

Variation and selection revision notes

Variation and selection looks at why individuals of the same species are different, where new alleles come from and how the environment shapes which individuals survive. It covers natural selection, adaptive features, and how humans use selective breeding to improve crops and animals. Extended candidates also explain adaptation, hydrophytes and xerophytes, and antibiotic-resistant bacteria.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

1 Variation Spec 18.1.1-18.1.10

Continuous and discontinuous variation Spec 18.1.1, 18.1.2, 18.1.3, 18.1.4, 18.1.5

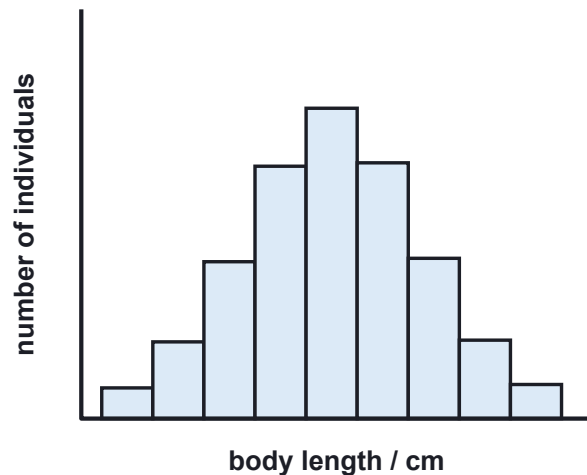
Variation is the differences between individuals of the same species. Two humans, two dogs or two pea plants are never exactly the same.

There are two types of variation: **continuous variation** and **discontinuous variation**.

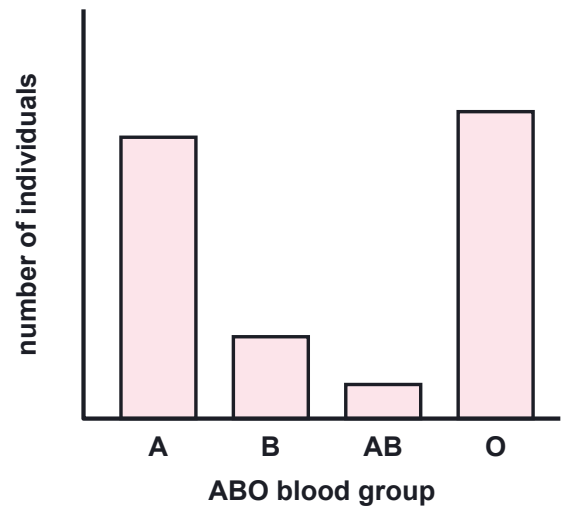
Continuous and discontinuous variation		
	Continuous variation	Discontinuous variation
Phenotypes	A range of phenotypes between two extremes	A limited number of phenotypes with no intermediates
Examples	Body length, body mass	ABO blood groups, seed shape in peas, seed colour in peas
Caused by	Both genes and the environment	Usually genes only
Graph	Histogram (bars touching), often bell-shaped	Bar chart (bars separate)

Think of height. People can be any height between very short and very tall, so there is a whole range. Blood group is different. You are A, B, AB or O. Nobody is half way between A and B.

The environment affects continuous variation. A plant with the genes to grow tall will still be short if it has too little light or water. Your blood group cannot be changed by diet or exercise.



continuous variation
a range of phenotypes
between two extremes



discontinuous variation
a limited number of phenotypes
with no intermediates

Continuous variation gives a range between two extremes (histogram); **discontinuous variation** gives a few distinct groups (bar chart).

Practical skill: Measure or observe one feature in a large sample (at least 30 individuals of the same species and similar age), for example leaf length to the nearest mm with a ruler, or seed colour. Record the results in a tally table, then plot a histogram for a measured (continuous) feature or a bar chart for categories (discontinuous).

Exam tip: Do not just say 'genes and environment'. Say discontinuous variation is usually caused by genes only, and continuous variation is caused by both genes and the environment.

Mutation and sources of genetic variation Spec 18.1.6, 18.1.7, 18.1.8, 18.1.9, 18.1.10

Mutation is genetic change. It is the way in which new alleles are formed. Most mutations have no effect or are harmful, but a few can be useful if the environment changes.

Some things make mutations happen more often. **Ionising radiation** (such as X-rays and gamma rays) and some chemicals (such as chemicals in tobacco smoke) increase the rate of mutation.

Supplement

Gene mutation is a random change in the base sequence of DNA. It is random because it cannot be predicted which gene will change, or when. A change in the base sequence can change the amino acids in a protein, so the protein may work differently.

Supplement

Sources of genetic variation in a population

Supplement

Four processes produce genetic variation in populations:

Supplement

- mutation: forms new alleles
- meiosis: makes genetically different gametes with different combinations of alleles
- random mating: any individual can mate with any other of the opposite sex, so different combinations of alleles come together
- random fertilisation: any male gamete can fuse with any female gamete

Supplement

Exam tip: Learn the four sources as a list: mutation, meiosis, random mating, random fertilisation. Do not give the environment: it affects phenotype but is not a source of genetic variation.

Quick check

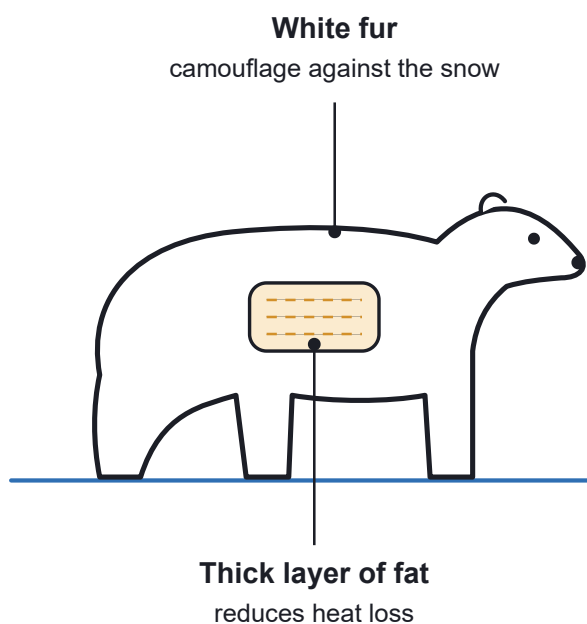
1. Define variation.
2. Give two examples of continuous variation.
3. Give an example of discontinuous variation in humans.
4. What is mutation?
5. **Supplement** State four sources of genetic variation in populations.

2 Adaptive features Spec 18.2.1-18.2.3

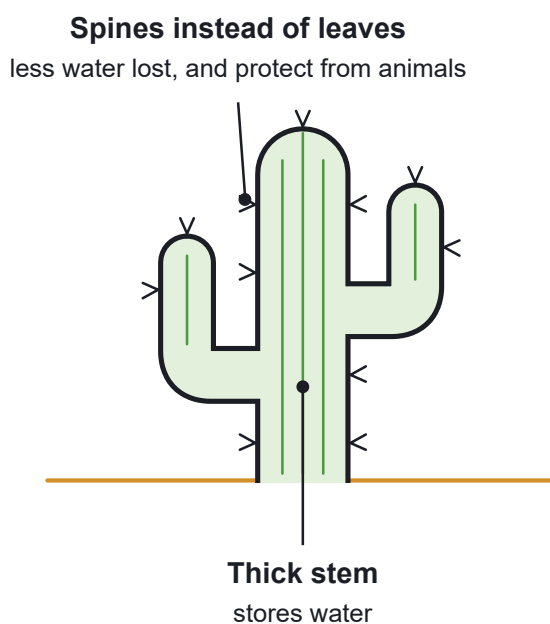
Adaptive features Spec 18.2.1, 18.2.2

An **adaptive feature** is an inherited feature that helps an organism to survive and reproduce in its environment.

The feature can be a body structure, such as the shape of a beak, or a way the body works, such as producing concentrated urine to save water. It can also be a pattern of behaviour. It must be **inherited**, so a skill learned during life is not an adaptive feature.



Polar bear: cold Arctic



Cactus: hot, dry desert

Adaptive features of a polar bear in the cold Arctic and a cactus in a hot, dry desert.

Interpreting a species

In the exam you are given a picture or some information about an organism. Link each feature to the environment and say how it helps survival or reproduction.

Linking feature to advantage	
Feature	How it helps
White fur (polar bear)	camouflage against the snow, so it is harder for prey to see it
Thick layer of fat (polar bear)	insulation, so less heat is lost
Spines instead of leaves (cactus)	smaller surface area, so less water is lost; protection from animals
Thick stem (cactus)	stores water for dry periods

Exam tip: Use the pattern: *feature, then what it does, then why that helps the organism survive.* 'White fur camouflages the bear so it can creep up on seals' scores; 'white fur because it is cold' does not.

Hydrophytes and xerophytes Spec 18.2.3 Supplement

Hydrophytes are plants adapted to live in water or very wet places. **Xerophytes** are plants adapted to live in dry places where water is scarce.

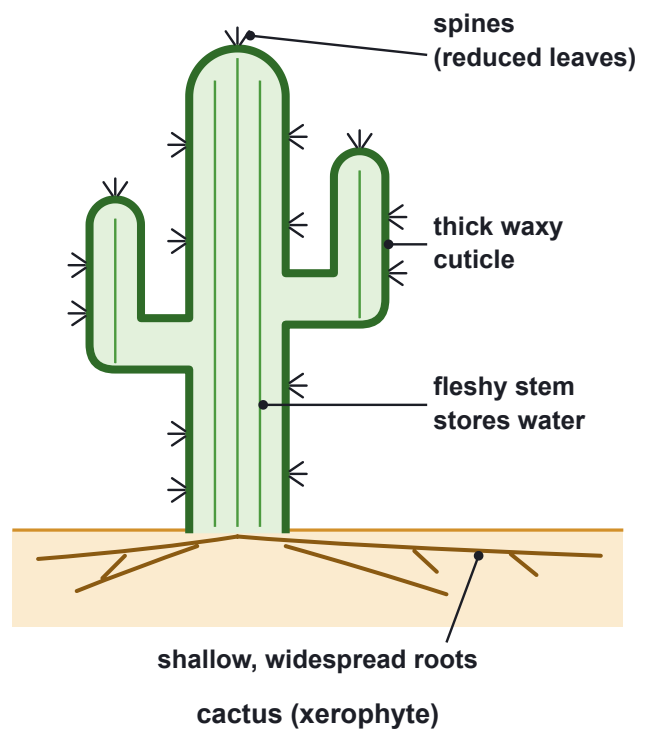
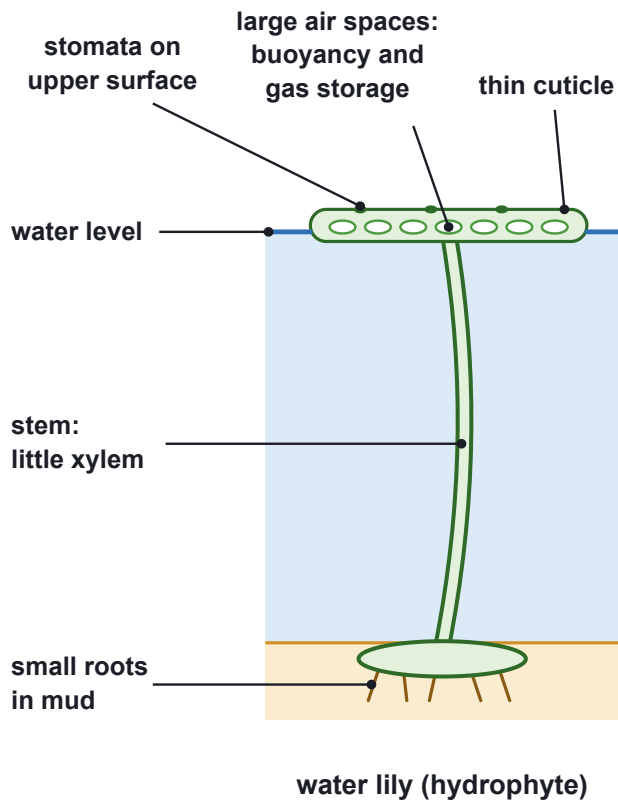
Hydrophytes (for example the water lily)

Adaptive features of a hydrophyte	
Feature	Explanation
Large air spaces in the leaves and stems	make the plant float so leaves are near the light; store oxygen and carbon dioxide for gas exchange
Stomata on the upper surface of floating leaves	the lower surface is in water, so the stomata on top can exchange gases with the air
Thin or no waxy cuticle	water is not scarce, so there is no need to prevent water loss
Small or reduced roots and little xylem	water can be absorbed over the whole surface and the water supports the plant

Xerophytes (for example cactus and marram grass)

Adaptive features of xerophytes	
Feature	Explanation
Thick waxy cuticle	reduces evaporation of water from the leaf surface
Leaves reduced to spines (cactus)	smaller surface area, so less water is lost by transpiration
Leaves rolled up with hairs (marram grass)	traps a layer of humid air next to the leaf, which reduces the concentration gradient of water vapour, so less water vapour diffuses out
Stomata in pits or sunken, few stomata	reduces diffusion of water vapour out of the leaf
Thick, fleshy stem (cactus)	stores water
Long roots or shallow, widespread roots	long roots reach water deep in the soil; widespread roots absorb rain water quickly over a large area

Supplement



A **hydrophyte** (water lily) and a **xerophyte** (cactus) have opposite adaptive features for water.

Supplement

Exam tip: 'Explain' means give a reason. For every feature say what it does and why that suits the environment, for example 'air spaces make the leaf float so it gets more light'.

Quick check

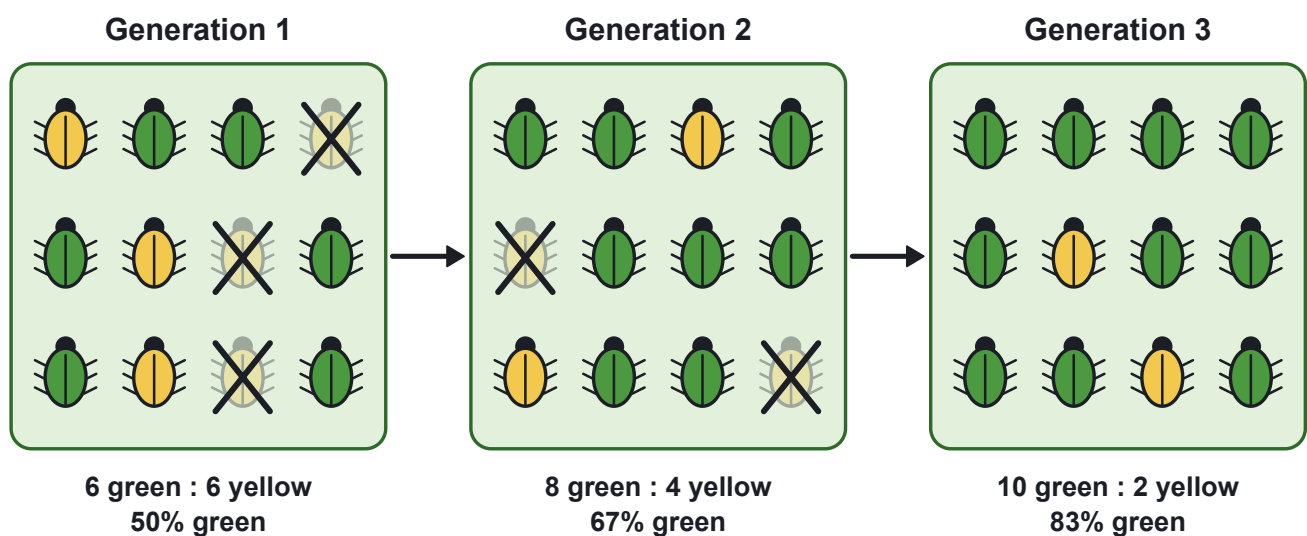
1. Define adaptive feature.
2. Why is a skill learned during life not an adaptive feature?
3. **Supplement** Where are the stomata on a floating water lily leaf?
4. **Supplement** Why do xerophytes have a thick waxy cuticle?

3 Selection Spec 18.3.1-18.3.6

Natural selection and adaptation Spec 18.3.1, 18.3.4

Natural selection is the process by which individuals that are better adapted to their environment survive and pass on their alleles. It can be described in five steps.

1. There is genetic variation within populations: individuals have different alleles.
2. Organisms produce many offspring, more than the environment can support.
3. There is a struggle for survival, including competition for resources such as food, water and mates, and pressure from predators and disease.
4. Individuals that are better adapted to the environment have a greater chance of surviving and reproducing than others.
5. These individuals pass on their alleles to the next generation, so the alleles for helpful features become more common.



= eaten by birds. Yellow beetles are easier to see on green leaves, so they are more likely to be eaten. Green beetles are more likely to survive, breed and pass on their alleles, so the proportion of green beetles rises.

Over generations the proportion of the better-adapted (green) beetles rises.

Supplement

Adaptation is the process, resulting from natural selection, by which populations become more suited to their environment over many generations.

Supplement

Notice that individuals do not change. It is the population that changes, because the proportion of individuals with helpful alleles increases from one generation to the next.

Common mistake: Do not write that organisms 'adapt because they need to' or that a mutation 'happens because it is needed'. Mutations are random. The environment only selects which individuals survive.

Antibiotic-resistant bacteria Spec 18.3.5 Supplement

The development of strains of **antibiotic-resistant bacteria** is an example of **natural selection**.

1. Among a population of bacteria, a random mutation produces a new allele that makes one bacterium resistant to an antibiotic.
2. The antibiotic is used. It kills the non-resistant bacteria.
3. The resistant bacterium survives because it is better adapted in the presence of the antibiotic, and it has less competition.
4. It reproduces, and passes the resistance allele to its offspring.
5. Over time, most of the population is resistant and the antibiotic no longer works.

Bacteria can reproduce very quickly, so a resistant strain can become common in a short time. Overuse of antibiotics increases the chance that resistant strains are selected.

Supplement

Common mistake: Say the bacteria are resistant, not the person. The antibiotic does not cause the mutation; it selects the bacteria that already have the resistance allele.

Selective breeding and artificial selection Spec 18.3.2, 18.3.3, 18.3.6

Selective breeding (artificial selection) is when humans choose which organisms breed so that the next generation has desirable features.

1. Humans select individuals with desirable features.
2. These individuals are crossed (bred together) to produce the next generation.
3. Offspring showing the desirable features are selected, and the process is repeated.

This is repeated over **many generations**. Each generation has more of the desirable features. It is used to improve crop plants and domesticated animals.

Examples of selective breeding

Organism	Desirable features that may be selected
Crop plants (wheat, rice)	higher yield, disease resistance, larger seeds or fruits, shorter stems
Dairy cattle	high milk yield
Beef cattle	large muscle mass, fast growth
Hens	large numbers of eggs, large eggs

Percentage increase in milk yield

A herd of cows had a mean milk yield of 4000 dm³ per year. After many generations of selective breeding the mean yield is 5200 dm³ per year. Calculate the percentage increase.

1. Increase = 5200 – 4000 = 1200 dm³
2. Percentage increase = (increase ÷ original) × 100 = (1200 ÷ 4000) × 100

Answer: 30%

Supplement

Natural and artificial selection compared

Supplement

Natural selection and artificial selection

	Natural selection	Artificial selection
What selects	the environment	humans
Features selected	those that help survival and reproduction	those that humans want
Purpose	organisms become better adapted to their environment	to improve crops and domesticated animals for human use
Speed	usually slow: takes a very long time	usually faster, because humans choose every breeding pair in each generation

Exam tip: In selective breeding questions state what is selected, that the selected individuals are crossed, that offspring with the feature are chosen, and that it is repeated over many generations.

Quick check

1. Give two things organisms compete for.
2. What happens to the alleles of better-adapted individuals?
3. Name the three stages of selective breeding.
4. **Supplement** Define adaptation.
5. **Supplement** Who or what selects in natural selection and in artificial selection?

Quick check answers

Variation

1. Differences between individuals of the same species.
2. Body length and body mass.
3. ABO blood groups.
4. Genetic change; it is the way new alleles are formed.
5. Mutation, meiosis, random mating and random fertilisation.

Adaptive features

1. An inherited feature that helps an organism to survive and reproduce in its environment.
2. It is not inherited.
3. On the upper surface.
4. To reduce evaporation of water from the leaf surface.

Selection

1. Any two from food, water, light, space, mates.
2. They are passed on to the next generation.
3. Select individuals with desirable features; cross them; select offspring showing the desirable features.
4. The process, resulting from natural selection, by which populations become more suited to their environment over many generations.
5. The environment selects in natural selection; humans select in artificial selection.