DP Biology – A3.1 (HL extension)

Species, keys and barcodes

- What is a species?
- What patterns of genome diversity appear within and between species?

HL statements A3.1.12–15. Textbook pp. 118–124.
Image: a dandelion seed head. Markus Bernet, CC BY-SA 2.0.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	A3.1.12–13	Explain why the biological species concept fails for some organisms, and why chromosome number is shared within a species
2	A3.1.14–15	Build a dichotomous key for local organisms, and explain how eDNA barcodes identify species

When the species concept struggles: asexual organisms

A3.1.12



Dandelion, Taraxacum officinale. Public domain.

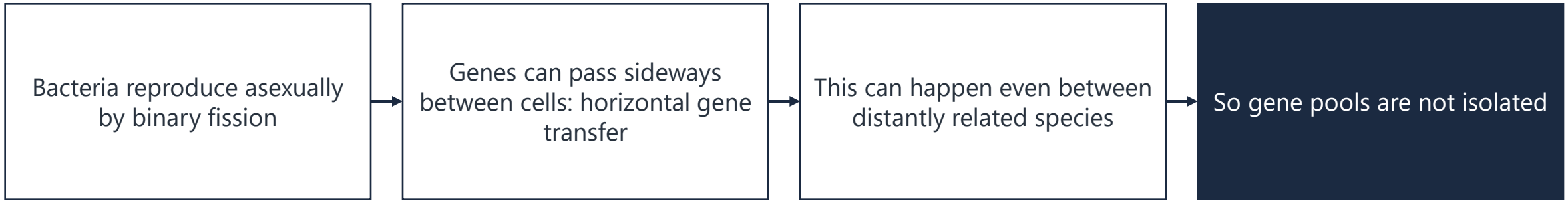
- The biological species concept defines a species as a group that can **interbreed** to produce fertile offspring
- Many dandelions make seeds **without fertilization**: offspring are clones
- Clones never interbreed, so by this definition each line would be a separate species
- Thousands of slightly different dandelion lines exist: biologists group them by similarity instead

Other examples

Bacteria, many fungi, some lizards and aphids at times all reproduce without mixing genes between individuals.

When the species concept struggles: bacteria

A3.1.12



Example

Genes for antibiotic resistance on plasmids spread between different species of bacteria. A bacterium can carry genes from many sources.

So how are bacteria named?

By shared features and by how similar their DNA is, for example in ribosomal RNA genes. The boundaries between bacterial species are partly a matter of convention.

Chromosome number within a species

A3.1.13



Human karyotype: 46 chromosomes. NHGRI, public domain.

Species	Chromosomes (2n)
Human	46
Chimpanzee	48
Horse	64
Donkey	62
Mule (hybrid)	63

Key idea

All members of a species share the same chromosome number. In meiosis, homologous chromosomes must pair. A hybrid of parents with different numbers has unpaired chromosomes, so its meiosis usually fails and it is infertile.

Hybrids show the barrier

A3.1.13



A mule. CC BY-SA 3.0.



A zebroid: zebra × horse hybrid. Public domain.

- Horse 64 + donkey 62: mule, 63
- Mules are almost always sterile

Try it

A horse gamete has 32 chromosomes and a donkey gamete 31. Explain why a mule can grow normally by mitosis, but cannot make gametes by meiosis.

Dichotomous keys

A3.1.14

	Feature	Go to
1	Leaf divided into leaflets	2
	Leaf simple, not divided	3
2	Leaflets spread from one point (palmate)	Horse chestnut
	Leaflets along a central stalk (pinnate)	Ash
3	Leaf edge with deep lobes	Oak
	Leaf edge toothed, not lobed	4
4	Leaf base uneven	Elm
	Leaf base even	Birch

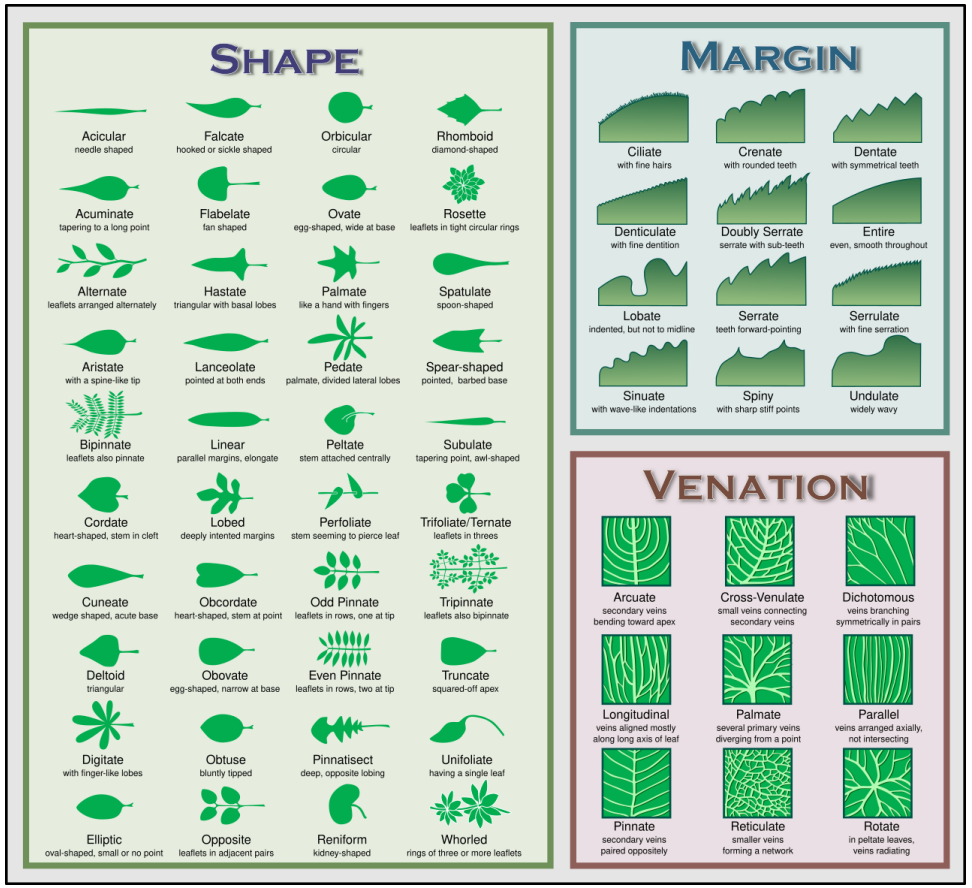
- Each step is a **couplet**: two opposite statements
- Use features that are easy to see and do not vary
- Each route ends with one species

Tips

Avoid size or colour alone. Use measurable or yes/no features, such as leaf arrangement, margin and venation.

Make a key for local species

A3.1.14



Leaf shapes, margins and venation. McSush, CC BY-SA 3.0.

1. Collect leaves, or photograph animals, from your school grounds
2. Identify each one with a field guide or app
3. Choose features that split the group into two
4. Write couplets until every species is reached
5. Swap keys with another group and test them

Respect

Take only common plants, one leaf from each; leave animals where you find them.

Environmental DNA and barcodes

A3.1.15



Sampling water for eDNA. Mukesh Bhendarkar, CC0.

- Organisms shed cells, skin, mucus and faeces into their surroundings: **environmental DNA**
- A **DNA barcode** is a short, standard section of DNA that differs between species
- Examples: a mitochondrial gene for animals, chloroplast genes for plants



Why use eDNA?

Strengths

Fast: one sample can reveal hundreds of species. Detects rare, hidden or night-active species without catching them. Finds invasive species early. Needs little expert knowledge of identification.

Limitations

DNA can drift from elsewhere or persist after the organism has gone. It shows presence, not numbers or health. Species missing from the database cannot be named. Contamination must be avoided.

Example

Water samples from a pond can show whether great crested newts live there, without disturbing them.

Check that you can explain

1. Why the biological species concept is hard to apply to asexual organisms
2. How horizontal gene transfer blurs bacterial species
3. Why chromosome number is shared within a species, and why hybrids are usually sterile
4. How to build and use a dichotomous key
5. How environmental DNA and barcodes identify species in a habitat
6. Strengths and limitations of eDNA surveys

Exit activity: 5 minutes

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

1. Explain why the biological species concept is difficult to apply to bacteria.
2. State why a mule is usually infertile.
3. Outline how eDNA is used to find which species live in a lake.

Image credits

Dandelion clock.jpg – Markus Bernet – CC BY-SA 2.0

Taraxacum officinale – Köhler–s Medizinal-Pflanzen-135.jpg – Walther Otto Müller – Public domain

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

Mule.jpg – Author not stated – CC BY-SA 3.0

Zebroid.jpg – Olliver at English Wikipedia – Public domain

Leaf morphology no title.svg – derivative work: McSush (talk) Leaf_morphology_no_title.png: – CC BY-SA 3.0

EDNA sampling.jpg – Mukesh Bhendarkar – CC0

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