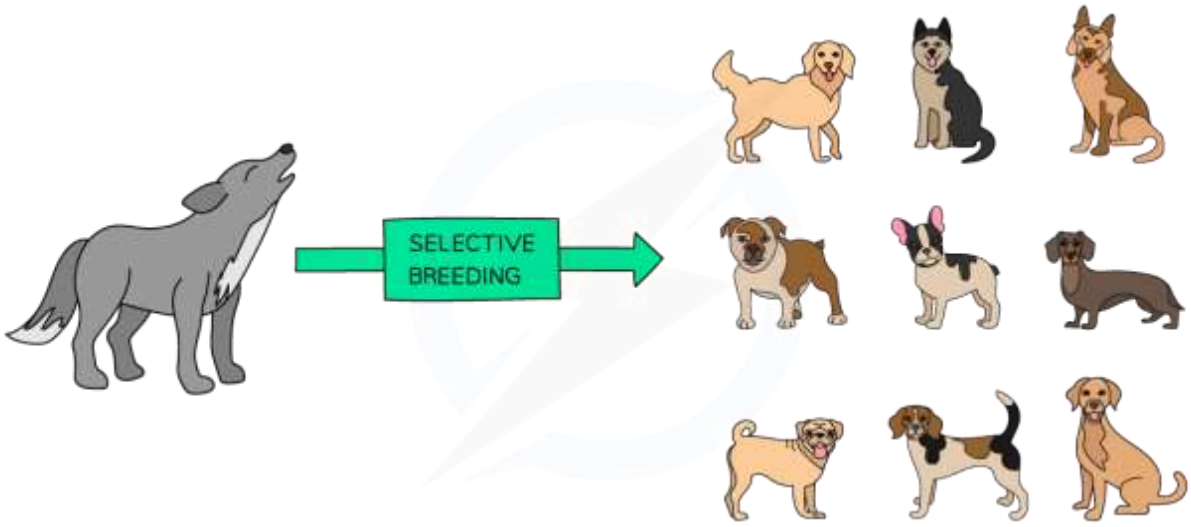
Greek Orthodox Patriarchate School
International - Fuhies

9. Variation



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Grade: 10 IGCSE

Subject: Biology / 0610

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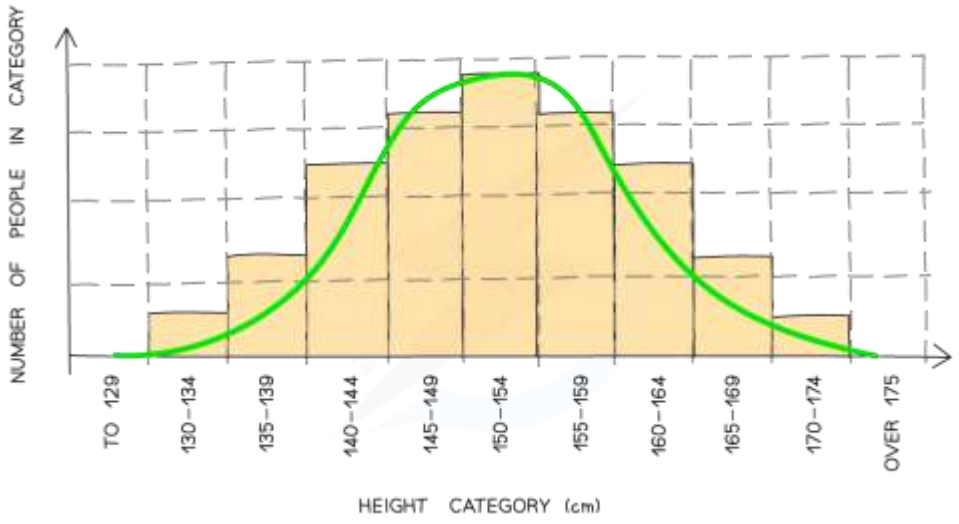
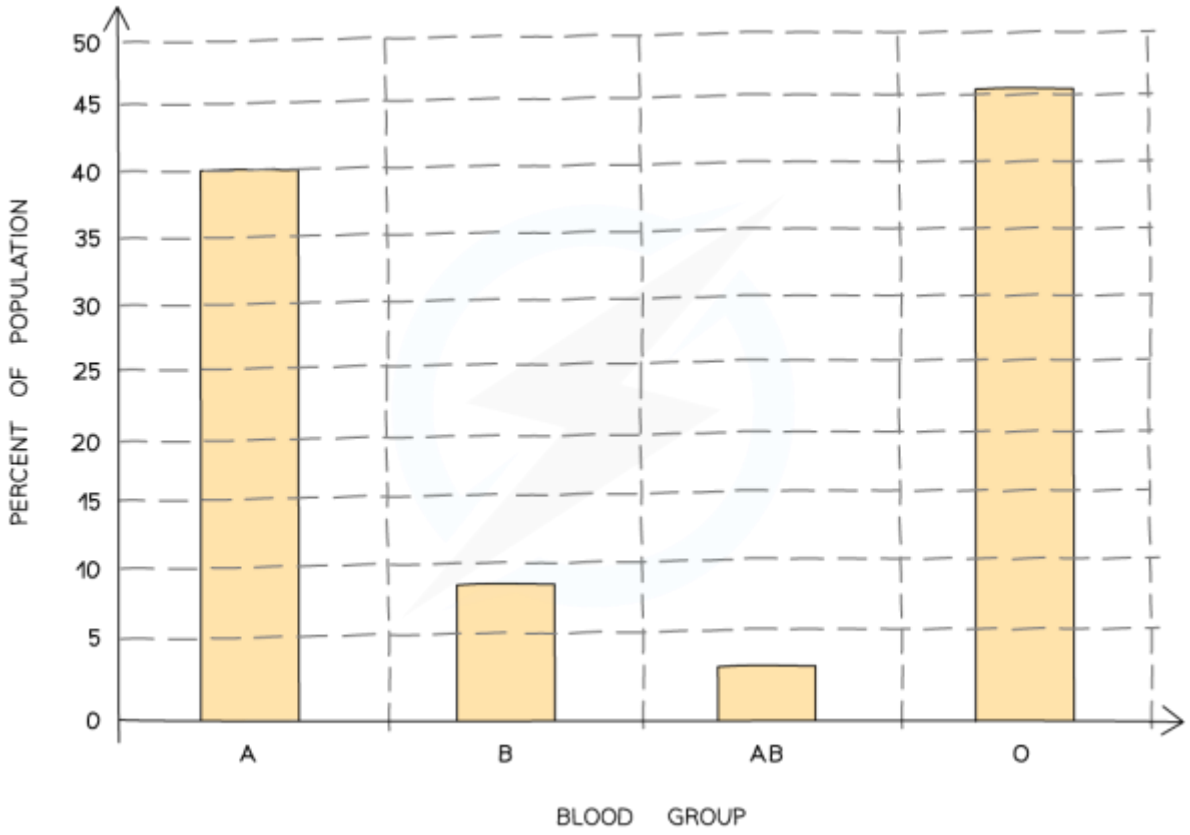
Variation

Types of Variation

- Variation is defined as **differences between individuals of the same species**
- **Phenotypic variation** is the difference in features between individuals of the same species
- Some of these differences are caused by differences in genes, which is **genetic variation**
- Phenotypic variation can be divided into two types depending on **how you are able to group the measurements:**
    - **Continuous Variation** is when there are very many small degrees of difference for a particular characteristic between individuals and they are arranged in order and can usually be measured on a scale
    - Examples include height, mass, finger length etc. where there can be many 'inbetween' groups
    - **Discontinuous Variation** is when there are distinct differences for a characteristic
    - For example, people are either blood group A, B, AB or O; are either male or female; can either roll their tongue or not - there are no 'inbetweens'
- When graphs of these data are plotted, continuous variation gives smooth bell curves (a result of all the small degrees of difference), whereas discontinuous gives a 'step – like' shape



Height is an example of continuous variation which gives rise to a smooth bell-shaped curve when plotted as a graph



Blood group is an example of discontinuous variation which gives rise to a step-shaped graph

Phenotypic Variation

- Phenotypic variation can be caused in two main ways:
  - It can be **genetic** - controlled entirely by genes
  - Or it can be **environmental** - caused entirely by the environment in which the organism lives

Genetic Variation

- Examples of genetic variation in humans include:
  - **blood group**
  - **eye colour**
  - **gender**
  - **ability to roll tongue**
  - **whether ear lobes are free or fixed**

Environmental Variation

- Characteristics of all species can be affected by environmental factors such as climate, diet, accidents, culture and lifestyle
- In this instance 'environmental' simply means 'outside of the organism' and so can include factors like climate, diet, culture, lifestyle and accidents during lifetime
- Examples include:
    - An accident may lead to **scarring** on the body
    - Eating too much and not leading an active lifestyle will cause **weight gain**
    - Being raised in a certain country will cause you to speak a certain **language** with a certain **accent**
    - A plant in the shade of a big tree will grow **taller** to reach more light

Genetic and Environmental Causes

- Discontinuous variation is usually caused by **genetic variation alone**
- Continuous features often vary because of a combination of genetic and environmental causes, for example:
    - tall parents will **pass genes** to their children for height
    - their children have the **genetic potential** to also be tall
    - however if their **diet is poor** then they will not grow very well
    - therefore their **environment** also has an impact on their height
- Another way of looking at this is that although genes decide what characteristics we inherit, the surrounding environment will affect how these inherited characteristics develop

Adaptations

- An adaptive feature is an **inherited feature that helps an organism to survive and reproduce in its environment**
- You should be able to interpret images or other information about a species in order to describe its adaptive features, for example:

(c) Plants that live in different types of habitat have leaves that show adaptations for survival.

Table 4.1 shows some features of the leaves of three species of plant from different types of habitat.

Table 4.1

species	habitat	orientation of the leaves	individual leaf area / cm^2	mean stomatal density / number of stomata per mm^2	
				upper epidermis	lower epidermis
annual meadow grass, *Poa annua*	grassland	vertical	1 – 10	125	135
white water lily, *Nymphaea alba*	the surface of ponds and lakes	horizontal	more than 1000	460	none
common myrtle, *Myrtus communis*	dry scrubland	horizontal	2 – 4	none	508

A typical question here might be to explain how the leaf area and distribution and density of stomata help different species of plant survive in their different habitats

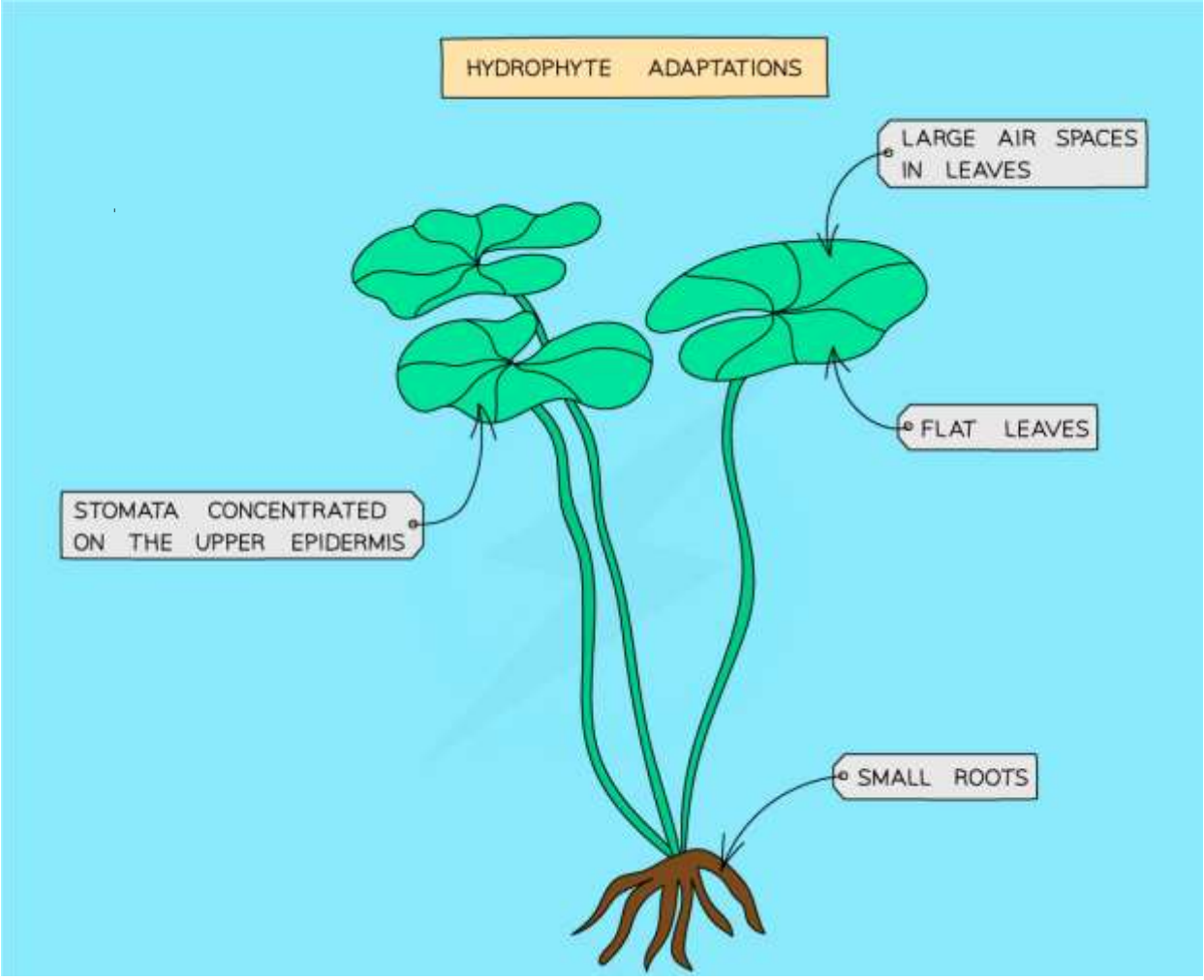
Adaptations & Fitness

- Adaptive features are the **inherited functional features of an organism that increase its fitness**
- Fitness is the **probability of an organism surviving and reproducing in the environment in which it is found**

Hydrophytes & Xerophytes

Hydrophytes

- Plants adapted to live in **extremely wet conditions**
- Common adaptations include:
    - **Large air spaces in their leaves** to keep them close to the surface of the water where there is more light for photosynthesis
    - **Small roots** as they can also extract nutrients from the surrounding water through their tissues
    - Stomata usually open all the time and **mainly found on the upper epidermis** of the leaf where they can exchange gases much more easily with the air

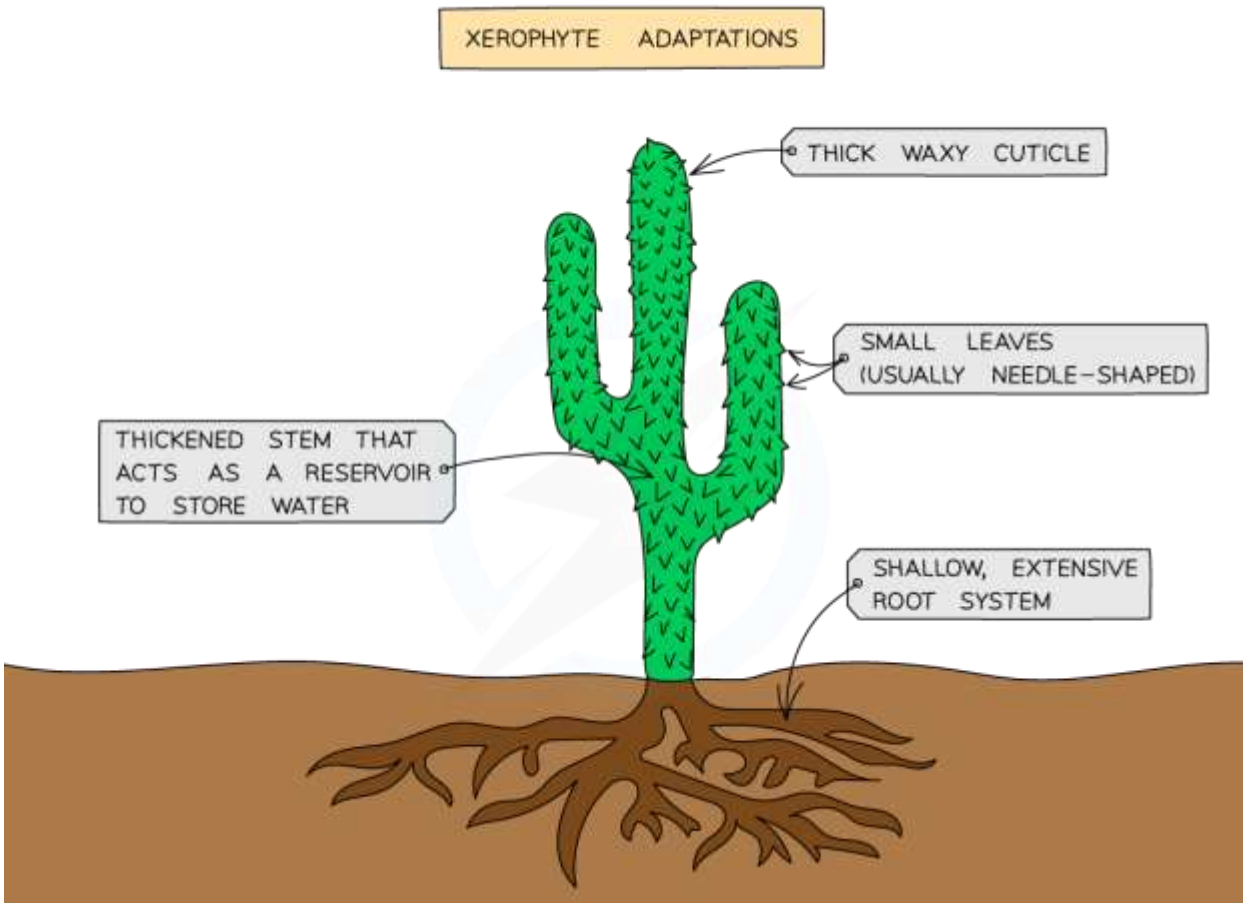


Hydrophytes are adapted to live in wet conditions such as ponds

Xerophytes

- Plant adapted to live in **extremely dry conditions**
- Common adaptations include:
    - **Thick waxy cuticle** - the cuticle cuts down water loss in two ways: it acts as a barrier to evaporation and also the shiny surface reflects heat and so lowers temperature
    - **Sunken stomata**: stomata may be sunk in pits in the epidermis; moist air trapped here lengthens the diffusion pathway and reduces evaporation rate
    - **Leaf rolled** with stomata inside and an inner surface **covered in hairs** - traps moist air and prevents air movement across stomata which reduces transpiration
    - **Small leaves**: many xerophytic plants have small, needle-shaped leaves which reduce the surface area and therefore the evaporating surface

- **Extensive shallow roots** allowing for the quick absorption of large quantities of water when it rains
- **Thickened leaves or stems** which contain cells that store water



Xerophytes are adapted to live in extremely dry conditions such as deserts

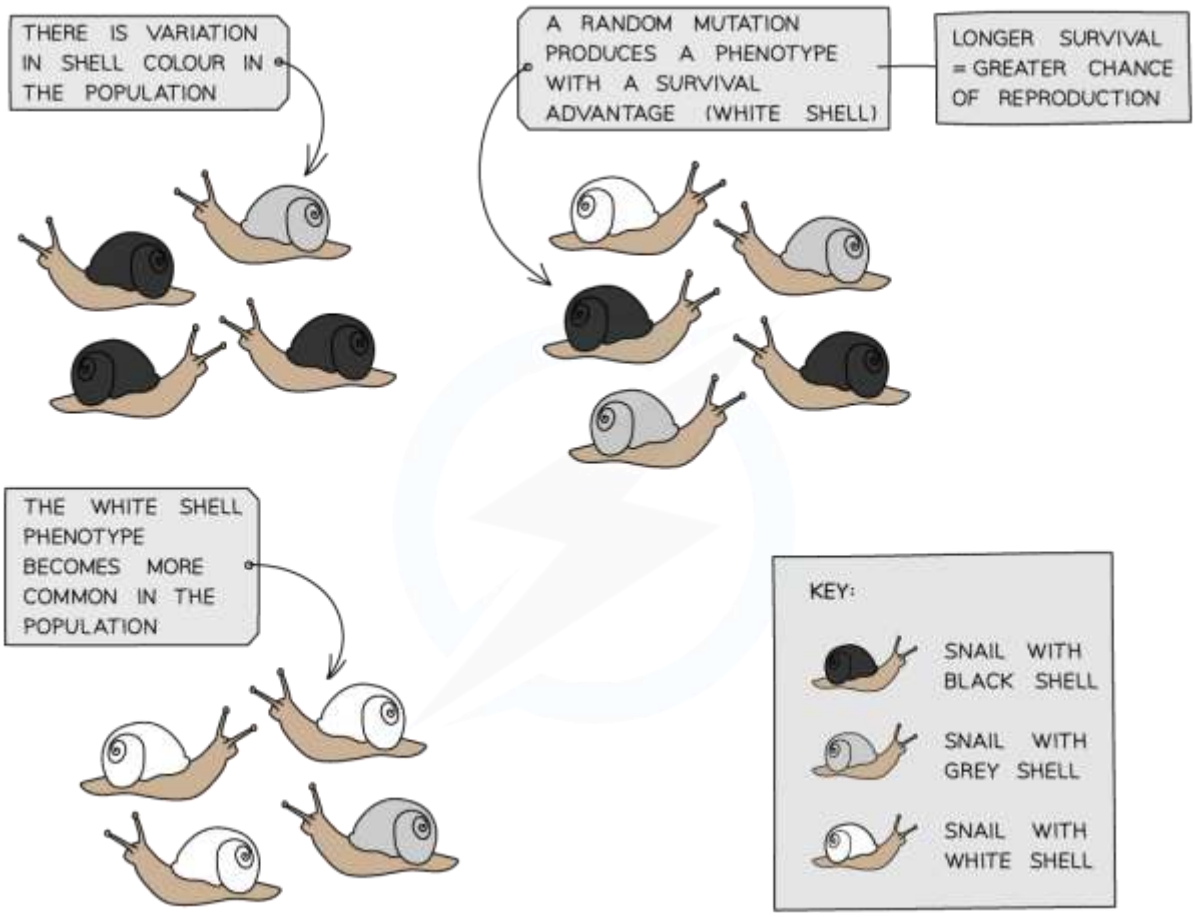
Natural Selection & Evolution

Natural Selection

- In any environment, the individuals that have the best adaptive features are the ones most likely to survive and reproduce
- This results in **natural selection**:
- Individuals in a species show a **range of variation** caused by differences in genes
- When organisms reproduce, they **produce more offspring** than the environment is able to support

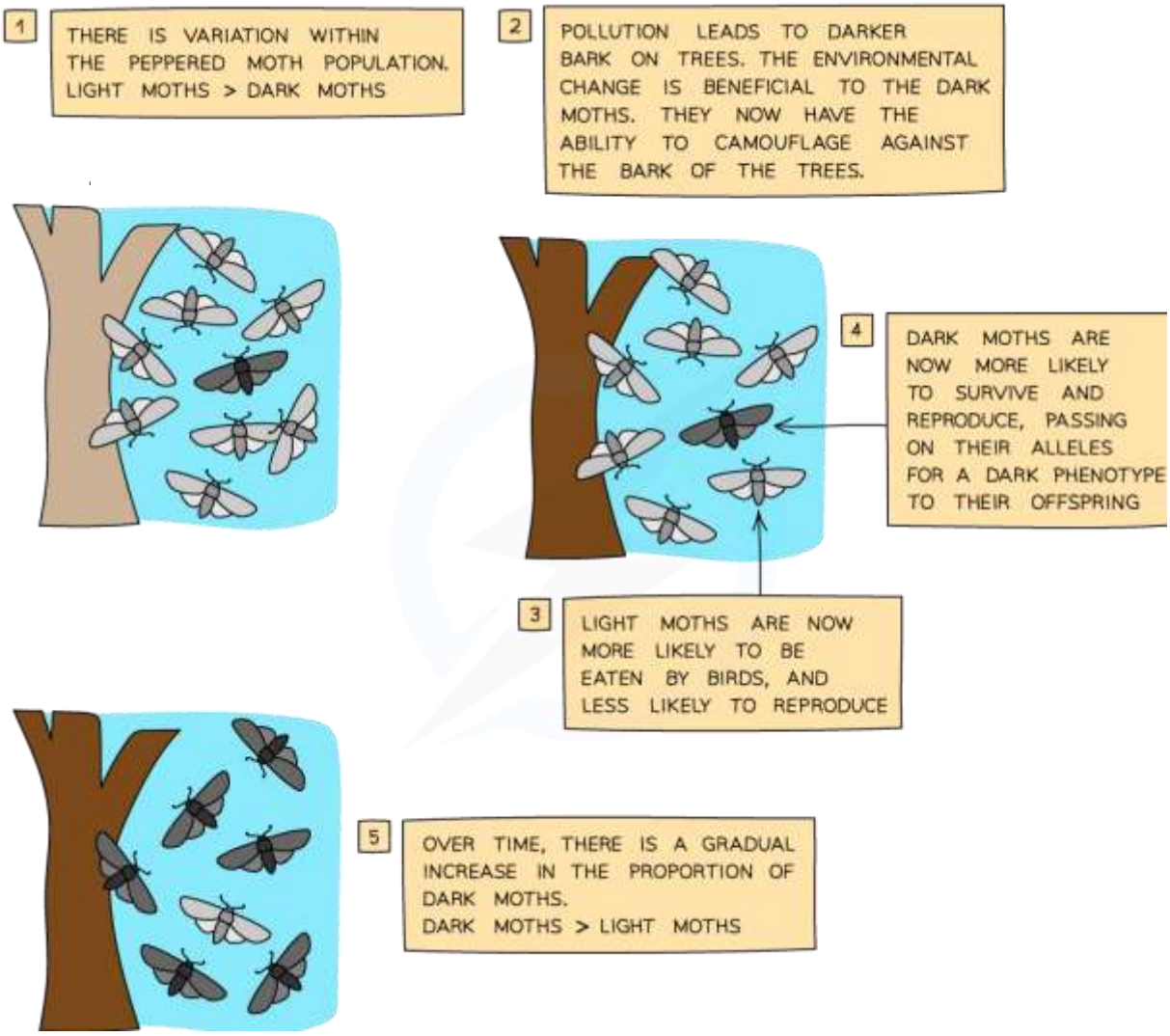
- This leads to **competition** for food and other resources which results in a **'struggle for survival'**
- Individuals with characteristics **most suited to the environment** have a higher chance of survival and **more chances to reproduce**
- Therefore the alleles resulting in these characteristics are **passed to their offspring at a higher rate** than those with characteristics less suited to survival
- This means that in the next generation, there will be a **greater number of individuals** with the **better adapted variations** in characteristics
- This theory of natural selection was put forward by **Charles Darwin** and became known as **'survival of the fittest'**

An example of natural selection



Natural selection illustrated by snail shell colour

- Within the population of snails there is variation in shell colour
- Normal varieties of shell colours in this snail species is black or grey (as evidenced by the first picture)
- **Chance mutations** lead to a small number of snails / one snail having a white shell
- This 'small number' is shown in the second diagram where there are less white shelled snails than black or grey shelled snails
- The white shelled snail(s) **survive longer**
- This is the 'survival of the fittest', a term used to explain why some organisms succeed in the competitive struggle for survival against other members of their population
- The reason the white shelled snail(s) survive longer is **because they are better camouflaged**
- This means that they are **less likely to be seen by predators** and eaten
- As they survive longer they get **more opportunities to reproduce**
- And so the allele for white shells is passed onto offspring more frequently than the alleles for black or grey shells
- **Over generations, this is repeated** until the majority of snails in the population have white shells



Another good example of natural selection is the evolution of the peppered moths

Exam Tip

There are hundreds of thousands of examples of natural selection and you cannot possibly be familiar with all of them, however, they ALL follow the same sequence described above:

- Based on the idea that within a species there is always variation and chance mutations, some individuals will develop a phenotype (characteristic) that gives them a survival advantage and therefore will:
  - live longer
  - breed more
  - and be more likely to pass their genes on
- Repeated over generations, the 'mutated' phenotype will become the norm

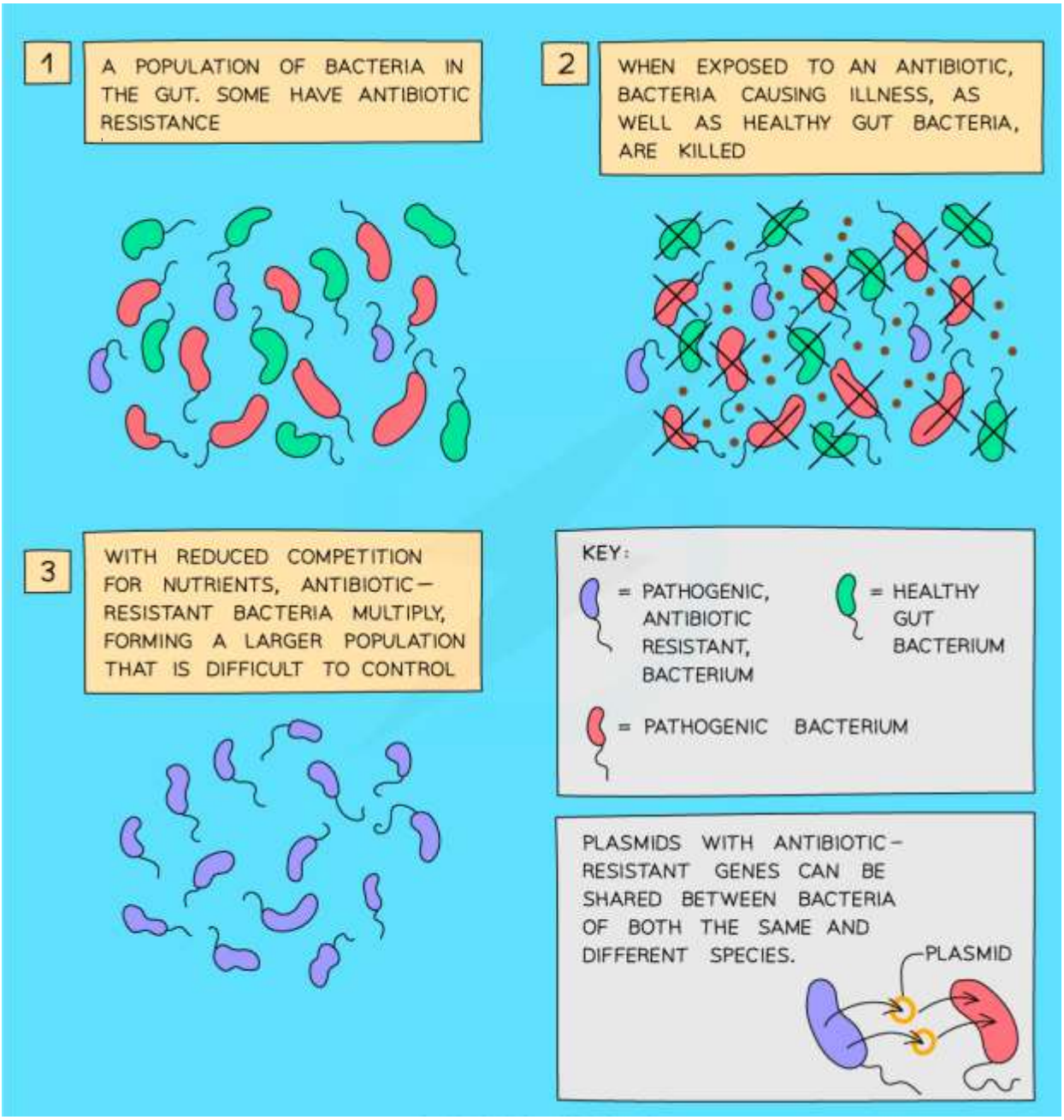
Remember, it is the concept you have to understand, not the specific example.

Evolution

- If the environment **does not change**, selection does not change
- This will favour individuals with the **same characteristics** as their parents
- If the environment **changes**, or a chance mutation produces a **new allele**, selection might now **favour individuals with different characteristics** or with the new allele
- So the individuals that survive and reproduce will have a **different set of alleles** that they pass on to their offspring
- Over time, this will bring about a **change in the characteristics of the species** - it will produce **evolution**
- Evolution is defined as the **change in adaptive features of a population over time as a result of natural selection**
- Natural selection results in a **process of adaptation**, which means that, over generations, those features that are better adapted to the environment become more common
- This means populations of organisms become **better suited to their environment**
- A good example of this is the **development of antibiotic resistance** by bacteria

Antibiotic Resistance in Bacteria

- An **antibiotic** is a chemical that can kill or inhibit the growth and reproduction of bacteria
- They are extremely useful to humans as some bacteria are **pathogenic** and can cause life-threatening disease
- Bacteria reproduce, on average, every 20 minutes and therefore **evolution occurs in a much shorter time span**
- Like all other organisms, **within a population there will be variation** caused by mutation
- A chance mutation might cause **some bacteria to become resistant** to an antibiotic (eg penicillin)
- When the population is treated with this antibiotic, the **resistant bacteria do not die**
- This means they can **continue to reproduce with less competition** from non-resistant bacteria, which are now dead
- Therefore the **genes for antibiotic resistance are passed on** with a much greater frequency to the next generation
- Over time the **whole population of bacteria becomes antibiotic-resistant** because the bacteria are best suited to their environment
- This is an example of natural selection that humans have helped to develop due to **overuse of antibiotics** in situations where they were not really necessary, for example:
    - for treatment of non-serious infections
    - routine treatment to animals in agriculture
    - failure to finish prescribed course of antibiotics



Development of antibiotic resistance in bacteria

- Increases in the population of antibiotic-resistant bacteria cause infections and diseases which are harder to control as it is **difficult to find antibiotics that certain strains of bacteria are not resistant to**
- An example of this is **MRSA**, a very dangerous bacterial strain that is resistant to most antibiotics
- If someone gets infected with MRSA they cannot be treated easily

- Adding to these difficulties, the number of new antibiotics discovered has slowed significantly

Artificial Selection

- Selective breeding means to **select individuals with desirable characteristics and breed them together**
- The process doesn't stop there though because it's likely that not all of the offspring will show the characteristics you want so **offspring that do show the desired characteristics are selected and bred together**
- This process has to be **repeated for many successive generations** before you can definitely say you have a **'new breed'** which will **reliably** show those selected characteristics in all offspring

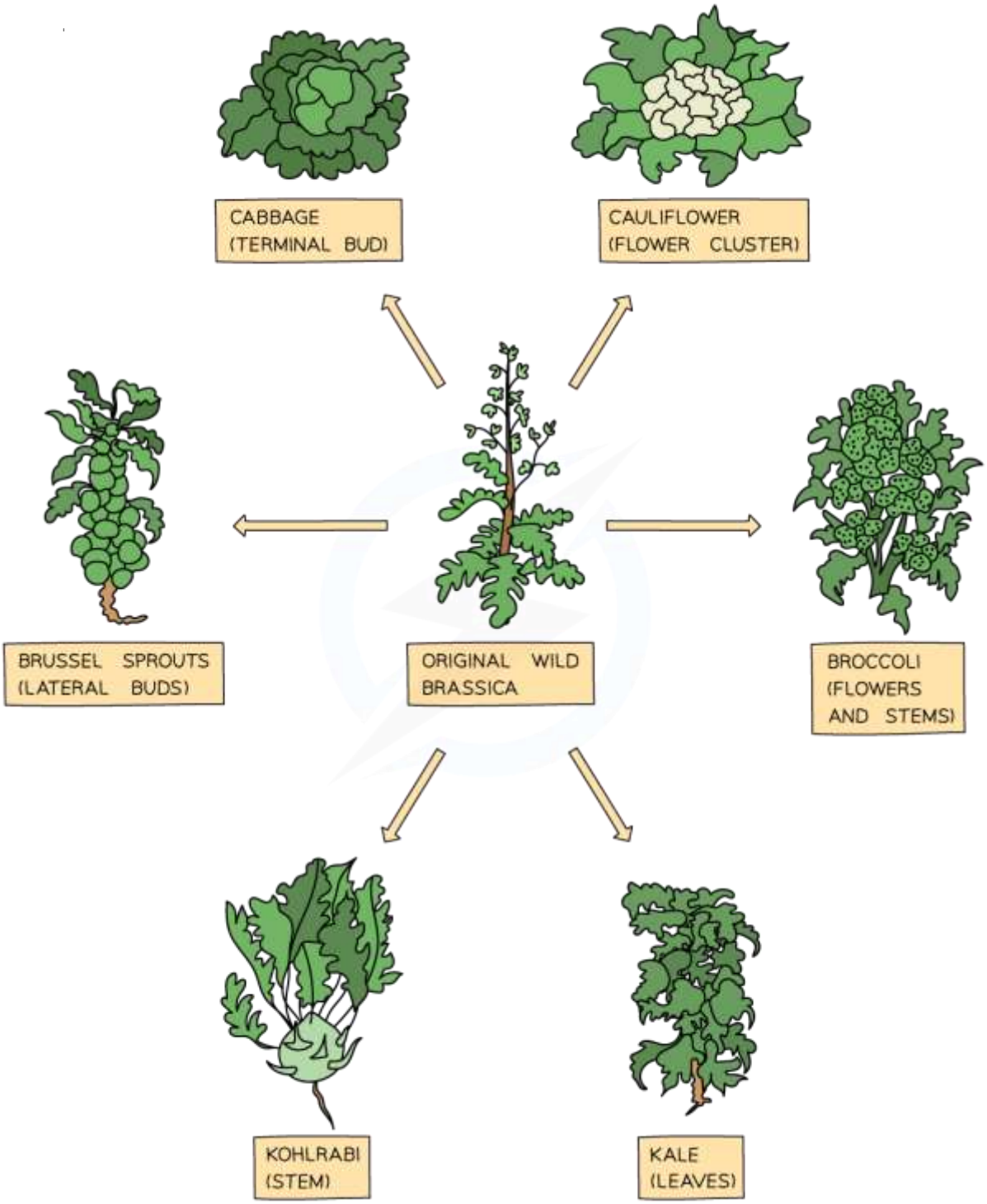
Natural vs Artificial Selection

NATURAL SELECTION	ARTIFICIAL SELECTION
OCCURS NATURALLY	ONLY OCCURS WHEN HUMANS INTERVENE
RESULTS IN DEVELOPMENT OF POPULATIONS WITH FEATURES THAT ARE BETTER ADAPTED TO THEIR ENVIRONMENT AND SURVIVAL	RESULTS IN DEVELOPMENT OF POPULATIONS WITH FEATURES THAT ARE USEFUL TO HUMANS AND NOT NECESSARILY TO SURVIVAL OF THE INDIVIDUAL
USUALLY TAKES A LONG TIME TO OCCUR	TAKES LESS TIME AS ONLY INDIVIDUALS WITH THE DESIRED FEATURES ARE ALLOWED TO REPRODUCE

Selective Breeding in Plants

- Plants are selectively bred by humans for development of many characteristics, including:
  - **disease resistance in food crops**
  - **increased crop yield**
  - **hardiness to weather conditions (e.g. drought tolerance)**
  - **better tasting fruits**
  - **large or unusual flowers**

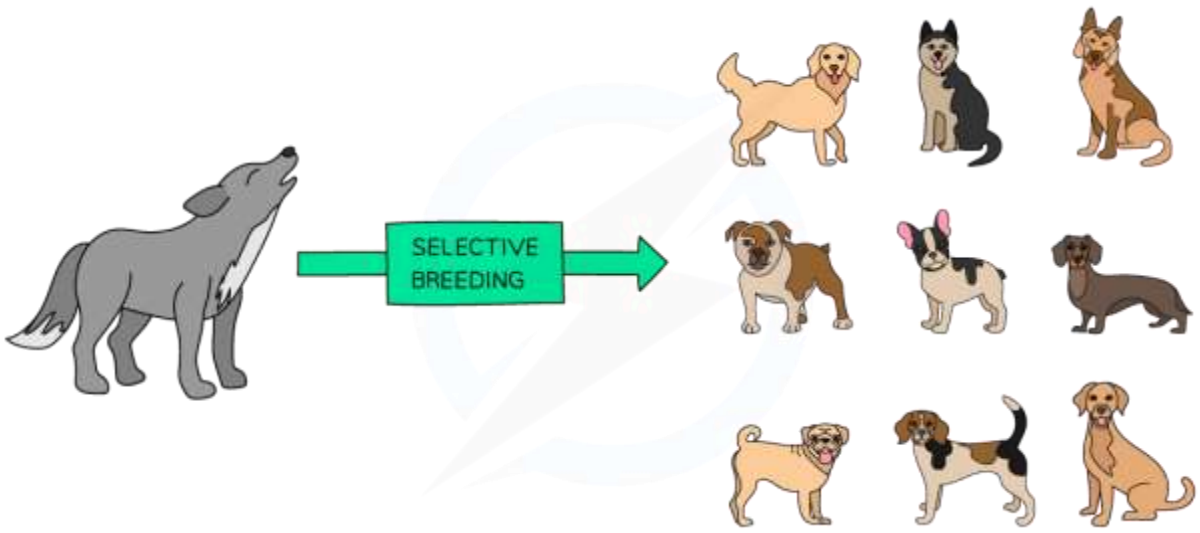
- An example of a plant that has been selectively bred in multiple ways is wild brassica, which has given rise to cauliflower, cabbage, broccoli, brussel sprouts, kale and kohlrabi:



An example of selective breeding in plants

Selective Breeding in Animals

- Selective breeding of animals has been carried out by humans for thousands of years
- It takes place in the same way as selective breeding of plants
- Individuals with the **characteristics you want are bred together** (often several different parents all with the desired characteristics are chosen so siblings do not have to be bred together in the next generation)
- Offspring that show the desired characteristics are **selected and bred together**
- This process is **repeated for many successive generations** before you can definitely say you have a 'new breed' which will reliably show those selected characteristics in all offspring
- Animals are commonly selectively bred for various characteristics, including:
    - **cows, goats and sheep that produce lots of milk or meat**
    - **chickens that lay large eggs**
    - **domestic dogs that have a gentle nature**
    - **sheep with good quality wool**
    - **horses with fine features and a very fast pace**
- An example of an animal that has been selectively bred by humans in many ways to produce breeds with many different characteristics is the **domestic dog**, all breeds of which are descended from wolves



Selective breeding has produced many different breeds of domestic dog