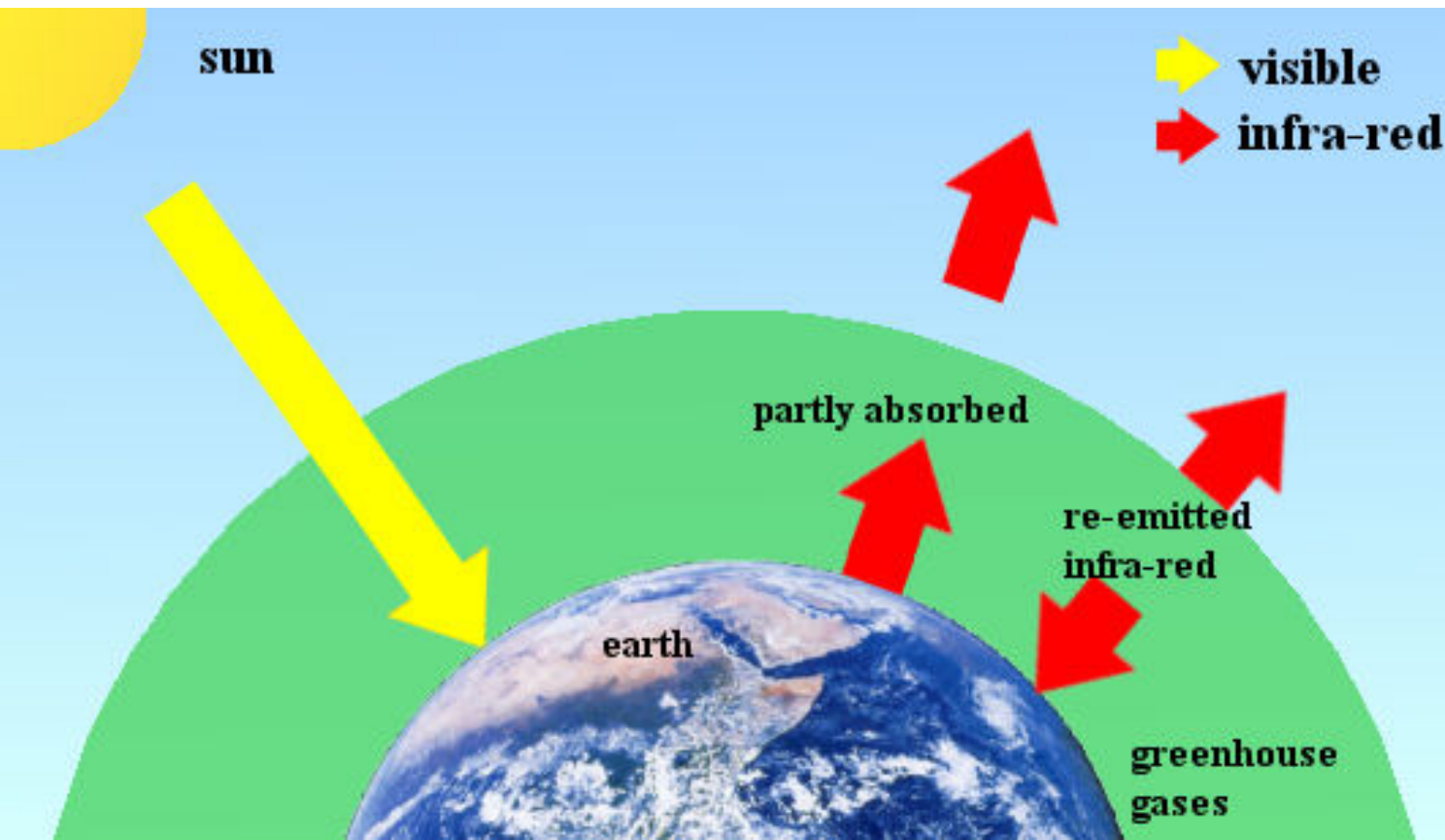
In this diagram, there is NO atmosphere, and the infrared radiation just goes back into space.

Greenhouse gases in the atmosphere transmit light (visible photons/radiation).

Light is absorbed by Earth and is radiated back to the atmosphere.



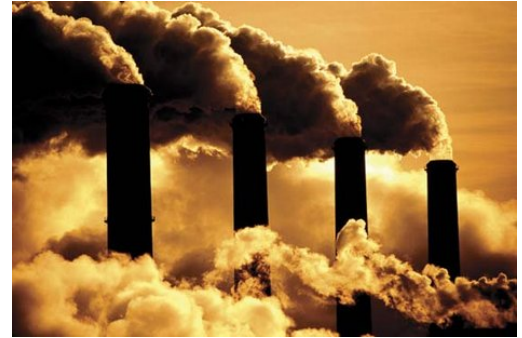
Greenhouse gases in the atmosphere absorb heat (infrared radiation). This heat is radiated back to Earth.



In this diagram, there is an atmosphere with greenhouse gases. The ghgs absorb infrared radiation (heat), and re-emit it back to Earth. Some of the heat gets re-emitted into space.

Some greenhouse gases

- Carbon dioxide — CO₂



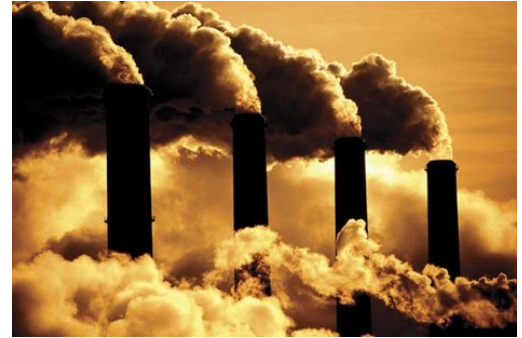
35 ggt CO₂/year
from human
activity



0.13-0.44 ggt CO₂/year
from volcanoes

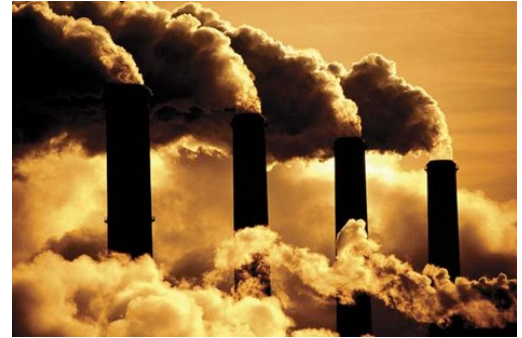
Some greenhouse gases

- Carbon dioxide — CO_2
- Methane — CH_4



Some greenhouse gases

- Carbon dioxide — CO_2



- Methane — CH_4

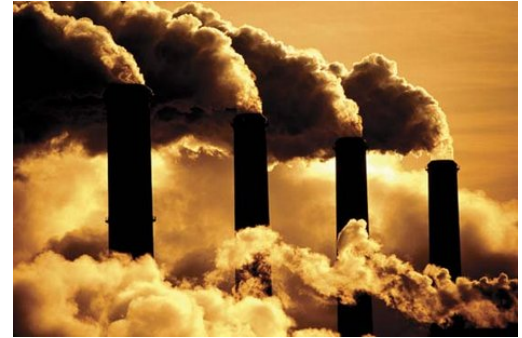


- Nitrous Oxide — N_2O



Some greenhouse gases

- Carbon dioxide — CO_2



- Methane — CH_4



- Nitrous Oxide — N_2O



- Chlorofluorocarbons (CFCs)



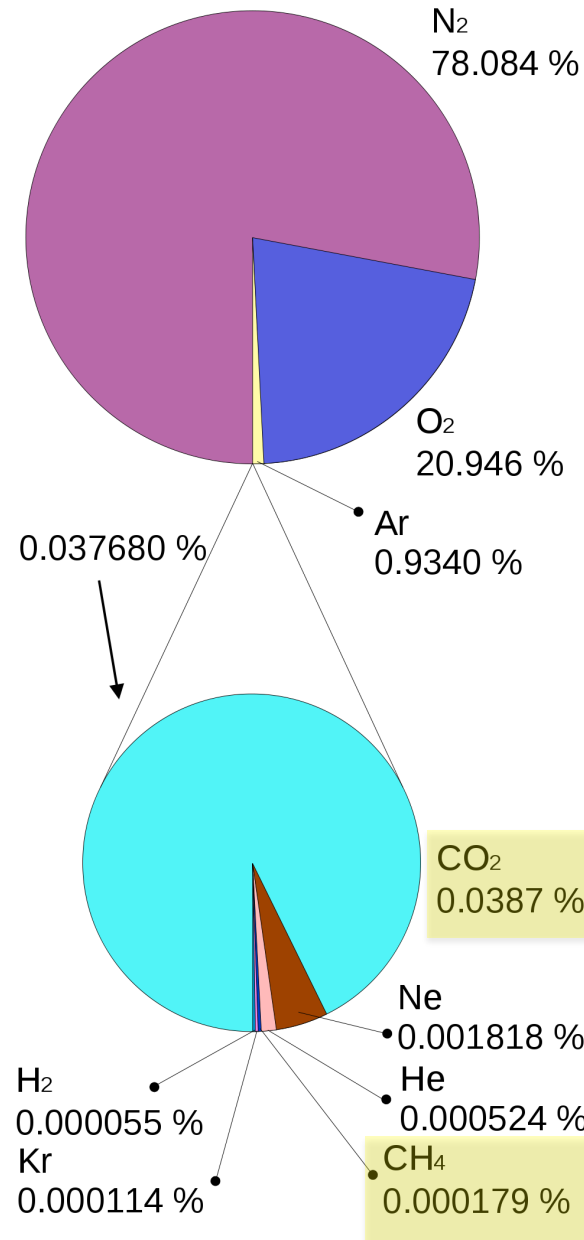
Reading about Greenhouse Effect

- Active Reading
 - Underline parts you think are important or interesting
 - Circle parts that are unclear or confusing
 - Write questions in the margin.
 - Pair up with someone and try to answer each other's questions.

CO₂ makes up what percent of the atmosphere?

- A. 38.7%
- B. 3.87%
- C. 0.387%
- D. 0.0387%

Greenhouse gases make up a small proportion of the atmosphere

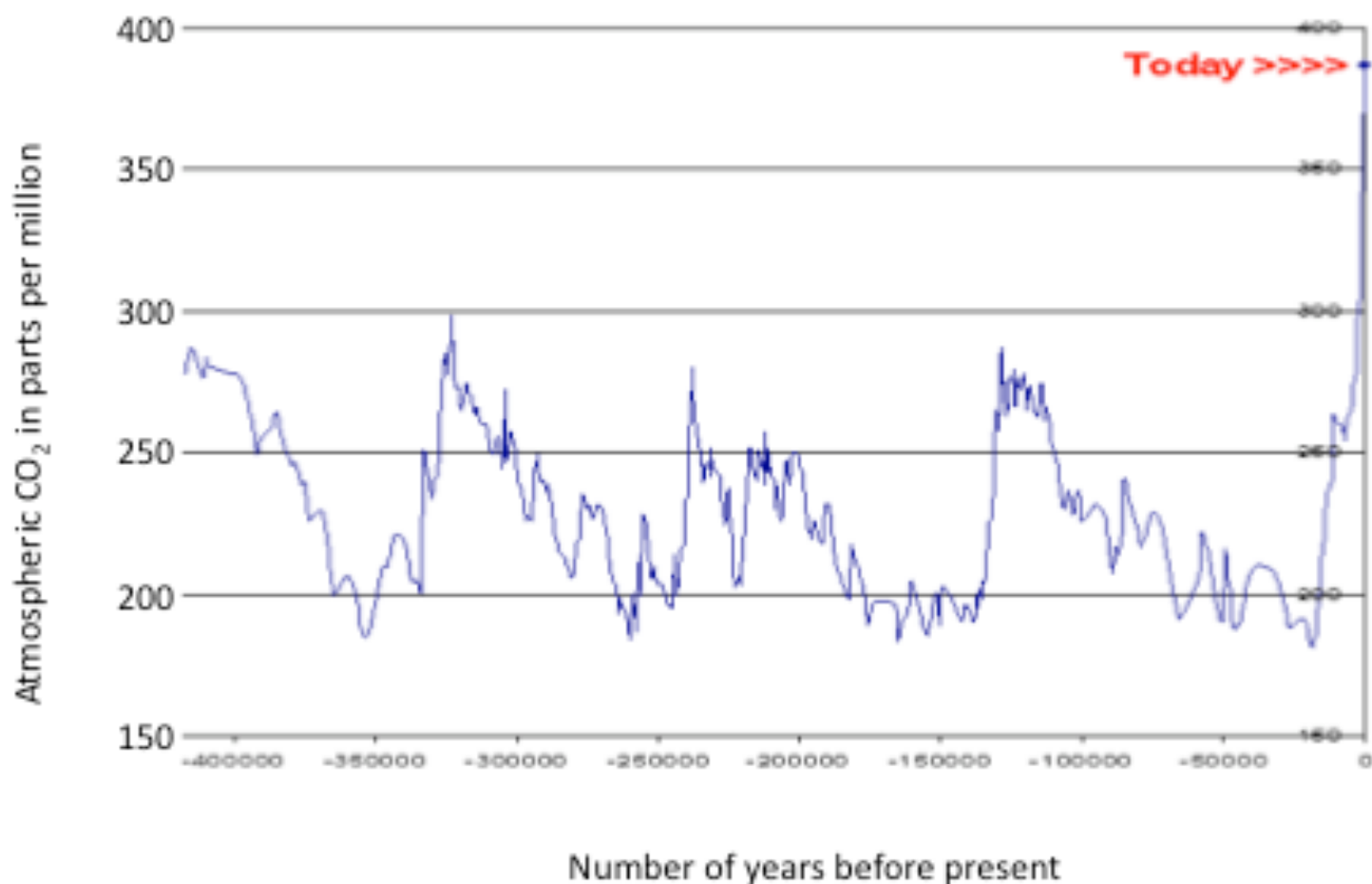


Parts per million—ppm

- CO₂ makes up 0.0387 percent—parts per hundred—of the atmosphere.
- CO₂ makes up 387 parts per million of the atmosphere.

→ concentration of CO₂ in atmosphere is 387 ppm

Atmospheric CO₂ from 400,000 Years Ago - present



Greenhouse gases make up a small proportion of the volume of the atmosphere.

Why does this small proportion of molecules have such a big effect on Earth's temperature?

Not all greenhouse gases are the same

- They interact with heat differently and vary in their efficiency as a greenhouse gas.
- They vary in the amount of time they spend in the atmosphere—their atmospheric lifetime.
- They vary in their Global Warming Potential—the increase in the greenhouse effect caused by 1 kilogram of the gas, relative to the effect caused by 1 kilogram of CO₂.

Not all greenhouse gases are the same

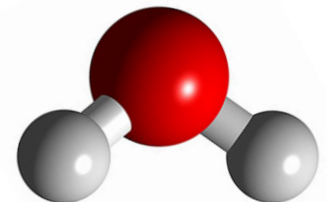
LIFETIME AND GLOBAL WARMING POTENTIAL OF HUMAN-GENERATED GREENHOUSE GASES						
Gas	CO ₂	CH ₄	N ₂ O	CFC-11	CFC-12	HCFC-22
Lifetime years	Multiple	12	114	45	100	12
Global warming potential						
20 years	1	72	289	6,730	11,000	5,160
100 years	1	25	298	4,750	10,900	1,810
500 years	1	8	153	1,620	5,200	549

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Global warming potential: increase in the greenhouse effect caused by 1 kilogram of the gas, relative to the effect caused by 1 kilogram of CO₂.

Feedback Loops Compound the Greenhouse Effect

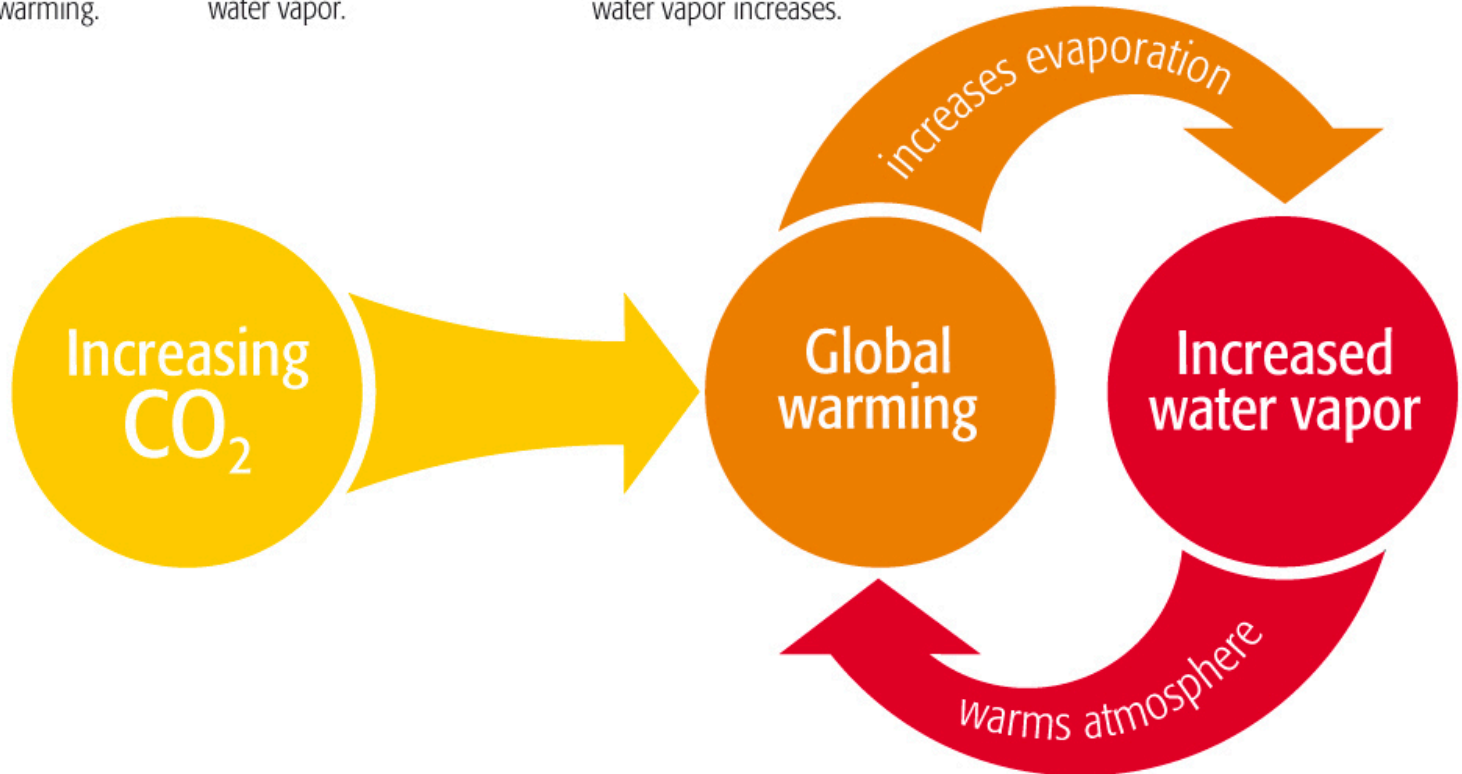
- Greenhouse gases have indirect effects on the climate, because they are part of Earth's climate system.
- Greenhouse gases warm the atmosphere, which makes surface water evaporate.
- This forms water vapor, which is a greenhouse gas.



Positive Feedback Loop

POSITIVE FEEDBACK LOOP

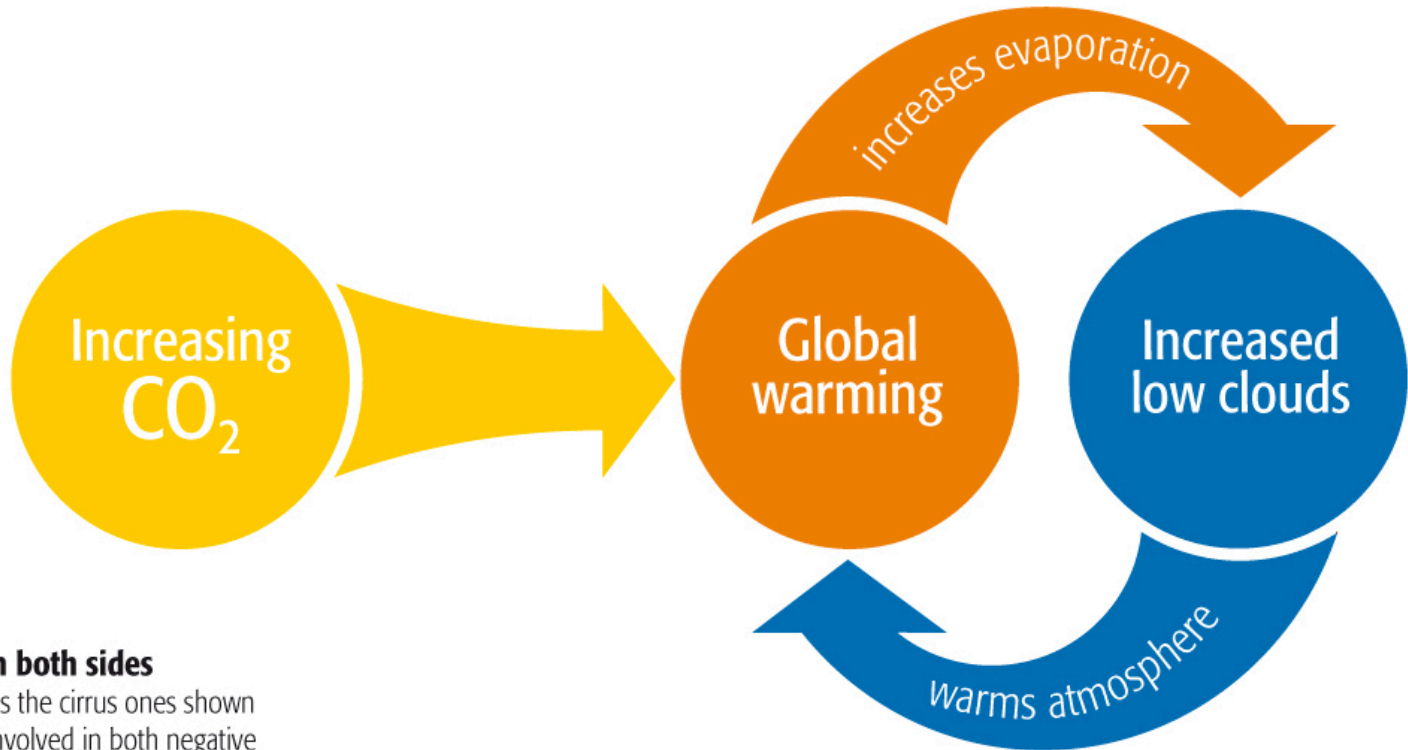
- Adding carbon dioxide to the atmosphere tends to warm the atmosphere, causing global warming.
- The warm atmosphere causes surface water to evaporate and become water vapor.
- Since water vapor is a greenhouse gas, the atmosphere tends to warm even more as water vapor increases.



Negative Feedback Loop

NEGATIVE FEEDBACK LOOP

- Adding carbon dioxide to the atmosphere tends to warm the atmosphere, causing global warming.
- The warm atmosphere causes surface water to evaporate and become water vapor.
- Some water vapor condenses to form clouds. Clouds contribute to the greenhouse effect by trapping heat in the atmosphere, but they also reflect solar energy back to space, helping to cool the planet.



Clouds from both sides

Clouds, such as the cirrus ones shown here, can be involved in both negative and positive climate feedback loops.

Which of these statements about greenhouse gases most surprised you? Discuss with your neighbor, then select your answer.

- A. They remain in the atmosphere for a long time.
- B. They trap heat from the Sun.
- C. Humans produce a lot of them.
- D. Greenhouse gases make up a very small percentage of atmospheric gases.

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