IB BIOLOGY | C4.1 | SL

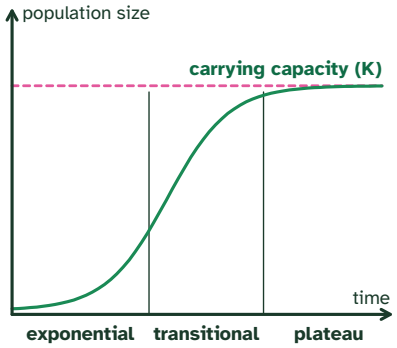
REVISION ON TWO PAGES

How many, and *why*

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

THE ONE IDEA

Populations grow until limited resources, predators and disease push back. Every interaction in a community helps set how many of each species there are.



Draw it like this. Three phases, no lag phase, levelling off at K.

C4.1.7, C4.1.8 START HERE

The *sigmoid* growth curve

- **Exponential:** resources are plentiful and little limits growth, so **births far exceed deaths**; numbers double in a fixed time, again and again.
- **Transitional:** resources run short, so the **growth rate slows**. **Plateau:** births plus immigration **equal deaths plus emigration**.
- **A model:** the curve is an **idealised simplification**; real populations overshoot and crash. Grow yeast or duckweed to collect your own data.
- **Test it:** plot numbers on a **log scale** against time on an ordinary scale. Exponential growth gives a **straight line**.

Case study, St Matthew Island: plenty of lichen, no predators. Reindeer rose exponentially, ate out the lichen and crashed.

29	6,000	42
reindeer released in 1944	by 1963	by 1966

C4.1.1, C4.1.2

One species, one *area*

- A **population**: one species in one area, interacting and, normally, **breeding**.
- **Reproductive isolation** separates populations: frogs either side of a motorway never meet.
- Counting all is rarely possible, so count a **random sample** (every spot equally likely) and scale up.

NATURE OF SCIENCE

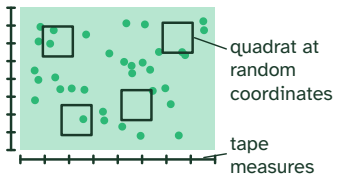
Sampling error

The estimate minus the true size. A bigger sample shrinks it; it never vanishes.

C4.1.3 SESSILE ORGANISMS

Random *quadrats*

- For **sessile organisms**: plants, barnacles, limpets.
- Tapes make a grid; **random numbers** give coordinates.
- **Estimate** = **mean per m² × area**.
- **Standard deviation:** how much counts vary round the mean. Large means patchy, so less certain.



C4.1.4 MOTILE ORGANISMS

Mark, release, *recapture*

- For **motile organisms**. Mark M, release, wait, then catch N, of which R are marked.
- **Lincoln index: M × N ÷ R**. Mark 20; recatch 15, 5 marked: 20 × 15 ÷ 5 = 60.
- **It assumes:** marks last and do no harm; equal chance of capture; full mixing; no births, deaths or migration.

20	5/15	60
marked	recaught	estimate

C4.1.5, C4.1.6

Carrying capacity and *feedback*

- **Carrying capacity** (K): the largest population an environment can support long term, set by the **limited resource** that runs short first: food, water, light, space, minerals.
- **Density-dependent factors** hit harder in a crowd: above K births fall and deaths rise; below K the reverse. That is **negative feedback**.

1	2	3
Competition for resources.	**Predation** more prey, easier hunting.	**Pathogens, pests** spread fast in a crowd.

- **Density-independent** factors (flood, frost, fire) knock numbers away from K but **never push them back**.

C4.1.9

Rivals and *allies*

- One species needs **exactly the same resources**, so **intraspecific competition** is fierce when food, light, territory or mates run short.
- Members **cooperate** when it gains each more than it costs.

Competition within a species

Tree seedlings shade each other out. Red deer stags fight in the rut. Great tits defend feeding territories.

Cooperation within a species

Emperor penguins huddle, taking turns outside. Wolves hunt in packs. Meerkats take turns as sentries.

Communities: how species *interact*

C4.1.10, C4.1.11 PLANTS, ANIMALS, FUNGI AND BACTERIA

A *community*: six interactions

- **Community**: **all the interacting populations** in an area.

INTERACTION	EFFECT	EXAMPLE
Herbivory	+ / −	Rabbits graze grass.
Predation	+ / −	Lynx kill snowshoe hares.
Competition	− / −	Grey and red squirrels.
Mutualism	+ / +	*Rhizobium* in bean roots.
Parasitism	+ / −	A tick sucks deer blood.
Pathogenicity	+ / −	Chytrid fungus kills frogs.

C4.1.12

Mutualism: both gain

Legume nodules (Fabaceae)
Rhizobium fixes nitrogen into ammonium for the plant, and gets sugars and a low-oxygen home.

Orchid mycorrhizae (Orchidaceae)
The fungus gives seeds sugars and minerals so they germinate; adult orchids pass sugars back.

Zooxanthellae in hard corals
Algae make most of its food by photosynthesis; the coral gives shelter, CO_2 and nitrogen compounds.

C4.1.13

Invasive species

- **Endemic**: native. **Invasive**: introduced, spreads and does harm.
- It wins by using a **shared resource more efficiently**.
- **Grey squirrels** digest tannin-rich acorns that reds cannot; reds have largely gone from England and Wales.

C4.1.14

Testing for *competition*

- Better **without the other** species: competition **indicated, not proved**.
- **Lab:** Gause's two *Paramecium* thrived alone; together one died out.
- **Field:** random sampling, or removal: without *Balanus*, *Chthamalus* lived lower (Connell).
- **Nature of science:** experiments manipulate; observations record.

C4.1.15 APPLICATION OF SKILLS

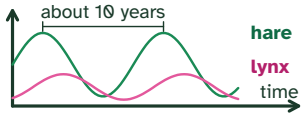
Chi-squared: *association*

- **Presence or absence** of two species in random quadrats, as a 2 × 2 table. H_0: independent.
- E = row total × column total ÷ grand total; $\chi^2 = \Sigma\ (O - E)^2 \div E$.
- **1 degree of freedom**: above **3.84** ($p = 0.05$) is significant. "Both" O below E: negative.

C4.1.16

Predator and prey

- **Hudson's Bay Company** fur records: snowshoe hares and lynx cycle, lynx a year or two behind.
- More hares, more lynx; hares crash, then lynx starve: **density-dependent**.



C4.1.17

Top-down or bottom-up

- **Top-down**: predators. **Bottom-up**: food. **One usually dominates**.

Top-down sea otters
Otters hunted out: urchins graze kelp to bare rock.

Bottom-up a lake
Fertiliser runs in: algae bloom, all above changes.

C4.1.18

Chemical *weapons*

- A **chemical released** into the environment **deters competitors**.

Allelopathy a plant
Black walnut releases juglone; nearby plants wilt and die.

Antibiotic a microbe
Penicillium secretes **penicillin**, killing rival bacteria.

WATCH OUT

Six mistakes that *cost marks*

- ✕ **No lag phase:** exponential, transitional, plateau.
- ✕ **Never place quadrats by eye:** you pick thick patches.
- ✕ **Lost marks inflate the Lincoln index:** R falls.
- ✕ **Frost does not regulate:** it never pushes back to K.
- ✕ **χ^2 does not prove competition:** soils may differ.
- ✕ **Parasites seldom kill hosts:** pathogens cause disease.

COVER THE SHEET

Can you *answer these?*

1. Describe how to estimate a plant population with quadrats.
2. Calculate N: 20 marked, then 5 of 15 recaught marked.
3. Outline the sigmoid curve's phases and what holds it at K.
4. State an example of each interspecific relationship.
5. Distinguish competition from cooperation within a species.
6. Describe what both partners gain in one mutualism.
7. Outline three tests for interspecific competition.
8. Distinguish top-down from bottom-up control.

IN THE EXAM

Lincoln index or χ^2: write the formula, substitute, calculate, then **say what it means** (for χ^2, compare with 3.84 and name the association).

GO FURTHER

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