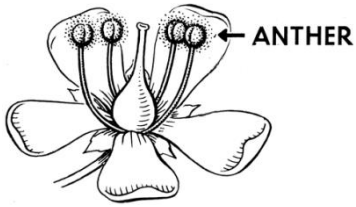
A. Reproduction part 1 – Sexual and asexual reproduction, meiosis, DNA and the genome and DNA structure

1. a) Strawberry plants can reproduce sexually or asexually. Describe **two** disadvantages to a commercial strawberry grower of restricting the plants to reproduce asexually. (2)

   All plants are genetically identical and so a new pathogen may wipe out the whole population

   Asexual reproduction does not produce a fruit crop

   b) Describe the stages involved in making pollen in the anthers of a strawberry plant. (4)



   The anther cells divide by meiosis

   Copies of the genetic information is made

   The cell divides twice

   To form four gametes (pollen)

   c) The mass of DNA in the nucleus of a pollen cell is 0.25micrograms (µg). (4)

   i) What will the mass of DNA be inside the nucleus of an unfertilised egg cell? ***0.25 µg***

   ii) What will the mass of DNA be inside a fertilised cell nucleus? ***0.5µg***

   iii) What will the mass of DNA be inside the nucleus of an anther cell in grams?

   0.5 µg = 0.5 x10^{-6}g

   iv) What will the mass of DNA be in an anther cell nucleus prior to cell division? ***1 µg or 0.000001g***

2. After the sperm and the egg nuclei fuse, the fertilised egg is known as a zygote. The single cell of the zygote divides every 15 hours to form two cells. These cells continue to divide every 15 hours to from a ball of cells known as the embryo.

   Calculate how long it will take in hours from fertilisation to the formation of a ball of 32 cells. (1)

   5 x 15 hours = 75 hours in total.

   1 cell to 2 cells = 15 hours

   2 cells to 4 cells = 30 hours

   4 cells to 8 cells = 45 hours

   8 cells to 16 cells = 60 hours

   16 cells to 32 cells = 75 hours

   2 marks for correct final answer

3. a) Suggest **two** ways in which the Human Genome Project (HGP) may improve the medical care for the future. (2)

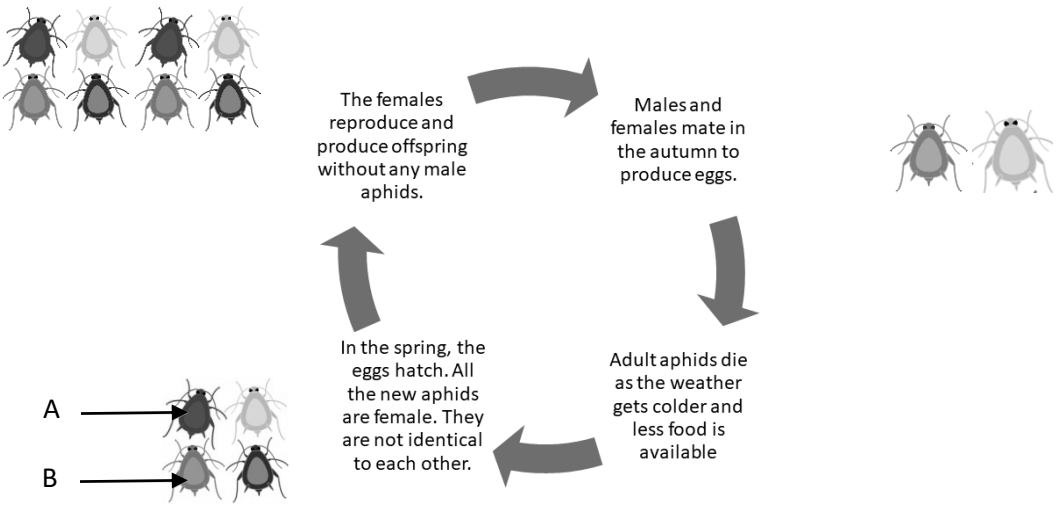
It will allow increased/improved use of gene therapy
Target drug treatment to reduce symptoms or delay onset of disorders
Enable people to be more informed and make lifestyle choices

b) Suggest **two** ways in which the HGP may have a negative effect on people. (2)

It could be used to refuse insurance cover for individuals who possess certain genotypes
It could make it more difficult to find employment if a potential employer is aware of an employee's genotype
Knowing that something may occur may increase peoples stress
May feel under pressure not to have children or terminate pregnancies
Ethical concerns regarding ownership of data and right to access it
Lead to more people wanting gene therapy and increased cost to NHS

4. a) Why do most organisms have even numbers of chromosomes in their body cells? (2)
Chromosomes are in pairs
Inherited one from each parent
One chromosome of each pair is found in each gamete
Gametes have an odd number of chromosomes so after fertilisation the fertilised cell has an even number.

Aphids have specialised mouth parts to feed on the sap from the phloem in a plant.



b) What method of reproduction is used by female aphids in the spring? (1)
Asexual reproduction / cloning

c) How will the genome of an offspring from aphid A compare with another offspring of Aphid A? (1) *They will be genetically identical*

d) How will the genome of an offspring from Aphid A compare with the genome of an offspring from Aphid B? (1)
They will be different/ show variation

e) Why are the female aphids not identical to each other? (2)
Sexual reproduction involves mixing of genetic material.

There will be different male and female parents for each set of offspring/eggs.

f) Suggest why aphids are able to reproduce sexually and asexually.(4)

If there is a shortage of male aphids then asexual reproduction can still occur
Sexual reproduction produces variation in the offspring
If the environment changes variation gives a survival advantage by natural selection
Producing eggs means the aphids can survive over the winter period when temperature and food supply is an issue.
Asexual reproduction produces lots of offspring very quickly to take advantage of the warmer temperatures and abundance of food

Biology only questions

Extended response question:

5. Daffodils can reproduce both sexually and asexually.

   Flowers produce gametes (pollen and eggs) which create seeds if fertilisation is successful.

   A daughter bulb grows from a bud at the base of a parent bulb. This will generate a new plant.

   Explain the advantages **and** disadvantages of sexual **and** asexual reproduction for the daffodil. (6)

- ***Level 3 (5-6 marks)***
  A detailed and coherent explanation is provided that considers a range of relevant points for both the advantages and disadvantages of both types of reproduction.
- ***Level 2 (3-4 marks)***
  Most relevant points made which cover both types of reproduction and most advantages and disadvantages written in a logical way.
- ***Level 1 (1-2 marks)***
  Some relevant points made with no logical structure.

Indicative content

Advantages of sexual reproduction

- ***Introduces variation into the population***
- ***The species can adapt to new environments***
- ***A disease is less likely to affect all individuals in a population***

Disadvantages of sexual reproduction

- ***Not possible for a single isolated plant***
- ***Relies on insects to transfer the pollen from one plant to another via insects***

Advantages of asexual reproduction

- ***Population increases rapidly***
- ***Can exploit a habitat quickly***
- ***Only one plant is needed***

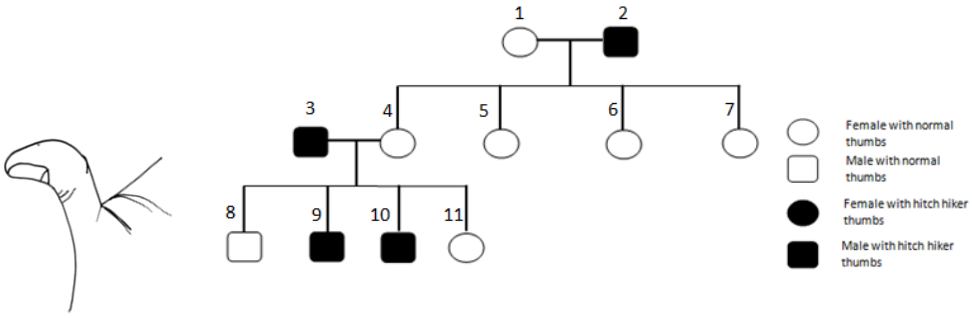
- *All new plants have same characteristics as parent plant*

Disadvantages of asexual reproduction

- *No variation*
- *Species may only be adapted to survive in one habitat*
- *Disease may affect all the plants in a population as they are all genetically identical*

B. Reproduction part 2 – Genetic Inheritance, inherited disorders and sex determination

1. Hitch hiker's thumb is a genetically inherited condition caused by a dominant allele T.



a) What is the genotype of person 1? *tt or homozygous recessive*
b) What is the phenotype of person 4 in relation to gender and thumb type? (1) *Female and normal thumbs*
c) Describe the genotype of parents 3 and 4. (1)
Genotype of parent 3 is heterozygous;
because if 3 was homozygous dominant for hitch hikers thumb;
all the offspring would inherit a dominant allele and possess hitch hikers thumb.
Person 4 is homozygous recessive;
because we are told they do not possess a dominant allele and do not have hitch hikers thumb.

d) Explain how their offspring 9 and 10 have inherited hitch hiker thumbs yet 8 and 11 have not. Complete the Punnett square diagram to show the possible offspring if 3 and 4 mated. (6)

		Person 4	
		t	*t*
Person 3	*T*	*Tt*	*Tt*
	t	*tt*	*tt*

The Punnett square shows there is a 1 in 2 (50:50 or 50%) possibility of parents 3 and 4 having a child with hitch hikers thumb or having normal thumbs.
In the family tree this is what occurred.

e) Mary has a genetic condition called cystic fibrosis which is a disorder of cell membranes. She and her husband John want to have children in the future. John is healthy but he does not want to know his genotype. Explain why it would be helpful for John's genotype to be known. (3)

Cystic fibrosis is caused by inheritance of a recessive allele from both parents. (1)

If John is a carrier: (1)
then there is a 1 in 4 chance (25%) of a child inheriting two recessive alleles/ cystic fibrosis.
Embryo screening could be carried out in the womb to see if the embryo had cystic fibrosis and a decision could be made to terminate the pregnancy at that point.

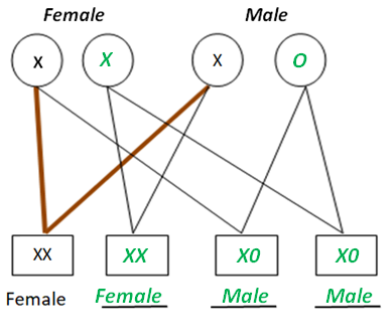
If John is not a carrier: (1)
there is 0% chance of their child having cystic fibrosis.
There is a 100% chance of their children becoming carriers and by knowing this the offspring can be warned later in life that they are carriers.

2. a) What happens to the chromosomes in the nucleus of an ovary cell when it forms egg cells? (3)

Chromosomes duplicate/double/copied
And separate into four sets/ divide twice
Number halved in the egg cell compared to the ovary cell

b) Male cockroaches only have one sex chromosome.
Their genotype is XO where O means there is no chromosome present.
Female cockroaches have the genotype XX

Complete the genetic diagram to show the possible genotypes and phenotypes of the offspring from two cockroaches. One has been done for you. (5)



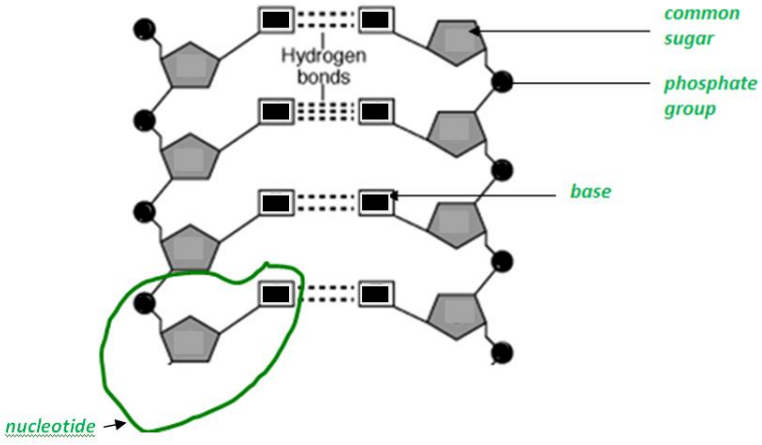
3. a) Complete the diagram of a DNA molecule by adding in the correct complementary bases. (3)

3 marks for all correct
2 marks for 1 error only
1 mark for 2 errors
0 marks for more than 2 errors.

G	A	*A*	*G*	C	*T*	*A*	*C*	G	*T*
C	*T*	T	C	*G*	A	T	G	*C*	A

b) Annotate the diagram of the DNA polymer below with the following 4 labels: (4)

base **common sugar** **phosphate group** **nucleotide**



C. Inheritance part 3 – Variation, evolution, selective breeding, genetic engineering and cloning

1. Sweet potato plants produce tubers.

A gardener uses some of the tubers for food and some to produce sweet potato plants.

The tubers are produced by asexual reproduction.

The gardener plants the tubers in different parts of the garden. She noticed that the plants did not all grow to become the same height despite having the same genome. Suggest **two** reasons why this has happened. (2)

Not all tubers are getting the same amount of water

Or the same amount of minerals

Or the same amount of light

They may be competing with other plants for space

Environmental variation

2. These trees are all the same species.

a) Convert the height of the bonsai tree into metres. (1)

300mm = 0.3m

b) What is the simplest ratio of height between the plantation tree and the field tree? (2)

35:25 simplified

35/5 = 7

25/5 = 5

Ratio is 7:5

c) What is the major cause of variation between these trees? (1)

Environmental

Competition for a named factor

d) If the Bonsai tree was planted outside in a field would it grow larger? Explain your answer (2)

Yes

The environmental factor restricting growth would be removed

The Bonsai tree has the genotype to be able to grow large

3. Organ donation in the UK still falls below the number of people who are placed on the transplant list. 1300 people died last year before they can receive a transplant. The table shows the list of people waiting for a transplant.

	Current at 05.10.17		Previous year
	Total	(Paediatric <18yrs)	at 31.10.16
Kidney	5062	(69)	5074
Pancreas	16	(0)	9
Kidney/pancreas	186	(0)	208
Pancreas islets	25	(0)	22
Heart	291	(33)	236
Lung	348	(7)	370
Heart/lung	18	(2)	16
Liver	469	(41)	532
Intestinal	8	(6)	6
Other (multi-organ)	39	(4)	45
TOTAL	6462	(162)	6518

a) What proportion of people waiting for a transplant in October 2017 are under the age of 18? (2)

162/6462 (1)

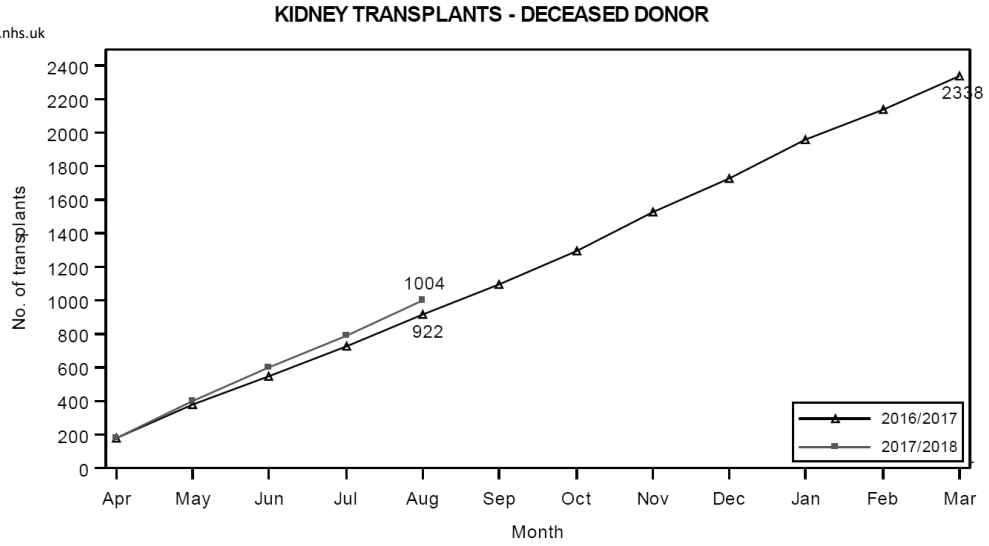
0.025 or 2.5 %(1)

b) Calculate how many of the people waiting for a transplant need a new liver in October 2017 as a percentage. (2) ***469/6462 x100 (1)***

7.26 or 7.3% (2 for correct answer)

The graph shows the number of kidney transplants which have been carried out in 2016/17 and 2017/18 so far using organs donated from people who have died.

Information from www.organdonation.nhs.uk



c) Suggest two conclusions which could be made from the data in the graph and the previous table. (2)

More kidney transplants have been carried out in 2017/18 so far than for the same time period last year.

More people have died whose organs were suitable for donation in the current year so far.

The majority of people who need a transplant do not get one in a year.

d) Research scientists want to genetically engineer organs in pigs which would not be rejected by humans. Suggest how they could do this. (3)

Identify the human gene for a type of human tissue

Isolate/cut out the gene from human DNA

Transfer the gene into the cells of the pig (gamete or embryo)

Check the cells for expression of the gene

e) The government has so far banned this type of research.

Suggest **two** benefits and **two** objections to this type of research. (4)

Pros:

- *Reduces shortage of suitable organs.*
- *Helps to save human life that could be saved if there were sufficient organs donated.*
- *Health costs will be reduced as more people will benefit and need less expensive treatment.*

Cons:

- *Unsure of the consequences of using another mammal's organs inside humans.*
- *People may consider it unethical to put pig's organs into a human.*
- *Moral objections to killing a pig to harvest its organs to benefit humans.*
- *May consider it against their religious beliefs.*

4. The photographs show a wild pig and a modern day pig known as the Large White.

The Large White is a descendant of the wild pig and has been produced by selective breeding. It is renowned for bacon production. The photographs are scaled to show the relative sizes.

a) Suggest two features you can see in the photograph that farmers selected for when breeding the Large White. (2)

No tusks
Colour of skin
Not much hair
Lots of meat/size

b) Explain how a farmer could use selective breeding to breed pigs which are very docile in nature.(3)

Choose pigs which are the most docile to breed from.

In the next generation only choose docile pigs to breed from.

Carry this on for many generations until all the pigs in the herd are docile.

Higher Tier Only

5. Explain how the human insulin gene and plasmids can be used to genetically modify bacteria. (4)

Enzymes are used to isolate the human insulin gene from human DNA
The bacterial plasmid is cut open
The gene is inserted into the bacterial plasmid
The plasmid with the inserted gene is placed into the bacterial cell

Biology Only Questions

Extended response question

6. Mutations occur continuously and on rare occasions some mutations result in an altered protein with a different shape being produced.

The mutation which results in cystic fibrosis results in bases being deleted.

Normal sequence of nucleotides:
A T C A T C T T T G G T G T T

Mutated sequence of nucleotides:
A T C A T T G G T G T T

In people without cystic fibrosis, the protein made functions as a channel across the membranes of cells which produce mucus. Chloride ions pass in and out of cells through this channel and aid the movement of water which is required to produce thin freely flowing mucus. This protein channel does not function in cystic fibrosis due to the changed shape of the protein produced.

Explain how this mutation would result in an altered protein being made which does not fold properly and so does not function. (6)

- ***Level 3 (5-6 marks)***
  A detailed and coherent explanation of how the missing bases affect the protein made and its function.
- ***Level 2 (3-4 marks)***
  Most relevant points made and written in a logical way.
- ***Level 1 (1-2 marks)***
  Some relevant points made with no logical structure.

Indicative content

Three bases have been deleted(CTT)

A sequence of three bases codes for a particular amino acid

The order of the bases controls the order in which amino acids are assembled to produce a particular protein

An amino acid is missing from the protein chain

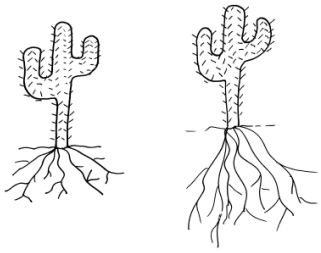
changing its shape so it will not fold properly

A differently shaped protein will not form the channel needed to make thin mucus

7. Cacti are normally found in arid habitats where water is scarce and day temperatures are high.

After a period of 10 years of drought in an area, researchers discovered that the mean length of roots in a cactus population had increased.

In the 1800s, Darwin and Lamarck had different theories to explain how the short roots of the cactus evolved into the longer present day roots of the cactus.



a) Use Lamarck's theory of natural selection to explain how the cacti roots evolved (2)

Cactus roots stretched during its lifetime to reach more water.

Stretched roots passed on to offspring

b) Explain Darwin's theory of natural selection to explain how longer roots evolved (4)

Variation occurs in the population / mutation

Longer rooted cacti get more water

And more survive during drought

Surviving cacti breed

Pass on genotype for longer roots to offspring

More of the population have longer roots

c) Suggest **two** reasons why scientists in the 1800s could not decide if Lamarck or Darwin was correct. (2)

Insufficient evidence available

Mechanism of inheritance not known

d) The general public in the 1800s had a different idea which explained how all life on Earth came about. What was this idea? (1)

God made all living things / creationism

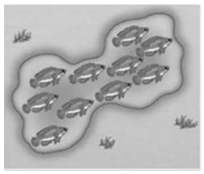
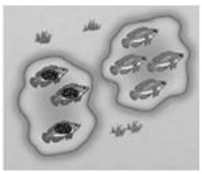
e) Describe **three** reasons why Darwin's theory of evolution by natural selection has now been widely accepted by everyone. (3)

Mechanism of inheritance now understood – characteristics are passed onto offspring in genes

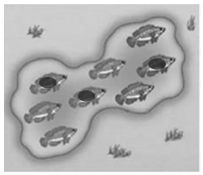
Evidence in the fossil record

Knowledge of how resistance to antibiotics evolves in bacteria

8. The lake in the picture was home to a large population of fish of the same species. Over a long period of time, the lake reduced in size and formed two smaller lakes.

In the winter of 2013 there was a lot of rainfall and the two lakes merged back into one.



Fishermen noticed that there seemed to be two different phenotypes of fish in the lake. Scientists found that two new species had been formed.

Explain how this has occurred. (5)

Isolation has occurred and formed two populations of fish

Mutations occur continuously

Because the two populations were not interbreeding the new alleles resulting from mutations were not being mixed.

There would be environmental differences in the two lakes over time which can cause variation

When the two lakes formed one lake again the two fish were so genetically different they could not breed and produce fertile offspring

Two new species have formed

Extended Response question

9. **Rubbish-filled ditch beside roadside burger van named as one of UK's 10 most important wildlife sites.** **Daily Mail.co.uk Feb 1, 2011.**

According to Natural England this is the only place in the country where self seeded Fen Ragwort grows. It was thought to have become extinct in the Victorian era.

a) Describe the benefits and disadvantages of the two methods of cloning which could be used to preserve the species. (6)

- ***Level 3 (5-6 marks)***
  A detailed and coherent explanation is provided that considers a range of relevant points for both the benefits and disadvantages of tissue culture and taking cuttings.
- ***Level 2 (3-4 marks)***
  Most relevant points made which cover both types of cloning
- ***Level 1 (1-2 marks)***
  Some relevant points made with no logical structure.

Indicative content

Tissue culture (1)

Cuttings (1)

Benefits of tissue culture: uses small groups of cells from the plant

Many new genetically identical plants can be grown from a few cells

Only a small amount of damage to the parent plant occurs

Reliable as even if some cells do not grow others are likely to

Disadvantages:

Expensive- needs to be done in a lab

Cannot be done by gardeners

Benefits of cuttings:

Simple and cheap

Produce genetically identical plants

Disadvantages:

Need to take a large amount of the plant to produce a small amount of cuttings

The cuttings may not take

D. Inheritance part 4 –Theory of evolution, speciation, evidence for evolution, fossils, extinction, resistant bacteria and classification of living organisms.

1. The Irish Elk (*Megaloceros giganteus*) lived in Europe at the end of the glacial period. It became extinct between 11 000 and 5000 years ago.

a) Suggest what factors may have contributed to the extinction of the Irish Elk. (3)

Humans – hunting

Change of climate

Change in food availability

Change in habitat

b) The photograph opposite is a model of how we might imagine an Irish Elk to look like using fossils. Describe how a fossil of the Irish Elk could have been formed. (3)

Animal dies

Soft tissues decompose/decay

Hard bones and antlers remain

Covered with sediment and then minerals replace the bone forming a fossil

2. a) Both of the birds in the photograph are known as robins. Suggest **two** reasons why this could be a problem. (2)

Turdus migratorius

Erithacus rubecula

They will not be able to interbreed

Possible confusion with accurate identification between scientists/ornithologists

b) What information do the scientific names of the robins provide? (3)

Genus

Species

c) Why can it be difficult to classify some living organisms? (2)

There is variation in all living organisms in the same species

Some organisms have very similar features that are common to more than 1 species/group

Carl Woese identified three distinct groups of organisms he called domains: Archaea, Bacteria and Eukaryota.

Feature	Archaea	Bacteria	Eukaryota
Type of chromosome	Circular	Circular	Linear
Number of protein molecules in RNA polymerase	10	5	12
Cell membrane	Branched hydrocarbon chains attached to glycerol by ether bonds	Unbranched fatty acid chains attached to glycerol by ester bonds	Unbranched fatty acid chains attached to glycerol by ester bonds
Peptidoglycan present	No	Yes	Yes
Size of ribosomes	70S	70S	80S

d) Using the information in the table, give evidence that agrees with Carl Woese's theory that archaea should be grouped separately to bacteria and eukaryota. (2)

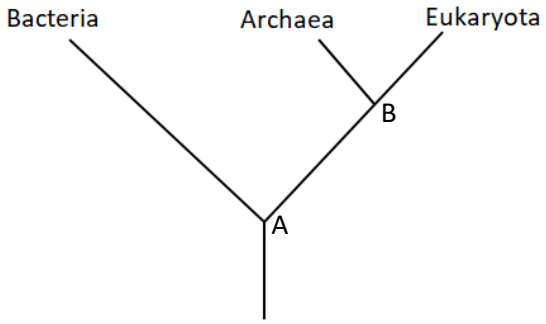
Archaea does not have peptidoglycan

Archaea has a different arrangement of molecules in its cell membrane to bacteria and eukaryota.

e) Woese put forward this simple evolutionary tree to show the relationships between the three domains. What has happened at points A and B on the diagram? (2)

A = bacteria and B have evolved from the common ancestor

B = Archaea and Eukaryota have evolved from their ancestor B



f) Which two domains are most closely related according to Woese? (1)

Archaea and Eukaryota (1)