DP Biology – A3.1

Diversity of organisms

- How do we define a species?
- What patterns of genome diversity appear within and between species?

SL statements A3.1.1–11. Textbook pp. 102–117.



Image: Carl Linnaeus, who devised two-part names. Alexander Roslin, public domain.

Objectives for each class

Class	Statements	By the end of the class, you can…
1	A3.1.1–3	Explain variation, the shared-traits idea of a species, and how to write binomial names
2	A3.1.4–5	Use the biological species concept, and explain why species can be difficult to separate from populations
3	A3.1.6–7	Compare chromosome numbers, read a karyogram, and evaluate the evidence for human chromosome 2
4	A3.1.8–11	Compare genomes within and between species, and outline current and future uses of sequencing

No two individuals are identical

A3.1.1

- Variation between organisms is a defining feature of life
- No two individuals share all of their traits, even within a species
- Patterns of variation are complex, and they are the basis for naming and classifying organisms
- Darwin saw that variation is what natural selection acts on (D4.1)

Discussion

A pair of identical twins share almost all of their base sequences. List differences you would still expect to find between them, and sort them into differences that are inherited and differences caused by the environment. Now consider why a species with no variation at all could be at risk.

Species as groups with shared traits

A3.1.2

- The original idea of a species, as used by Linnaeus, was a group with **shared traits**
- Species were described by their outer form and inner structure
- This is known as the morphological species concept

Where shape can mislead	Example
Look alike, but are separate species	Golden-fronted and Hoffmann's woodpeckers
Look different, but are one species	Brittle stars with varied colours and patterns

Key idea

Physical appearance is useful and quick, but it can be misleading. Other evidence is needed, including breeding and genetic data.

Binomial names

A3.1.3

- Each species has a two-part name
- First part: **genus**, with a capital letter
- Second part: **species**, in lower case
- Printed in italics; underlined when handwritten
- Species in one genus have similar traits

Common name	Binomial
Human	Homo sapiens
Lion	Panthera leo
Tiger	Panthera tigris

Why use it?

Common names differ between places and languages. A binomial name is understood worldwide.

Common mistake

Write Homo sapiens, not homo Sapiens, and do not write sapiens alone. After the first use, the genus may be shortened to H. sapiens.

The biological species concept

A3.1.4



A zebra and horse hybrid. Olliver, public domain.

- A **species** is a group that can breed and produce **fertile offspring**
- Different species are usually reproductively isolated
- A horse and a zebra can produce young, but the young are normally infertile

Example

A German shepherd and a chihuahua can produce fertile young, so they are one species.

Limits of this concept

It cannot be applied to organisms that reproduce asexually, to extinct species known only from fossils, or to populations that never meet. Competing species concepts exist, including ecological and evolutionary ones, and each has strengths and weaknesses.

Where does a population end and a species begin?

A3.1.5

- A **population** is a group of one species living in the same area at the same time
- **Speciation** is the splitting of one species into two or more
- It usually happens gradually, with populations becoming more and more different
- So there is no single moment at which one species clearly becomes two

Key idea

When two populations stop interbreeding, they diverge. In the middle of this process, deciding whether they are one or two species can be somewhat arbitrary.

Discussion

Two populations can interbreed in captivity, yet never do so in the wild. Should they count as one species or two? What evidence would help you to decide?

Chromosome numbers vary

A3.1.6

Species	Diploid number
Human	46
Chimpanzee	48
Dog	78
Fruit fly	8
A roundworm of horses (one form)	2
Adder's tongue fern	About 1,260



Chimpanzee. Thomas Lersch, CC BY 2.5.

Key idea

Number does not show how complex an organism is.

You need to know that humans have 46 and chimpanzees 48. The other values show how wide the range is. Individuals with different numbers usually cannot produce fertile young.

Karyotypes and karyograms

A3.1.7



A human male karyogram. NHGRI, public domain.

- A **karyotype** is the number and type of chromosomes in a cell
- A **karyogram** is an image of them arranged in pairs
- Pairs are sorted by **length**, **banding pattern** and **centromere position**
- Sex chromosomes come last: XX or XY

Practice

How many chromosomes are there? How can you tell the sex of this individual?

Evidence: human chromosome 2

A3.1.7

- Chimpanzees and other great apes have 24 pairs, and humans have 23
- Hypothesis: two chromosomes **fused** in our ancestors, after the split from the chimpanzee lineage
- Banding on human chromosome 2 matches two separate chimpanzee chromosomes
- It has telomere sequences in its middle, and a second, inactive centromere

Common mistake

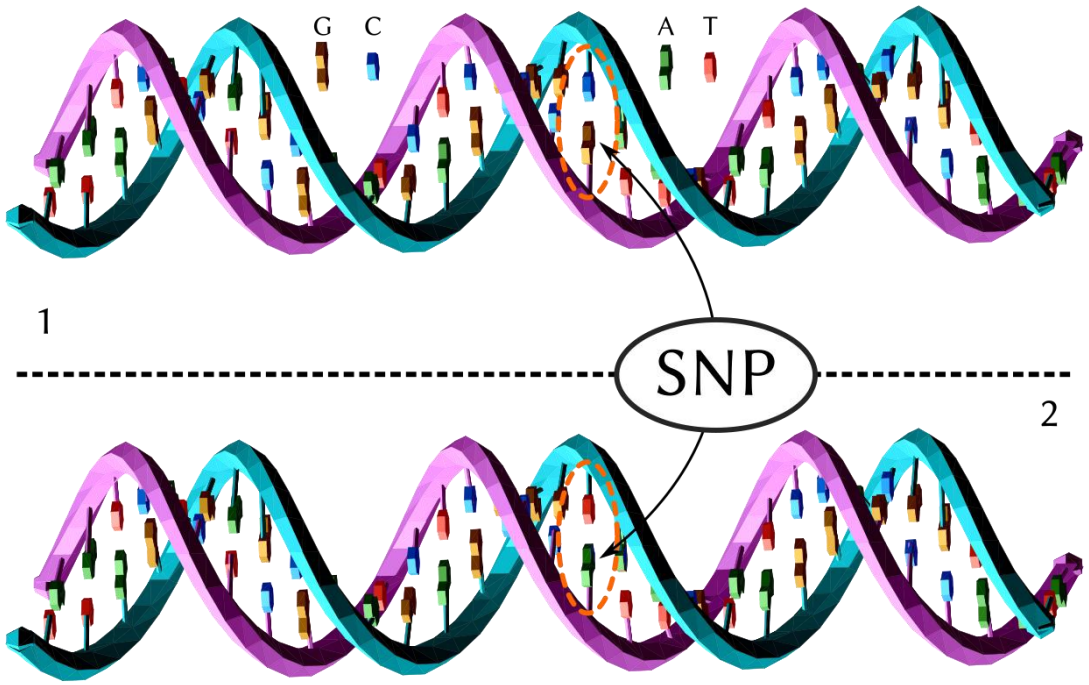
Humans did not evolve from modern chimpanzees. Chimpanzee chromosomes did not fuse. Each line has evolved from a shared ancestor, and the fusion took place only in the line leading to humans.

Evaluate

How strong is this evidence? Think about what you would expect to see if the hypothesis were false, and what other explanations might be possible.

Genomes within a species

A3.1.8



A single-nucleotide polymorphism. David Eccles, CC BY 4.0.

- A **genome** is all of the genetic information of an organism
- Members of a species share most of their genome
- Variations such as **SNPs** give some diversity
- A SNP is a position where a single base differs between individuals

Key idea

Unity and diversity: any two humans have almost identical genomes, yet differences at millions of positions contribute to our variation, including our risk of some diseases.

Genomes between species

A3.1.9–10

Organism	Genome size / million base pairs
Escherichia coli (a bacterium)	5
Fruit fly	140
Human	3,100
Lungfish	About 130,000
Paris japonica (a plant)	About 150,000

- Genomes vary in **size**, the total amount of DNA, and in **base sequence**
- Variation between species is much greater than within one
- Size does not simply track complexity

Using a database

Look up genome sizes for several groups in an online database, then plot them. Does complexity explain the pattern? Much DNA in large genomes does not code for protein.

Sequencing whole genomes

A3.1.11

- Sequencing has become much **faster** and much **cheaper**
- The first human genome took over a decade; now it can take days, at a tiny part of the cost

When	Uses
Now	Research into evolutionary relationships, by comparing sequences between species
Future	Personalized medicine, with treatment chosen to suit a person's genome

Discussion

If sequencing your genome showed a raised risk of a disease that has no treatment, would you want to know? Who else should be allowed to know?

Check that you can explain

1. Why variation is a feature of life
2. Shared traits as a species concept
3. How to write a binomial name
4. The biological species concept and its limits
5. Why populations and species can be hard to separate
6. Chromosome numbers in humans and chimpanzees
7. How to read a karyogram
8. The evidence for chromosome 2 fusion
9. SNPs and genome variation
10. Why genome sequencing matters

Exit activity: 5 minutes

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

1. Write the binomial name of humans correctly, and label the genus and the species.
2. State one limitation of the biological species concept.
3. State three features used to arrange chromosomes in a karyogram.

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Schimpanse Zoo Leipzig.jpg – Thomas Lersch – CC BY 2.5

NHGRI human male karyotype.png – Courtesy: National Human Genome Research Institute – Public domain

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