IB BIOLOGY | D4.3 | SL AND HL

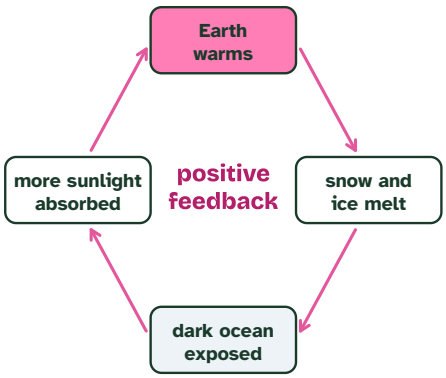
REVISION ON TWO PAGES

When the climate *shifts*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Extra carbon dioxide and methane warm the Earth. Warming feeds itself, and habitats, ranges and the timing of life all move with it.



Follow the loop. Each turn adds more warming, so the feedback is positive.

D4.3.2 START HERE

Warming that makes *more warming*

- A **positive feedback cycle**: a change sets off effects that make the same change bigger, so warming becomes faster warming.
- **Snow and ice** reflect most sunlight (**high albedo**). As they melt, the dark ocean beneath absorbs that light, warms and melts more ice.
- **The other loops add carbon:** warm water **holds less dissolved CO_2**; peat and permafrost decompose; thawing permafrost **releases methane**; drought brings more fires.

THE FIVE FEEDBACK LOOPS

Icy Oceans Push Polar Fires

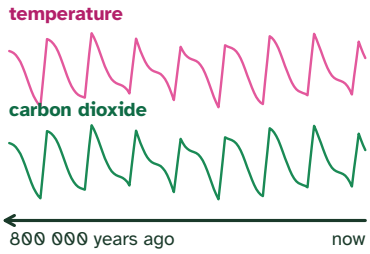
I Ice less sunlight reflected	**O** Ocean deep CO_2 released	**P** Peat dries and decomposes	**P** Permafrost CO_2 and methane	**F** Fires drought burns carbon

D4.3.1

The *anthropogenic* causes

- **Greenhouse effect:** greenhouse gases absorb infrared from the warm surface and re-emit some back down. Adding more **strengthens the effect**.
- **Carbon dioxide:** mostly **burning coal, oil and gas**; also clearing forests and making cement.
- **Methane:** cattle and sheep, rice paddies, landfill, gas and coal leaks. Stronger per molecule, but it lasts only about a decade.

Methane sources: *Cows Rarely Leave Gas*



Ice cores: the two rise and fall together. Shape only, not data.

Correlation not proof
Positive: both increase together. **Negative:** one increases as the other decreases.

Causation other evidence
CO_2 **absorbs infrared**, shown in the lab and by satellites. That confirms the link.

D4.3.3

The taiga *tips*

- Boreal forest (taiga) has long stored more carbon than it loses: **net carbon accumulation**.
- Warmer temperatures and **less winter snow** bring drought: primary production falls and trees brown (**forest browning**).
- Fires grow more frequent and intense, burning centuries of soil carbon: **legacy carbon combustion**.
- When losses beat growth, the forest flips from sink to source: a **tipping point**.

BEFORE
Net sink
Growth beats losses.

AFTER
Net source
Fire and decay beat growth.

D4.3.4 POLAR HABITATS

Ice that *leaves early*

- **Landfast ice** is sea ice frozen to the coast; **sea ice** floats free. Warming melts both earlier, so animals lose habitat.
- Emperors raise one chick a year, so they **cannot replace many lost years**.
- Either the common or the scientific name is accepted in an exam.

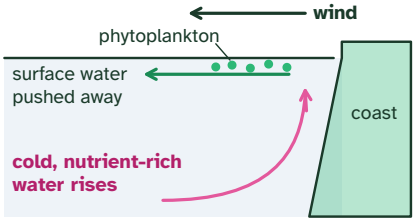
Emperor penguin *Aptenodytes forsteri*
Breeds on Antarctic landfast ice. **Early break-out** drops chicks into the sea before they can swim.

Walrus *Odobenus rosmarus*
Rests on Arctic sea ice between dives. As it retreats, walruses **haul out on land**, far from food.

D4.3.5

When *upwelling* fails

- **Upwelling:** winds push surface water from a coast and **cold, nutrient-rich water rises**.
- A warmer surface is lighter, so layers stop mixing: upwelling **weakens, starts later or stops**.
- Fewer nutrients: **primary production falls**, so less energy flows up marine food chains.

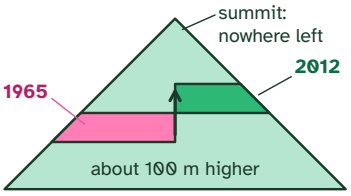


Reefs, ranges and the *timing* of life

D4.3.6

Shifting *ranges*

- Warming moves each species' zone **poleward and upslope**; populations follow by dispersal.
- **New Guinea:** most bird species on Mount Karimui **moved uphill**, about 100 m, from 1965 to 2012.
- **North American trees:** many **spread north**; more **contract** in the south.



D4.3.7

Coral reefs *collapse*

- Polyps build reefs of **calcium carbonate**. **Zooxanthellae**, algae in their cells, give most of their food.
- **Loss of corals** collapses the reef ecosystem, home to a quarter of marine species.

More CO_2 acidification
Carbonic acid uses up carbonate ions: **calcification is suppressed**.

Warmer water bleaching
Weeks at 1 °C over the usual summer maximum: corals **expel their zooxanthellae**, whiten and starve.

D4.3.8

Putting carbon *back*

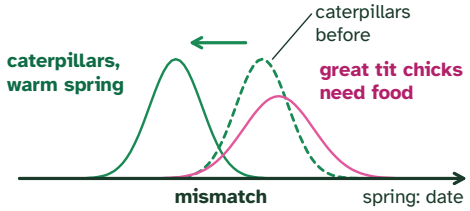
- **Afforestation:** planting trees where no forest has grown for a long time.
- **Forest regeneration:** letting a cleared or burnt forest grow back.
- **Peat restoration:** re-wetting drained bogs. Peat forms in **waterlogged soil**, in temperate and boreal zones, and very fast in some tropical swamps.

NATURE OF SCIENCE
Still debated
Non-native plantations or **rewilding with natives**: which sequesters more carbon?

D4.3.9, D4.3.10 HIGHER LEVEL

Phenology and lost synchrony

- **Phenology**: research into the timing of flowering, budburst, bud set, migration and nesting.
- **Photoperiod** is the same on a date every year; **temperature** varies. Warming moves only temperature-cued events.
- **Greenland:** chickweed (*Cerastium arcticum*) grows earlier; reindeer (*Rangifer tarandus*) arrive by day length: fewer calves survive.
- **Oak woods:** caterpillars peak earlier; great tit (*Parus major*) chicks **hatch after the feast**.



D4.3.11 HIGHER LEVEL

More *beetle* generations

- Spruce bark beetle (*Ips typographus*) larvae feed under spruce bark, killing the tree.
- Each generation needs a **set amount of warmth**: one in a cold year, two in a warm one, three in the hottest.

D4.3.12 HIGHER LEVEL

Evolution in tawny owls

- Tawny owl (*Strix aluco*) colour is **heritable**. In snowy winters, grey owls have **higher fitness**.
- Less snow weakens selection against brown, so the **brown variant becomes more common**: evolution.

1 in 8
brown, 1960s (Finland)

4 in 10
brown, by 2008

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Correlation is not causation.** Ice cores show CO_2 and temperature together; infrared absorption shows the cause.
- ✕ **Positive feedback amplifies.** It speeds the change up; it is not "good".
- ✕ **CO_2 acidifies; heat bleaches.** Never blame acidification for bleaching.
- ✕ **Warm seas lack nutrients, not light.** A warm layer stops upwelling.
- ✕ **Day length cannot shift.** Only temperature-cued events move earlier.
- ✕ **Owls do not change colour.** The proportion of brown owls changes.

COVER THE SHEET

Can you *answer these?*

1. Outline the sources of anthropogenic CO_2 and methane.
2. Explain how melting sea ice is a positive feedback.
3. Outline how a boreal forest becomes a carbon source.
4. Explain how early ice break-out harms emperor penguins.
5. Explain how warm surface water cuts ocean productivity.
6. Describe two range shifts caused by warming.
7. Distinguish the two threats to coral reefs.
8. Outline three ways to sequester carbon.
9. Explain how warming breaks phenological synchrony. HL
10. Explain why warm years bring more bark beetles. HL
11. Explain why the rise in brown tawny owls is evolution. HL

IN THE EXAM
Write the chain: the climate change (warmer, less ice or snow, more CO_2), what it does to the **habitat or cue**, then the **consequence for the population**.

GO FURTHER
Animated figures, a dry lab and a marked Check are in the full guide online.