DP Biology – D4.3

Climate change

- What is driving climate change?
- How does climate change affect ecosystems?

SL statements D4.3.1–8. Textbook pp. 820–833. Phenology and evolution in response to warming are at HL.
Image: bleached coral. Acropora, CC BY-SA 3.0.



Objectives for each class

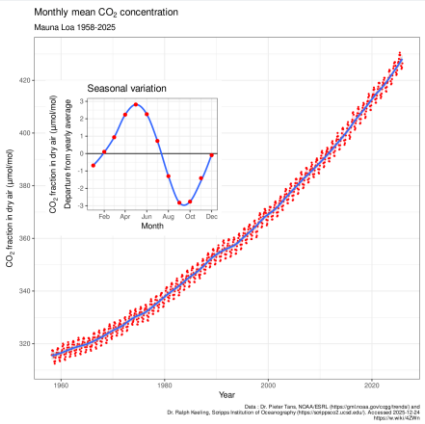
Class	Statements	By the end of the class, you can...
1	D4.3.1–4	Explain human causes of climate change and positive feedback, and use boreal forests and polar ice as examples
2	D4.3.5–8	Explain effects on ocean currents, species ranges and coral reefs, and outline ways of sequestering carbon

Human causes of climate change

D4.3.1

- Carbon dioxide and methane absorb long-wave radiation from the Earth, warming the atmosphere
- The natural greenhouse effect keeps Earth warm enough for life

Gas	Main human sources
Carbon dioxide	Burning fossil fuels; deforestation
Methane	Cattle and other ruminants; rice fields; landfill sites; leaks from gas and oil



Evidence

The Keeling curve shows the rise in carbon dioxide (C4.2). Temperature records and ice cores show that warming follows it. The rise in these gases is the enhanced greenhouse effect. Oxygen and nitrogen are not greenhouse gases, as they do not absorb this radiation. Graph: Oeneis, CC BY-SA 4.0.

Positive feedback in global warming

D4.3.2

Feedback	How it speeds up warming
Melting snow and ice	Less reflection, so more solar radiation is absorbed
Warmer deep ocean	Less carbon dioxide stays dissolved, so more is released
Thawing permafrost	Faster decomposition releases carbon dioxide and methane
Droughts and fires	Forests burn, releasing stored carbon

Common mistake

Positive here does not mean good. It means that a change produces an effect that makes the change larger. Draw one of these feedback loops as a cycle.

Boreal forests as a tipping point

D4.3.3



Siberian taiga. V. Argenberg, CC BY 4.0.

- Boreal forests, or taiga, have long stored carbon: cold conditions slow decomposition
- Warmer temperatures and less winter snow lead to more drought
- Primary production falls, trees turn brown and die, and fires increase
- The forest may change from a net carbon store to a net source

Key idea

A tipping point is a threshold beyond which a system changes state. Here, the forest moves from gaining carbon each year to losing it, and this release of carbon could add to warming: a positive feedback.

Melting ice and polar habitats

D4.3.4



Emperor penguins. Mtpaley, CC BY 2.5.



Species	Depends on	Risk
Emperor penguin, Antarctic	Landfast ice, attached to the shore, for breeding	Early break-up, before chicks are ready
Pacific walrus, Arctic	Sea ice as a resting place, near food in shallow water	Longer trips to food; crowding on shore

Key idea

Ice is the habitat itself. When it melts, there is no alternative habitat nearby, so polar species are especially at risk. Image below left: walruses. Joel Garlich-Miller, USFWS, public domain.

Ocean currents and upwelling

D4.3.5

- **Upwelling** brings cold, nutrient-rich deep water to the surface
- Warmer surface water is less dense, so the layers mix less, and this is called stratification
- This can prevent upwelling, changing its timing and its extent
- Less upwelling means lower primary production, and so less energy flows through marine food chains

Also affected

Melting ice adds fresh water to the ocean, which can change currents. Warmer water also absorbs less carbon dioxide.

Activity

Draw a flow chart linking warming of surface water to fewer fish in a fishery. Then suggest how this could affect seabirds there.

Species move to higher and cooler places

D4.3.6

Shift	Why	Example
Upslope	Each elevation warms, so species move up to stay in their climate	Birds in the mountains of New Guinea
Poleward	Warmer temperatures and more drought in the south	Tree species in North America

The limit

Species at the top have nowhere to go. On two mountains in Papua New Guinea, the upper limits of bird species moved up by about 110 to 150 m between the 1960s and 2012–13.

Discussion

A tree cannot walk, so how does a tree species shift its range? Why could trees move too slowly to keep up? How might competitive exclusion add to the risk?

Threats to coral reefs

D4.3.7



Bleached coral. Acropora, CC BY-SA 3.0.



Threat	Cause	Effect
Ocean acidification	More carbon dioxide dissolves, and pH falls	Corals lay down calcium carbonate more slowly
Bleaching	Warmer water stresses corals	Corals expel their algae, and may die

Potential collapse

Reefs support very high diversity. Loss of corals removes habitat and food for many other species, so the whole ecosystem could collapse. Image below left: a healthy reef. Jim Maragos, public domain.

Capturing carbon

Approach	How it works
Afforestation	Planting trees where there was no forest
Forest regeneration	Letting forests regrow or replanting them after felling
Restoring peat wetlands	Raising water levels, blocking drains, re-establishing sphagnum moss



Examples

Hinewai Reserve in New Zealand has regenerated rapidly from degraded farmland. A local example: Swiss moors and peatlands, many of them drained in the past, are now being restored. Why does waterlogged peat store carbon? Image: sphagnum moss, NC Wetlands, CC0.

Check that you can explain

1. Human sources of carbon dioxide and methane
2. Positive feedback cycles, with examples
3. Boreal forests as a tipping point
4. Effects of melting ice on named species
5. How warming affects upwelling
6. Upslope and poleward range shifts
7. Ocean acidification and bleaching
8. Three approaches to sequestering carbon

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Explain how melting ice is an example of positive feedback.
2. Explain how a rise in carbon dioxide threatens coral reefs.
3. State three approaches to carbon sequestration.

Image credits

Bleachedcoral.jpg – Acropora at English Wikipedia – CC BY-SA 3.0

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Lake Baikal, Pine forest, Siberian taiga, Siberia, Russia.jpg – Vyacheslav Argenberg – CC BY 4.0

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Coral reef fish pacific blue tan paracanthurus hepatus.jpg – Jim Maragos, U.S. Fish and Wildlife Service – Public domain

Sphagnum moss in Panthertown Valley bog.jpg – NC Wetlands from Raleigh, NC – CC0

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