IB BIOLOGY | A3.1 | SL AND HL

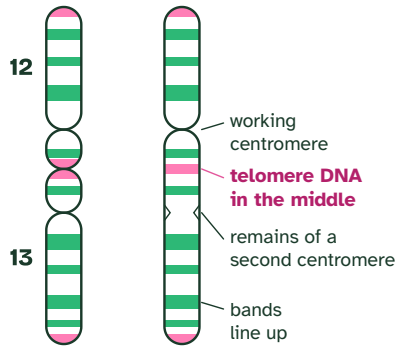
REVISION ON TWO PAGES

No two alike, yet still *species*

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

THE ONE IDEA

No two organisms are alike, yet they fall into species. Traits, breeding, chromosomes and DNA each help to draw the line.



Draw it like this. The two ape chromosomes end to end beside human 2: the same bands, and telomere DNA (pink) at the join.

A3.1.7 SKILL: CLASSIFY AND EVALUATE

Reading a *karyogram*

- A cell's chromosomes, photographed and arranged in pairs, make a **karyogram**. Pair them by **length, banding and centromere position**, longest first.
- **Hypothesis:** human chromosome 2 formed when two ape chromosomes, **12 and 13**, fused end to end in an ancestor shared with chimpanzees.

EVIDENCE 1	EVIDENCE 2	EVIDENCE 3
Bands match	**Telomere inside**	**Spare centromere**
End to end, the ape pair matches 2 in length and banding.	Chromosome-end DNA sits in the middle of 2.	The switched-off remains of a second one.

- **Testable:** it predicted telomere DNA mid-chromosome, which could have been absent. "It fused so humans could think" predicts nothing: **not testable**.
- Three lines of evidence agree, but no one saw the fusion: they **support it, not prove it**.

A3.1.1 and 2 VARIATION AND SPECIES

No two *alike*

- No two individuals are identical in every trait, not even identical twins. **Variation** is a defining feature of life.
- Its **patterns**, in steps (blood group) or smooth (height), are the basis for **naming and classifying**.
- **Linnaeus** grouped similar, never identical, organisms by shared body form: the **morphological species concept**.

A3.1.3 BINOMIAL NAMES

A name in *two parts*

- The **genus** comes first, then the **species**. Species in one genus have similar traits: *Panthera leo* (lion), *Panthera tigris* (tiger).

THE FOUR RULES — *Green Sloths Inch Along*

G Genus first, capital: *Homo*	**S** Species next, lower case	**I** Italics or underlined	**A** Abbreviate later: *E. coli*

A3.1.4 and 5 BREEDING TEST

Can they *breed*?

- **Biological species concept:** a group that can **breed and produce fertile offspring**.
- **Competing species definitions exist** (by DNA, or by way of life).
- **Speciation**, one species splitting into two or more, is usually **gradual**, so calling two populations one species or two can be arbitrary.

WHERE IT STRUGGLES — *Five Apes Hug Grumpy (Aunts Happily)*

F Fossils cannot be bred	**A** Apart never meet	**H** Hybrids fertile in oaks	**G** Gradual no split day

A3.1.6 CHROMOSOME NUMBERS

Counting *chromosomes*

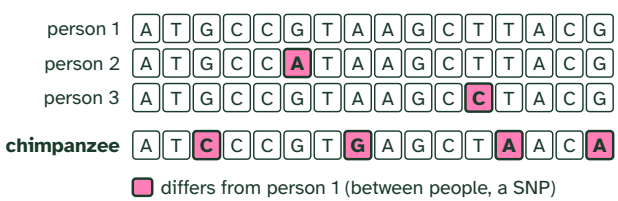
- Each species has its own chromosome number, and **numbers vary widely**.
- Diploid cells have an **even number**: chromosomes come in homologous pairs, one from each parent.
- Chromosome number is not the number of genes, nor the amount of DNA.

46 human body cell	**48** chimpanzee body cell

A3.1.8 and 9 GENOMES WITHIN AND BETWEEN SPECIES

One genome, *many versions*

- The **genome** is all the genetic information of an organism.
- One species shares most of its genome (two people about 99.9%); **single nucleotide polymorphisms** (SNPs) give diversity.
- Between species, genomes differ in **size** (total DNA) and **base sequence**: **far more than within a species**.

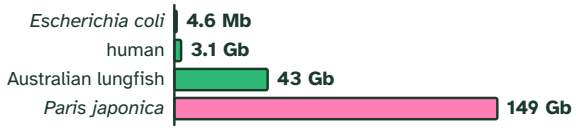


Genomes, and where the species idea *breaks*

A3.1.10 SKILL: USE A DATABASE

Big genome, *small* organism

- Genome size, in base pairs (Mb millions, Gb billions), **varies enormously** and is **not a measure of complexity**: much DNA is non-coding or repeated.
- **The skill:** compare genome sizes from a database with complexity.



A3.1.11 USES NOW AND TO COME

Reading a *whole genome*

- Sequencing reads every base of a genome, ever **faster and cheaper**: the first human genome took over ten years and billions of dollars; now days.
- **Current use:** comparing genomes shows how closely species are related: **evolutionary relationships**.
- **Future use: personalised medicine**, the drug and dose chosen from a patient's own genome.
- A genome can also show SNPs that raise the risk of a disease, so it can be watched for.

A3.1.12 TWO MORE PLACES IT STRUGGLES

When the breeding test *fails*

- **Asexual species (Aunts):** bacteria and other **asexual** organisms make clones, so "fertile offspring?" has no answer.
- **Horizontal gene transfer (Happily):** genes pass between living cells, **even between species** (plasmids in conjugation).
- Gene pools are not closed, so the concept fits poorly. Bacteria are grouped by structure, metabolism and DNA instead.

A3.1.13 HIGHER LEVEL

The number that *has to match*

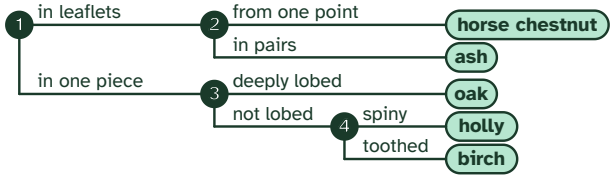
- Chromosome number is a **shared trait** within a species.
- At meiosis each chromosome needs a partner. If parent numbers differ, a hybrid's cannot all pair, so it is **unlikely to be fertile**.

32 + 31	63
horse plus donkey gamete	mule: odd, so sterile

A3.1.14 SKILL: BUILD A KEY

Building a *dichotomous key*

- Each step offers **two choices**, until one name is left. Use features that **do not change**; avoid size, colour, behaviour.
- Key out six to ten **local species**, then test it on others.



A3.1.15 HIGHER LEVEL

Species from *environmental DNA*

- **eDNA** is DNA from water, soil or air. A **DNA barcode** is a short stretch, alike within a species but different between species.
- It surveys a habitat's biodiversity **rapidly**, unseen species too.

THE STEPS — *Cats Eat Any Sausage Mostly*

C	E	A	S	M
Collect a sample	**Extract** the DNA	**Amplify** by PCR	**Sequence** the copies	**Match** to a library

WATCH OUT

Six mistakes that *cost marks*

- ✕ **The capital is for the genus only:** *Homo sapiens*, never *Homo Sapiens*.
- ✕ **Say "fertile offspring", not "can mate".** The mule is sterile.
- ✕ **Humans did not come from chimpanzees.** Both come from a shared ancestor.
- ✕ **A bigger genome is not a more complex organism.** The extra DNA is mostly non-coding.
- ✕ **A SNP is a place where genomes differ, not a disease.** Everyone carries thousands.
- ✕ **eDNA shows who left DNA, not how many.** It names only species in the reference library.

COVER THE SHEET

Can you *answer these?*

1. Outline the morphological species concept.
2. State the rules for writing a binomial name.
3. State two problems with the biological species concept.
4. Explain why diploid chromosome numbers are even.
5. Evaluate the evidence that chromosome 2 is a fusion.
6. Compare genome variation within and between species.
7. Explain why genome size does not show complexity.
8. Outline two uses of whole genome sequencing.
9. Explain why the species concept fits bacteria poorly. HL
10. Explain why a mule is sterile. HL
11. Describe two features of a good dichotomous key. HL
12. Outline how eDNA barcoding surveys a pond. HL

IN THE EXAM

For "evaluate" on chromosome 2, **name each piece of evidence**, then say it **supports the hypothesis but cannot prove it**.

GO FURTHER

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