IB BIOLOGY | A4.1 | SL AND HL

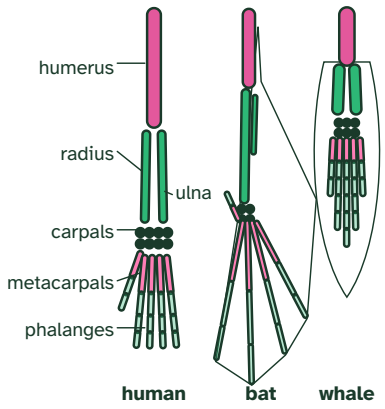
REVISION ON TWO PAGES

How life *evolves*

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

THE ONE IDEA

Populations change in what they inherit. A new species forms only when one population splits and the parts stop sharing alleles.



Same colour, same bone. One plan, reshaped for each job.

A4.1.4 START HERE

One bone plan: *homologous* structures

- Homologous structures are built on a **plan inherited from a common ancestor**, even when they now do very different jobs.
- The **pentadactyl limb**: one upper arm bone, two forearm bones, a block of wrist bones, a row of palm bones, then the digits.
- A human arm, a bat wing, a whale flipper and a horse leg have the **same bones in the same order**, each modified for its own way of life.
- "Pentadactyl" names the plan, not a count: a horse keeps only one digit.

SHOULDER TO FINGERTIP

Hungry Rats Chew My Pencils

H	**Humerus** upper arm	**R**	**Radius, ulna** forearm	**C**	**Carpals** wrist	**M**	**Metacarpals** palm	**P**	**Phalanges** digits

A4.1.1

What *evolution* is

- Evolution: a change, over generations, in the **heritable characteristics of a population**.
- **Not evolution: acquired changes** (a weightlifter's muscles) never reach the gametes. Lamarck wrongly thought they were inherited.
- **Example:** after a 1977 drought, deep-beaked finches survived; the next generation's beaks were about 4% deeper.

NATURE OF SCIENCE

Why a "theory"

It explains so much that it is unlikely ever to be falsified, but it cannot be formally proved: a pragmatic truth.

A4.1.2

Evidence in *sequences*

- Compare one gene or protein: **fewer differences, more recent common ancestor**.
- After a split, **mutations build up** separately in each line, so differences grow with time.
- Bases change faster than amino acids (most have several codons): bases sort close relatives, amino acids reach further back.

Cytochrome c: amino acids that differ from the human one

0	chimpanzee	**1**	rhesus monkey	**40+**	yeast

A4.1.5

Analogous structures

- Analogous structures have the **same function but different evolutionary origins**.
- They arise by **convergent evolution**: unrelated lines meet similar demands with similar solutions.
- Another pair: the camera eyes of octopuses and of vertebrates.

Bird wing a forelimb
Bones inside, humerus to digits, carrying feathers.

Insect wing no bones
A thin fold of the body wall, with no bones at all.

A4.1.3

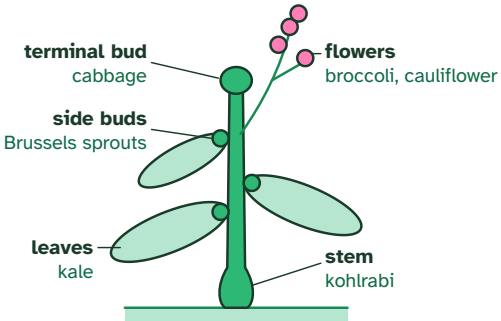
Evidence from *selective breeding*

- **Selective breeding:** people choose which plants or animals breed, generation after generation.
- Kale, cabbage, Brussels sprouts, kohlrabi, broccoli and cauliflower were all bred from **wild cabbage**, and all are still *Brassica oleracea*.
- They differ far more than the wild species varies, and the changes are **heritable**. Most dog breeds, all from wolves, arose in a few centuries: **evolution can be rapid**.

THREE LINES OF EVIDENCE

Darwin's Big Hunch

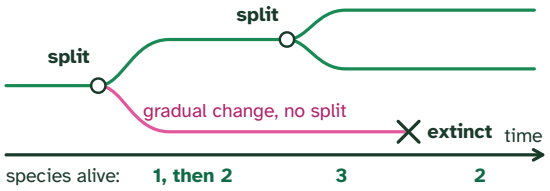
D	**DNA, proteins** fewer differences, closer kin	**B**	**Breeding** big heritable changes, fast	**H**	**Homologous** one bone plan, many jobs



A4.1.6

New species only by *splitting*

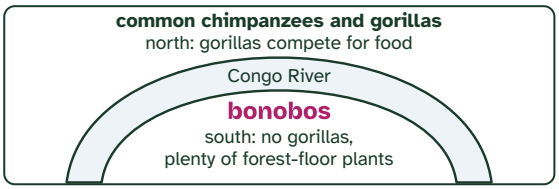
- Speciation: a species **splits** into populations that stop interbreeding and diverge. It is **the only way new species appear**.
- **Speciation adds** species to the Earth; **extinction removes** them.
- **Gradual change** without a split is evolution, **not speciation**.



A4.1.7

Isolation, then *differential* selection

- **Reproductive isolation** stops alleles passing between populations. A river, sea or mountains cause **geographical isolation**.
- **Differential selection**: each side favours different traits.
- **Congo River:** neither ape swims. It split chimpanzees from bonobos 1 to 2 million years ago.



A4.1.8 HIGHER LEVEL

Two routes: *allopatric* and *sympatric*

	ALLOPATRIC *other homeland*	SYMPATRIC *same homeland*
Gene flow stops by	A **geographical barrier**: **geographic** isolation.	In one place: **behavioural** or **temporal** isolation.
Example	Bonobos and chimpanzees, either side of the Congo.	Apple maggot flies: apple flies mate earlier, on apples.

Alike: gene flow stops, then the groups diverge.

Isolation: *Grumpy Birds Tweet*

A4.1.9 HIGHER LEVEL

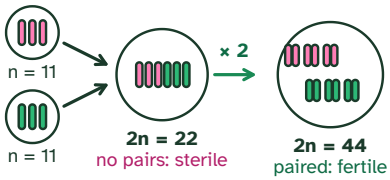
Adaptive *radiation*

- One ancestor's descendants split again and again, each adapting to a **different niche**.
- It needs **vacant niches**: about 18 Darwin's finch species came from one seed-eater, each beak suited to its food.
- Different foods let related species **coexist without competing**, so **biodiversity rises**.

A4.1.10, A4.1.11 HIGHER LEVEL

Sterile *hybrids*, fertile polyploids

- **Before fertilisation: courtship behaviour** usually prevents hybridisation.
- **After it:** a hybrid may be **sterile**. A **mule** (horse × donkey) has 63 chromosomes that **cannot all pair at meiosis**.
- **Plants:** a sterile hybrid's **chromosome number doubles**, so it is fertile but cannot breed with either parent: **a new species at once**.
- **Example:** smartweeds, *Persicaria*, such as redshank (2n = 44). Either name is accepted.



WATCH OUT

Six mistakes that *cost marks*

- ✕ **Acquired changes are not evolution.** Only alleles in gametes are inherited.
- ✕ **Humans did not evolve from chimpanzees.** Both came from a common ancestor.
- ✕ **Flippers are homologous as limbs.** Whale and penguin flippers share pentadactyl bones; only the shape converged.
- ✕ **No split, no speciation.** Gradual change adds no species.
- ✕ **The river did not change the apes.** It stopped gene flow; selection did the changing.
- ✕ **A hybrid adds gametes.** A mule has 32 + 31 = 63 chromosomes, not 64 + 62.

COVER THE SHEET

Can you *answer these?*

1. Distinguish evolution from an acquired change.
2. Explain how protein sequences show common ancestry.
3. Outline how selective breeding is evidence for evolution.
4. Draw a pentadactyl limb and label its bones.
5. Distinguish homologous from analogous structures.
6. State the only way new species arise.
7. Explain how bonobos and chimpanzees diverged.
8. Compare allopatric and sympatric speciation. HL
9. Explain how adaptive radiation raises biodiversity. HL
10. Explain why a mule is sterile but a polyploid is not. HL

IN THE EXAM

For any speciation answer, give three steps: what isolates the populations ("the Congo River"), that **gene flow stops**, and how **differential selection** then acts on each side.

GO FURTHER

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