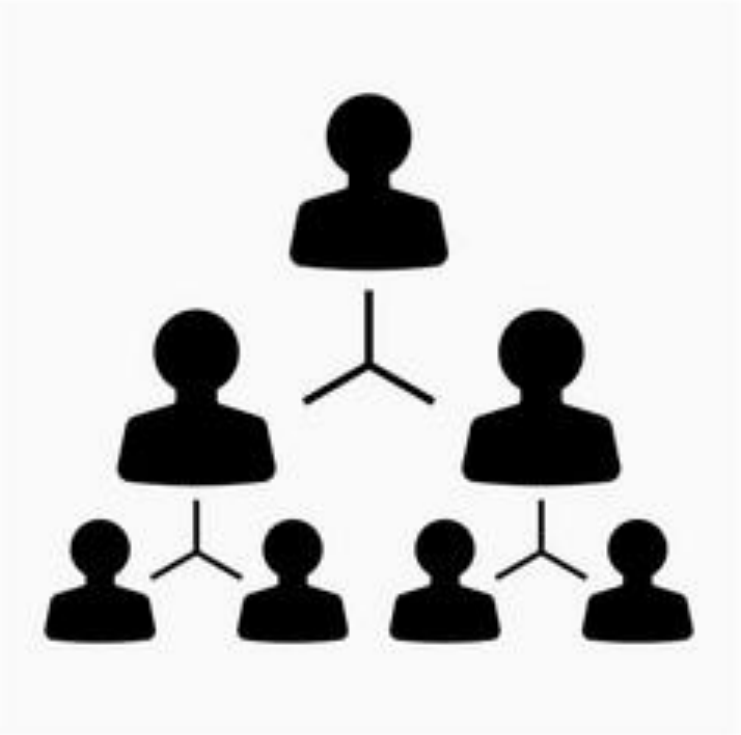
Year 10 Biology Workbook



The Polesworth School

Inheritance, Variation and Evolution

Part 1- Reproduction

Reproduction is a vital process of all living things. In fact, if we recall that a virus is not alive because it cannot reproduce independently, you could argue that it is the defining characteristic of life.

Reproduction comes in two main forms:

1. Asexual: Where 1 parent provides all the genetic information. The offspring is an exact copy (clone) of the parent.
2. Sexual: Where 2 parents provide the genetic information. A unique offspring is created

Humans only reproduce sexually. Bacteria only reproduce asexually. Most plants can reproduce both sexually and asexually.

Gametes

Gametes is the name given to sex cells. These are specialised cells which contain half the number of chromosomes needed to make a healthy offspring. Sperm and Egg cells are human gametes. Pollen and Ovum are the names of the gametes in flowering plants. Gametes are produced by a process called meiosis.

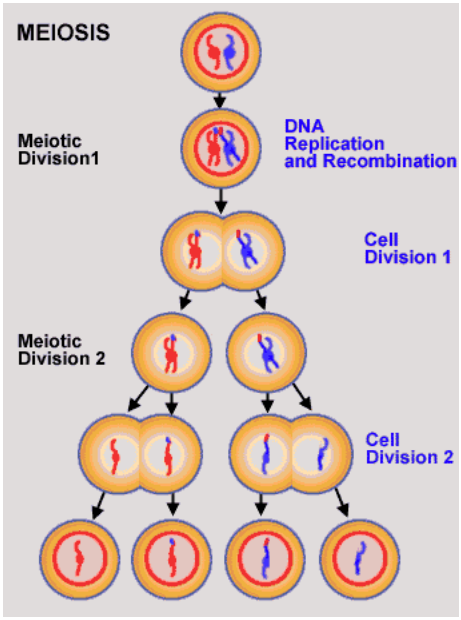
Asexual reproduction

For an organism to reproduce asexually it must divide by mitosis. If you recall from year 10, mitosis is a stage in the cell cycle. First the chromosomes and cell organelles are copied, then the chromosomes are pulled to opposite sides of the cell (**mitosis**) and the nucleus divides. Finally, the cytoplasm and cell membrane divides. Two identical 'daughter cells' are produced. Because they have identical genetic information to the parent cell, they are called clones.

Mitosis happens in humans when a tissue grows, but we do not use it to reproduce.

Sexual reproduction

Sexual reproduction is defined by the fusion of gametes. This means the offspring will have a unique combination of genes from both parents. This leads to variation within the population.



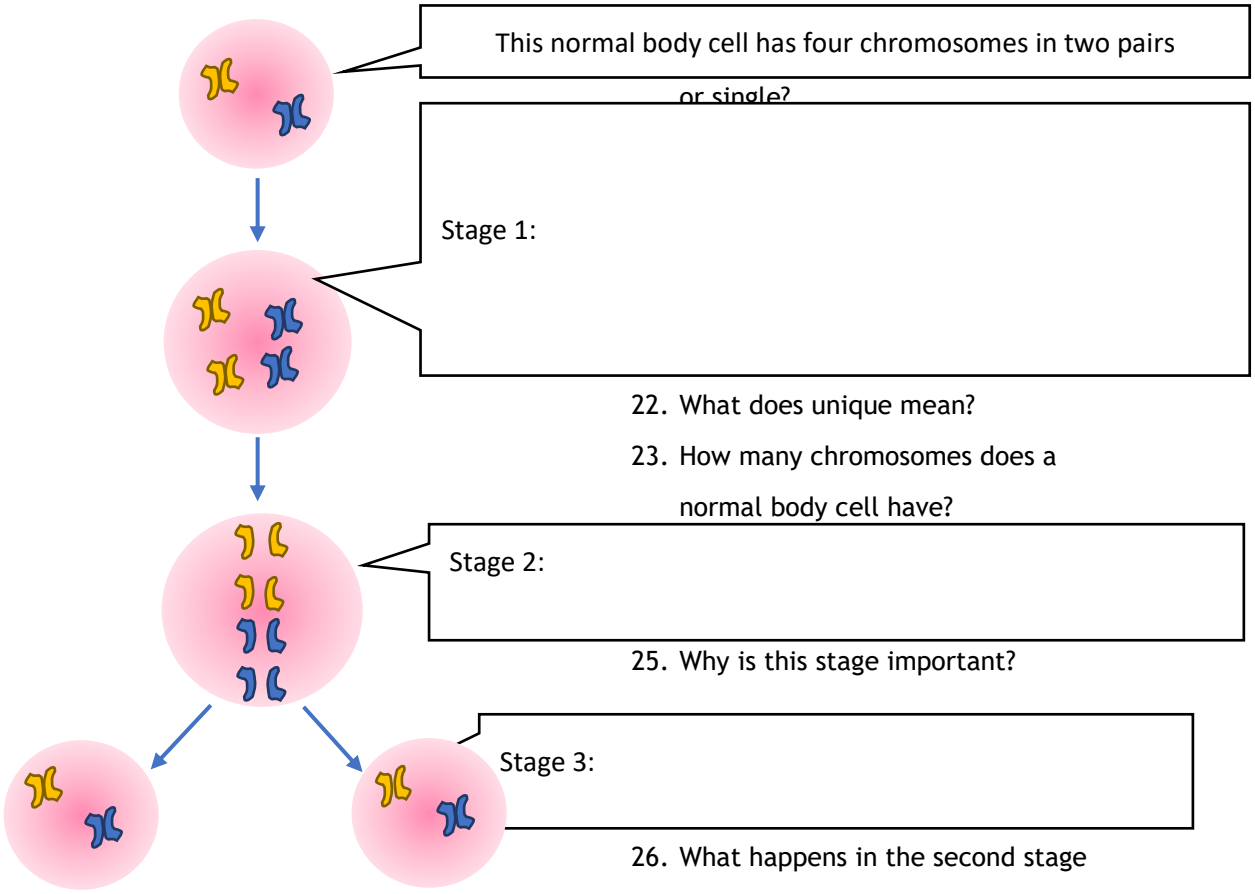
Gametes are made by a process called **meiosis.** Meiosis is a special form of cell division that occurs in the sexual organs. Meiosis follows the same steps as mitosis to start, but once the daughter cells have formed, they undergo a second division. This results in 1 parent cell forming 4 gametes, each with **half** the number of chromosomes as an adult cell. We say these cells have a **haploid** nucleus because they have half the number of chromosomes. In humans the haploid number is 23.

Fertilisation

Fertilisation occurs when two gametes **fuse** (join). At this stage the first cell of a new organisms has been formed, called a zygote, with unique characteristics and the correct number of chromosomes (a **Diploid** nucleus, 46 chromosomes). This one cell then **divides** (by mitosis) before **differentiating** into all the specialised cells that make up an organism.

1. Write a definition for reproduction.
2. Why is a virus not alive?
3. Name the two types of reproduction
4. Name a species which can reproduce in both ways.
5. What is a gamete? Give an example.
6. Where are gametes made?
7. Define mitosis
8. Define meiosis

9. Monica says “Sperm and egg cells are made by mitosis. When a sperm meets and egg differentiation occurs. The sex cells fuse and make a new offspring. The offspring is unique because it has genes from both parents”. She has made some mistakes. Write out the correct version in your book.
10. A bacterium divides every 20 minutes by mitosis. How many bacteria will there be in 2 hours?
11. Define daughter cells
12. Why is it important that gametes have half the number of chromosomes?
13. Define haploid. What type of cells have a haploid nucleus?
14. Define diploid. What kind of cells have a diploid nucleus?
15. Below is a diagram which shows the stages of the cell cycle in order. Add labels to the spaces from the information above

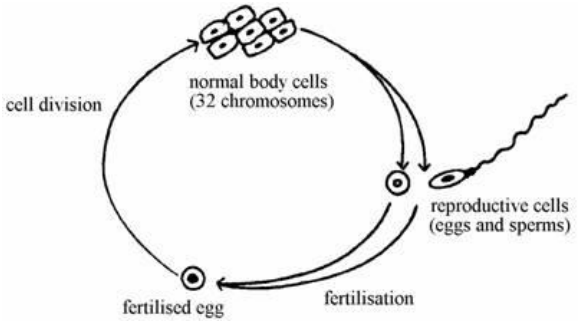


16. What is a chromosome?
22. What does unique mean?
23. How many chromosomes does a normal body cell have?
25. Why is this stage important?
26. What happens in the second stage of Mitosis?
27. What happens in the third stage of mitosis?
28. State the uses of mitosis.

29. Complete the table below to compare mitosis and meiosis. The first row has been completed for you.

	Mitosis	Meiosis
Do the chromosomes and organelles replicate at the start?	Yes	Yes
Do they chromosomes line up and get pulled apart?		
How many times does the cell divide		
How many daughter cells are produced?		
What is the number of chromosomes in the daughter cells		
Are the cells clones?		

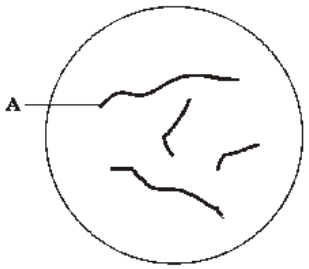
30. The diagram shows three types of cells in a life history of a simple animal.



(a) How do the chromosomes of the body cells compare with the chromosomes in the fertilised egg from which they came?

(b) Describe what happens to chromosomes in the nucleus of a body cell when it forms reproductive cells.

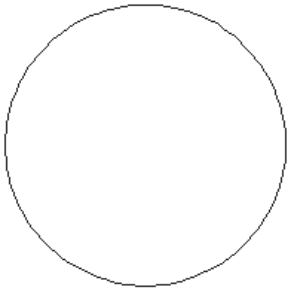
31. Diagram **1** shows the nucleus of a cell at the start of meiosis.



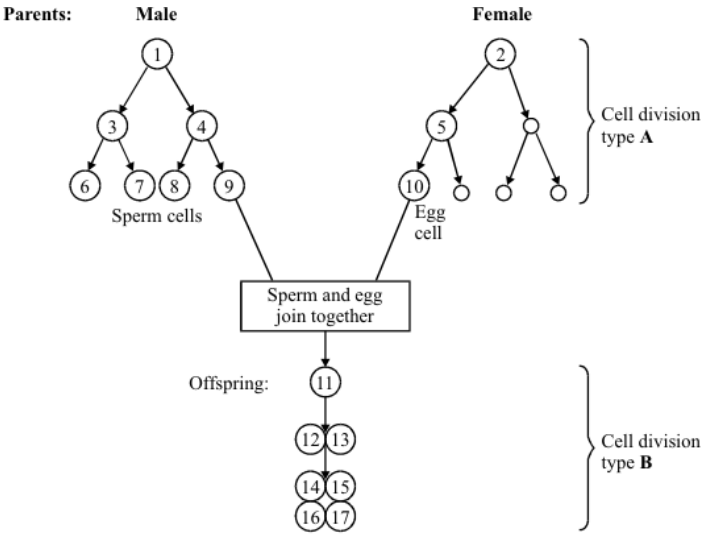
(a) Name structure **A**.

(b) During meiosis, the nucleus shown in diagram **1** will divide twice to form four nuclei.

Complete diagram **2** to show the appearance of one of these nuclei.



32. What organelle is responsible for making all the proteins in the cell.
33. What is the function of the cell membrane?
34. What organelle provides the extra energy needed for a cell to undergo meiosis?
35. Name the organs where meiosis occurs in males and females.
36. How many chromosomes are in an egg cell?
37. The diagram shows two patterns of cell division. Cell division type **A** is used in gamete formation. Cell division type **B** is used in normal growth.



(a) Name the two types of cell division, **A** and **B**, shown in the diagram.

(b) Name the process in which an egg and sperm join together.

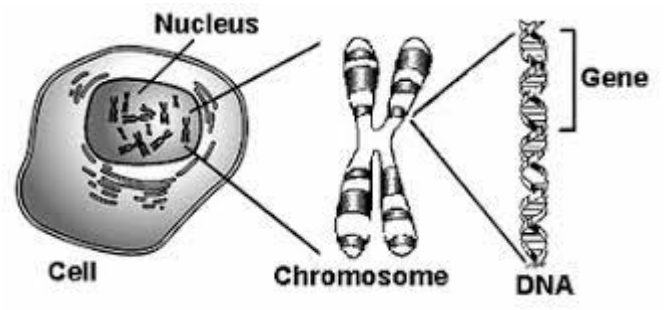
(c) Cell **1** contains 46 chromosomes. How many chromosomes will there be in:

(i) cell **10?**

(ii) cell **14?**

Part 2- DNA and the genome

DNA is often described as the molecule of life. It is responsible for the instructions to make proteins and as such all life's variation and complexity is written in its' DNA. DNA stands for Deoxyribose nucleic acid, and no you don't have to remember that!

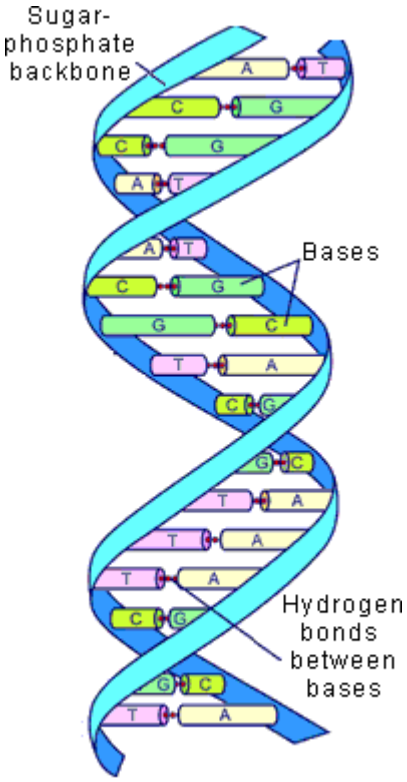


All the DNA is stored as long tightly wound strands called chromosomes. An organisms complete set of genetic material is called its genome.

In 1953 Rosalind Franklin managed to become the first person to prove the structure of DNA. It exists as a **double helix**, formed of two strands which join up and are twisted. DNA is a code. It contains a sequence of **base pairs** which tell the ribosomes the order to place certain **amino acids**. By changing the order of amino acids, different **proteins** are made.

Each **chromosome** is split into sections called **genes**. A gene is a section of DNA which codes for a **protein**. We have now developed the technology to sequence an entire genome. This allows us to know the sequences of bases on each chromosome in an individuals nucleus. The human genome is over 3 billion base pairs long. So far we have used this technology to find genes that link to certain diseases, for example cancer or heart disease. We have also used it to improve our understanding of inherited disorders like cystic fibrosis. The migration of humans throughout history has also been possible. People who share common ancestors also share genes so we can trace the movment of early humans across the globe from their starting point in africe over 1 million years ago. There is hope that this technology will lead to future medical treatments, although as we learn more about the human genome we begin to realise how complex it is and how much more we need to learn.

38. Name the genetic material enclosed in a nucleus of a eukaryotic cell.
39. Where is this genetic material found in a prokaryotic cell?
40. Describe the structure of double helix.
41. Name the structure the genetic material organised itself into.
42. Define 'gene'.
43. Define 'genome'.
44. How many base pairs are found in the human genome?
45. Name 3 uses for the sequenced human genome?
46. What organelle makes proteins from amino acids?



Part 3- Genetic inheritance

Individuals within a species all display variation. This is due to **sexual reproduction**. In sexual reproduction **gametes fuse** to form a unique offspring. They are unique because they have inherited half their **chromosomes** from their father and half from their mother. Each time a new offspring is conceived a different combination of the chromosomes combine; this is why you will resemble your brother/sister but are not identical to them.

Different forms of the same gene are known as **alleles**.

There are 2 copies of every chromosome in a body cell nucleus (1 copy inherited from the mother the other copy inherited from the father). Therefore, there are 2 copies of every gene. These copies may be different alleles and the combination of the 2 alleles (the **genotype**) determines the characteristic (the **phenotype**).

If the 2 alleles for a gene are the same, we call this combination **homozygous**, whereas if the 2 alleles are different, we call this combination **heterozygous**.

For most genes, one allele is said to be **dominant** and the other **recessive**. If a dominant allele is present, only its phenotype is expressed. This means individuals that have 2 dominant alleles (**homozygous dominant**) OR one dominant and one recessive allele (**heterozygous**) will express the dominant phenotype. Both alleles need to be recessive (**homozygous recessive**) for the recessive phenotype to be expressed. Due to this relationship, we often refer to the alleles using the same letter, the dominant in UPPER case and the recessive in lower case e.g. "B" is dominant, "b" is recessive.

For example: Consider a flowering plant that can have pink or white petals. Pink is the dominant allele, so our code is P= pink and p=white

- PP is the homozygous dominant, its phenotype is pink.
- Pp is heterozygous, its phenotype is also pink as pink is dominant to white.
- pp is homozygous recessive; its phenotype is white.

In our work we will be looking at characteristics that are controlled by one gene. In reality multiple genes work together to create the overall phenotype. A good analogy is that of an orchestra, with many different instruments working in harmony to create the music.

47. Define all the terms in **bold**

    The gene for flower colour in pea plants has 2 alleles, purple and white. The purple allele is represented by "R" and the white allele by "r".
48. What is the homozygous dominant genotype?
49. What is the homozygous dominant phenotype?
50. What is the homozygous recessive genotype?
51. What is the homozygous recessive phenotype?
52. What is the heterozygous genotype?
53. What is the heterozygous phenotype?

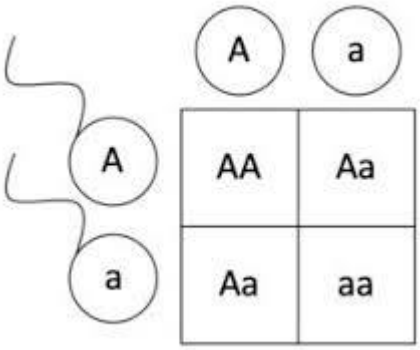
54. Complete the table below. The first one has been done for you.

	Homozygous dominant		Homozygous recessive		Heterozygous	
Scenario	genotype	phenotype	genotype	phenotype	genotype	phenotype
A. The gene for eye colour in humans has 2 alleles, blue and brown. The brown allele is represented by "B" and the blue allele by "b".	BB	Brown	bb	Blue	Bb	Brown
B. The gene for plant height in sunflowers has 2 alleles, tall and dwarf. The dwarf allele is represented by "d" and the tall allele by "T".						
C.The gene for flower position in courgettes has 2 alleles, terminal (F) and axial (f).						
D.The gene for coat colour in cows has 2 alleles, roan (g) and white (G).						

Punnett squares.

When examining the inheritance of alleles through multiple generations we use genetic cross diagrams or punnett squares.

Below is the punnett square for the inheritance of recessive condition called Albinism.



55. Label the punnett square with the following labels: *alleles from father, alleles from mother, possible genotypes*
56. What proportion of the possible genotypes is homozygous dominant?
57. What proportion of the possible genotypes is heterozygous?
58. What proportion of the possible genotypes is homozygous recessive?
59. What proportion of the possible offspring will be healthy?

60. What proportion of the possible offspring will have Albinism?

The gene for flower colour in pea plants has 2 alleles, purple and white. The purple allele is represented by “R” and the white allele by “r”.

For each of the questions below:

a) Draw a Punnett square to show the 4 possible offspring genotypes from this breeding.
b) For each offspring, label the phenotype.
c) For each offspring, describe the genotype using the words homozygous, heterozygous, dominant and recessive.
d) Calculate the probability of each phenotype.

61. Two pea plants both with the genotype Rr breed.
62. Rr x rr
63. RR x rr
64. Rr x RR

Part 3- Inherited disorders

Sometimes a mutation happens in the chromosomes of a gamete. In this case the faulty gene will be present in every cell of the body. In some very rare cases this can cause an inherited disorder. The disorder is inherited because there is a chance it can be passed down to the next generation. Some inherited disorders are dominant and other are recessive, we will look at an example of both.

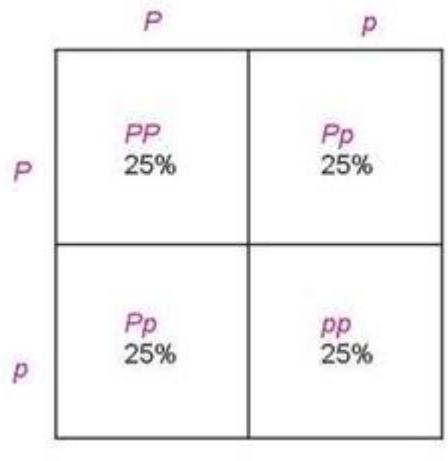
Polydactyly

Picture 1
Normal Hand

Picture 2
Hand with Polydactyly

Polydactyly is an inherited disorder that results in the child growing extra fingers or toes. It does not have any significant long term health problems. It is caused by a **dominant allele**. This means that only one parent needs to pass on the faulty allele for the child to suffer from polydactyly, So a **homozygous dominant** parent is guaranteed to have a polydactyly child and a **heterozygous** parents will have a chance of having one.

To the right is a punnett square showing the chances of having child with polydactyly when one parent with the disorder mates with a homozygous recessive partner.



In this example:

Genotypes

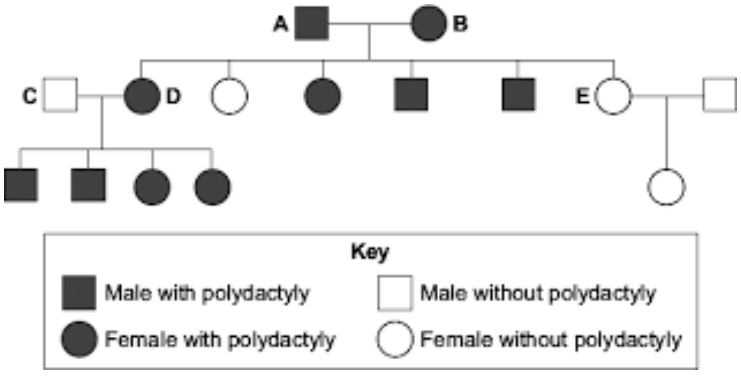
- 25% chance of the homozygous dominant PP
- 50% chance of the heterozygous Pp
- 25% chance of the homozygous recessive

Phenotypes

- 75% chance of having polydactyly (as it is dominant)
- 25% chance of being unaffected

65. Using the example above, draw a punnett square to show the outcomes of the following crosses:
    a) Pp x Pp
    b) A heterozygous father and a homozygous recessive mother
66. Suggest why polydactyly is not considered a serious inherited disorder

Another way of determining the dominant nature of polydactyly is through a **family tree** diagram. The clue to its dominant nature is the breeding between D and C. As their children all suffer from the disease there is a very strong chance the condition is dominant.

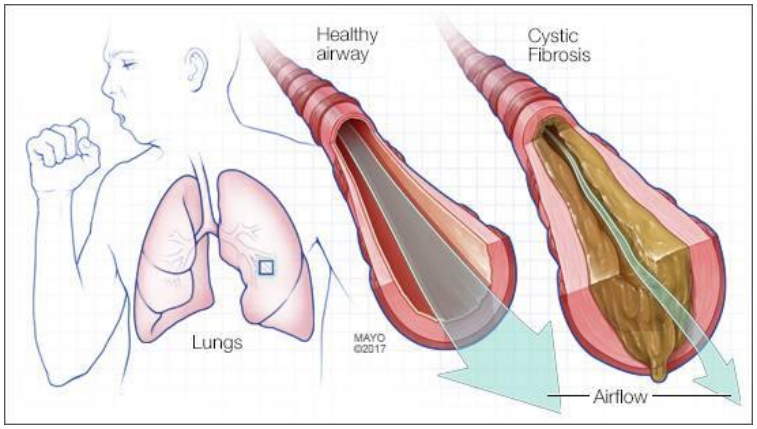


Cystic Fibrosis

Cystic fibrosis is an inherited disorder which affects the mucus that lines the respiratory and digestive tract. Cystic fibrosis sufferers have much thicker mucus than normal. This makes breathing harder and increases their chance of chest infections. Their pancreatic duct can also be blocked, resulting in less digestive enzymes making their way into the small intestine. This can affect the amount of nutrients they get from their food. Currently the disorder is managed using a combination of physical therapy (to remove

the mucus) and drugs (to improve the digestion). A more long term solution is for a heart and lung transplant.

Cystic fibrosis is caused by a recessive allele. This means that only **homozygous recessive** people are suffering from the disorder and **heterozygous** people are completely normal, but they have a chance of having a child which suffers from it. They are known as **carriers**. In the uk it is estimated that 1 in 25 people is a heterozygous carrier. Currently there are approximately 10,500 people with cystic fibrosis in the UK. This is about 1 in every 2500 babies born.



To the right is the punnett square for a cross between two heterozygous carriers. C= healthy, c= cystic fibrosis

	C	c
C	CC	Cc
c	Cc	cc

In this example:

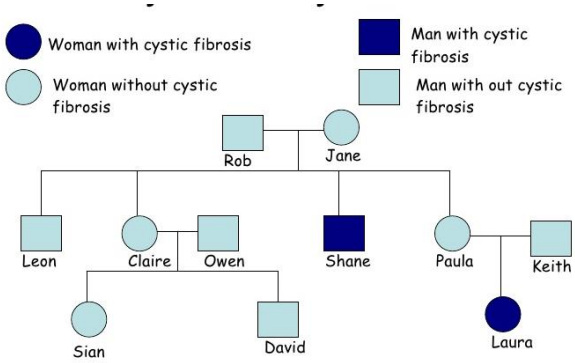
Genotypes

- 25% chance of the homozygous dominant CC
- 50% chance of the heterozygous Cc
- 25% chance of the homozygous recessive cc

Phenotypes

- 25% of being unaffected CC
- 50% of having no symptoms but being a carrier Cc
- 25% chance of suffering from cystic fibrosis cc

If we look at the family tree a key clue to it being a recessive condition can be seen.



Recessive inherited conditions have the ability to skip generations. Consider Rob and Jane. Both did not suffer from CF, but had a child (Shane) who did. This pattern is also repeated with Paula and Keith. In both cases it must be that they were both heterozygous carriers, a key defining factor of a recessive inherited condition.

67. Using the example above, draw a punnett square to show the outcomes of the following crosses:
    c) CC x cc
    d) A heterozygous father and a homozygous recessive mother
68. If 1 in 25 people are carriers suggest why so few babies are born with cystic fibrosis?
69. If the population of the UK is 6.6×10^6 people how many people are carriers? Give your answer in standard form.

Genetic tests

Genetic testing involves analysis of a person's DNA to see if they carry alleles that cause genetic disorders. It can be done at any stage in a person's life.

- **Antenatal testing** is used to analyse an individual's DNA or chromosomes before they are born. This testing is offered to couples who may have an increased risk of producing a baby with an inherited disorder, but it can't detect all the risks of inherited disorders.
- **Neonatal testing** known as the new born blood spot test involves analysing a sample of blood that is taken from pricking a baby's heel. It detects genetic disorders in order to treat them early.
- **Pre-implantation genetic diagnosis (PGD)** is also called **embryo screening.** It is used on embryos before implantation. Fertility drugs stimulate the release of several eggs. The eggs are collected and fertilised in a Petri dish. This is known as in vitro fertilisation (IVF). Once the embryos have reached the eight-cell stage, one cell is removed.

The cells are tested for the disorder causing alleles. Embryos that don't contain the disorder allele are implanted into the uterus.

Limits of genetic testing

Genetic tests are not available for every possible inherited disorder, and are not completely reliable. They may produce false positive or false negative results, which can have serious consequences for the parents involved.

False positives

A false positive is a genetic test that wrongly detected a certain allele or faulty chromosome. The individual could believe something is wrong, when it is actually fine.

False negatives

A false negative is a genetic test has failed to detect a certain allele or faulty chromosome. The parents may be wrongly reassured. These results can have a major impact on the lives of individuals, through pregnancy termination, future decisions and planning the level of care needed for children with inherited disorders.

On top of the technical problems, people can be against these tests for moral and spiritual reasons. Most of these stem from a strong belief that it is wrong to tamper with the natural process of reproduction. With embryo screening techniques some of the embryos are

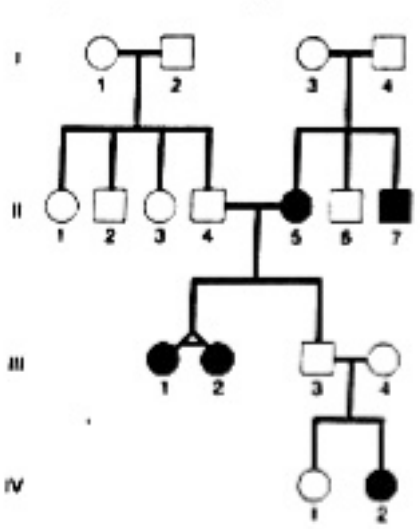
destroyed. Some people believe that this is the same as murder and so are against this process.

70. What is the meaning of ‘inherited disorder’?
71. Mariana says “Measles is an inherited condition because my dad had it when he was young and now I’ve had it!” Explain why she is wrong.
72. What medical treatment could Mariana’s parents have given her when she was young to prevent her catching measles?
73. Explain the difference between a dominant and recessive inherited disorder.
74. What are the symptoms of poydactyly?
75. What are the symptoms of cystic fibrosis?
76. What can you not be a carrier of polydactyly?
77. What three ways are inherited disorders tested for?
78. Why is every baby born given the heel prick test (neonatal), but only high risk pregnancies given antenatal testing?
79. Why would a person who is against abortion refuse PGD?
80. What is the difference between a false positive and a false negative? Which do you think is worse?

Huntington’s disease is a dominant inherited condition. It causes problems in a persons’ ability to use their muscles, including breathing and swallowing. There is no cure. Symptoms begin to show during a person’s 30’s and 40’s.

81. Can you be a carrier for huntington’s?
82. Will the huntington’s allele be H or h?
83. Draw a punnett square for a heterozygous and homozygous recessive breeding. Give the proportions of each genotype and phenotype.

Thalassemia is an inherited disorder. It causes the red blood cells to twist into a different shape. This affects the person's ability to get oxygen to their organs, causing fatigue, and a yellowing of the skins.



84. Look at the family tree for Thalassemia. Is it a dominant or recessive inherited condition? Give a reason.
85. Draw a punnett square for a heterozygous and a homozygous recessive. Give the proportions of the genotypes and the phenotypes.

86. In humans, chromosome **X** and chromosome **Y** are the sex chromosomes.

(a) Most cells in the human body contain two sex chromosomes. Which type of cell does **not** have two sex chromosomes? Choose from Liver cell, Nerve cell, Red blood cell

(b) Apart from the sex chromosomes, how many **other** chromosomes are there in most human body cells?

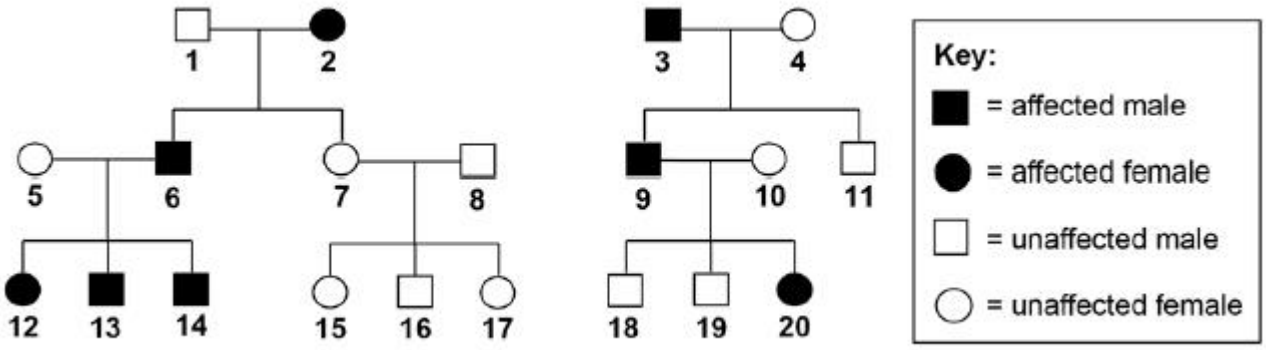
Stickler syndrome is an inherited disorder that causes damage to the eye.

One of the symptoms of Stickler syndrome is that black spaces can appear in the visual image.

(c) Which part of the eye is affected by Stickler syndrome?

Stickler syndrome is caused by the inheritance of a dominant allele.

The diagram shows the inheritance of Stickler syndrome in two families.



Use the following symbols in your answers to (d) and (e):

A = the dominant allele for Stickler syndrome

a = the recessive allele for unaffected vision.

(d) Explain why none of the children of persons **7** and **8** have Stickler syndrome.

(e) Person **12** marries person **18**.

Use a Punnett square diagram to find the probability that their first child will be a female with Stickler syndrome.

Part 3 – Sex determination

Ordinary human body cells contain 23 pairs of chromosomes. 22 pairs control characteristics only, but one of the pairs carries the genes that determine sex.

• In females the sex chromosomes are the same (XX).

• In males the chromosomes are different (XY).

In the punnett square it shows the possible gender outcomes of sexual reproduction.

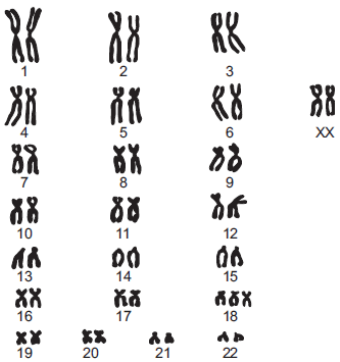
	X	X
X	XX	XX
Y	XY	XY

87. What is the percentage chance a baby is female.
88. What re the possible genotypes of the sperm?

89. Genetic disorder **E** is a condition caused by a change in the chromosomes.

(a) **Figure 1** shows the chromosomes from one cell of a person with genetic disorder **E**.

Figure 1

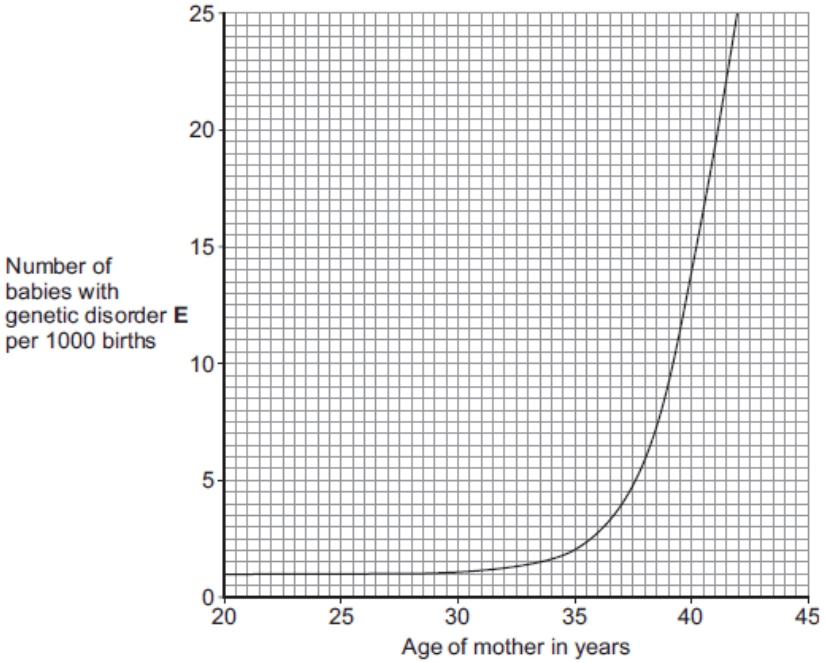


(i) How do you know this person is female? Use information from **Figure 1**.

(ii) Describe how the chromosomes shown in **Figure 1** are different from the chromosomes from a person who does not have genetic disorder **E**.

(b) As a woman gets older, the chance of her having a baby with genetic disorder **E** increases. **Figure 2** shows this.

Figure 2



(i) The chance of a 35-year-old woman having a baby with genetic disorder **E** is 2 per 1000 births.

What is the chance of a 40-year-old woman having a baby with genetic disorder **E**?

(ii) A 40-year-old woman is more likely than a 35-year-old woman to have a baby with genetic disorder **E**. How many times more likely?

(c) A 41-year-old woman wants to have a baby. A 41-year-old woman has an increased chance of having a baby with genetic disorder **E**. Doctors can screen embryos for genetic disorder **E**. The table gives some information about two methods of embryo screening.

Method 1	**Method 2**
1. The woman is given hormones to cause the release of a few eggs. The eggs are taken from her body in a minor operation. The eggs are fertilised in a glass dish.	1. The woman gets pregnant in the normal way.
2. One cell is taken from each embryo when the embryo is 3 days old.	2. Cells are taken when the embryo is 10 weeks old.
3. Cells are screened for genetic disorder **E**.	3. Cells are screened for genetic disorder **E**.
4. An unaffected embryo is placed in the woman's uterus. Embryos that are not used are destroyed or used in medical research.	4. An unaffected fetus is allowed to develop. If the fetus has genetic disorder **E**, the woman can choose to have an abortion.
5. This method costs about £6000.	5. This method costs about £600.

Use information from the table to give **two** advantages and **one** disadvantage of **Method 1**compared with **Method 2** for detecting genetic disorder **E**.

Part 4- Variation

Every living organism is different in some ways, even those within the same species. These different characteristics among different individuals are called **variations**. Variations can be caused by two key factors: **genetics** and **environment**. There are some characteristics that are caused purely by genetic factors or environmental factors, but quite a lot are caused by a mix of both. Here are some examples:

- Purely genetics: Gender, shape of earlobes, eye colour
- Purely environmental: *It is rather rare that a variation is led purely by the environment. One possible example is scars, as they are formed only if you had an injury, although the "ability" to form scars is varied by genetics.*
- Mix of both: Weight, height, skin colour, hair colour

Twin studies are carried out to investigate what the causes of certain variations may be. Scientists would compare four groups/pairs of adults and measure the differences (eg. Height, mass, IQ) between the pairs:

- Identical twins brought up together (same genes and environment)
- Separated identical twins (same genes, different environment)
- Non-identical twins brought up together (different genes, same environment)
- Same sex, non-twin siblings brought up together (different genes, same environment)

The measured differences indicate what characteristics are dominated by genetic factors, which are dominated by environmental factors.

These genetic and environmental variations can arise due to a variety of reasons. Here are some:

A.) Genetic variations:

- **Random mutation:** DNA changes spontaneously that lead to a different allele (a different version of the same gene) that can give a different characteristic. Eg. Dominant allele for brown eyes mutated into a recessive allele for blue eyes
- **Meiosis:** The chromosomes from the father and mother may mix to exchange alleles. Also they may split up differently that leads to a different combination of alleles, which could give the child a different characteristic compared to his/her parents.

B.) Environmental variations:

- Lifestyle: Diet and the amount of exercise could affect one's physical appearance and fitness.
- Exposure to the sun: Change skin colour
- Dyeing your hair: Change hair colour
- Piercings
- Injuries: Lead to scar formation

Mutations happen all the time; mostly they have no effect on the organism. Sometimes they might influence the phenotype. Very rarely will they change the phenotype completely.

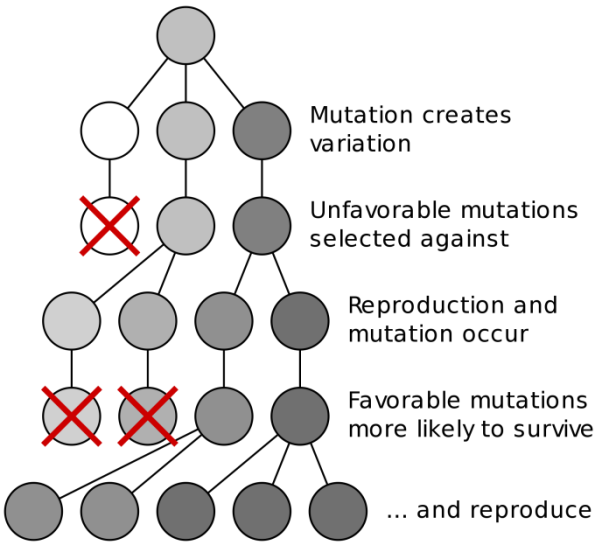
90. What is variation?
91. Genes determine the phenotype of an organism – true or false?
92. Within a population, there is normally very little genetic variation – true or false?

93. What are the two factors that cause variation?
94. Sort whether the following factors are influenced by genes, environment or both:
    a.) Height:
    b.) Scars:
    c.) Eye colour:
    d.) Hair colour:
95. Apart from the ones mentioned above, suggest one genetic factor and one influenced by both genes and environment that lead to variation.
    - Genetic:
    - Both:
96. How are identical twins 'identical' to one another?
97. In a pair of identical twins, one is taller than the other. Suggest why.
98. How are identical twins formed?
99. *How are non-identical twins formed?
100. Define phenotype.
101. What are the two main types of mutation?
102. Name the four bases of DNA.
103. What would be the complimentary code to bond with AGCGCTAA ?

Part 5- Evolution by natural selection

The organisms that exist nowadays are very different from those billions of years ago. Over time it appears that organisms have become more complex. This is due to **evolution** by **natural selection.**

Natural selection is the process where **nature selects** what characteristics (controlled by genes) are best for organisms to survival in that particular environment and hence allows it to reproduce. In simple terms, this is the **survival of the fittest**, where "fittest" refers to those **best adapted** to their environment, but not necessarily the strongest. Evolution occurs after natural selection occurs over **many generations**. This is the process:



- Individual organisms in a species have a range of **pre-existing genetic variation** due to random **mutation**.
- Certain individuals may have certain **adaptations (or phenotypes**) that give them a survival advantage due to their

advantageous/favourable alleles. (*Those without the favourable allele are more likely to die before they could reproduce.)*

- **Natural selection** occurs: They are more likely to **survive and reproduce**, passing the **favourable alleles** on.
- Overtime, more individuals within the population have those favourable alleles. If these variations accumulate, they may eventually evolve into a new species (**speciation**), where they can no longer interbreed to form fertile offspring.

Be careful: Avoid saying "organisms adapt to their environment" in your answer. Organisms ***cannot*** (choose to) adapt to a certain environment ***within*** their lifetime. Evolution must happen over ***many generations***! And it is not by choice, but by natural selection.

104. What causes genetic variation?
105. Explain how the cause above can lead to variation in phenotype.
106. State the theory of evolution by natural selection.
107. What is a 'species'?
108. Define 'natural selection'.
109. What is evolution?
110. Why can genetic mutation be beneficial to organisms in a changing environment?
111. Pick one of the following. Would the best organism within a species to survive and reproduce be:
    a) the strongest?
    b) the one which reproduces the fastest?
    c) the best adapted to the environment?
112. *Describe the process of evolution by natural selection.
113. Suggest how giraffes having long necks may be a result from evolution by natural selection.
114. *In the beginning, there are more white peppered moths than black peppered moths living on trees. However, during and after the Industrial Revolution period, the number of black peppered moths drastically increased. Explain in detail.

Keywords to use: Black soot, natural selection, reproduce, survive, characteristics, variation, time.

Part 6- Selective breeding

Humans can speed up evolution by doing **selective breeding** (artificial selection). It is the process by which humans breed plants and animals for desired characteristics. Here is a list of desired characteristics (and quite often *the* advantages to selective breeding):

- Disease resistance
- Increased food production/crop yield
- Gentle nature of domestic animals (eg. Dogs)
- Heavily scented flowers

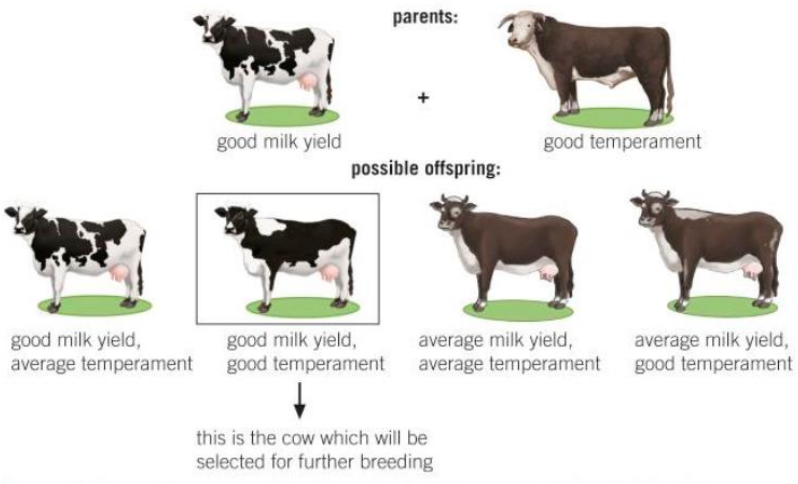
It is especially useful in agriculture, where farmers want all or most of their animals or plants to be resistant to diseases and can grow in size quickly, so they could farm and harvest as efficiently as possible for profit. This is the **process of selective breeding:**

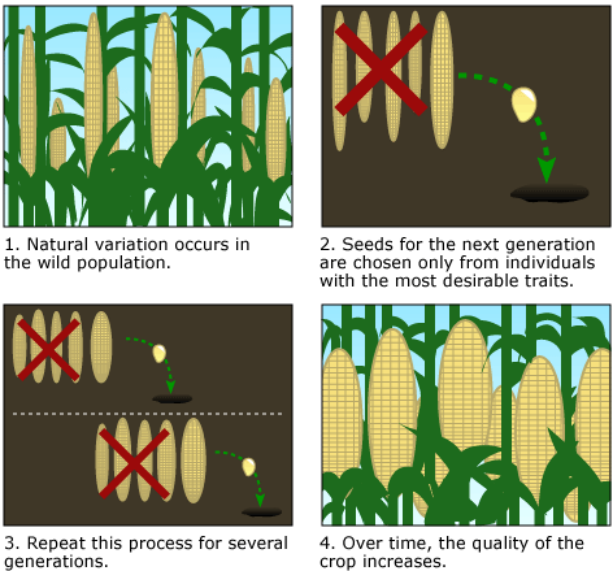
1. Choose two individuals with the desired characteristic(s) from a mixed population.

2. Allow them to breed, which produces offspring with a range of characteristics.

3. Choose the few offspring with the (most) desired trait(s) and allow them to breed.

4. Repeat this cross-breeding process over many generations until **all** the offspring show the desired characteristic.





There are pros and cons to selective breeding.

Advantages	**Disadvantages**
Disease resistance in food crops	Reduces genetic variation (lose allele variation) ▫ less likely to be able to cope with major environmental changes ▫ die out
Animals which produce more meat or milk	Inbreeding ▫ more prone to certain diseases/inherited conditions (more likely to inherit homozygous recessive alleles ▫ recessive genetic disorders)
Domestic dogs with a gentle nature	
Large or unusual flowers	

115. Define 'selective breeding'.
116. What are the desired characteristics in farm animals? Explain.
117. Describe the process of selective breeding.
118. Name two historic examples of selective breeding.
119. State four modern examples of selective breeding.
120. How do breeders of domestic pets use selective breeding to produce many pets?
121. Give two desirable characteristics in crops.
122. Explain how selective breeding reduces genetic variation.
123. Explain how selective breeding can lead to extinction of a species.
124. State another problem with selective breeding and explain why that is a problem.
125. Name the gametes of a cow
126. Name the gametes of a maize plant
127. A cow body cell has 60 chromosomes. How many will its gametes have?
128. Calculate the percentage increase in chromosome number from human gametes to cow gametes.
129. Selective breeding has increased milk production by 40%. If a modern cow produces approximately 23 liters of milk, how much milk did early cows produce?

130. Many different types of animals are produced using selective breeding.

Some cats are selectively bred so that they do not cause allergies in people.

(a) Suggest **two other** reasons why people might selectively breed cats.

(b) Selective breeding could cause problems of inbreeding in cats.
Describe **one** problem inbreeding causes.

(c) Many people have breathing problems because they are allergic to cats.

The allergy is caused by a chemical called Fel D1. Different cats produce different amounts of Fel D1. A cat has been bred so that it does not produce Fel D1.

The cat does **not** cause an allergic reaction.

Explain how the cat has been produced using selective breeding.

Part 7- Genetic engineering

Genetic engineering is the process where a gene from an organism is transferred to the genome of another organism to give it a desired characteristic. Many organisms have been genetically modified (GM) for the benefits of humans, for example, GM crops becoming disease/pest-resistant and make bigger better fruits; GM bacteria producing human insulin to treat diabetes.

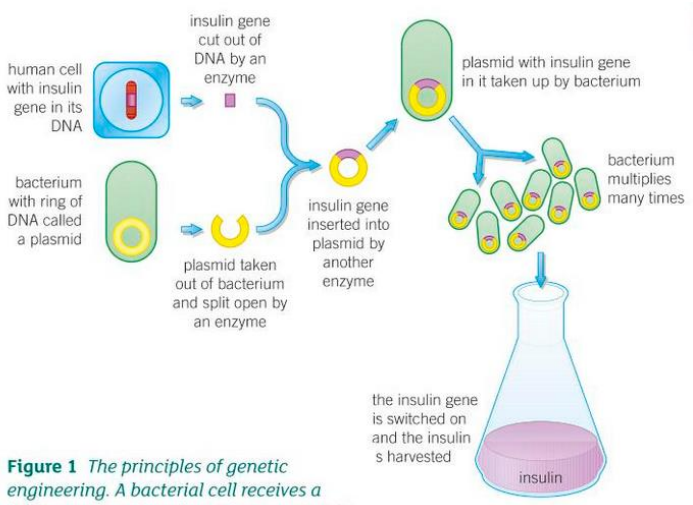


Figure 1 *The principles of genetic engineering. A bacterial cell receives a human gene so it makes a human protein –*

The process of genetic engineering (for making insulin) HT ONLY:

1. Extract human DNA from human cell and the **plasmid** (**vector**) from bacteria
2. Cut out **desired gene** (eg. Insulin gene) from human DNA using **restriction enzyme**
3. Using the same restriction enzyme, cut the plasmid
4. Insert desired gene into plasmid, becoming **recombinant DNA**
5. Put recombinant DNA into bacteria, becoming a **transgenic bacteria/organism**
6. Allow transgenic bacteria to multiply by mitosis. All GM bacteria make human insulin
7. Extract human insulin to treat diabetes

Some pros and cons of genetic engineering:

Advantages	Disadvantages
Can mass produce desired proteins/products	Resistant genes could be transferred to natural populations (wildtype) this affects biodiversity
Can modify crops to be resistant to pests/diseases this increases crop yield	Expensive

131. What is genetic engineering?

132. What is the term used to describe organisms that are genetically modified?

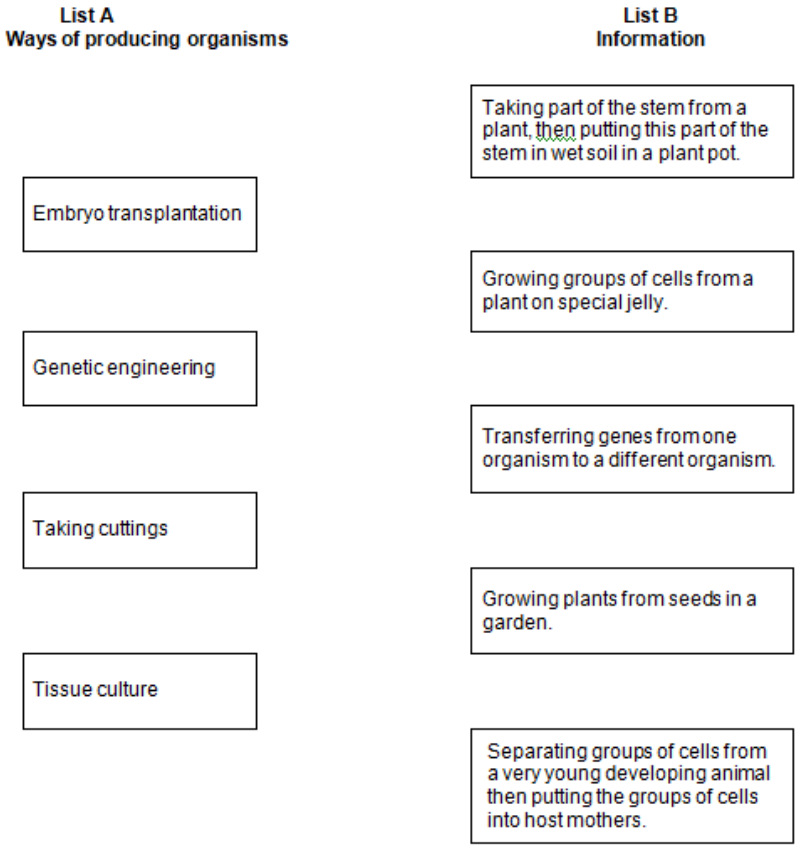
133. Why is genetic engineering useful?
134. Give two examples of vectors used in genetic engineering.
135. Give two ways in which genetic engineering is useful in agriculture.
136. Explain how genetic engineering is useful in treating diabetes.
137. *Suggest what genes could be engineered into crops to make them pest-resistant.
138. *How can genetically modified (GM) crops affect the growth and survival of natural (wildtype) crops/plants?
139. Complete the sentences below:

    Genetic engineering is useful for society because….

    Genetic engineering is useful for society but….

    Genetic engineering is useful for society so….

140. We can now produce organisms with the characteristics we want the organisms to have. Draw a line from each way of producing organisms to the correct information in list B.



141. **HT ONLY** How is a gene "cut out" from the genome of one species and inserted the genome of another? Into what is the gene inserted?

142. **HT ONLY** Describe the process of genetic engineering. You may draw a diagram to help illustrate.

143. **HT ONLY** Read the information.

> Insects can be both useful and harmful to crop plants.
> Insects such as bees pollinate the flowers of some crop plants. Pollination is needed for successful sexual reproduction of crop plants.
> Some insects eat crops and other insects eat the insects that eat crops.
>
> Corn borers are insects that eat maize plants.
> A toxin produced by the bacterium *Bacillus thuringiensis* kills insects.
> Scientists grow *Bacillus thuringiensis* in large containers. The toxin is collected from the containers and is sprayed over maize crops to kill corn borers.
>
> A company has developed genetically modified (GM) maize plants. GM maize plants contain a gene from *Bacillus thuringiensis*. This gene changes the GM maize plants so that they produce the toxin.

(a) Describe how scientists can transfer the gene from *Bacillus thuringiensis* to maize plants.

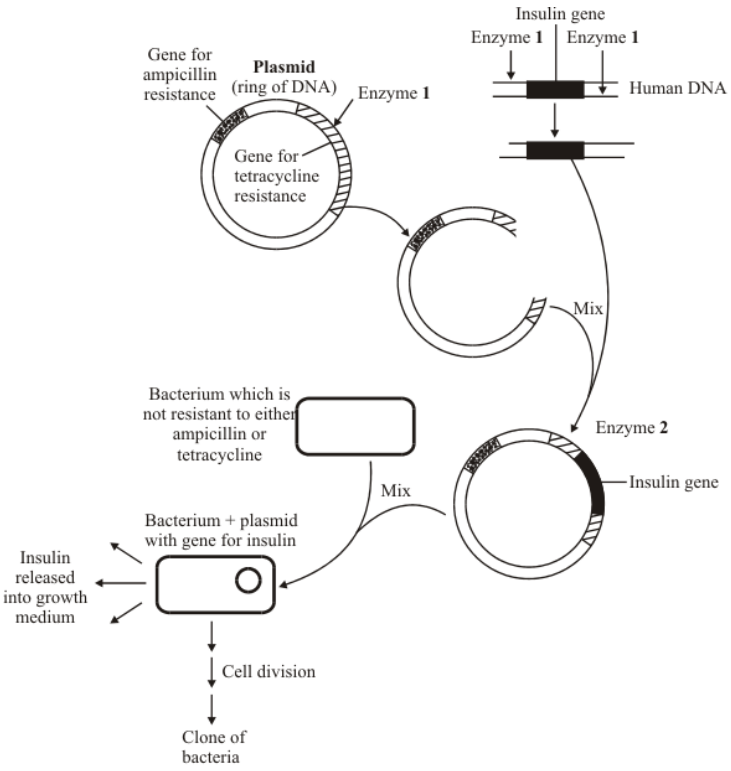
(b) Would you advise farmers to grow GM maize plants?

Justify your answer by giving advantages and disadvantages of growing GM maize plants.

Use the information from the box and your own knowledge to help you.

144. **HT ONLY** The diagram shows how genetic engineering can be used to produce human insulin from bacteria. Ampicillin and tetracycline are two types of antibiotic. Study the diagram carefully and answer the questions.

In experiments like these, some bacteria take up the plasmid (ring of DNA) containing the insulin gene. Other bacteria fail to take up a plasmid, or they take up an unmodified plasmid (a ring of DNA which has not been cut open and which does not contain the insulin gene).



(a) Complete the table by putting a tick (✓) in the correct boxes to show which bacteria would be able to multiply in the presence of ampicillin and which bacteria would be able to multiply in the presence of tetracycline.

	Bacterium can multiply in the presence of	
	Ampicillin	**Tetracycline**
Bacterium + plasmid with the insulin gene		
Bacterium without a plasmid		
Bacterium with an unmodified plasmid		

(b) The bacterium with the plasmid containing the insulin gene multiplies by cell division to form a clone of bacteria.

Will **all** the bacteria in this clone be able to produce insulin? Explain your answer.

Part 8- Ethics of genetic technologies

When it comes to evaluating genetic technologies, we need to consider them in terms of four aspects: scientific, economic, social and ethical aspects.

Benefits	Concerns
Increase growth rate of plants and animals	Unsure of long-term effects
Increase food value (eg. Higher yield)	Unsure of effect of eating GM food on human health
Designed to be resistant to poor environments (eg. Dry, cold)	Affect wildtype organisms' chances of survival
Designed to be pest/herbicide-resistant	Ethical concerns of potential human engineering

145. State two ways in which genetic engineering can be used in medicine.
146. State two ways in which genetic engineering can be used in agriculture.
147. Give one benefit of growing GM crops to humans.
148. What are the two concerns people have on GM crops?
149. Explain why people have ethical concerns about animal genetic engineering.

Part 9- Evidence for evolution

The process of evolution is only a theory. It needs to be supported by evidence – fossils. **Fossils are the remains of organisms from millions of years ago, preserved in the environment (eg. rock, ice).** Through looking at fossil records, we can see how organisms are structurally adapted in the past. It also helps scientists to understand how they have changed since life developed on Earth, which can act as evidence for evolution by natural selection.

There are different forms of fossils, depending on how they are formed. A lack of decay is key to forming fossils. There are a few factors needed for decay:

- Bacteria (as decomposers – the nutrients inside organisms are their food source and raw material for respiration)
- Oxygen (for aerobic respiration of bacteria)
- Correct temperature (too hot – enzymes in bacteria denature, leading to their death; too cold – enzymes are inactive, leading to a lack of respiration)

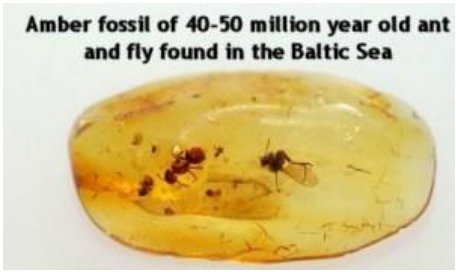
It is nearly impossible to have no bacteria in the environment; hence the environment must be lacking in oxygen and/or at a wrong temperature in order for fossilisation to occur. For example:

A.) Organisms **not decay** after death **due to lack of decay conditions**

Situation A: Organism drowned in water which froze relatively quickly

- *There are decomposers, however there may be a lack of oxygen and it is very cold, meaning bacteria would die and their enzymes would be inactive anyway, hence decay cannot occur. The whole organism is intact.*
- *Eg. A whole baby mammoth (with muscles, blood, fur intact) was found frozen in ice*

Situation B: Organisms (eg. flies, ants) trapped in tree sap



- *There may be very few decomposers within the tree sap. Even though the temperature may be appropriate, the lack of oxygen means decay cannot occur as bacteria cannot respire aerobically.*
- *Overtime the tree sap hardens to become amber with insects trapped inside*

B.) Preserved traces of organisms left behind

- Organisms left a particular imprint on wet mud, like a mould. Overtime, it dried out with the traces formed and hardened into rocks.
- Eg. Footprints, burrows, rootlet traces, droppings

C.) Harder parts of organisms (eg. Bones) replaced by minerals

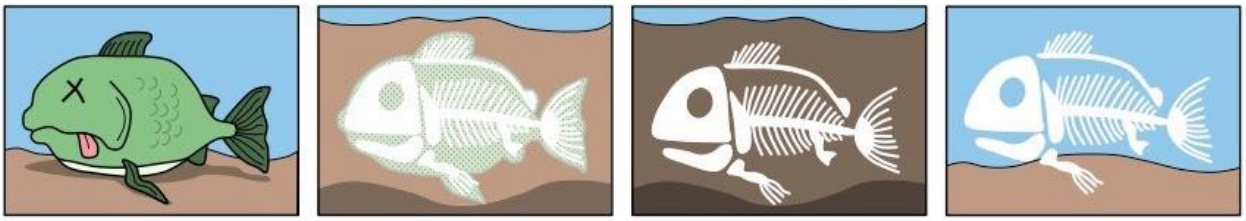
- This is the most common form of fossils, like the ones you can see in museums

<u>Process of fossilisation of skeletons</u>

1. Organism **dies** and falls to the ground
2. Soft parts (eg. Flesh) **decompose**, leaving the **bones** behind as they are **harder to decay**
3. The skeleton is then covered in sand/soil
4. The skeleton becomes **mineralised** (bone tissue replaced by mineral ions) over millions of years → turns to rock

It is important to remember that bone tissues can still decay as they are organic, but just takes a longer time to do so. If they get replaced by the minerals before they decay, meaning the minerals can form a mould of their shapes, then the fossil can be made.

Even though fossils are a great way to support the theory of evolution, it is not enough as we do



not have a complete fossil record. The reasons for this are as follows:

- Many early life forms are **soft-bodied**, which means they decay quickly and cannot be mineralised to form fossils
- Geological activity **destroyed** some fossils, such as earthquakes
- Most organisms **did not become fossilised** – the conditions for fossilisation are very rare, and any imprints made are washed away easily.
- Many **undiscovered** fossils – we do not know exactly how many fossils they are still buried, hence we may be missing parts of the record

150. What are fossils?
151. What are the three criteria for decay to occur?
152. Describe the five steps of fossilisation by mineralisation.
153. Why is it harder for bones to decay?
154. What are the three different types of fossils that can be formed?
155. Fossils which are older often appear to be simpler organisms. What theory does this proived evidence to support?
156. Complete the following sentences:

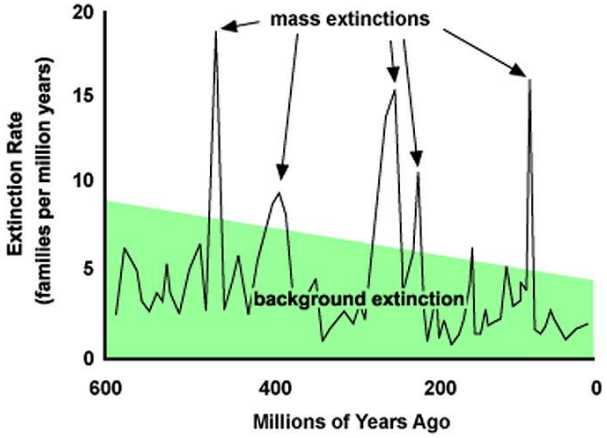
The fossil record is incomplete because…

The fossil record is incomplete but…

The fossil record is incomplete so…

Part 10- Extinction

Extinction is the **permanent loss** of **all** members of **one** species. Mass extinction, on the other hand, is the loss of **many or most** species on Earth, and it usually happens over several million years. So far, there have been five mass extinction events, as seen on the five major peaks in the graph.



Extinctions can be caused by different factors.

Biotic causes of extinction

- New **predators** – organisms could not adapt quickly enough to survive the new predators and were all killed before they could reproduce and pass on favourable alleles
- Successful interspecific **competition** – the species that got outcompeted for food, territory/shelter etc. may become extinct overtime
- New **diseases/pathogens** – if the majority of the species could not (adapt to) survive the new disease then they may become extinct

Abiotic causes of extinction

- **Climate change**
- Single **catastrophic** event – eg. volcanic eruption, asteroid collision- Often link to climate change!

A single catastrophic event is perhaps the more common cause of mass extinction. The dinosaurs are believed to become extinct during one of the mass extinction events. One of the most supported theories is that an asteroid collision triggered it. The collision alone may kill many dinosaurs, but how may it caused them to become extinct (which usually requires a longer time)?

- Asteroid collision caused tectonic plates to shift
- This triggered earthquakes and tsunamis, which then subsequently triggered volcanic eruptions
- The lava itself could kill many organisms already. On top of that, the eruption(s) could produce a massive ash cloud which may cover a large portion (if not all) of the earth
- The ash cloud blocked out sunlight, preventing them from reaching the surface. This could then have two effects:

  A.) Plants (producers) don't get sunlight and cannot do photosynthesis. They then die out,

which then affects the food chain

B.) Global temperature drops, eventually leading to the ice age

157. How is the fossil record helpful?
158. Define 'extinction'.
159. State three causes of extinction.
160. What causes mass extinction? Suggest two examples of this cause.
161. What is the difference between extinction and mass extinction?
162. Suggest a chain of events initiated by an asteroid collision that could lead to the extinction of dinosaurs.
163. Fossils give evidence about organisms that lived a long time ago.

(a) Scientists have found very few fossils of the earliest life forms. Give **one** reason why.

This is a photograph of a fossilised fish.

(b) Suggest how the fossil in the photograph above was formed.

(c) The species of fish shown in the photograph above is now extinct.

Give **two** possible causes of extinction.

Modern fish species have evolved from fish that lived a long time ago.

Evolution is caused by mutation and natural selection.

(d) What is a mutation?

(e) Describe the process of natural selection.

164. Over millions of years:

- new groups of organisms have evolved
- other groups of organisms have become extinct.

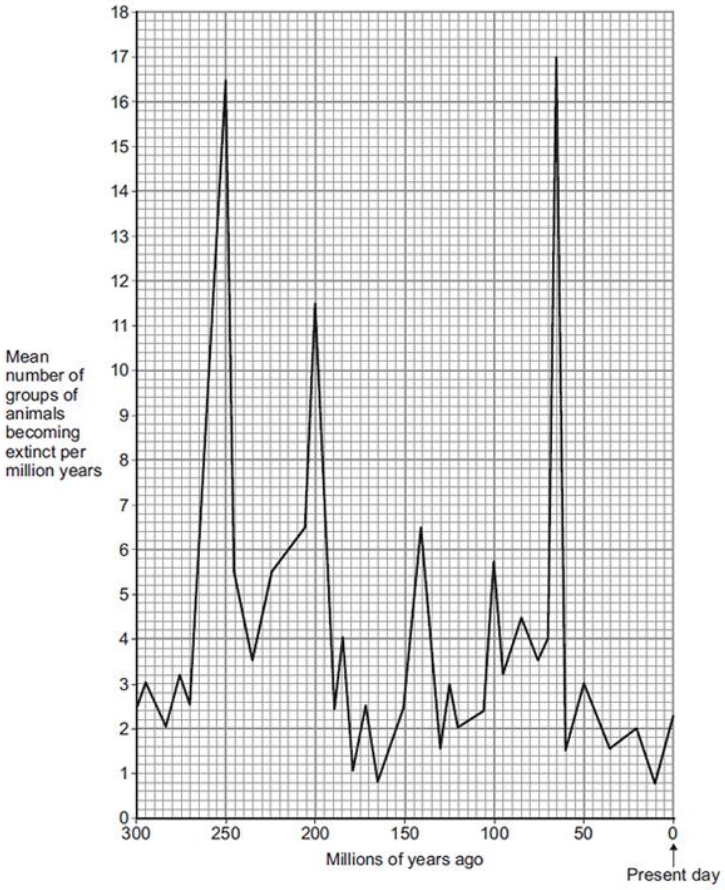
(a) If an asteroid collided with the Earth, large amounts of dust and water vapour would be thrown up into the air. This would mean less light and heat would reach the Earth's surface from the Sun.

(i) A reduced amount of light and heat could have caused the extinction of plants. Suggest how.

(ii) How could the extinction of plants have caused the extinction of some animals?

(iii) Give **two** reasons, other than collision with an asteroid, why groups of animals may become extinct.

(b) The graph shows how the rate of extinction of groups of animals has varied over the past 300 million years.



(i) If more than 10 groups of animals become extinct in a 1 million year period, scientists call this a 'mass extinction'.

How many mass extinctions occurred over the past 300 million years?

(ii) How do we know what types of animals lived hundreds of millions of years ago?

(c) Use information from the graph to answer part (i) and (ii).

(i) How many years ago did the most recent mass extinction of animals occur?

(ii) What was the mean number of groups of animals becoming extinct per million years in the most recent mass extinction?

(iii) Why are scientists not sure how many groups of animals became extinct in the most recent mass extinction?

165. The photograph shows a fossil footprint. The fossil was found in a rock at the bottom of a shallow river.

Scientists believe this is the footprint of a dinosaur. The dinosaur was alive 110 million years ago.

(a) (i) Suggest how the fossil shown in the photograph was formed.

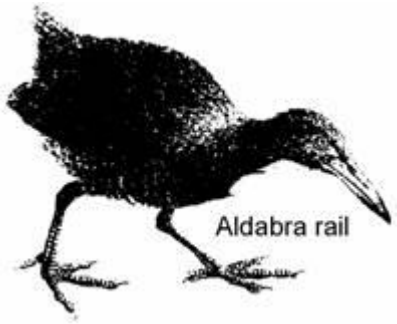
(ii) Fossils may also be formed by other methods. Describe **one** other method of forming a fossil.

(b) Dinosaurs are now extinct. Give **two** factors that can cause extinction.

(c) How can fossils give evidence for evolution?

(d) Scientists are uncertain about how life began on Earth. Why?

166. Flightless birds called Rails once inhabited 20 islands in the Pacific Ocean. During the last two centuries they have disappeared from 15 of these islands. The Aldabra Rail, shown below, is one of the few survivors. The island which it lives on is very remote.



Suggest **three** reasons why Rails have disappeared from 15 of the 20 islands they once inhabited.

167. The dodo is an extinct bird. The drawing shows an artist's impression of the bird.

The dodo lived on a small island in the middle of the Indian Ocean. Its ancestors were pigeon-like birds which flew to the island millions of years ago. There were no predators on the island. There was a lot of fruit on the ground. This fruit became the main diet of the birds. Gradually, the birds became much heavier, lost their ability to fly and evolved into the dodo.

(a) Suggest an explanation for the evolution of the pigeon-like ancestor into the flightless dodo.

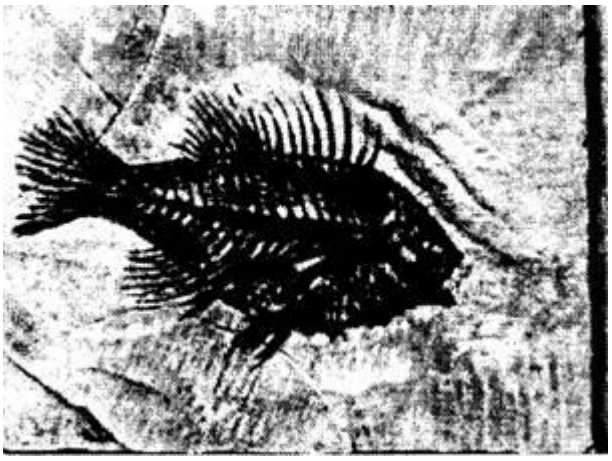
(b) The dodo became extinct about 80 years after Dutch sailors first discovered the island in the eighteenth century. Scientists are uncertain about the reasons for the dodo's extinction. Suggest an explanation for this uncertainty.

168. When animals die, bacteria make them decay.
Warmth, moisture and oxygen are needed for this to happen.

(a) (i) In northern Russia whole bodies of mammoths have been found in the frozen soils.

Explain why they did not decay.

(ii) Fish fossils have been found in mudstone rock. Explain why they did not decay?



(b) Some of the mammoths had flint weapons in their bodies. Suggest **two** things that this tells us about human evolution.

(c) Mammoths are now extinct. Suggest **two** reasons for this.

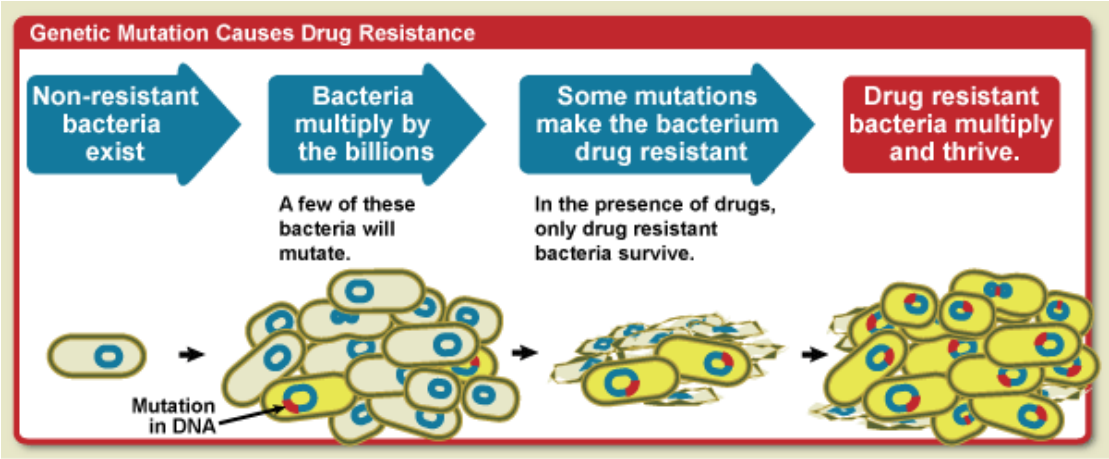
Part 11 - Antibiotic resistant bacteria

Bacteria becoming resistant to certain antibiotics is an example of evolution, which happens at a comparatively much faster pace than evolution of multicellular organisms like animals and plants. The reason for this is because **mutations** occur much quicker in bacteria due to their rapid reproduction by binary fission, compared to how long it takes for animals/plants to reproduce. Mutation is a change in DNA (specifically alleles). It would need to be a mutation that favours survival that lead to successful evolution.

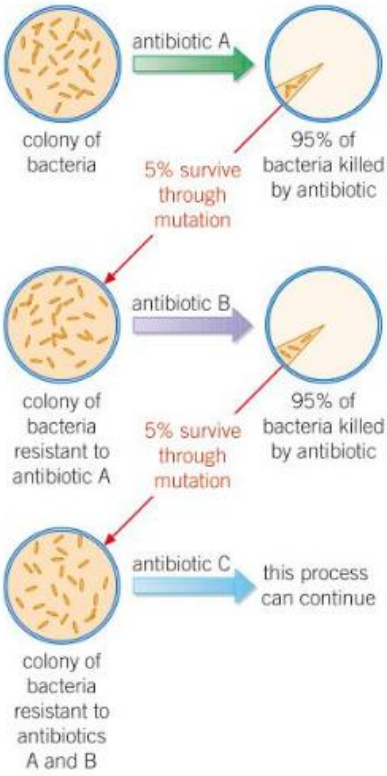
1. **Random** mutation makes a bacterium within a population resistant to a particular antibiotic
2. When the population is exposed to the antibiotic, the resistant strain **outcompetes** non-resistant strain – those original bacteria die, but the mutated bacterium can survive and reproduce by mitosis/binary fission

3. This makes more bacteria with that particular antibiotic resistance gene, increasing its strain **population**

4. The cycle may repeat starting with a new mutation, allowing them to become resistant to another antibiotic



This is of particular concern in the current medical world, as more and more bacteria are becoming resistant to various antibiotics. This ultimately may lead to the rise of "superbugs", which are bacteria strains that are resistant to almost all antibiotics. They pose a massive threat as it is a slow and expensive process to develop new antibiotics to counteract them. MRSA (methicillin-resistant *Staphylococcus aureus*) is the most classic example of superbugs. Therefore, it is important that we know how to prevent more bacteria from developing antibiotic resistance and to prevent their spread:



- Don't overuse antibiotics – restrict its use only for severe bacterial infections
- Finish the course of antibiotics – ensure all bacteria strain are killed, none survive and reproduce (as seen in the diagram)
- Regulate agricultural use of antibiotics – some bacteria may affect both animals and humans
- Only use specific antibiotics for specific bacteria – limit exposure of unnecessary antibiotics to bacteria
- Maintain hygiene – personal and large-scale (hospital) level
- Isolation – isolate patients infected with antibiotic-resistant bacteria

169. What is antibiotic resistance?

170. What causes antibiotic resistance?
171. Describe the steps in which a bacteria strain develops resistance to an antibiotic.
172. Why can bacteria evolve quicker than other organisms?
173. Suggest 3 methods to prevent and slow down the development of antibiotic-resistant strains.
174. Why must patients finish their course of antibiotics every time?
175. Suggest 3 ways in which a hospital can reduce the spread of antibiotic-resistant strains.
176. Why is it difficult to develop new antibiotics to combat the appearance of new antibiotic-resistant strains of bacteria?
177. Why are bacteria prokaryotic organisms?
178. Is binary fission sexual or asexual reproduction?
179. What is the role of the DNA plasmid for bacteria?
180. What type of cell in your blood fights infection?
181. Define 'pathogen'
182. How does your body fight a bacterial infection?
183. Define 'allele'
184. Sue says 'antibiotic resistance isn't a big deal, we can just make more antibiotics' Do you agree? Give a reason.
185. Why will your doctor not prescribe antibiotics for a cold?
186. Antibiotics can be used to protect our bodies from pathogens.

    (a) What is a pathogen?

    (b) Bacteria may become resistant to antibiotics. How can doctors reduce the number of bacteria that become resistant to antibiotics?

    (c) Scientists grow microorganisms in industrial conditions at a higher temperature than is used in school laboratories.

    (i) Which temperature would be most suitable for growing bacteria in industrial conditions?

    (ii) What is the advantage of using the temperature you gave in part (c)(i)?

187. Many strains of bacteria have developed resistance to antibiotics.

The table shows the number of people infected with a resistant strain of one species of bacterium in the UK.

Year	004	005	006	007	008
ber of people infected the resistant strain	499	553	767	809	131

(a) Calculate the percentage increase in the number of people infected with the resistant strain between 2004 and 2008.

Show clearly how you work out your answer.

(b) Explain, in terms of natural selection, why the number of people infected with the resistant strain of the bacterium is increasing.

Pathogenic bacteria and viruses may make us feel ill if they enter our bodies.

(a) Why do bacteria and viruses make us feel ill?

(b) Most drugs that kill bacteria cannot be used to treat viral infections. Explain why.

(c) Antibiotic-resistant strains of bacteria are causing problems in most hospitals.

Explain, as fully as you can, why there has been a large increase in the number of antibiotic-resistant strains of bacteria.

188. Some diseases can be tackled by using antibiotics and vaccination.
Explain fully why antibiotics cannot be used to cure viral diseases.

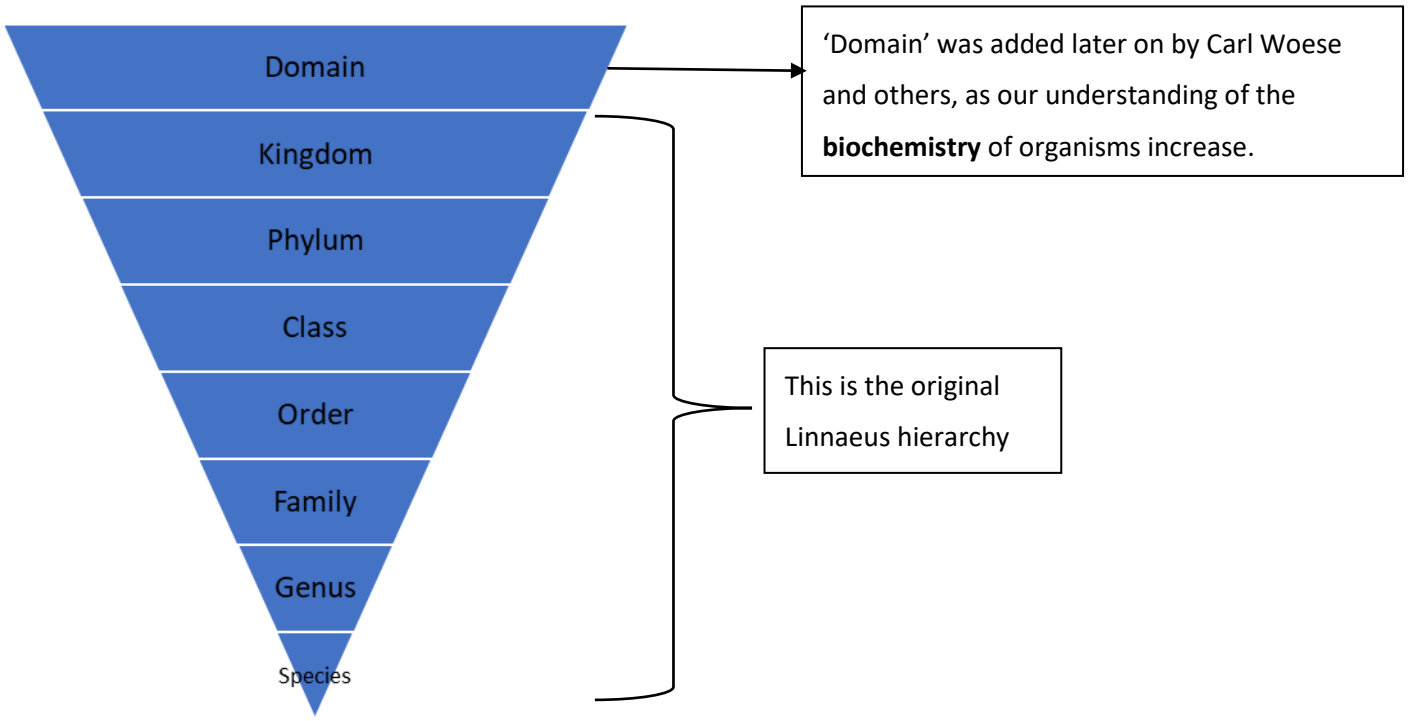
(ii) A recent study found that babies in 90 % of hospitals are infected with the MRSA bacterium. Explain how the MRSA bacterium has developed resistance to antibiotics.

(b) A person can be immunised against a disease by injecting them with an inactive form of a pathogen. Explain how this makes the person immune to the disease.

Part 12- Classification

Classification is the organisation of living organisms into groups according to similarities. Organisms are classified based on their structure and characteristics into a specific hierarchy. It is developed by Carl Linnaeus (a Swedish botanist), but was updated later on by Carl Woese and other scientists as we gain better understanding of living organisms.

The "updated" Linnaeus hierarchy



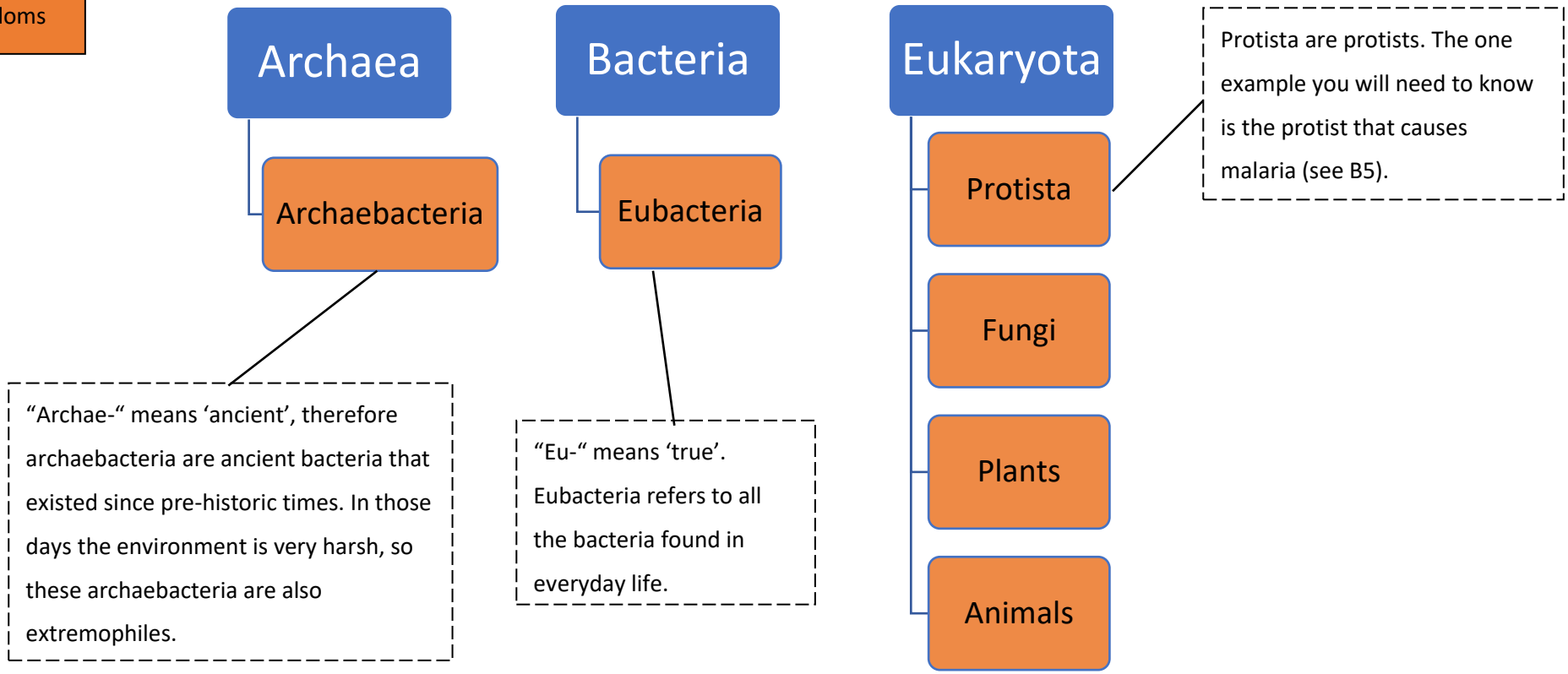
You need to know the three domains, six kingdoms and what a species is.

Species refers to a group of organisms that can **interbreed** to produce **fertile** offspring.

Originally there were five kingdoms, but with more understanding there are distinct enough differences within the prokaryote kingdom that it was split into two kingdoms: archaebacteria and eubacteria.

The three domains

The six kingdoms



For example, humans are classified like so:

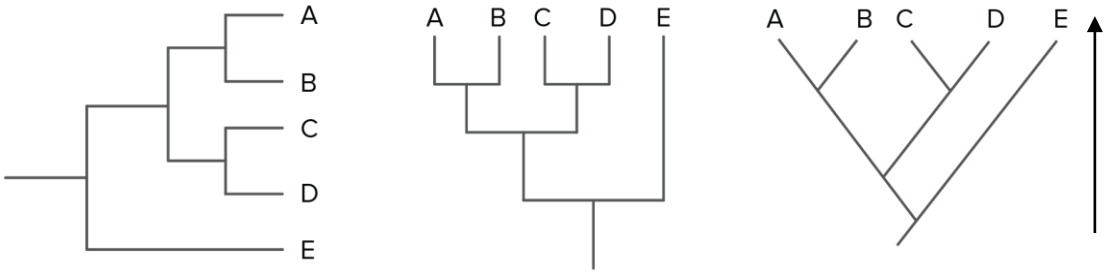
Classification	Human
Domain	Eukaryota
Kingdom	Animals
Phylum	Chordates
Class	Mammals
Order	Primates
Family	Hominids
Genus	*Homo*
Species	*Sapiens*

When talking about classification, we refer to humans as *Homo sapiens*. This type of naming is called **binary naming**. It is "binary", as the name is made up of two words – the genus and species names. It is in Latin, as it is considered as the universal scientific language, so this helps scientists of different countries who speak different languages to understand each other better. Since it is in **Latin**, it needs to be written slightly differently. The fact that it uses **genus** and **species** to name particular organisms, it helps us see some basic information of their evolutionary relationships. If two organisms have the same genus name but different species name, we then know they are somewhat closely related just by looking at their names.

Rules of binary naming

1. When typed, it needs to be in ***italics***; when handwritten, it needs to be **underlined**
2. The first letter of 'genus' must be in capital
3. The first letter of 'species' must be in small letter

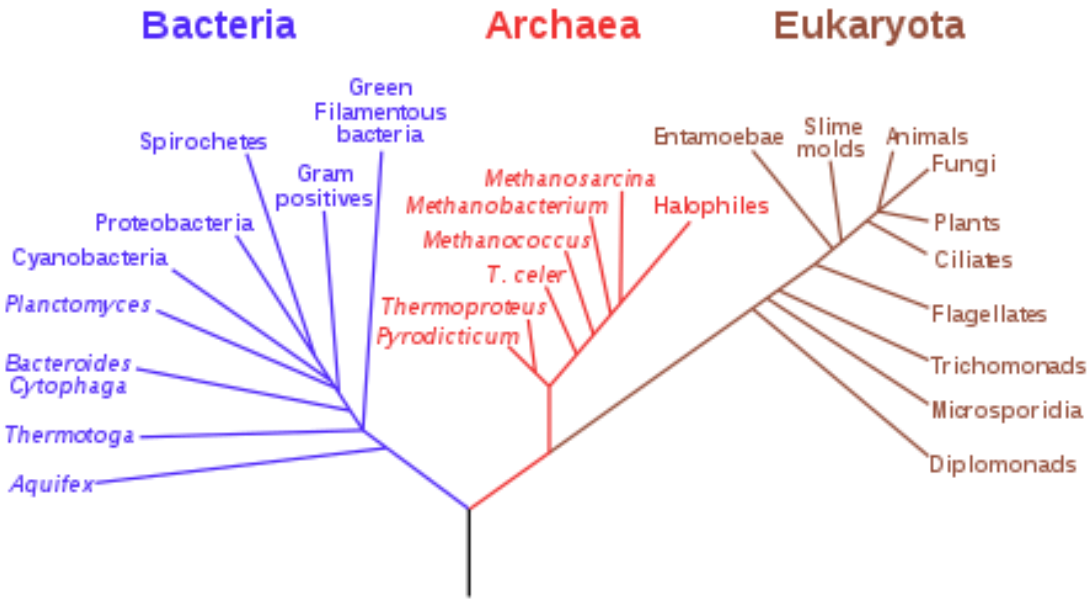
We can use models like **evolutionary trees** to show relationships between organisms.

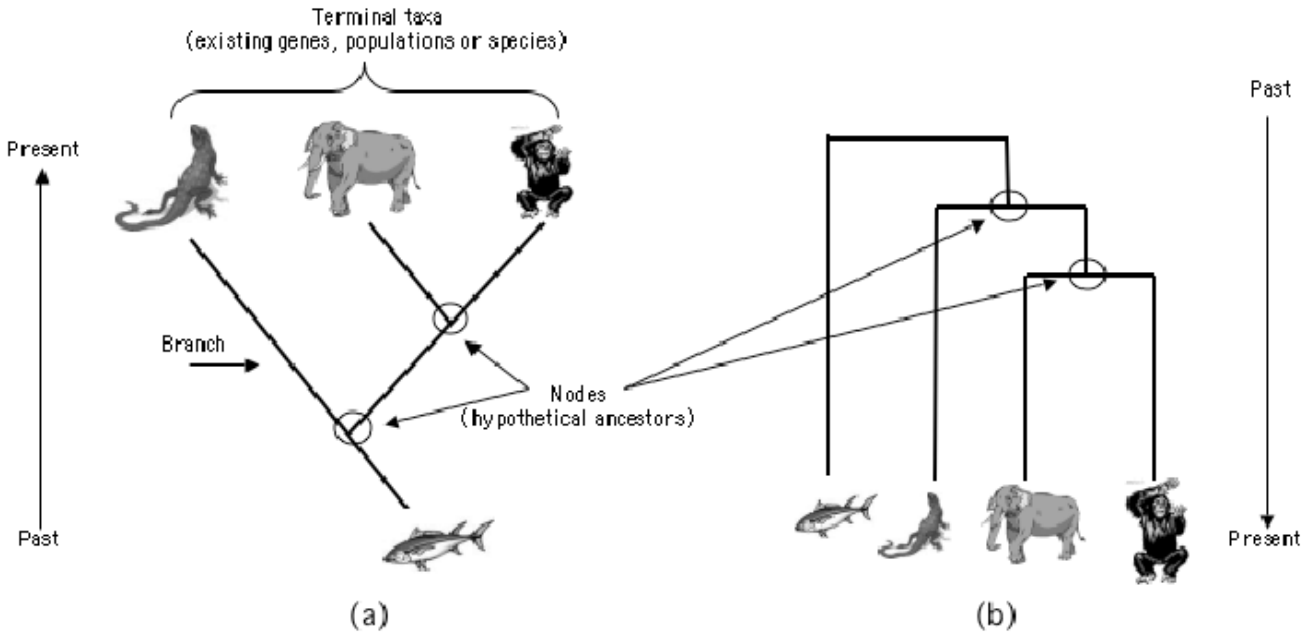


Although the above three trees look slightly different, they suggest the same relationships between organisms A-E. From the trees, we can tell that A is closely related to B, C is closely related to D, whereas E is not. However, they all originated from the same common ancestor.

Extension – Phylogenetic trees

For the third tree, it is worth noting it can also be called a phylogenic tree. It is presented in such a way to also show the evolutionary timeline – the bottom of the tree is the beginning of time on Earth. As we go up the tree (or the arrow) we become closer to the present time. In some sense, the length of the lines extended from the bottom gives an estimation of their period of existence. Those that are not extended to the very top means they are already extinct. Below is another example of a phylogenetic tree, showing the suggested relationships between the organisms within the three domains. Do note that there are slightly different versions of phylogenetic trees when you do further reading or research online.





189. What does classification of organisms mean?
190. Name the person who first developed the classification system.
191. State the 7 hierarchical levels of the Linnaean classification system.
192. Every organism has a scientific name using a binomial system. What does binomial mean?
193. Which language does the binomial naming system use?
194. The binomial name of an organism is made up of two words. What does each word represent of that organism?
195. What are the three rules of writing a binomial scientific name of a species?
196. Why do we use the binomial naming system?
197. How many domains and kingdoms do scientists now consider in classification?
198. Based on what knowledge were the three domains set?
199. Who developed the three-domain system?
200. What are the three domains?
201. What are the six kingdoms?
202. How is classification helpful?
203. Name the type of models that are used to show how different organisms are related.
204. How are evolutionary trees made?
205. What aspects of knowledge would be considered when suggesting evolutionary relationships?
206. Living organisms are classified into the following groups:

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

(a) Which scientist first suggested this type of classification system?

The stone plant, *Lithops bromfieldi*, is adapted to live in very dry deserts.

Figure 1 shows several stone plants.

Figure 1

(b) Give the genus to which the stone plant belongs.

(c) The stone plant has many adaptations that help it to survive in the desert.

Draw **one** line from each adaptation to how the adaptation helps the stone plant to

Adaptation	How the adaptation helps survival
	Can trap a lot of light
Plants look like stones	Absorb water from deep in the ground
Leaves with thick, waxy cuticles	Help cross-pollination
Many long, branching roots	Are not easy to see and so are not eaten
Thick, fleshy leaves	Reduce water loss
	Store water

survive.

The jerboa is a small desert animal.

Figure 2 shows a jerboa.

Figure 2

The jerboa is adapted for survival in the desert.

The jerboa spends the daytime in its underground burrow.

The jerboa only leaves its burrow to look for food during the night.

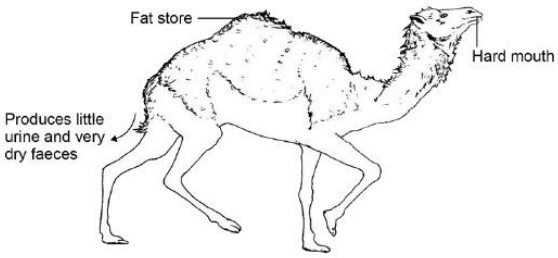
(d) Describe how these adaptations help the jerboa to survive in the desert.

(e) What type of adaptations are described in Question (d)?

207. **Figure 1** shows a type of camel called a dromedary (*Camelus dromedarius*).

The dromedary lives in hot, dry deserts.

Figure 1



(a) One adaptation of the dromedary is 'temperature tolerance'.

This means that the animal's body temperature can rise by up to 6 °C before it starts to sweat.

Explain how temperature tolerance can help the dromedary to survive in the desert.

(b) Three more adaptations of the dromedary are given in **Figure 1**.

Give a reason why each adaptation helps the animal survive in the desert.

- Fat store
- Produces little urine and very dry faeces
- Hard mouth

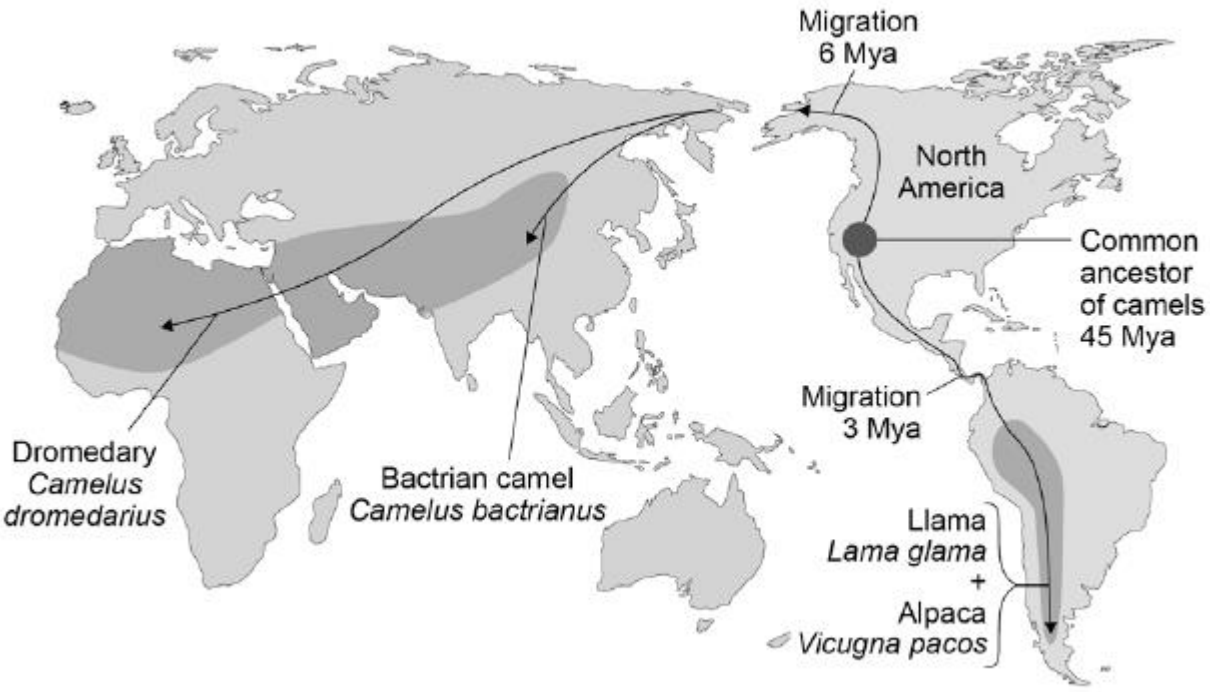
There are several species of the camel family alive today.

Scientists think these species evolved from a common ancestor that lived in North America about 45 million years ago (Mya).

Figure 2 shows:

- where four modern species of the camel family live today
- how the ancestors of these camels migrated from North America.

Figure 2



(c) Which **two** of the four modern species of camel do scientists believe to be most closely related to each other?

Give the reason for your answer.

(d) Describe the type of evidence used for developing the theory of camel migration shown in **Figure 2**.

(e) Explain how several different species of camel could have evolved from a common ancestor over 45 million years.