DP Biology – D4.1

Natural selection

- What can change allele frequencies in a population?
- What part does reproduction play in natural selection?

SL statements D4.1.1–8. Textbook pp. 779–789. Allele frequency calculations are at HL.
Image: a male lesser bird-of-paradise. Or Hiltch, CC BY 2.0.



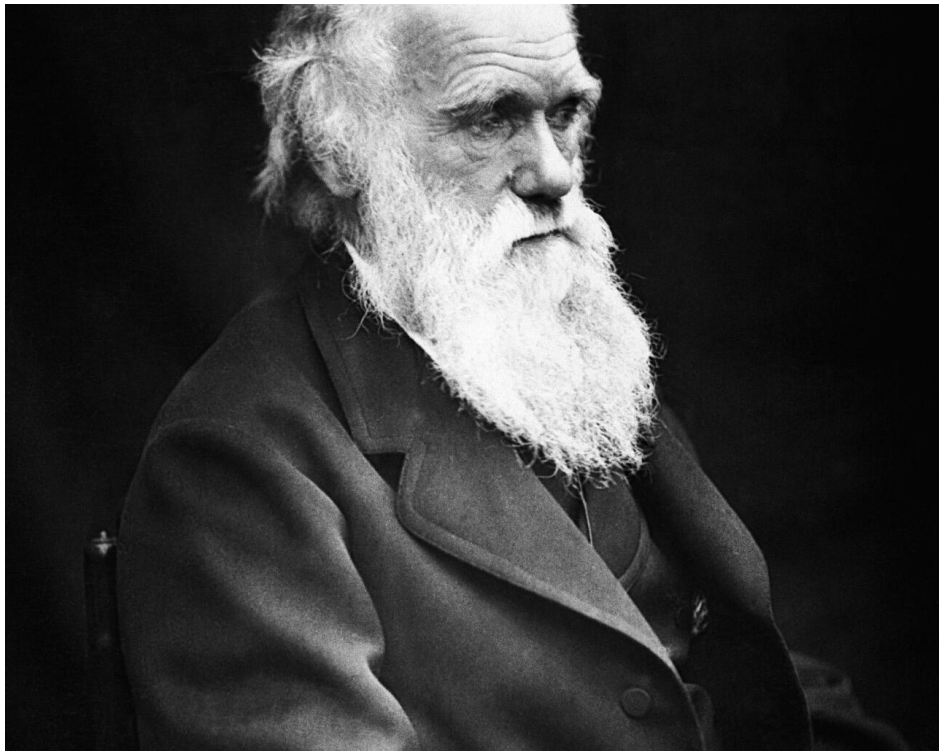
Objectives for each class

Class	Statements	By the end of the class, you can...
1	D4.1.1–4	Explain natural selection, the sources of variation, overproduction and competition, and abiotic selection pressures
2	D4.1.5–6	Use fitness to explain differences in survival and reproduction, and explain why traits must be heritable
3	D4.1.7–8	Explain sexual selection, and interpret Endler's experiments with guppies

Natural selection drives evolution

D4.1.1

1. Individuals in a population vary
2. More offspring are produced than can survive
3. Those better adapted survive and reproduce more
4. They pass on their heritable traits
5. Allele frequencies change over generations



Charles Darwin. Julia Margaret Cameron, public domain.

Key idea

Natural selection operates all the time and has done for billions of years. Over this time, it has produced the biodiversity of life on Earth.

Sources of variation

D4.1.2

Source	What it does
Mutation	Creates new alleles, and is the original source of all variation
Crossing over, in meiosis	Creates new combinations of alleles on a chromosome
Random orientation, in meiosis	Creates new combinations of maternal and paternal chromosomes
Random fertilization	Combines alleles from two parents

Common mistake

Sexual reproduction makes new combinations of alleles, while only mutation makes new alleles. Organisms also do not mutate because they need to (D1.3).

Overproduction and competition

D4.1.3

- Species tend to produce more offspring than resources can support
- Examples of limits: food, water, space, nesting sites, light
- Members of a species compete: this is **intraspecific competition**
- The largest population an environment can support is its **carrying capacity**

Activity: modelling beaks

Use tools such as forceps, spoons and pegs as beaks, and beads of different sizes as seeds. Collect food for 30 seconds in each round. Only those who collect enough food "survive" and "reproduce". Record the number of each tool over several rounds, then describe what this model shows and what it misses.

Abiotic factors as selection pressures

D4.1.4

	Density-dependent	Density-independent
Effect	Grows stronger as population rises	Acts the same at any density
Examples	Food supply, disease	Very high or low temperatures, drought, flood, fire

- Abiotic factors can reduce survival in a whole population, whatever its density
- Individuals with heritable traits suited to the conditions are more likely to survive

Example

In a severe drought on a Galapagos island, finches with larger beaks survived better, as they could crack the large seeds that remained.

Example: the peppered moth

D4.1.4–5



Peppered moths. Chiswick Chap, CC BY-SA 3.0.

- Light and dark forms exist
- In polluted areas, soot darkened tree trunks
- Birds saw light moths more easily there
- Dark moths survived and reproduced more
- When air became cleaner, light moths increased again

Key idea

The environment does not cause the colour to change. Both forms existed, and selection altered how common each was.

Fitness: survival and reproduction

D4.1.5

- Individuals in a population differ in how well they are adapted
- **Fitness** is how likely a genotype is to survive and to leave offspring
- An organism with high fitness passes on more of its alleles
- An individual that survives without reproducing does not contribute to the next generation

Discussion

A green beetle and a brown beetle live on brown soil. Birds eat the green ones more often. Explain why brown beetles have the higher fitness here. Would the same be true on green leaves? This shows that fitness depends on the environment, and is not simply about strength or size.

Only heritable traits can evolve

D4.1.6

Heritable: can evolve	Acquired: cannot evolve
Variation in base sequences	A broken leg
Migration direction in blackcaps	Muscles from training
Coat colour in mice	Pink colour in flamingos, which comes from their food

Key idea

Characteristics acquired during a life, because of the environment, are not encoded in the base sequence of genes, so they are not passed on. For evolution to occur, a trait must be inherited as well as varying between individuals and affecting survival or reproduction.

Sexual selection

D4.1.7



Peacock. Jatin Sindhu, CC BY-SA 4.0.



Proboscis monkey. David Dennis, CC BY-SA 2.0.

- Traits that help in attracting a mate spread through a population
- These can include colour, size, display or song

Key idea

Exaggerated traits can be costly: they may attract predators or use up energy. A male who survives with them, and can afford to grow them, may be signalling good health. Females choosing such males pass on alleles for the trait to sons, and for the preference to daughters.

Modelling selection: Endler's guppies

D4.1.8



Guppies, female and male. Amy E. Deacon et al., CC BY 4.0.

- Male guppies with bright spots attract more females
- Bright spots also attract predators
- Endler let guppies breed for 6 months, then added no predator, a weak predator or a dangerous one
- He then counted spots on males over generations

Key idea

This is a model with controlled selection pressures. It shows natural selection and sexual selection working against each other, and also how quickly a trait can change, in only a few generations.

Interpreting data from a guppy experiment

D4.1.8

Pond	Predators added	After 5 months	After 14 months
No predators	10.0	11.5	12.5
Weak predators	10.0	11.0	12.0
Dangerous predators	10.0	9.0	8.5

Mean number of spots per male. Figures simplified from the pattern in Endler's work, for practice.

Activity

Describe the trend in each pond. Explain each trend using natural selection and sexual selection. What would you expect if males were moved from the dangerous pond to a pond with no predators? Why were populations with weak predators useful to include?

Check that you can explain

1. How natural selection changes populations
2. How mutation and sexual reproduction create variation
3. Overproduction, competition and carrying capacity
4. Abiotic selection pressures
5. Fitness, and why it depends on the environment
6. Why only heritable traits can evolve
7. Sexual selection and Endler’s guppies

Exit activity: 5 minutes

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

1. Explain why natural selection needs variation between individuals.
2. Give one example of a trait that is not heritable, and explain why it cannot evolve.
3. Explain why bright spots become less common in guppies when predators are present.

Image credits

Paradisaea minor -Jurong Bird Park -male-8a.jpg – Or Hiltch – CC BY 2.0

Charles Darwin 01.jpg – Julia Margaret Cameron – Public domain

Biston.betularia.7200.jpg – Chiswick Chap – CC BY-SA 3.0

Peacock Plumage.jpg – Jatin Sindhu – CC BY-SA 4.0

Proboscis Monkey in Borneo.jpg – David Dennis – CC BY-SA 2.0

Trinidadian guppy (Poecilia reticulata) male and female.png – Amy E. Deacon, Hideyasu Shimadzu, Maria Dornelas, Indar W. R – CC BY 4.0

All from Wikimedia Commons (commons.wikimedia.org, search the file name). Some images are cropped. CC licences: creativecommons.org/licenses