Causes and feedbacks

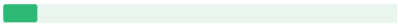
60 minutes • D4.3.1, D4.3.2 • Chapters 1, 2 • The dry lab

How carbon dioxide and methane from human activity warm the planet, correlation and causation in the ice core record, and the positive feedbacks that speed the warming

BY THE END, STUDENTS CAN

- [ ] Explain how human emissions of carbon dioxide and methane cause climate change, and tell correlation from causation in the ice core record D4.3.1
- [ ] Describe five positive feedback cycles that speed up global warming D4.3.2

TIMING

0–5	5 min	**Do now: the curve**	
5–15	10 min	**The greenhouse effect**	
15–32	17 min	**Reading an ice core**	
32–47	15 min	**Five loops**	
47–60	13 min	**Exit**	
	60 min	**One lesson**	

STARTER

5 min

Do now: the curve

Show the Keeling curve with no labels. “What is being measured? Why does the line wiggle every year?” Pairs write one guess for each.

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

01 The blanket we keep thickening

CHAPTER 01 IN THE SLIDES

Play the animation, Trapping the heat. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Sunlight streams in from the Sun as **short-wave radiation**. Clouds, snow and ice reflect some of it straight back to space.
2. The rest passes through the air and is **absorbed** by the land and the sea, which warm up.
3. The warm surface gives off **long-wave infrared**. Some escapes to space; some is sent back down by gases in the air.
4. Zoom into the air. **Nitrogen** and **oxygen**, almost all of it, let infrared pass straight through.
5. A **carbon dioxide** molecule absorbs the infrared and vibrates, then gives it out again in any direction: some back down.
6. **Methane** does the same. Gases that absorb and re-emit infrared hold heat near the ground: the **greenhouse effect**.
7. Burning coal, oil and gas adds **carbon dioxide**; cattle, rice paddies and landfill add **methane**. More infrared comes back down.
8. At Mauna Loa, carbon dioxide has risen from about 315 ppm in 1958 to about 420 ppm today. More greenhouse gas, more heat held in: the **enhanced greenhouse effect**.

Show the figure.

> **Predict box:** Ice cores from Antarctica show that over 800 000 years, temperature and carbon dioxide rose and fell together. What does this correlation show on its own? Hands up or mini whiteboards first.
>
> **Answer B: That the two are linked, but not which one causes the other, or whether a third factor drives both**

Remember it: Cows Rarely Leave Gas (Cattle and sheep, Rice paddies, Landfill, Gas and coal).

02 Warming that makes more warming

CHAPTER 02 IN THE SLIDES

Play the animation, Warming that feeds itself. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. The Arctic Ocean in summer. Bright **sea ice** reflects most of the sunlight that reaches it straight back out to space.
2. As the Arctic warms, the ice **melts**: pools of meltwater spread over the floes, and they shrink and break apart.
3. Dark open water reflects only a few percent of the sunlight. It **absorbs** the rest, and the sea warms.
4. A warmer sea melts more ice, which lets in more heat: a **positive feedback**. The change speeds itself up.
5. The ocean holds a vast store of dissolved **carbon dioxide**, much of it in cold, deep water.
6. As the air warms, so does the sea, from the surface down.
7. Warm water holds **less dissolved gas** than cold, so carbon dioxide leaves the warming sea, and deep water brings stored carbon back up.
8. More carbon dioxide in the air traps more heat and warms the sea further: a **positive feedback**.
9. Under the tundra lies **permafrost**: ground frozen for thousands of years, full of the remains of plants that never decomposed.
10. Warmer summers thaw it deeper each year. The ice in the ground melts, and **peat** that was frozen or waterlogged starts to rot.
11. **Microbes** decompose the thawed matter and give off **carbon dioxide**; in waterlogged mud with no oxygen, they make **methane**.
12. More greenhouse gas means more warming and a deeper thaw: a **positive feedback**.
13. The boreal forest: spruce and larch on cold soil packed with carbon. Warmer winters bring **less snow**.
14. With less snowmelt and hotter summers, the soil dries out. **Drought** cuts photosynthesis, and the trees turn brown.
15. Dry, dying trees burn: fires come **more often and burn hotter**, down into old carbon stored in the soil.
16. The fires release **carbon dioxide**, and fewer trees are left to take it up: more warming, more drought, more fire.

Predict box: Why is the thawing of permafrost a positive feedback, not a negative one? Hands up or mini whiteboards first.

Answer B: Decomposers break down the thawed organic matter, releasing greenhouse gases that cause more warming and more thawing

Remember it: Icy Oceans Push Polar Fires (Ice and snow, Ocean, Peat, Permafrost, Fires and drought).

THE LESSON

10 min — The greenhouse effect

Chapter 1's film, step by step. Students name what passes through the atmosphere (visible light) and what is absorbed (infrared). Then the methane mnemonic: Cows Rarely Leave Gas.

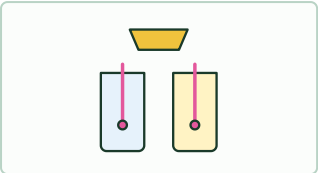
17 min — Reading an ice core

The dry lab in pairs. Each pair samples the core every 20 000 years, then the scatter graph. Ask: is the correlation positive or negative? Does it show what causes what? Chapter 1's predict box settles it.

15 min — Five loops

Chapter 2's film: run each loop in turn. Students draw each as a circle of four arrows on mini whiteboards, then learn Icy Oceans Push Polar Fires.

ACTIVITIES



PRACTICAL

Greenhouse in a bottle

Two identical clear bottles, one filled with air and one with carbon dioxide (from a cylinder, or vinegar and bicarbonate), each with a thermometer, under the same lamp. Record the temperature every minute for 15 minutes. Discuss what else could make the bottles differ, and why this is a model, not the atmosphere.

Needs: two bottles, two thermometers or probes, a lamp, carbon dioxide.



CARD SORT

Close the loop

Cards for the steps of the five feedback loops, shuffled. Pairs build each loop as a circle, and the first pair to make all five explains one to the class. Add two negative feedback cards (more plant growth, more cloud) as a challenge: where do they go?

Needs: a printed card set for each pair.

PLENARY

13 min

Exit

Explain why an increase in carbon dioxide concentration causes global warming (2 marks), then outline one positive feedback cycle (3 marks).

WHAT STUDENTS GET WRONG

"The greenhouse effect is caused by humans." The greenhouse effect is natural and keeps the Earth habitable. Humans have *enhanced* it.

"The ozone hole causes global warming." Ozone depletion and the greenhouse effect are different problems.

"Greenhouse gases trap the sun's rays." They absorb infrared given off by the warm surface, not the incoming visible light.

"A correlation proves causation." It shows two variables change together. Other evidence is needed to show cause.

STRETCH AND SUPPORT

Support: a labelled diagram of the greenhouse effect with the arrows to colour in: visible light in, infrared out, infrared absorbed and re-emitted.

Stretch: in the ice cores, temperature sometimes rises a few centuries before carbon dioxide. Does that mean carbon dioxide does not cause warming?

IN THE GUIDE

1 The blanket we keep thickening

2 Warming that makes more warming

Lab Dry lab: Reading an ice core

All The whole guide, with the figures that play

PPTX This lesson's slides, in the order of this plan

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on D4.3 at standard level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=D4.3&level=SL&paper=quiz&marks=15&src=ep

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- Tarsia puzzle, dominoes and picture reveal on D4.3, built from its key terms and ready to print
- A pub quiz with rounds on D4.3, to present or run with no projector
- An escape room built from the question bank on D4.3

ALREADY ON THE SITE FOR D4.3

- Quiz: Climate Change
- Revision map: D4.3 Climate change, to fill in
- Exam questions: D4.3 in the exam maker, a paper with its markscheme

CARD SETS ON SPLYCR

Open a set to host it as a class game, or make a copy to edit.

- D4.3 Climate Change

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.