AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.4.3 GENETIC DIVERSITY VIA MUTATION AND MEIOSIS

SCORE	PERCENTAGE
/561	%

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Q1.

Read the following passage.

Sizes of populations of normal intestinal bacteria are usually controlled by T cells that are produced slowly and in small numbers by the immune system. These T cells do not normally survive for very long. As a result, they do not release large amounts of cytokines. Cytokines are chemicals that can cause swelling of the lining of the intestines.

Crohn's disease is a long-lasting disease that causes swelling of the lining of the intestines. It is believed that Crohn's disease can be caused by a loss of tolerance to normal intestinal bacteria, as shown by an unusually large response by T cells. This response can be triggered by pathogenic bacteria in the intestines of people with a genetic tendency to Crohn's disease.

Some people's Crohn's disease can be controlled by a drug called 5-aminosalicylic acid (5-ASA) that reduces swelling. Another drug called 6-mercaptopurine (6-MP) may also be used. 6-MP inhibits an enzyme required to make adenine and guanine. This is effective because most cells can recycle nucleotides, but T cells are not able to do so.

Use information from the passage and your own knowledge to answer the questions.

(a) The Crohn's disease symptom of swelling of the lining of the intestines could be triggered by pathogenic bacteria in the intestines (lines 6–10).

Suggest how.

(3)

(b) Suggest the meaning of ‘a genetic tendency to Crohn’s disease’ (line 10).

(2)

(c) Suggest why 5-ASA is only effective in controlling the swelling of the lining of the intestines in **some** people with Crohn’s disease (lines 11–12).

(2)

(d) Suggest why 6-MP can be used to control the symptoms of Crohn's disease (lines 13–15).

Do **not** include details of enzyme inhibition or protein synthesis in your answer.

(3)

(Total 10 marks)

Q2.

(a) Draw the general structure of an amino acid.

(1)

Table 1 shows mRNA codons and the amino acids coded for by each codon. It also shows some properties of the R group of each amino acid.

Table 1

1st base	2nd base				3rd base
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		Stop	Stop	A
				Trp	G
C	Leu	Pro	His	Arg	U
					C
			Gin		A
					G
A	Ile	Thr	Asn	Ser	U
					C
			Lys	Arg	A
	Met				G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

Key to the properties of the R group of each amino acid

No overall change Positively charged Negatively charged

(b) The genetic code is described as degenerate.

What is meant by this? Use an example from **Table 1** to illustrate your answer.

(2)

A scientist investigated changes in the amino acid sequence of a human enzyme resulting from mutations. All these amino acid changes result from single base substitution mutations.
This enzyme is a polypeptide 465 amino acids long.

Table 2 shows the result of three of the base substitutions.

Table 2

Amino acid number	Correct amino acid	Amino acid inserted as a result of mutation
203	Val	Ala
279	Glu	Lys
300	Glu	Lys

(c) What is the minimum number of bases in the gene coding for this polypeptide?

Answer = _____

(1)

(d) Use information from **Table 1** to tick (✔) one box that shows a single base substitution mutation in DNA that would result in a change from Val to Ala at amino acid number 203

CAA ⟶ CGA ☐

GUU ⟶ GCA ☐

GUU ⟶ GUC ☐

CAC ⟶ CGG ☐

(1)

(e) A change from Glu to Lys at amino acid 300 had no effect on the rate of reaction

catalysed by the enzyme. The same change at amino acid 279 significantly reduced the rate of reaction catalysed by the enzyme.

Use all the information and your knowledge of protein structure to suggest reasons for the differences between the effects of these two changes.

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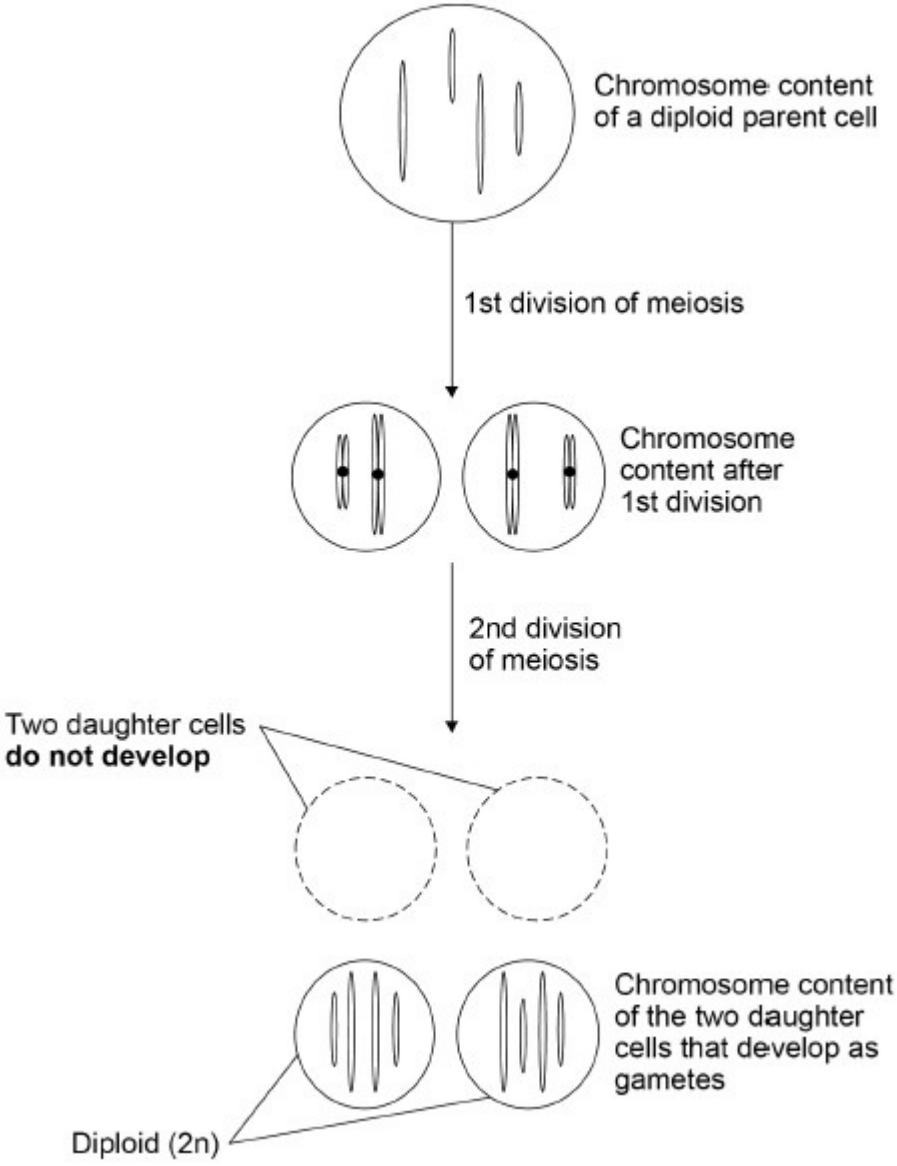
(3)

(Total 8 marks)

Q3.

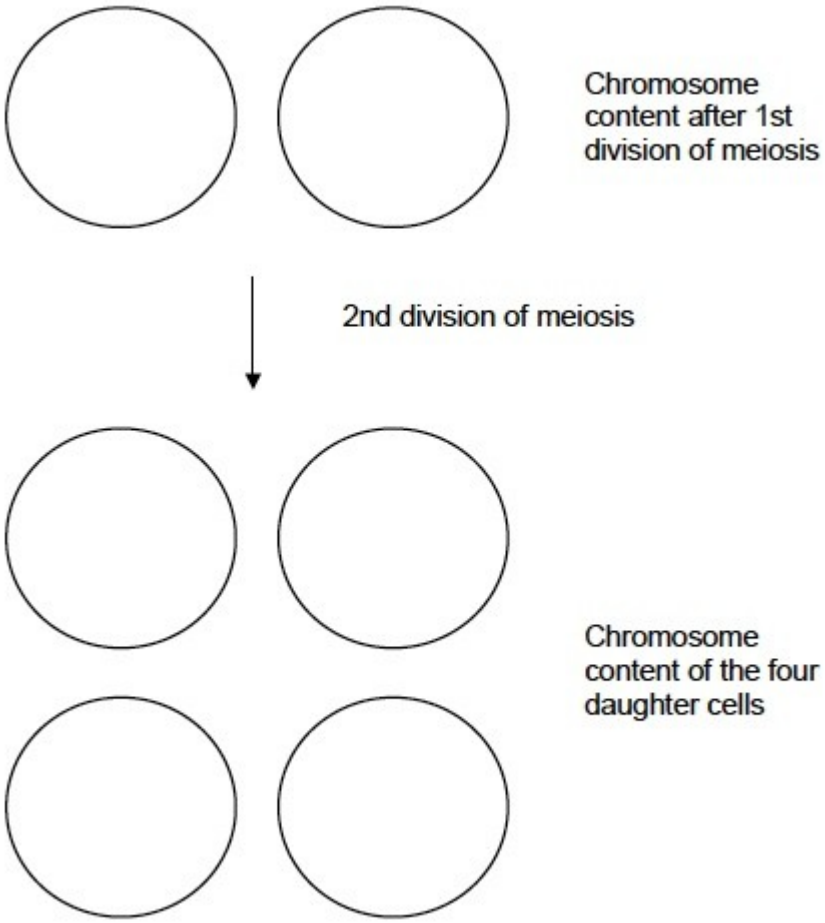
Figure 1 shows a faulty form of meiosis that can occur in some plants.

Figure 1



(a) Complete **Figure 2** to show the chromosome content of the cells that would result from a normal meiotic division of the diploid parent cell shown in **Figure 1**.

Figure 2



(2)

(b) If two diploid (2n) gametes fuse at fertilisation, it can result in the growth of a tetraploid plant which has 4 copies of each chromosome.

Red clover is a plant grown to produce cattle feed. Tetraploid red clover plants produce a higher yield than diploid red clover plants.

Whether a red clover plant produces 2n gametes is genetically controlled.

Scientists investigated the possibility of breeding red clover plants that only produced 2n gametes.

- In breeding cycle 0, they grew red clover plants and identified plants that produced 2n gametes.
- In breeding cycle 1, they used the plants producing 2n gametes to produce offspring.
- In breeding cycles 2 and 3, they identified plants producing 2n gametes and used these to produce offspring.

Their results are shown in the table.

	Observed		**Expected**	
Breeding cycle	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes	Number of plants that **did not** produce 2n gametes	Number of plants that **did** produce 2n gametes

0	50	4	50	4
1	14	42		
2	2	44		
3	0	56		

The scientists used the following null hypothesis.

'The proportion of plants that produce 2n gametes will not change from one breeding cycle to the next.'

Complete the table to show the **expected number** of plants that **did not** produce 2n gametes and the expected number of plants that **did** produce 2n gametes after 1 cycle.
Give each answer to the nearest whole number.

(2)

(c) The scientists tested their null hypothesis using the chi-squared statistical test.
After 1 cycle their calculated chi-squared value was 350
The critical value at P=0.05 is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

_____

_____

_____

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_____

(2)

(d) Use your knowledge of directional selection to explain the results shown in the table.

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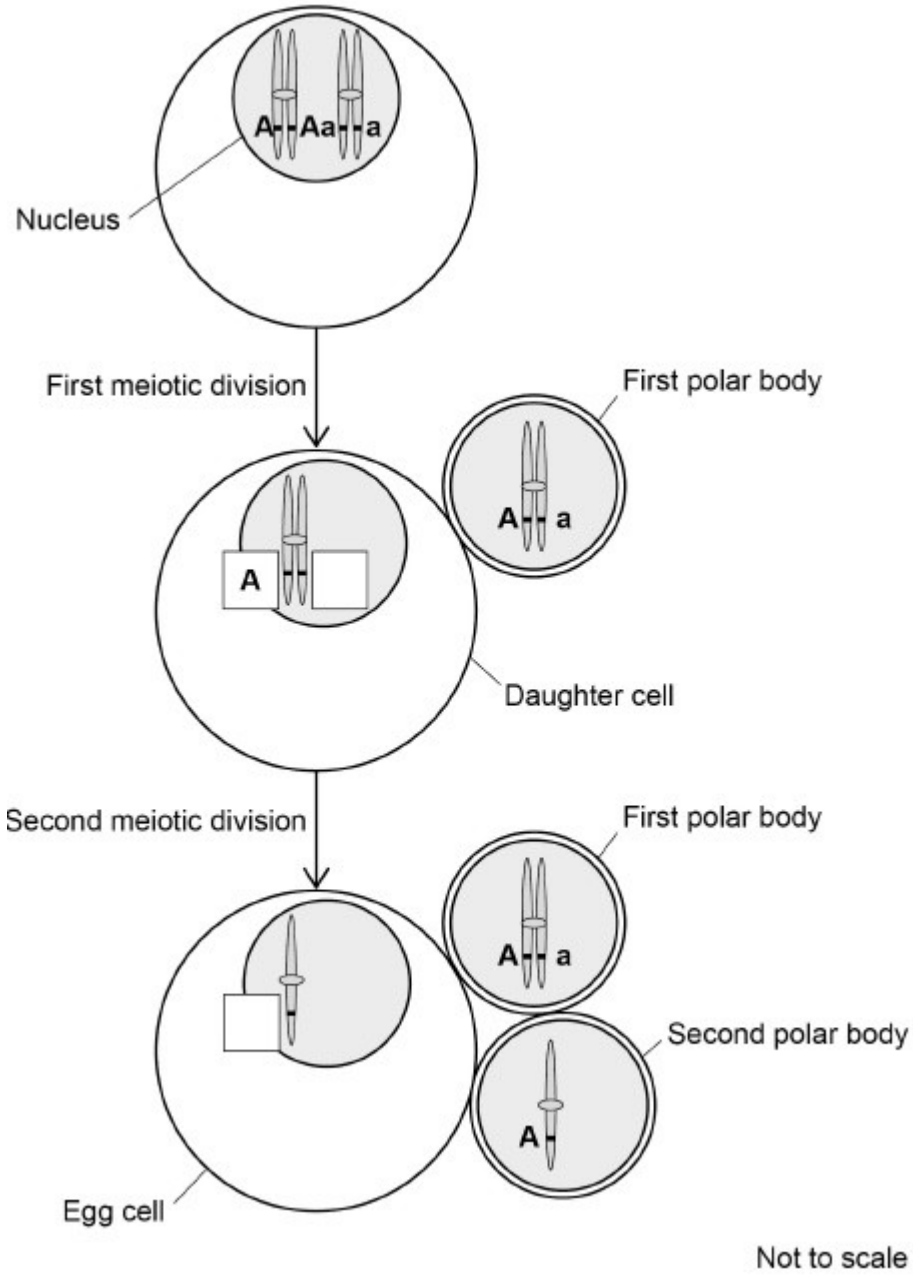
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(3)
(Total 9 marks)

Q4.

In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell consists of a nucleus surrounded by a very small amount of cytoplasm and a cell-surface membrane. This very small daughter cell is called a polar body. Polar bodies do not usually divide. The same process occurs in the second division of meiosis, resulting in one egg cell and two polar bodies.

The diagram shows the formation of an egg cell and two polar bodies during meiosis. It also shows what happens to one pair of homologous chromosomes. This pair carries two alleles of gene A.



(a) Complete the diagram by putting **A** or **a** in the boxes. One box has been completed for you with **A**.

(1)

(b) Put a tick (✓) in the box next to the name of the process that produced the combination of alleles on the chromosome in the first polar body in the diagram.

Anaphase ☐

Crossing over ☐

Independent assortment ☐

Semi-conservative replication ☐

(1)

(c) A scientist measured the diameter of a polar body and the diameter of the nucleus inside it. The diameter of the polar body was 10.4 μm and the diameter of the nucleus was 7.0 μm. The density of mitochondria in the cytoplasm of the polar body (outside of the nucleus) was 0.08 mitochondria per μm^3.

Calculate the number of mitochondria in the polar body. You should assume polar bodies and nuclei are spherical.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

Show your working.

Number of mitochondria =_____

(2)

(d) Mitochondrial diseases are caused by faulty mitochondria. All of a person's mitochondria are inherited from their mother via the egg cell. An egg cell contains approximately 3×10^5 mitochondria.

One proposed treatment to prevent passing on faulty mitochondria involves

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the contents of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest how this treatment prevents inheritance of mitochondrial diseases.

_____

_____

(2)

(e) If most of the mitochondria in a cell are faulty, this prevents many important enzyme-catalysed reactions taking place or slows them down.

Suggest and explain **one** reason why.

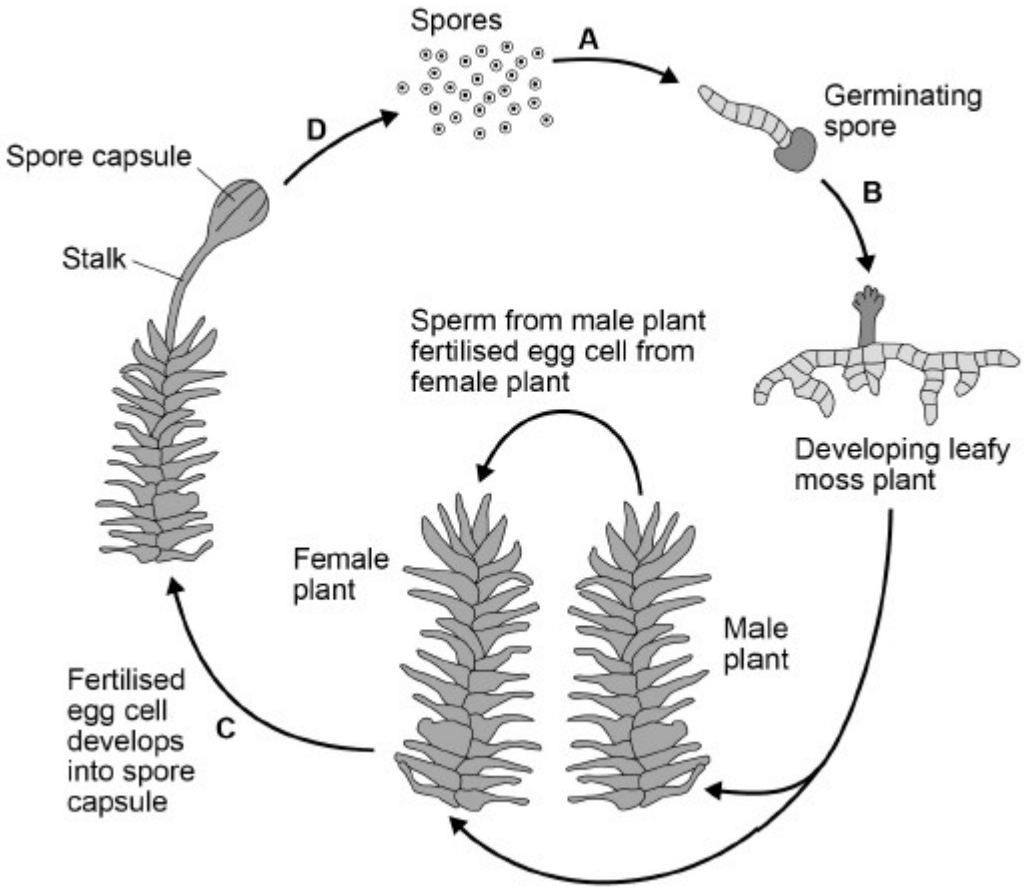
(2)

(Total 8 marks)

Q5.

Figure 1 shows the life cycle of a moss plant. In this life cycle, **only** the stalk and spore capsule are **diploid**. All the cells in all the other stages of the life cycle of the moss are **haploid**.

Figure 1



(a) Which letter, **A**, **B**, **C** or **D**, in **Figure 1**, shows where meiosis occurs in the life cycle of the moss? Write the appropriate letter in the box provided.

(1)

(b) Explain how the chromosome number is halved during meiosis.

(2)

(c) **Figure 2** shows a cell from the moss plant.

The cell is in the **second** meiotic division.

Figure 2



What is the haploid number of chromosomes for this species of moss?

_____

(1)

(d) Crossing over greatly increases genetic diversity in this species of moss.

Describe the process of crossing over and explain how it increases genetic diversity.

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(4)

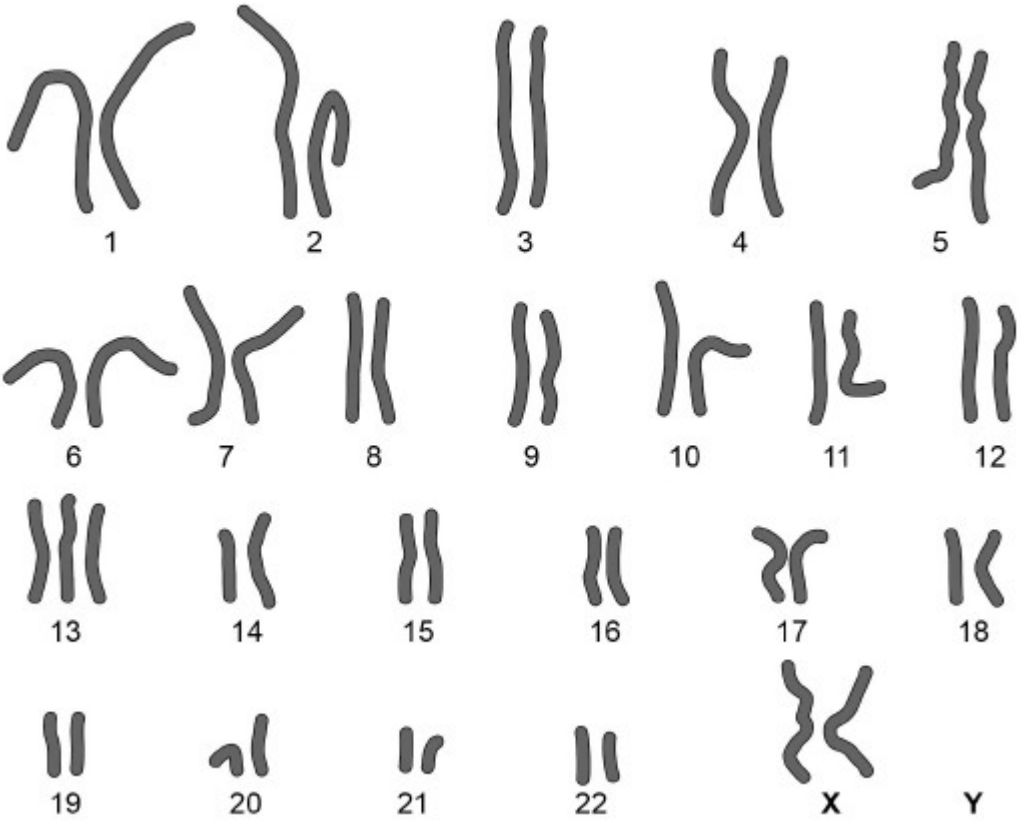
(Total 8 marks)

Q6.

Patau syndrome is a condition caused by a mutation affecting chromosome number. All the cells of the body will have this mutation.

Figure 1 shows the chromosomes from one of the cells of a female who has Patau syndrome.

Figure 1



(a) What is the effect of Patau syndrome on the chromosomes of this female?

_____

_____

(1)

(b) Describe how the change in chromosome number in Patau syndrome was produced.

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(2)

(c) Explain why all the cells of the body will have this mutation.

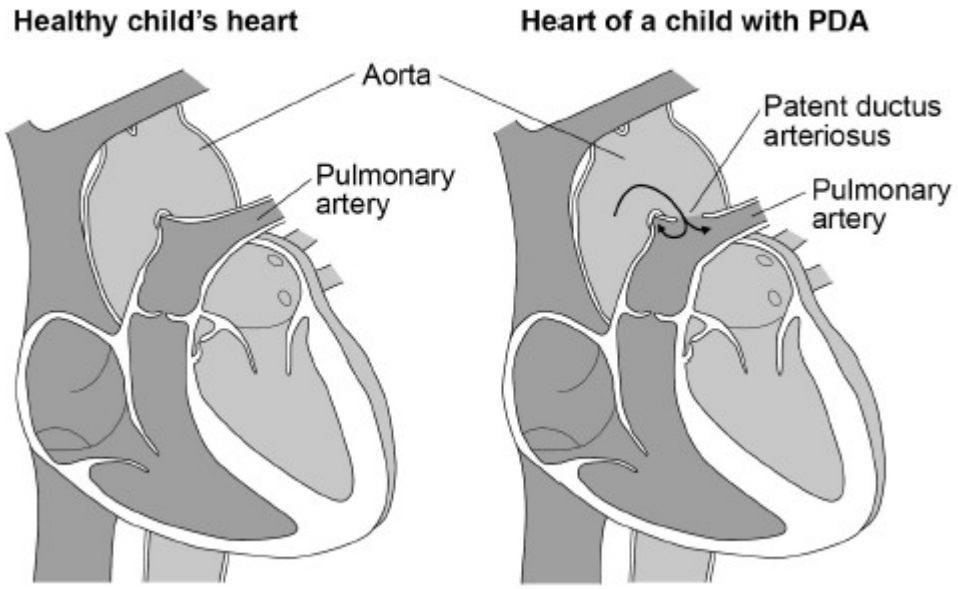
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(2)

(d) Most children born with Patau syndrome die in the first 12 months, often due to defects of circulation of blood.

One of these defects is patent ductus arteriosus (PDA). This can result in some of the blood flowing between the aorta and the pulmonary artery.
Figure 2 shows a healthy child's heart and the heart of a child with PDA.

Figure 2



Suggest how the flow of some of the blood between the aorta and pulmonary artery could cause children to die in the first 12 months.

_____

(3)

(Total 8 marks)

Q7.

(a) Contrast how an optical microscope and a transmission electron microscope work **and** contrast the limitations of their use when studying cells.

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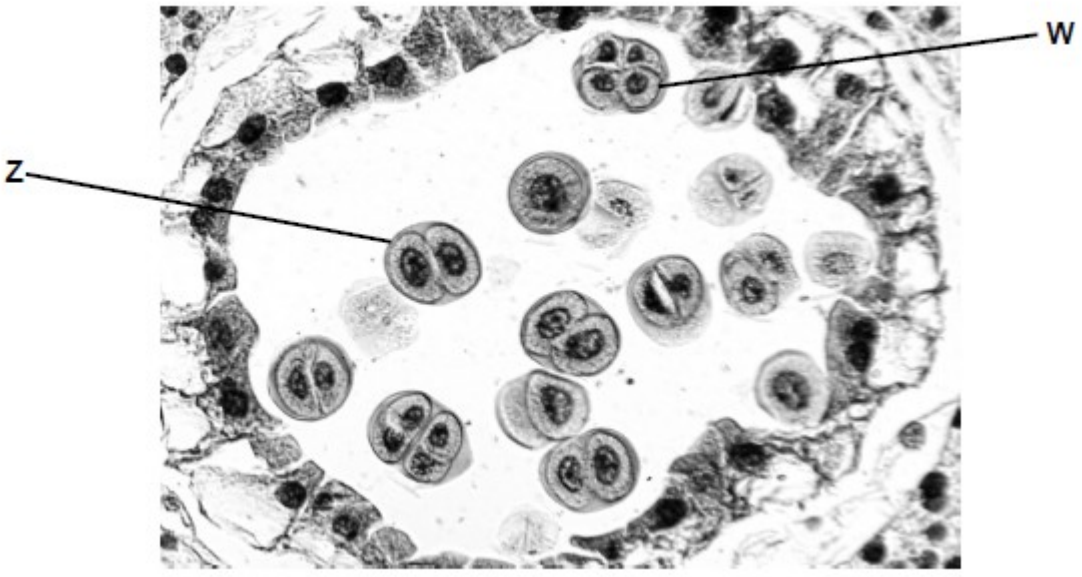
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(6)

(b) The diagram shows an image from an optical microscope of meiosis occurring in a flower bud of a flowering plant. **W** and **Z** are undergoing meiosis.



Explain the appearance of **W** and **Z**.

(4)

(c) An environmental scientist investigated a possible relationship between air pollution and the size of seeds produced by one species of tree.

He was provided with a very large number of seeds collected from a population of trees in the centre of a city and also a very large number of seeds collected from a population of trees in the countryside.

Describe how he should collect and process data from these seeds to investigate whether there is a difference in seed size between these two populations of trees.

(5)

(Total 15 marks)

Q8.

(a) Describe the appearance and behaviour of chromosomes during mitosis.

(5)

(b) Describe and explain the processes that occur during meiosis that increase genetic variation.

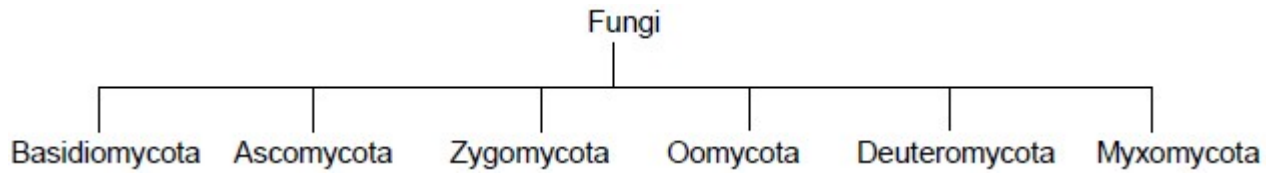
(5)

(Total 10 marks)

Q9.

Figure 1 shows one way in which the kingdom Fungi can be classified.

Figure 1



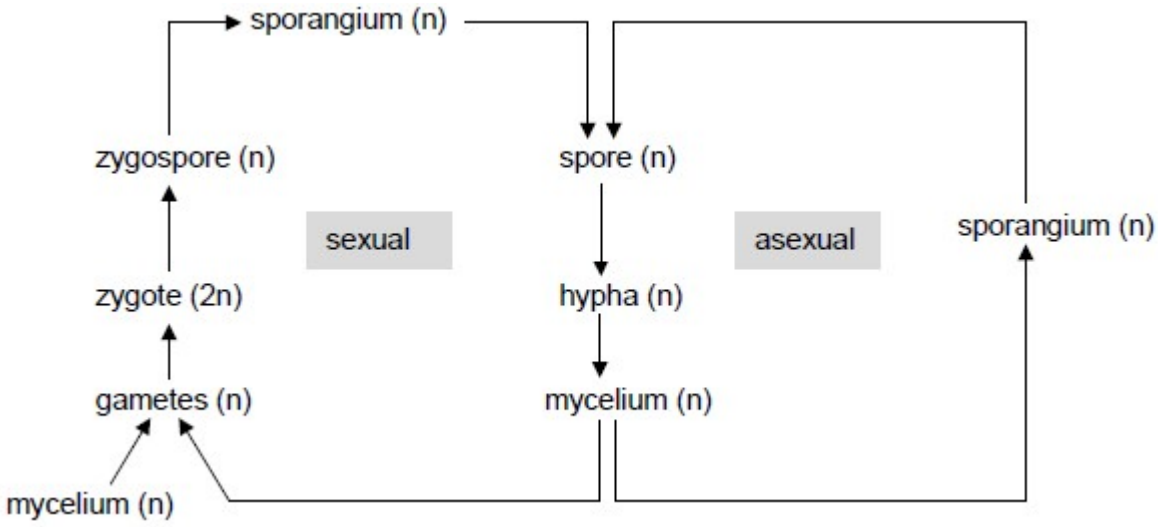
(a) Name the taxon represented by Zygomycota.

(1)

Rhizopus is a member of the Zygomycota. It has thread-like hyphae that form a mass, called a mycelium, across its food source. Vertical hyphae form spore-carrying sporangia. A new hypha grows from each spore.

Figure 2 shows the life cycle of *Rhizopus*.

Figure 2



(b) Write the letter **M** on **Figure 2** to show where meiosis occurs.

(1)

(c) **Figure 2** shows that *Rhizopus* is able to reproduce both asexually and sexually. Suggest and explain **one** advantage of asexual reproduction and **one** advantage of sexual reproduction in this life cycle.

Asexual _____

_____

_____

Sexual _____

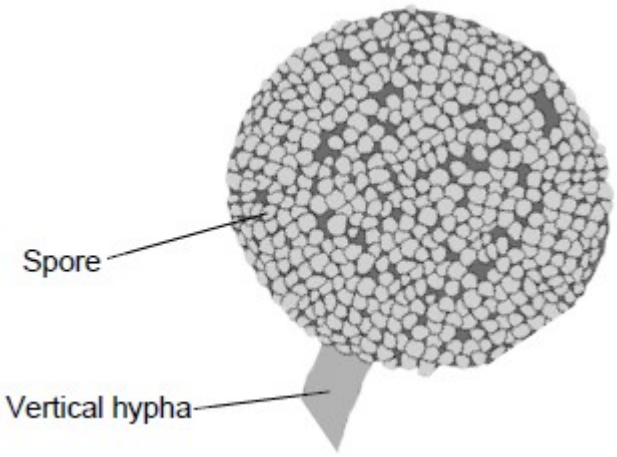
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(2)

Figure 3 shows one spore-carrying sporangium from *Rhizopus*. The magnification of **Figure 3** is × 700.

Figure 3



(d) The hypha supporting the spore-carrying sporangium is vertical.
Suggest **one** advantage of the hypha being vertical.

_____

_____

(1)

(e) A scientist wanted to calculate the mean volume of *Rhizopus* spores.
Describe how she could use **Figure 3** do this.
You may assume the spores are perfectly spherical.

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(3)

(Total 8 marks)

Q10.

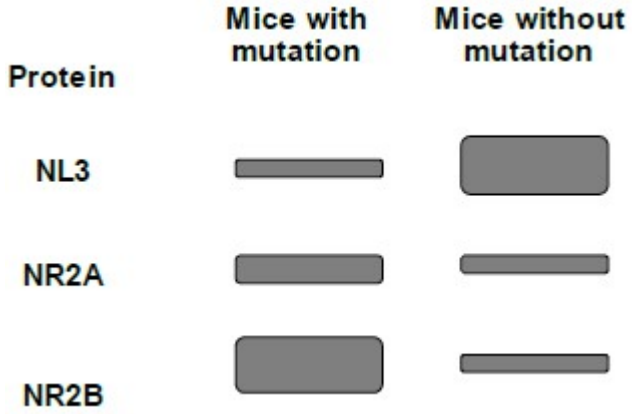
Some autism spectrum disorders (ASDs) are associated with a mutation affecting the neuroligin-3 gene. This gene codes for a protein called NL3, that is found in synapses.

Scientists investigated the effects of a mutation affecting NL3 in mice. They obtained brains from mice with the mutation and from mice without the mutation. For each type of mouse they:

- obtained a solution containing all of the proteins from synapses in one part of the brain
- separated these proteins using gel electrophoresis
- identified and measured the amount of three proteins from the solution using three different labelled antibodies.

The three proteins are parts of a postsynaptic membrane receptor.

The diagram below shows the scientists' results. Each band shows the presence of a protein. The size of a band shows the amount of the protein present.



(a) The mutation affecting NL3 in these mice was a substitution in the neuroligin-3 gene.

What is a substitution mutation?

_____

_____

_____

(1)

(b) Suggest how gel electrophoresis separated the proteins obtained from the synapses.

_____

_____

_____

_____

_____

(2)

(c) Each type of labelled antibody binds specifically to one of the proteins.

Explain why.

_____

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(3)

(d) What do these data show about the effects of the mutation on the proteins?

_____

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(2)

(e) These proteins are part of a receptor found in synapses in the part of the brain called the hippocampus. A high ratio of NR2B to NR2A protein in this receptor has been associated with good memory.

Using all of the information, suggest how the mutation affecting the NL3 protein may affect a mouse.

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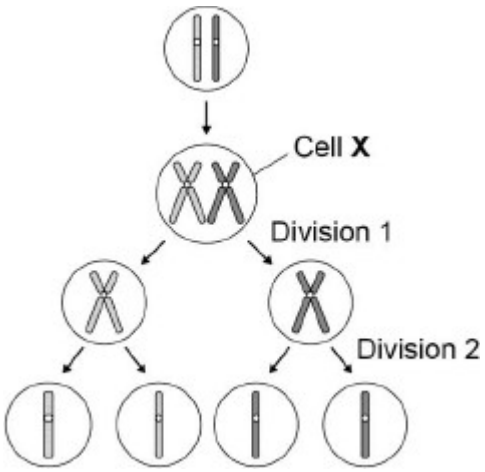
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(2)

(Total 10 marks)

Q11.

The figure below summarises the process of meiosis. The circles represent cells and the structures within each cell represent chromosomes.



(a) Describe and explain the appearance of **one** of the chromosomes in cell **X**.

_____

_____

_____

_____

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(3)

(b) Describe what has happened during division 1 in the figure above.

_____

_____

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_____

(2)

(c) Identify **one** event that occurred during division 2 but **not** during division 1.

_____

(1)

(d) Name **two** ways in which meiosis produces genetic variation.

1. _____

2. _____

(2)

(Total 8 marks)

Q12.

The table shows the taxons and the names of the taxons used to classify one species of otter. They are **not** in the correct order.

	Taxon	Name of taxon
J	Family	Mustelidae
K	Kingdom	Animalia
L	Genus	Lutra
M	Class	Mammalia
N	Order	Carnivora
O	Phylum	Chordata
P	Domain	Eukarya
Q	Species	lutra

(a) Put letters from the table above into the boxes in the correct order. Some boxes have been completed for you.

		O	**M**			**L**	**Q**

(1)

(b) Give the scientific name of this otter.

_____

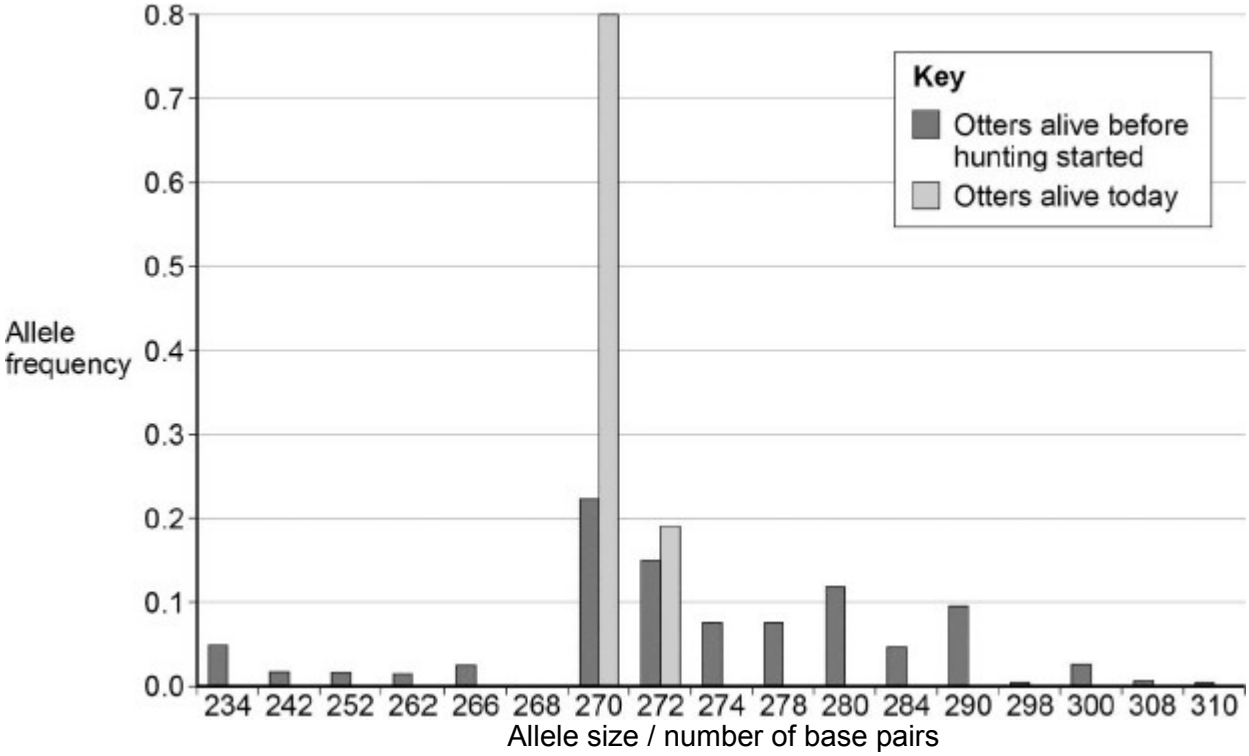
(1)

Scientists investigated the effect of hunting on the genetic diversity of otters. Otters are animals that were killed in very large numbers for their fur in the past.

The scientists obtained DNA from otters alive today and otters that were alive before hunting started.

For each sample of DNA, they recorded the number of base pairs in alleles of the same gene. Mutations change the numbers of base pairs over time.

The figure below shows the scientists' results.



(c) The scientists obtained DNA from otters that were alive before hunting started.

Suggest **one** source of this DNA.

_____

_____

(1)

(d) What can you conclude about the effect of hunting on genetic diversity in otters? Use data from the figure above to support your answer.

_____

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(2)

(e) Some populations of animals that have never been hunted show very low levels of genetic diversity.

Other than hunting, suggest **two** reasons why populations might show very low levels of genetic diversity.

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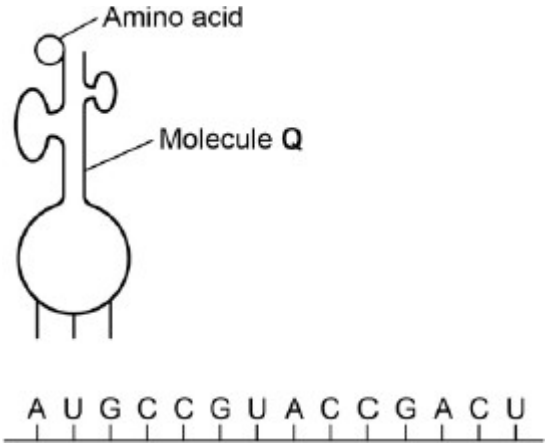
2. _____

_____

(2)
(Total 7 marks)

Q13.

The diagram below represents one process that occurs during protein synthesis.



(a) Name the process shown.

_____

(1)

(b) Identify the molecule labelled **Q**.

_____

(1)

(c) In the diagram above, the first codon is AUG. Give the base sequence of:

the complementary DNA base sequence _____

the missing anticodon _____

(2)

The table below shows the base triplets that code for two amino acids.

Amino acid	**Encoding base triplet**
Aspartic acid	GAC, GAU
Proline	CCA, CCG, CCC, CCU

(d) Aspartic acid and proline are both amino acids. Describe how two amino acids differ from one another. You may use a diagram to help your description.

_____

_____

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(1)

(e) Deletion of the sixth base (G) in the sequence shown in the diagram above would change the nature of the protein produced but substitution of the same base would not. Use the information in the table and your own knowledge to explain why.

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(3)

(Total 8 marks)

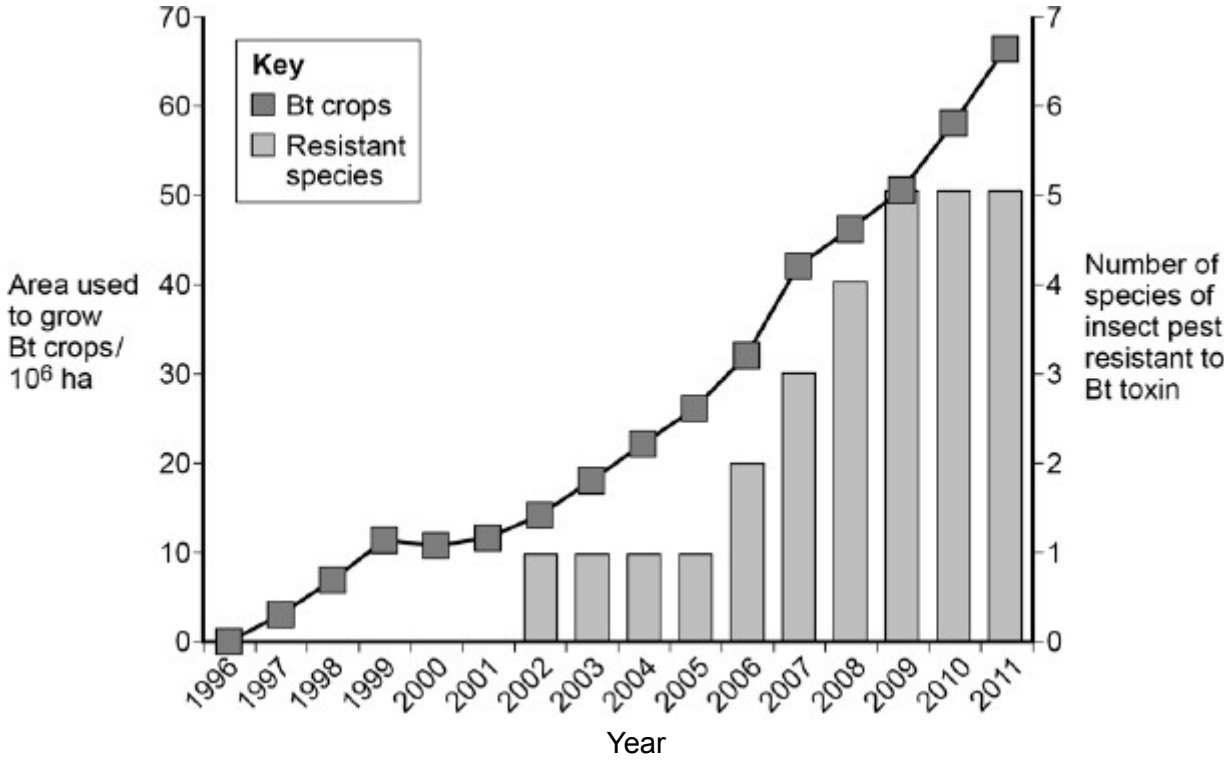
Q14.

To reduce the damage caused by insect pests, some farmers spray their fields of crop plants with pesticide. Many of these pesticides have been shown to cause environmental damage.

Bt plants have been genetically modified to produce a toxin that kills insect pests. The use of Bt crop plants has led to a reduction in the use of pesticides.

Scientists have found that some species of insect pest have become resistant to the toxin produced by the Bt crop plants.

The figure below shows information about the use of Bt crops and the number of species of insect pest resistant to the Bt toxin in one country.



(a) Can you conclude that the insect pest resistant to Bt toxin found in the years 2002 to 2005 was the same insect species? Explain your answer.

_____

_____

(1)

(b) One farmer stated that the increase in the use of Bt crop plants had caused a mutation in one of the insect species and that this mutation had spread to other species of insect. Was he correct? Explain your answer.

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(4)

(c) There was a time lag between the introduction of Bt crops and the appearance of the first insect species that was resistant to the Bt toxin.
Explain why there was a time lag.

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_____

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(3)

(Total 8 marks)

Q15.

Table 1 shows how a bird called the bluethroat (*Luscinia svecica*) is classified by biologists.

Table 1

Taxon	Name of taxon
Domain	Eukaryota
	Animalia
	Chordata
	Aves
	Passeriformes
	Muscicapidae
Genus	
Species	

(a) Complete **Table 1** by filling the seven blank spaces with the correct terms.

(2)

A group of scientists investigated genetic diversity in different species of bird. For each species, the scientists:

- collected feathers from a large number of birds
- extracted DNA from cells attached to each feather
- analysed the samples of DNA to find genetic diversity.

Table 2 summarises their results.

Table 2

Species of bird	Number of genes examined	Number of genes examined that showed genetic diversity

Willow flycatcher	708	197
House finch	269	80
Bluethroat	232	81

(b) In this investigation, what is meant by **genetic diversity?**

_____

_____

(1)

(c) The scientists concluded that the bluethroat showed greater genetic diversity than the willow flycatcher. Explain why they reached this conclusion. Use calculations to support your answer.

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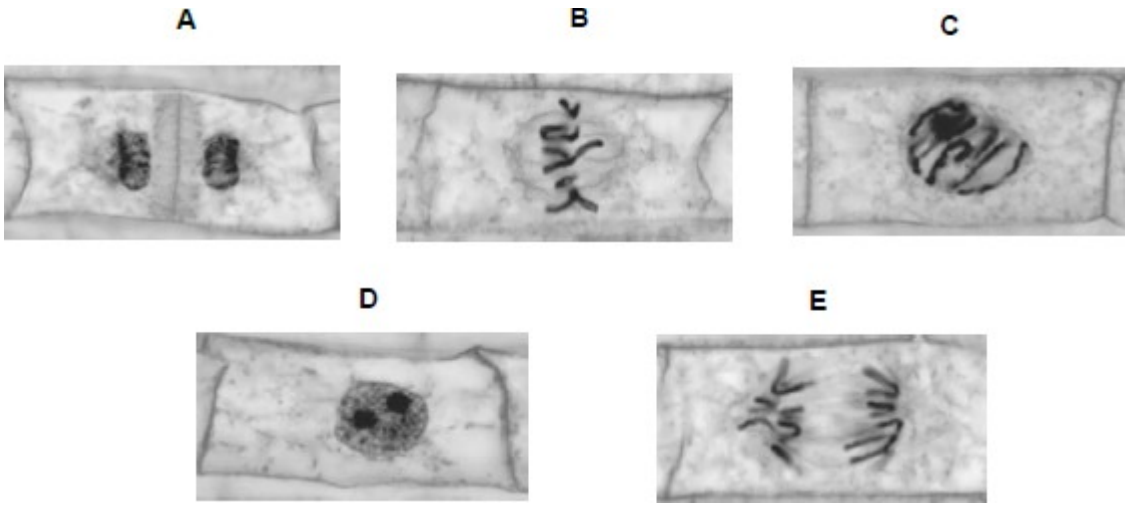
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(2)

(Total 5 marks)

Q16.

The figure below shows some cells from an onion root tip at different stages of the cell cycle.



© Ed Reschke/Oxford Scientific/Getty Images

(a) Place stages **A** to **E** in the correct order. Start with stage **D**.

D

_____

(1)

To obtain these images, the onion root tip was cut off, stained and put on a microscope

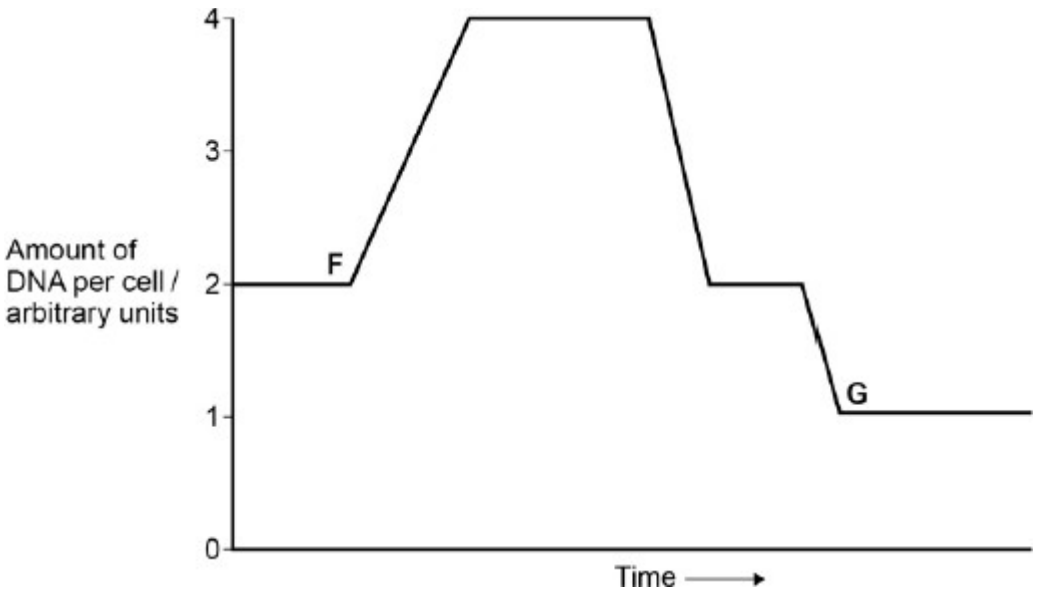
slide. A cover slip was placed on top. The root tip was then firmly squashed and viewed under an optical microscope.

(b) Complete the table below to give **one** reason why each of these steps was necessary.

Step	Reason
Taking cells from the root tip	
Firmly squashing the root tip	

(2)

The figure below shows how the amount of DNA per cell changed during interphase and meiosis in an animal.



(c) Explain how the behaviour of chromosomes causes these changes in the amount of DNA per cell between **F** and **G**.

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(3)

(d) What would happen to the amount of DNA per cell at fertilisation of cell **G?**

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(1)

(Total 7 marks)

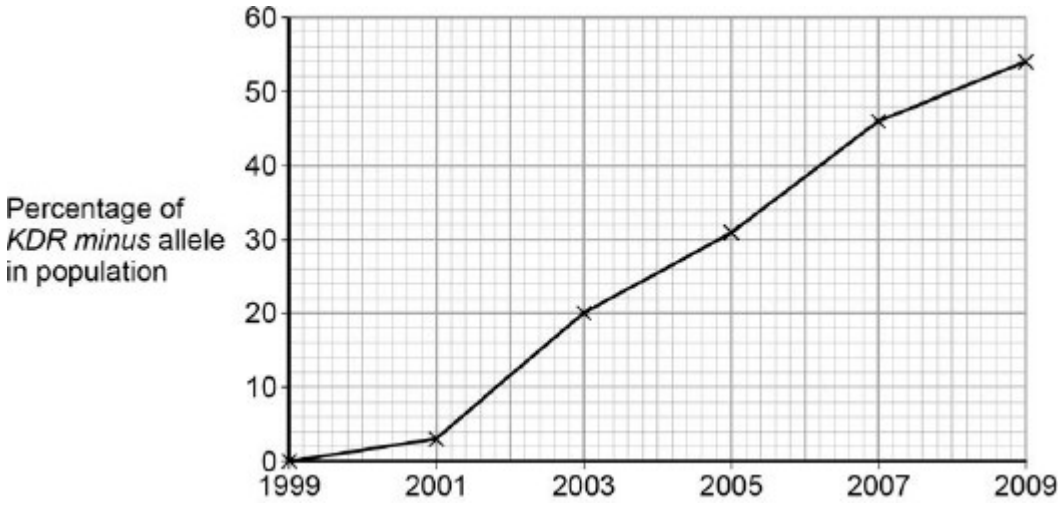
Q17.

Malaria is a disease that is spread by insects called mosquitoes. In Africa, DDT is a pesticide used to kill mosquitoes, to try to control the spread of malaria.

Mosquitoes have a gene called *KDR*. Today, some mosquitoes have an allele of this gene, *KDR minus*, that gives them resistance to DDT. The other allele, *KDR plus*, does not give resistance.

Scientists investigated the frequency of the *KDR minus* allele in a population of mosquitoes in an African country over a period of 10 years.

The figure below shows the scientists' results.



(a) Use the Hardy–Weinberg equation to calculate the frequency of mosquitoes heterozygous for the *KDR* gene in this population in 2003.

Show your working.

Frequency of heterozygotes in population in 2003 _____

(2)

(b) Suggest an explanation for the results in the figure above.

_____

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(4)

The *KDR plus* allele codes for the sodium ion channels found in neurones.

(c) When DDT binds to a sodium ion channel, the channel remains open all the time. Use this information to suggest how DDT kills insects.

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(2)

(d) Suggest how the *KDR minus* allele gives resistance to DDT.

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(2)

(Total 10 marks)

Q18.

Read the following passage carefully.

A large and growing number of disorders are now known to be due to types of mitochondrial disease (MD). MD often affects skeletal muscles, causing muscle weakness.

We get our mitochondria from our mothers, via the fertilised egg cell. Fathers do not pass on mitochondria via their sperm. Some mitochondrial diseases are caused by mutations of mitochondrial genes inside the mitochondria. Most mitochondrial diseases are caused by mutations of genes in the cell nucleus that are involved in the functioning

of mitochondria. These mutations of nuclear DNA produce recessive alleles.

One form of mitochondrial disease is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the tRNA. This results in the formation of a non-functional protein in the mitochondrion.

There are a number of ways to try to diagnose whether someone has a mitochondrial disease. One test involves measuring the concentration of lactate in a person's blood after exercise. In someone with MD, the concentration is usually much higher than normal. If the lactate test suggests MD, a small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation.

Use information in the passage and your own knowledge to answer the following questions.

(a) Mitochondrial disease (MD) often causes muscle weakness (lines 1–3). Use your knowledge of respiration and muscle contraction to suggest explanations for this effect of MD.

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(3)

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease. The type of mitochondrial disease was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

(b) Use the information in lines 5–9 and your knowledge of inheritance to suggest why:

- all of couple **A**'s children had an MD
- only one of couple **B**'s children had an MD.

Couple **A** _____

_____

_____

Couple **B** _____

(4)

(c) Suggest how the change in the anticodon of a tRNA leads to MD (lines 10–13).

(3)

(d) If someone has MD, the concentration of lactate in their blood after exercise is usually much higher than normal (lines 15–17). Suggest why.

(3)

(e) A small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation (lines 18–19).

From this sample:

- how would enough DNA be obtained for sequencing?
- how would sequencing allow the identification of a mutation?

(2)

(Total 15 marks)

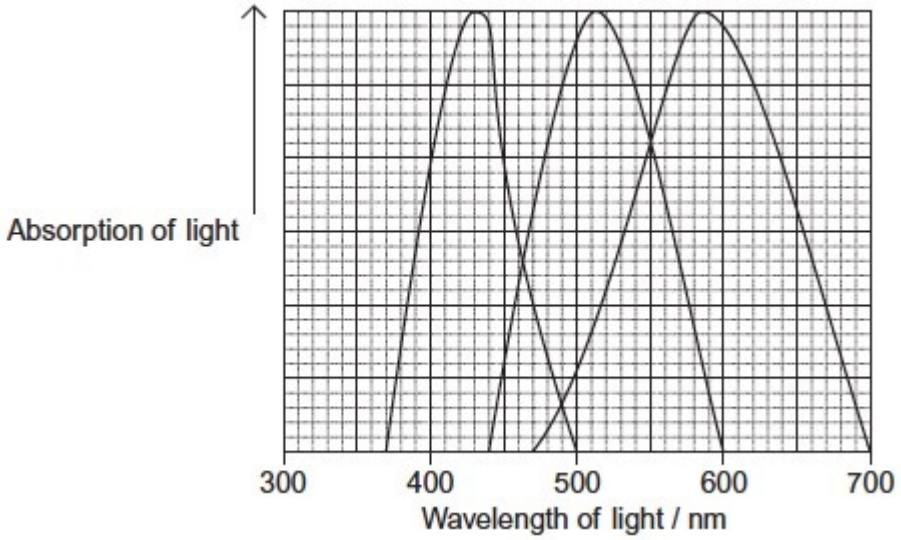
Q19.

The retinas in the eyes of humans and birds have cone cells that absorb light of different wavelengths.

Resource A

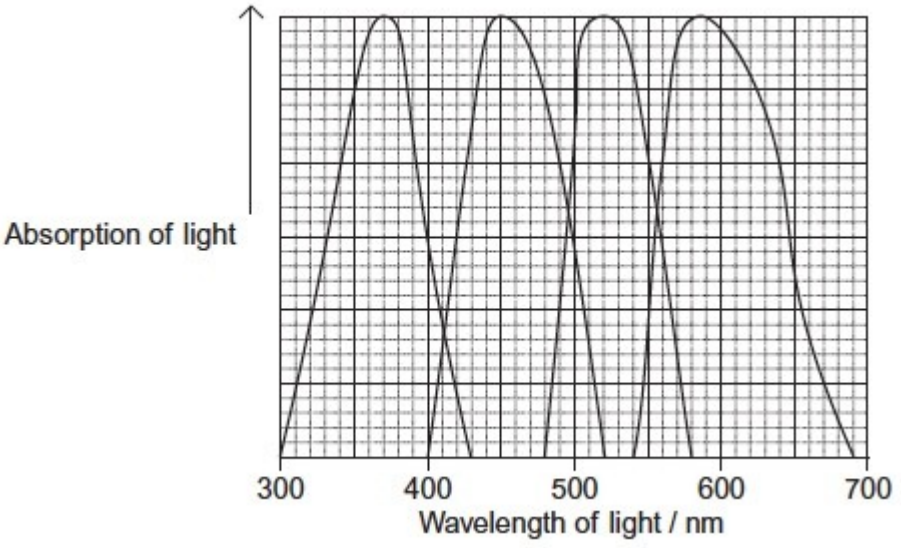
A scientist recorded the absorption of light of different wavelengths by different types of human cone cells. Her results are shown in **Figure 1**. Each curve shows the absorption of light by one type of cone cell.

Figure 1



She also recorded the absorption of light of different wavelengths by different types of bird cone cells. These results are shown in **Figure 2**. Each curve shows the absorption of light by one type of cone cell.

Figure 2



Resource B

Bluethroats are a species of small brightly coloured bird. The feathers on the throats of male birds reflect UV light (370 nm). Scientists investigated the response of female bluethroats to this reflected UV light.

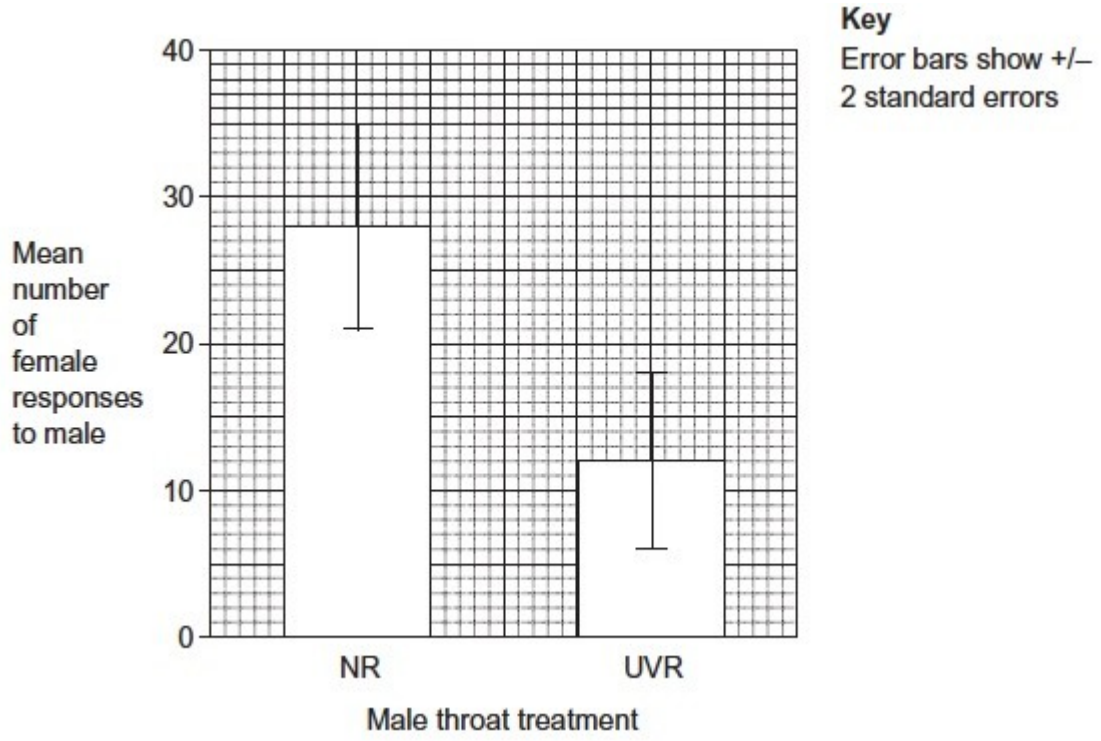
The scientists used 40 male birds selected because they were very similar to each other. The scientists treated the throat feathers of male birds as follows:

- they put a clear oil on the throat feathers of 20 males. They described these males as no UV reduction (NR).
- they put the same oil on the throat feathers of another 20 males but the oil contained a substance that absorbs UV light. They described these males as UV reduced (UVR).

In each experiment, the scientists placed two males where a female could see them. One male was NR and the other was UVR. During the next 5 minutes, they recorded how many times the female responded by moving towards each male.

Their results are shown in **Figure 3**.

Figure 3



Use **Resource B** to answer Questions (a) to (d).

(a) The male birds were selected because they were very similar to each other. Suggest **two** reasons why it was important that they were of similar age.

1

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(2)

(b) Of the 40 male birds the scientists selected 20 to receive the NR treatment. They selected these birds at random.
Suggest how.

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(1)

(c) The scientists recorded how many times each female moved towards a male.

In designing the experiment, suggest **two** assumptions the scientists made when they decided to record this movement.

1
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(2)

(d) The pigment in the throat feathers of the male birds that reflects UV light is a protein.
This protein arose by a gene mutation.
Explain how a gene mutation could result in a new protein.

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(3)

Use **Resources A and B** to answer Question (e).

(e) A student who read both resources concluded that female bluethroats are attracted to the blue throat feathers of males when selecting a mate.

Do these data support this conclusion? Give reasons for your answer.

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(4)

(Total 12 marks)

Q20.

Read the following passage.

Alzheimer's disease leads to dementia. This involves small β-amyloid proteins binding together to form structures called plaques in the brain.

Nerve cells in the brain produce a large protein called amyloid-precursor protein that has a complex shape. This protein is the substrate of two different enzymes, α-secretase and β-secretase. These enzymes are normally produced in the brain. One product of the reaction catalysed by β-secretase is a smaller protein that can lead to β-amyloid protein formation. Many people with Alzheimer's disease have mutations that decrease α-secretase production, or increase β-secretase production.

One possible type of drug for treating Alzheimer's disease is a competitive inhibitor of β-secretase. When some of these types of drugs were trialled on patients, the trials had to be stopped because some patients developed serious side effects.

Use information from the passage and your own knowledge to answer the following questions.

(a) Suggest how amyloid-precursor protein can be the substrate of two different enzymes, α-secretase and β-secretase (lines 3–5).

_____

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(2)

(b) One product of the reaction catalysed by β-secretase is a smaller protein (lines 6–7).

Describe what happens in the hydrolysis reaction that produces the smaller protein from amyloid-precursor protein.

_____

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(2)

(c) Many people with Alzheimer's disease have mutations that decrease α-secretase production, or increase β-secretase production (lines 8–9).

Use the information provided to explain how these mutations can lead to Alzheimer's disease.

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(3)

(d) One possible type of drug for treating Alzheimer's disease is a competitive inhibitor of β-secretase (lines 10–11).

Explain how this type of drug could prevent Alzheimer's disease becoming worse.

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(2)

(e) When some of these types of drugs were trialled on patients, the trials were stopped because some patients developed serious side effects (lines 11–13).

Using the information provided, suggest why some patients developed serious side effects.

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(1)

(Total 10 marks)

Q21.

(a) HIV attaches to a specific protein receptor on helper T cells. A low percentage of people have a mutation of the *CCR5* gene which codes for this protein receptor. This mutation results in a non-functional protein receptor.

Explain how this mutation can result in the production of a non-functional protein receptor.

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(4)

(b) People with the *CCR5* mutation show a greater resistance to developing AIDS.

Explain why.

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(2)

(c) The frequency of the *CCR5* mutation is highest in Europe. Scientists have collected data on the history and number of HIV infections in Europe. Using these data, scientists have concluded that the high frequency of the *CCR5* mutation is not due to natural selection in response to HIV.

Suggest **two** reasons why scientists reached this conclusion.

1. _____

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2. _____

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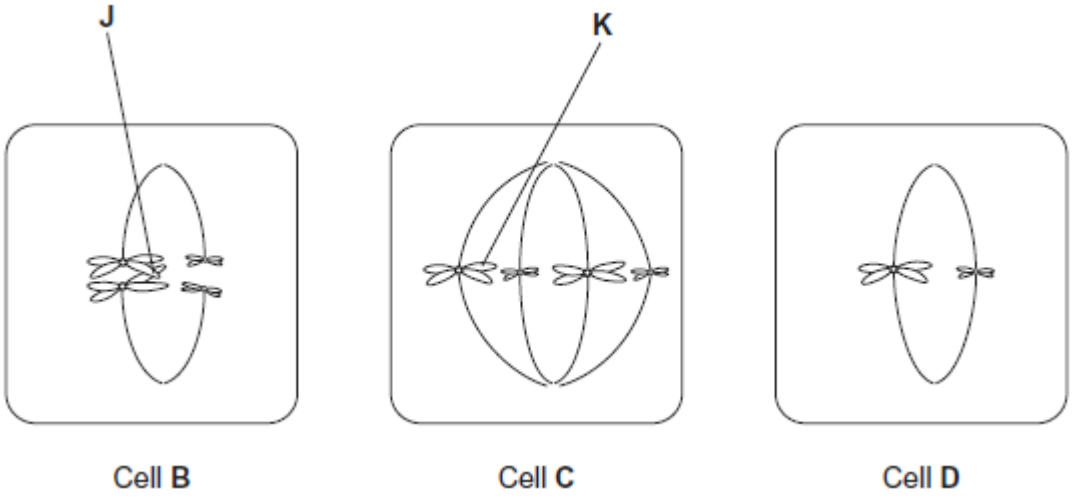
(2)

(Total 8 marks)

Q22.

Figure 1 shows three cells, **B**, **C** and **D**, from tissues in the same organism. Each cell is in a stage of either mitosis or meiosis.

Figure 1



(a) Complete the table with a tick if the cell shows the feature.

	Cell B	Cell C	Cell D
homologous chromosomes are present			
a stage of mitosis			

(2)

(b) Describe and explain the appearance of chromosome **K** in cell **C**.

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(2)

(c) Explain what is happening at point **J** in cell **B**.

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(2)

(d) Use information from all three cells in **Figure 1** to explain how the number of chromosomes in cell **D** was produced.

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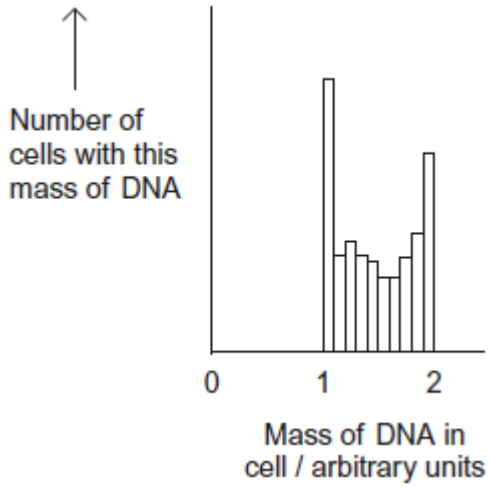
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(1)

(e) **Figure 2** shows the mass of DNA present in cells of a population of healthy cells where mitosis is occurring.

Figure 2



Explain why some cells contain a mass of DNA between 1 and 2 arbitrary units.

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(1)

(Total 8 marks)

Q23.

(a) A mutation can lead to the production of a non-functional enzyme. Explain how.

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(6)

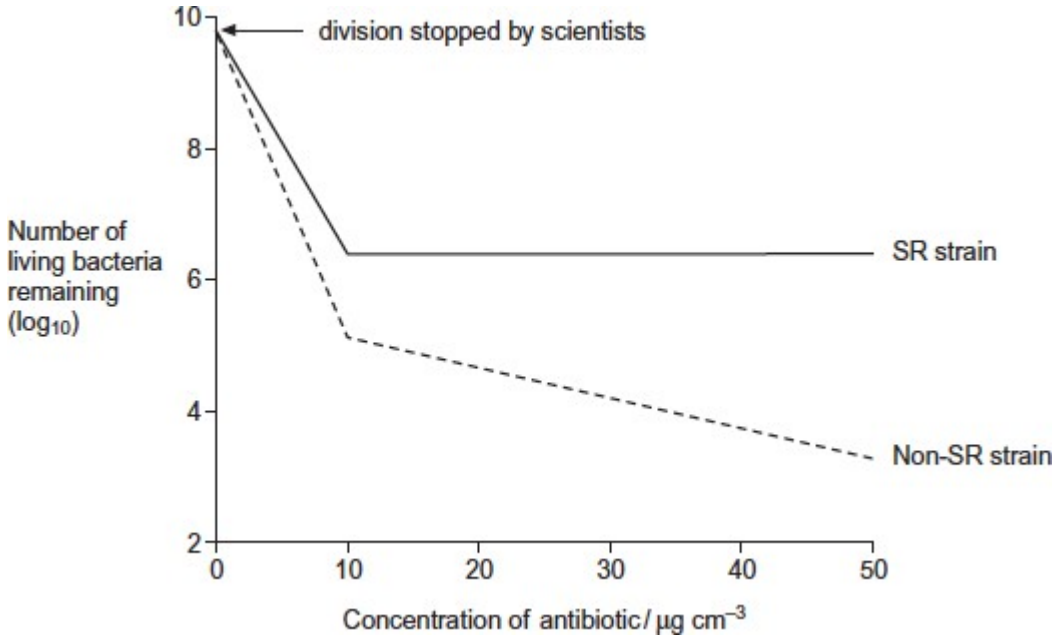
Scientists investigated the effect of a specific antibiotic on two strains of the same species of bacterium.

- One strain, SR, shows a **stringent response** in the presence of this antibiotic. Part of this response involves stopping cell division. This gives this strain a greater resistance to the effects of this antibiotic.
- The other strain, non-SR, cannot carry out a stringent response.

The scientists grew cultures of the SR strain and the non-SR strain containing the same number of bacterial cells. They then stopped each strain from dividing and exposed them to different concentrations of the antibiotic. After a fixed time, the scientists estimated the number of living bacteria remaining in the cultures.

Figure 1 shows their results.

Figure 1



(b) Describe differences in the effect of increasing the concentration of antibiotic on the SR strain and the non-SR strain.

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(2)

(c) One way in which the stringent response gives resistance to this antibiotic is by stopping cell division.

The scientists concluded that stopping cell division is not the **only** way in which the stringent response gives resistance to this antibiotic.

Explain how **Figure 1** supports this conclusion.

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(2)

(d) The stringent response involves a number of enzyme-catalysed reactions.

Explain how scientists could use this knowledge to design drugs that make the treatment of infections caused by the SR strain more successful.

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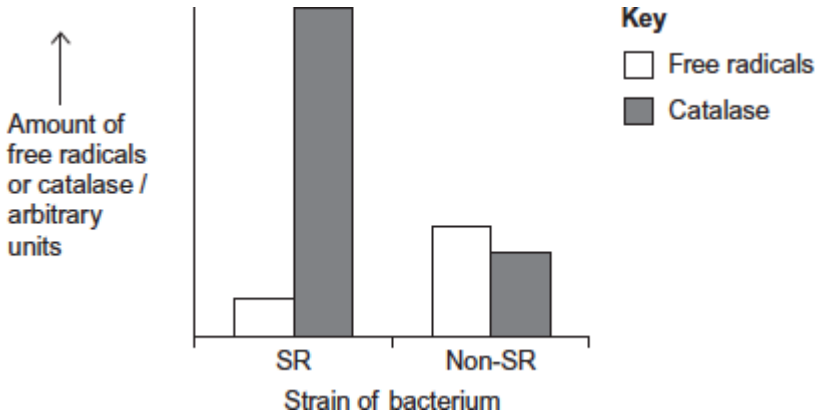
(2)

The antibiotic damages the bacterium by causing the production of substances called free radicals.

The scientists exposed the SR strain and the non-SR strain to the antibiotic. They then measured the amounts of free radicals and an enzyme called catalase in both strains.

Figure 2 shows their results.

Figure 2



(e) Use the information provided and **Figure 2** to suggest an explanation for the greater resistance of the SR strain to this antibiotic.

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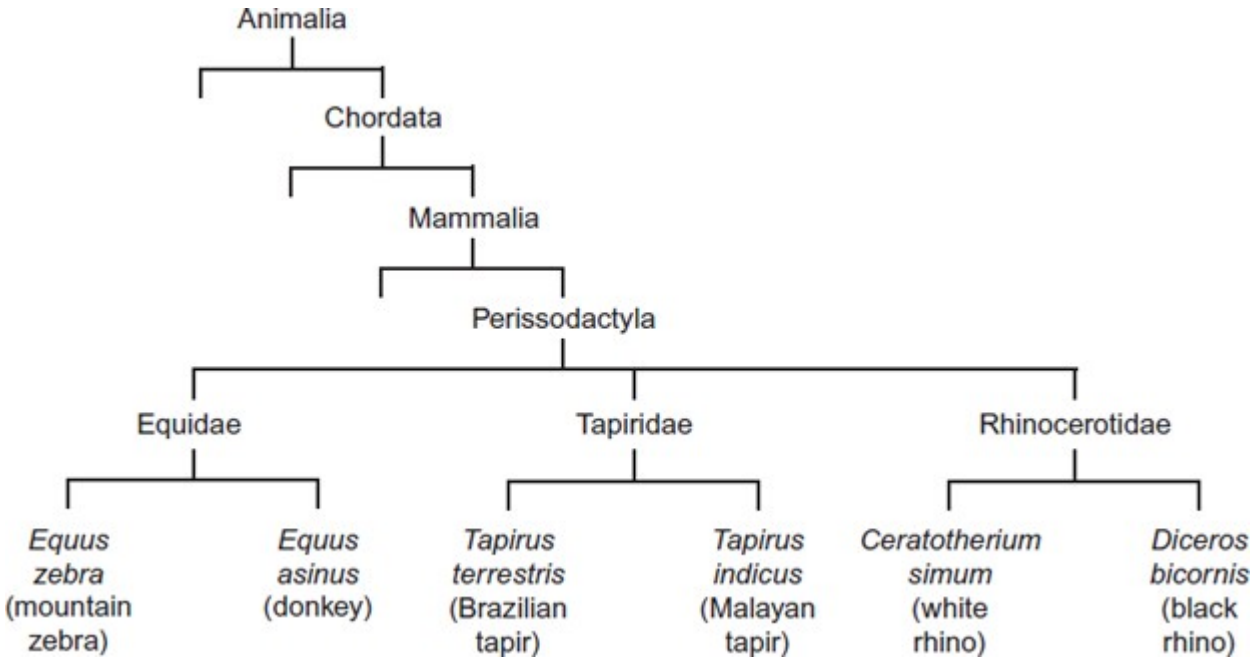
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(3)

(Total 15 marks)

Q24.

The following figure shows how some animals with hooves are classified.



(a) This type of classification can be described as a phylogenetic hierarchy.

(i) What is meant by a **hierarchy**?

_____

_____

_____

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(2)

(ii) How many different families are shown in the figure?

☐

(1)

(iii) To which phylum does the white rhino belong?

_____

(1)

(b) (i) Explain the role of independent segregation in meiosis.

_____

_____

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(2)

(ii) A zedonk is the offspring produced from breeding a mountain zebra with a donkey.

- The body cells of a mountain zebra contain 32 chromosomes.
- The body cells of a donkey contain 62 chromosomes.

Use this information to suggest why zedonks are usually infertile.

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(2)

(Total 8 marks)

Q25.

(a) Explain how the structure of DNA is related to its functions.

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(6)

Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different combinations of N and M alleles of the genes. A risk value of 1.00 indicates no

increased risk. The following table shows the scientists' results.

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(b) What do these data suggest about the relative importance of the mutant alleles of genes **C**, **D** and **E** on **increasing** the risk of developing lung cancer? Explain your answer.

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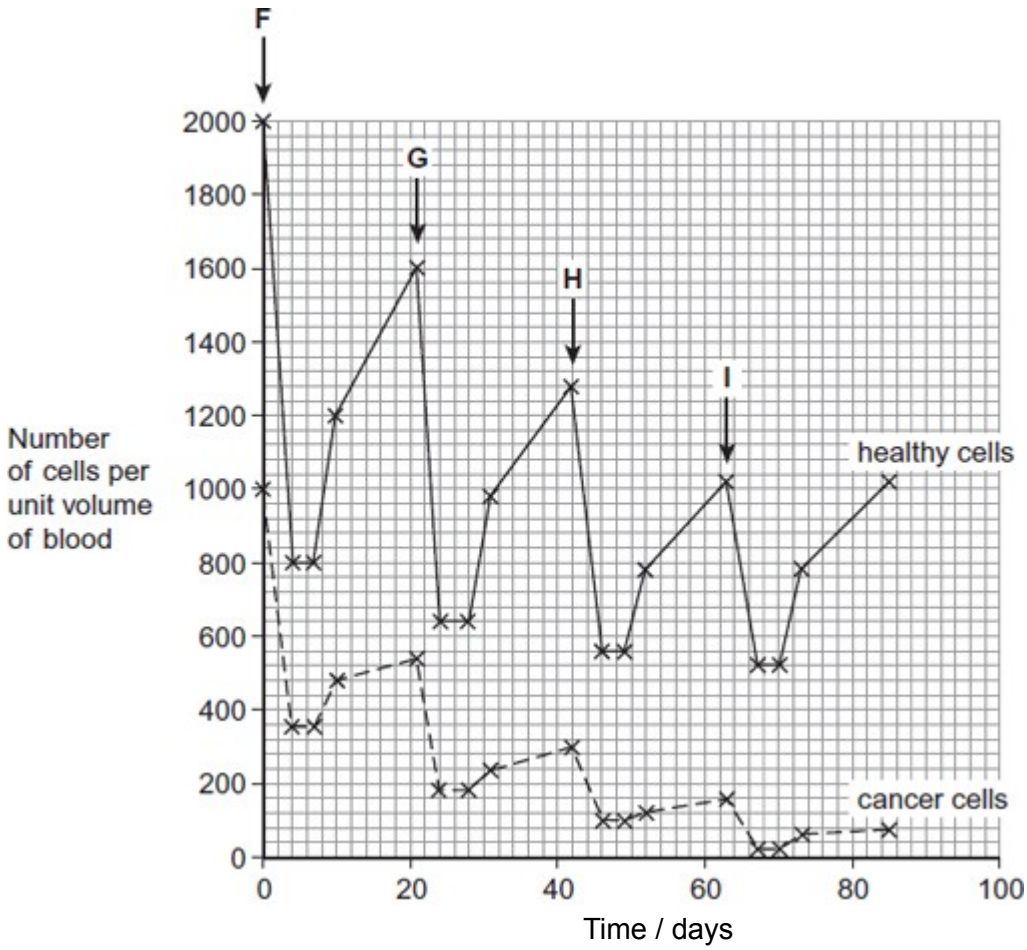
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(3)

Chemotherapy is the use of a drug to treat cancer. The drug kills dividing cells.
The figure below shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.



(c) Calculate the rate at which healthy cells were killed between days 42 and 46.

_____ cells killed per unit volume of blood per day

(1)

(d) Describe similarities and differences in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

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(3)

(e) More cancer cells could be destroyed if the drug was given more frequently.

Suggest why the drug was **not** given more frequently.

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(2)

(Total 15 marks)

Q26.

(a) (i) Why is the genetic code described as being universal?

_____

_____

(1)

(ii) The genetic code uses four different DNA bases. What is the maximum number of different DNA triplets that can be made using these four bases?

(1)

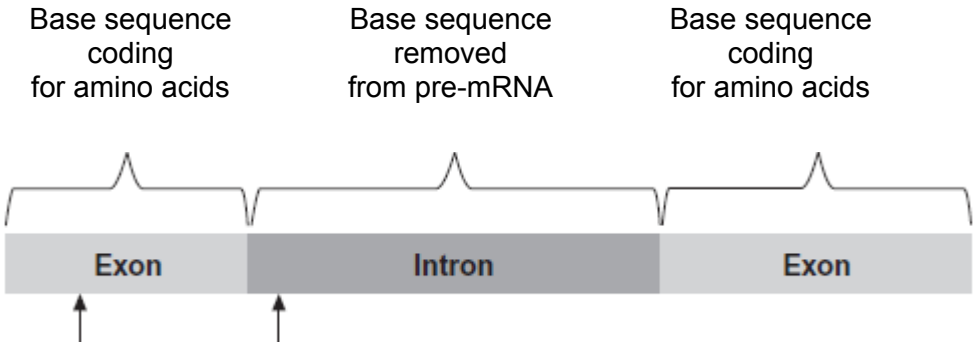
Transcription of a gene produces pre-mRNA.

(b) Name the process that removes base sequences from pre-mRNA to form mRNA.

_____

(1)

(c) The figure below shows part of a pre-mRNA molecule. Geneticists identified two mutations that can affect this pre-mRNA, as shown in the figure.



Mutation 1, single base deletion

Mutation 2, single base substitution

(i) **Mutation 1** leads to the production of a non-functional protein.

Explain why.

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(3)

(ii) What effect might **mutation 2** have on the protein produced?

Explain your answer.

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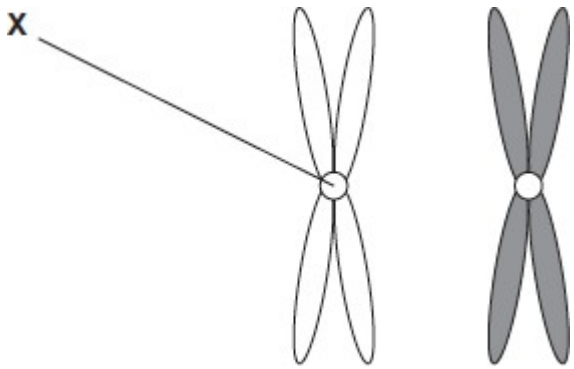
(2)

(Total 8 marks)

Q27.

(a) **Figure 1** shows one pair of homologous chromosomes.

Figure 1



(i) Name **X.**

_____

(1)

(ii) Describe the role of **X** in mitosis.

_____

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(2)

(iii) Homologous chromosomes carry the same genes but they are **not** genetically identical.Explain why.

_____

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_____

(1)

(b) **Figure 2** shows three pairs of homologous chromosomes in a cell at the end of cell division.

Figure 2



(i) The appearance of each chromosome in **Figure 2** is different from those shown in **Figure 1.** Explain why.

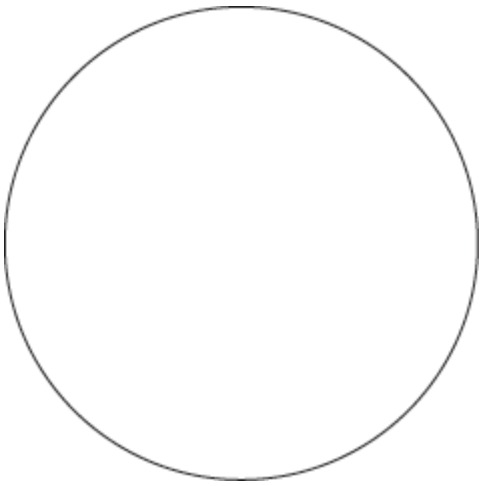
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(1)

(ii) Complete the diagram to show the chromosomes in one cell that could be produced from the cell in **Figure 2** as a result of meiosis.



(2)

(iii) Other than independent segregation, give **one** way in which meiosis allows the production of genetically different cells.

_____

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(1)

(Total 8 marks)

Q28.

Phenylketonuria is a disease caused by mutations of the gene coding for the enzyme PAH. The table shows part of the DNA base sequence coding for PAH. It also shows a mutation of this sequence which leads to the production of non-functioning PAH.

DNA base sequence coding for PAH	C	A	G	T	T	C	G	C	T	A	C	G
DNA base sequence coding for non-functioning PAH	C	A	G	T	T	C	C	C	T	A	C	G

(a) (i) What is the maximum number of amino acids for which this base sequence could code?

(1)

(ii) Explain how this mutation leads to the formation of non-functioning PAH.

_____

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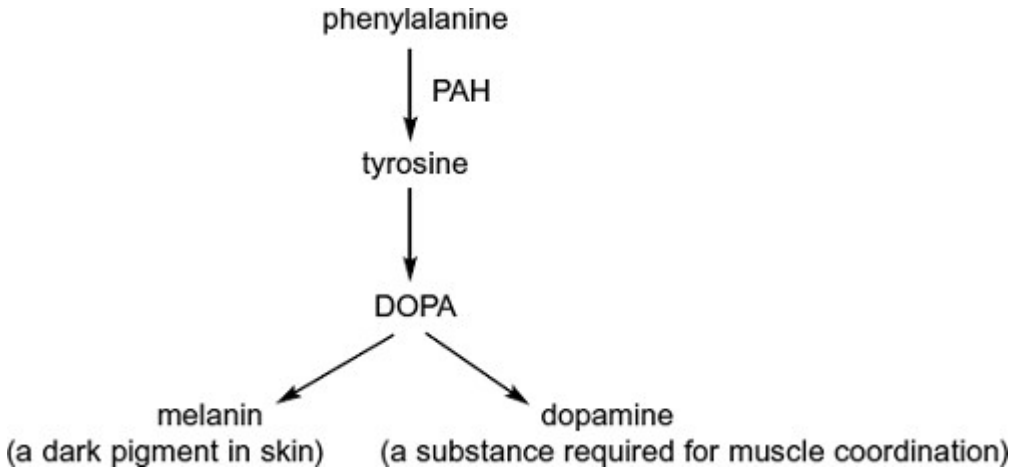
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(3)

PAH catalyses a reaction at the start of two enzyme-controlled pathways.
The diagram shows these pathways.



(b) Use the information in the diagram to give **two** symptoms you might expect to be visible in a person who produces non-functioning PAH.

1. _____

2. _____

(2)

(c) One mutation causing phenylketonuria was originally only found in one population in central Asia. It is now found in many different populations across Asia. Suggest how the spread of this mutation may have occurred.

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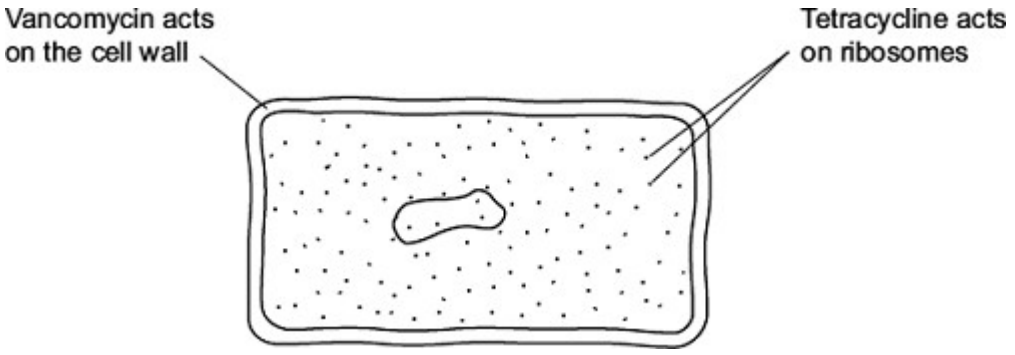
_____

(1)

(Total 7 marks)

Q29.

The diagram shows the structure of a bacterium and the sites of action of two antibiotics.



(a) (i) Use information in the diagram to explain why vancomycin does **not** affect human cells.

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(1)

(ii) Use information in the diagram to explain how tetracycline prevents bacterial growth.

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(1)

(b) Frequent treatment with vancomycin can result in resistant strains of bacteria. Explain how.

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(2)

(Total 4 marks)

Q30.

(a) Explain what is meant by genetic diversity.

_____

_____

(1)

(b) Apart from genetic factors what other type of factor causes variation within a species?

_____

(1)

(c) The spotted owl is a bird. Numbers of spotted owls have decreased over the past 50 years. Explain how this decrease may affect genetic diversity.

_____

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_____

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(2)

(Total 4 marks)

Q31.

(a) *Clostridium difficile* is a bacterium that is present in the gut of up to 3% of healthy adults and 66% of healthy infants.

(i) *C. difficile* rarely causes problems, either in healthy adults or in infants. This is because its numbers are kept low by competition with harmless bacteria that normally live in the intestine.

Use this information to explain why some patients treated with antibiotics can be affected by *C. difficile*.

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(2)

(ii) Suggest why older people are more likely to be affected by *C. difficile*.

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_____

(1)

(b) The antibiotic methicillin inhibits the enzyme transpeptidase. This enzyme is used by some bacteria to join monomers together during cell wall formation. Methicillin has a similar structure to these monomers. Use this information to explain how methicillin inhibits the enzyme transpeptidase.

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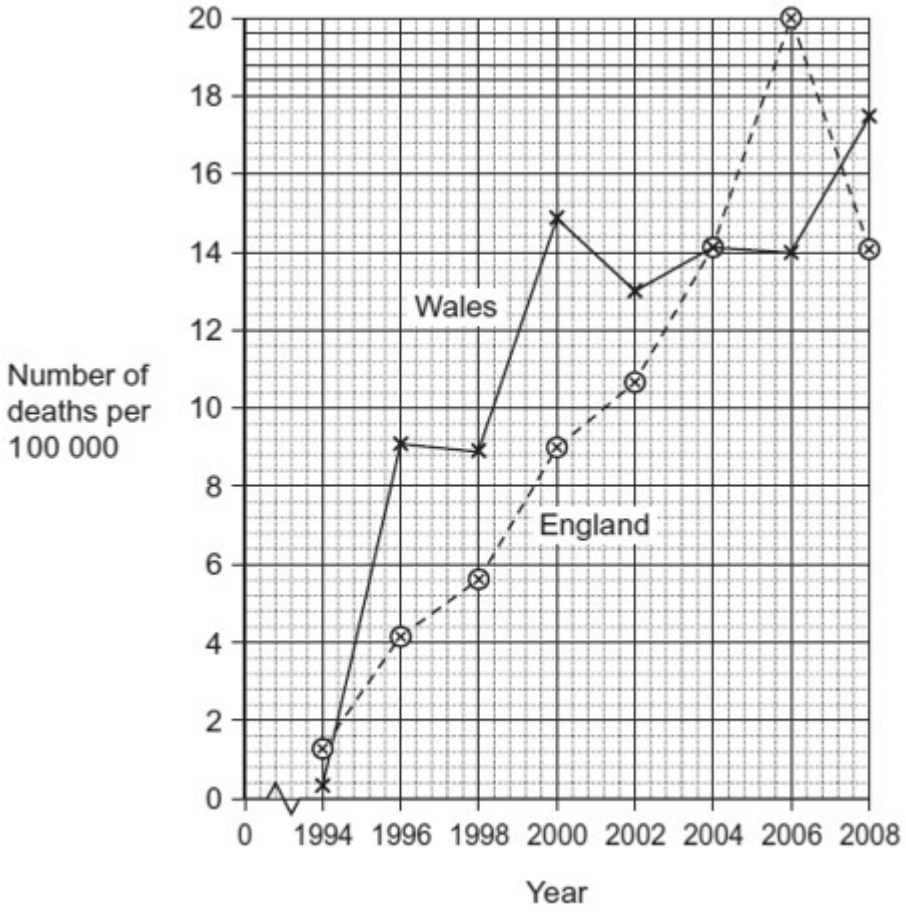
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(2)

(c) MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused

by this bacterium because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA. The graph shows the number of deaths in England and Wales between 1994 and 2008 caused by MRSA.



(i) It may be difficult to identify MRSA as the actual cause of death. Explain why.

_____

_____

_____

(1)

(ii) Describe the change in the number of deaths caused by MRSA in England in the period shown in the graph.

_____

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(1)

(iii) Calculate the percentage increase in the number of deaths caused by MRSA in Wales from 1996 to 2006. Show your working.

Answer _____

(2)

(Total 9 marks)

Q32.

The table shows some differences between three varieties of banana plant.

	Variety **A**	Variety **B**	Variety **C**
Number of chromosomes in a leaf cell	22	33	44
Growth rate of fruit / cm^3 $week^{-1}$	2.9	6.9	7.2
Breaking strength of leaf / arbitrary units	10.8	9.4	7.8

(a) (i) How many chromosomes are there in a male gamete from variety **C**?

(1)

(ii) Variety **B** cannot produce fertile gametes. Use information in the table to explain why.

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(2)

In some countries very strong winds may occur. Banana growers in these countries choose to grow variety **B**.

(b) (i) Use the data in the table to explain why banana growers in these countries choose to grow variety **B** rather than variety **A**.

_____

_____

_____

(1)

(ii) Use the data in the table to explain why banana growers in these countries choose to grow variety **B** rather than variety **C**.

_____

_____

_____

(1)

(c) Banana growers can only grow new variety **B** plants from suckers. Suckers grow from cells at the base of the stem of the parent plant.

Use your knowledge of cell division to explain how growing variety **B** on a large scale will affect the genetic diversity of bananas.

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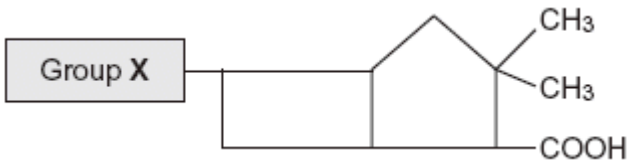
(2)

(Total 7 marks)

Q33.

Penicillins are antibiotics. Some bacteria produce an enzyme that breaks down one sort of penicillin.

(a) There are different sorts of penicillin. All of these have the same basic chemical structure shown in the diagram but group **X** is different.



A bacterial infection that cannot be treated with one sort of penicillin can be treated with a different sort. Use your knowledge of enzyme action to explain why the different sort of penicillin is effective in treating the infection.

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(3)

(b) Farmers often keep large numbers of cattle together. Farmers used to give cattle food which had antibiotics added to it.

(i) Suggest how adding antibiotics to the food of the cattle increased profit for the farmers.

_____

_____

_____

_____

(2)

(ii) Adding antibiotics to the food of cattle is now banned in many countries. Use your knowledge of selection to explain why adding antibiotics was banned.

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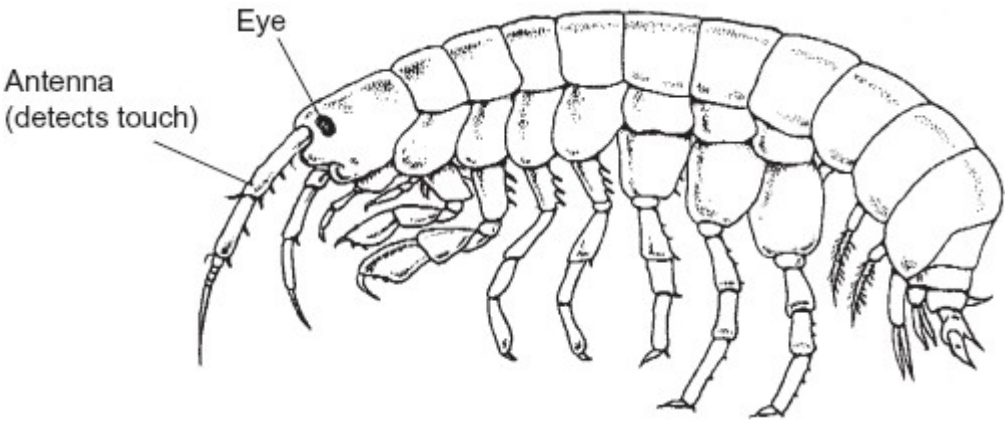
(2)

(Total 7 marks)

Q34.

Figure 1 shows a fresh-water shrimp.

Figure 1



Biologists collected shrimps from a stream inside a cave and from the same stream when it was in the open.

They measured the maximum diameter of each shrimp's eye. They also measured the length of its antenna. From these measurements they calculated the mean values for each site. **Figure 2** shows their results.

Figure 2

	Shrimps from the stream	
	Inside the cave	In the open
Mean diameter of eye /mm	0.09	0.24
Mean length of antenna /mm	8.46	5.81

(a) The biologists measured the maximum diameter of each shrimp's eye.

Explain why they measured the **maximum** diameter.

_____

_____

_____

(1)

(b) A scientist working many years earlier suggested that animals which live in caves had similar adaptations. These adaptations included

- smaller eyes
- greater use of sense organs such as those involved in detecting touch.

(i) Do the data in **Figure 2** support this scientist's suggestion? Explain your answer.

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(2)

(ii) The data in **Figure 2** are mean values. Explain how standard deviations of these cmean values would help you to interpret the data in **Figure 2**.

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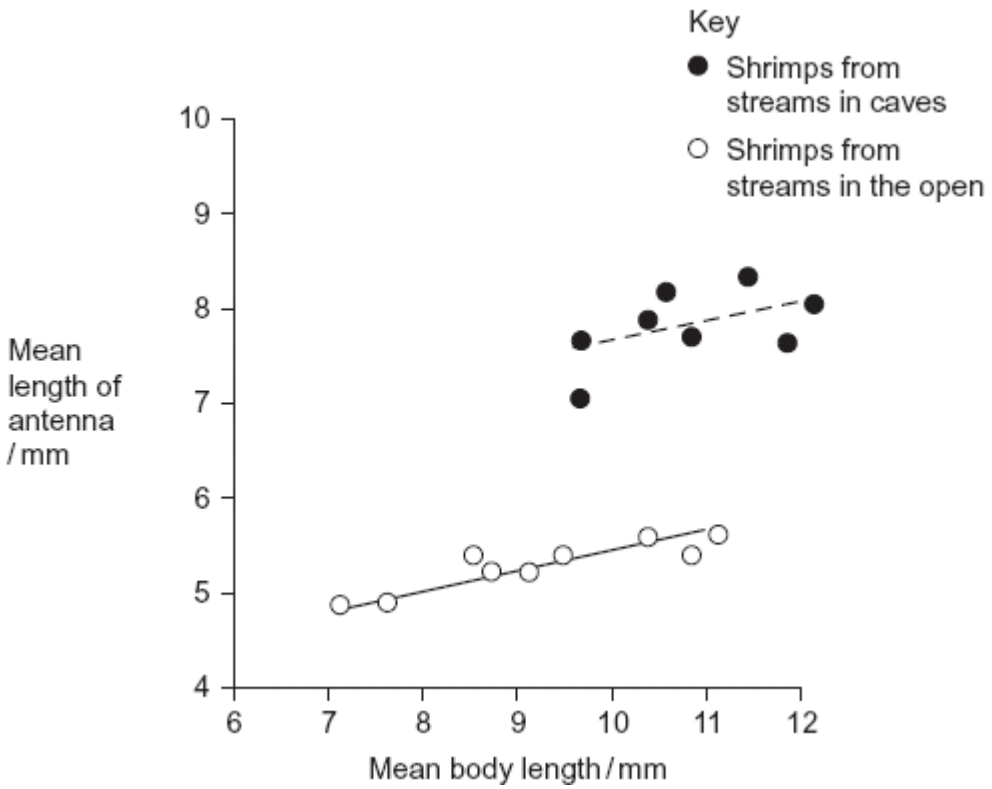
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(2)

(c) The biologists investigated shrimps living in other streams. They measured the length of the antennae of these shrimps. They also measured their body length. **Figure 3** shows the mean antenna length plotted against mean body length for each site.

Figure 3



(i) What does the information in the graph suggest about the body lengths of shrimps living in caves and living in the open?

_____

_____

_____

_____

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(2)

(ii) Do the data in the graph support the conclusion that shrimps with longer bodies have longer antennae? Give the reason for your answer.

_____

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(1)

Other biologists investigated the genetic diversity of these shrimps. **Figure 4** shows some of the data they collected.

Figure 4

Gene	Allele	Percentage of shrimps with this allele in steam	
		Inside a cave	In the open
PGI	**A**	0.9	2.5
	B	0.0	3.3
	C	98.2	66.4
	D	0.9	6.6
	E	0.0	21.3
ACO2	**J**	0.0	5.6
	K	0.0	76.7
	L	100.0	17.8

(d) The biologists concluded that the shrimps in the open had a higher genetic diversity than those in the cave. Explain how the data in **Figure 4** support this conclusion.

_____

_____

_____

(1)

(e) The percentage of shrimps with allele **L** in the cave is different from the percentage of shrimps with allele **L** in the open. Use your knowledge of the founder effect to suggest a reason for this difference.

_____

_____

_____

_____

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_____

(3)

(f) The biologists who studied these shrimps wanted to know if the shrimps living in the cave were the same species as those living in the open. They used breeding experiments to investigate this.

(i) Describe how the biologists should carry out these breeding experiments.

_____

_____

_____

_____

(ii) The results of breeding experiments would help the biologists to decide whether the shrimps were the same species. Explain how.

_____

_____

(3)

(Total 15 marks)

Q35.

(a) What name is used for the non-coding sections of a gene?

_____

(1)

Figure 1 shows a DNA base sequence. It also shows the effect of two mutations on this base sequence. **Figure 2** shows DNA triplets that code for different amino acids.

Figure 1

Original DNA base sequence	A	T	T	G	G	C	G	T	G	T	C	T
Amino acid sequence												
Mutation **1** DNA base sequence	A	T	T	G	G	A	G	T	G	T	C	T
Mutation **2** DNA base sequence	A	T	T	G	G	C	C	T	G	T	C	T

Figure 2

DNA triplets	Amino acid
GGT, GGC, GGA, GGG	Gly
GTT, GTA, GTG, GTC	Val
ATC, ATT, ATA	Ile
TCC, TCT, TCA, TCG	Ser
CTC, CTT, CTA, CTG	Leu

(b) Complete **Figure 1** to show the sequence of amino acids coded for by the original DNA base sequence.

(1)

(c) Some gene mutations affect the amino acid sequence. Some mutations do not. Use the information from **Figure 1** and **Figure 2** to explain

(i) whether mutation **1** affects the amino acid sequence

_____

_____

_____

_____

(2)

(ii) how mutation **2** could lead to the formation of a non-functional enzyme.

_____

_____

_____

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_____

_____

(3)

(d) Gene mutations occur spontaneously.

(i) During which part of the cell cycle are gene mutations most likely to occur?

_____

(1)

(ii) Suggest an explanation for your answer.

_____

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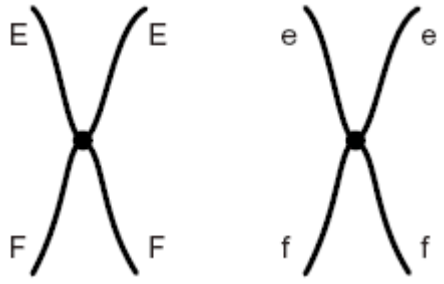
(1)

(Total 9 marks)

Q36.

Figure 1 shows a pair of chromosomes at the start of meiosis. The letters represent alleles.

Figure 1



(a) What is an allele?

_____

_____

(1)

(b) Explain the appearance of one of the chromosomes in **Figure 1**.

_____

_____

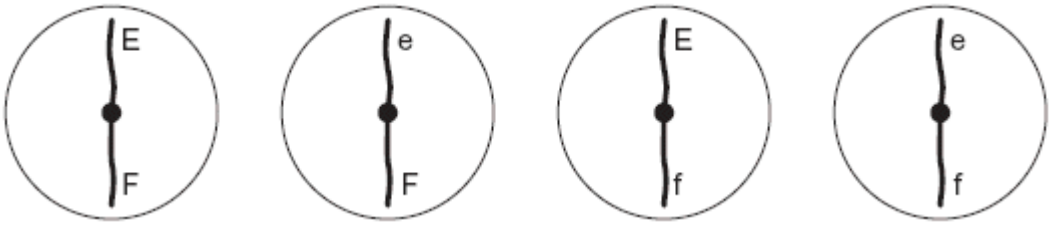
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(2)

(c) The cell containing this pair of chromosomes divided by meiosis. **Figure 2** shows the distribution of chromosomes from this pair in four of the gametes produced.

Figure 2



(i) Some of the gametes formed during meiosis have new combinations of alleles.

Explain how the gametes with the combinations of alleles Ef and eF have been produced.

_____

_____

_____

_____

(2)

(ii) Only a few gametes have the new combination of alleles Ef and eF. Most gametes have the combination of alleles EF and ef. Suggest why only a few gametes have the new combination of alleles, Ef and eF.

_____

_____

(1)

(d) **Figure 3** shows a cell with six chromosomes.

Figure 3



(i) This cell produces gametes by meiosis. Draw a diagram to show the chromosomes in one of the gametes.

(2)

(ii) How many different types of gametes could be produced from this cell as a result of different combinations of maternal and paternal chromosomes?

☐

(1)

(Total 9 marks)

Q37.

(a) The number of patients infected with the bacterium MRSA has increased in some hospitals. Scientists have suggested ways to reduce the transmission of MRSA in hospitals. Suggest **two** ways to reduce the transmission of MRSA in hospitals.

1. _____

_____

2. _____

_____

(2)

(b) The minimum inhibitory concentration (MIC) is the lowest concentration of a substance that prevents the growth of a microorganism.

When antibiotics are prescribed for treating patients, higher doses than the MIC are recommended. Suggest **two** reasons why.

1. _____

_____

2. _____

_____

(2)

Scientists tested a new group of drugs for their effectiveness against four species of bacteria. The scientists used MICs to compare the effectiveness of four drugs. The results are shown in the table.

	Minimum inhibitory concentration / μg cm^{-3}			
Drug	*Escherichia coli*	*Staphylococcus aureus*	*Enterococcus faecalis*	*Pseudomonas aeruginosa*
P	0.39	0.049	0.049	3.13
Q	1.54	0.049	0.195	3.13
R	0.39	0.049	0.195	1.56
S	1.56	0.098	0.390	12.50

(c) Which of the four drugs is

(i) most effective against *Enterococcus faecalis*?

☐

(1)

(ii) least effective against all the species of bacteria used?

☐

(1)

(d) The effectiveness of these drugs was tested in double-blind trials using human volunteers. In a double-blind trial neither the volunteers nor the scientists know which treatment a particular volunteer is receiving.

(i) Suggest **two** ways in which a double-blind trial improves reliability.

1. _____

_____

2. _____

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(2)

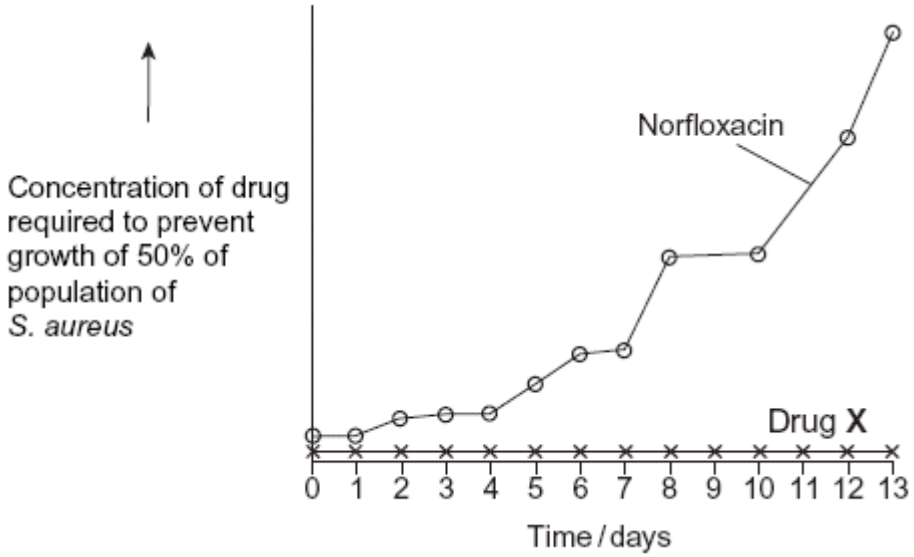
(ii) Suggest **two** factors the scientists should have considered when selecting adult volunteers for this trial.

1. _____

2. _____

(2)

(e) Scientists investigated resistance of the bacterium, *S. aureus* to the antibiotic Norfloxacin. They grew the bacteria in a medium containing a low concentration of Norfloxacin. The concentration of Norfloxacin that they added killed some of the bacteria. It did not kill all of them. Every 24 hours, they removed a sample of the bacteria from the culture. They tested the sample to find the concentration of Norfloxacin that prevented the growth of 50 % of the bacteria in the sample.
The scientists then used the same method to investigate the resistance of *S. aureus* to a new drug, drug **X**. The results of both investigations are shown in the graph.



Describe the results obtained with Norfloxacin.

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_____

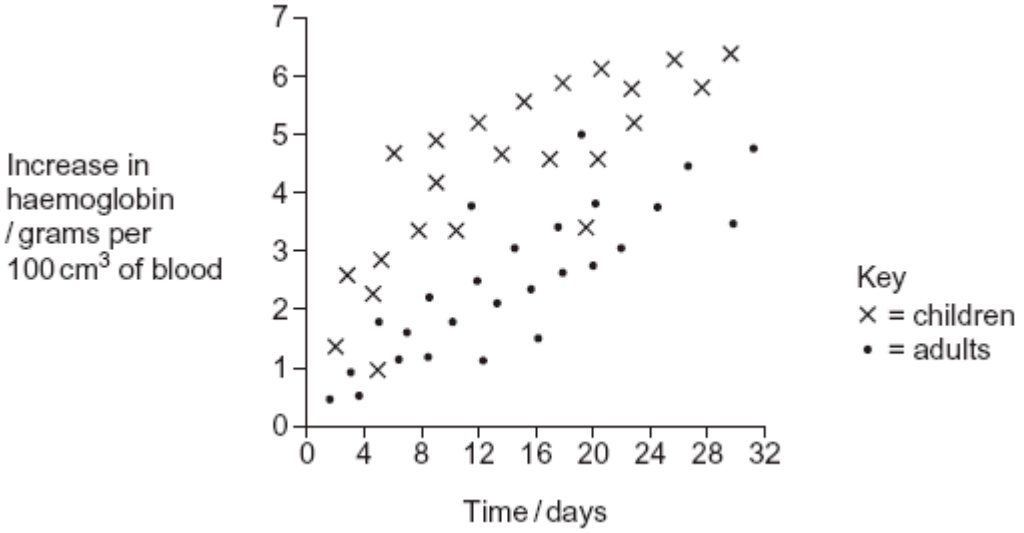
(1)

(Total 11 marks)

Q38.

(a) Haemoglobin contains iron. One type of anaemia is caused by a lack of iron. This type of anaemia can be treated by taking tablets containing iron. A number of patients were given a daily dose of 120 mg of iron. **Figure 1** shows the effect of this treatment on the increase in the concentration of haemoglobin in their red blood cells.

Figure 1



(i) Give **one** difference in the response of adults and children to this treatment.

_____

_____

(1)

(ii) You could use the graph to predict the effect of this treatment on the increase in haemoglobin content of an adult after 40 days. Explain how.

_____

_____

_____

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(2)

(iii) Haemoglobin has a quaternary structure. Explain what is meant by a quaternary structure.

_____

_____

(1)

(b) (i) Pernicious anaemia is another type of anaemia. One method of identifying pernicious anaemia is to measure the diameter of the red blood cells in a sample of blood that has been diluted with an isotonic salt solution. Explain why an isotonic salt solution is used to dilute the blood sample.

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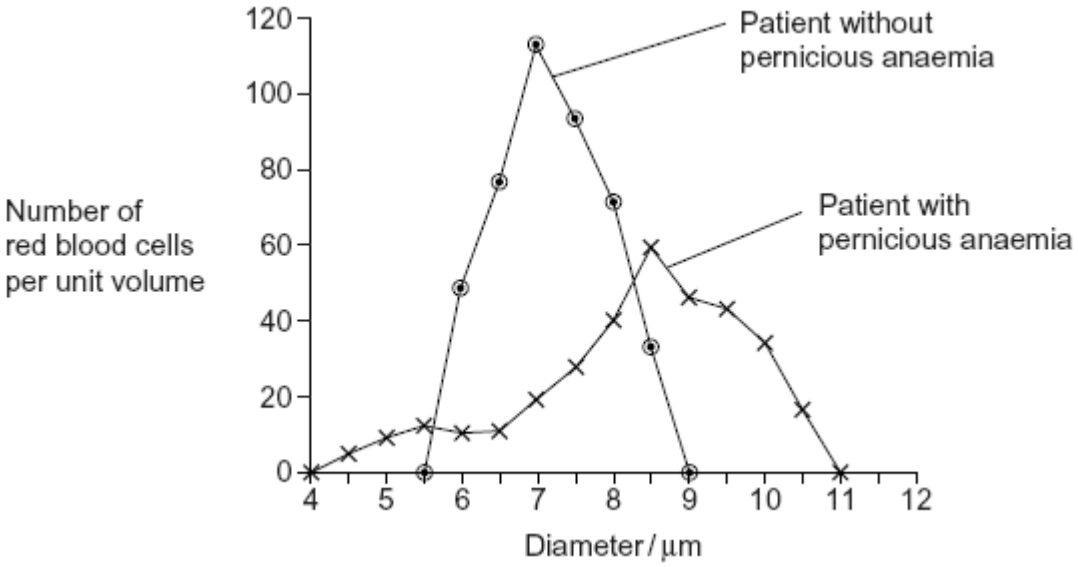
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(3)

(ii) A technician compared the red blood cells in two blood samples of equal volume. One sample was from a patient with pernicious anaemia, the other was from a patient who did not have pernicious anaemia. **Figure 2** shows some of the results she obtained.

Figure 2



Describe **two** differences between the blood samples.

1. _____

_____

2. _____

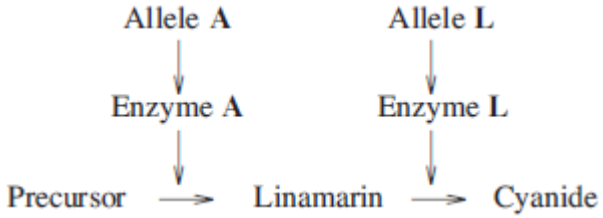
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(2)

(Total 9 marks)

Q39.

Cyanide is a poisonous substance. Cyanogenic clover plants produce cyanide when their tissues are damaged. The ability to produce cyanide is controlled by genes at loci on two different chromosomes. The dominant allele, **A**, of one gene controls the production of an enzyme which converts a precursor to linamarin. The dominant allele, **L**, of the second gene controls the production of an enzyme which converts linamarin to cyanide. This is summarised in the diagram.



(a) Acyanogenic clover plants cannot produce cyanide. Explain why a plant with the genotype **aaLl** cannot produce cyanide.

_____

_____

(1)

(b) A clover plant has the genotype **AaLl**.

(i) Give the genotypes of the male gametes which this plant can produce.

_____

(1)

(ii) Explain how meiosis results in this plant producing gametes with these genotypes.

_____

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(2)

(c) Two plants, heterozygous for both of these pairs of alleles, were crossed. What proportion of the plants produced from this cross would you expect to be acyanogenic but able to produce linamarin? Use a genetic diagram to explain your answer.

(3)

In an investigation, cyanogenic and acyanogenic plants were grown together in pots. Slugs were placed in each pot and records were kept of the number of leaves damaged by the feeding of the slugs over a period of 7 days. The results are shown in **Table 1**.

Table 1

	Undamaged	**Damaged**
Cyanogenic plants	160	120
Acyanogenic	88	192

plants		

(d) A x^2 test was carried out on the results.

(i) Suggest the null hypothesis that was tested.

_____

_____

(1)

(ii) x^2 was calculated. When this value was looked up in a table, it was found to correspond to a probability of less than 0.05. What conclusion can you draw from this?

_____

_____

_____

_____

_____

_____

(3)

A second investigation was carried out in a field of grass which had been undisturbed for many years. **Table 2** shows the population density of slugs and the numbers of cyanogenic and acyanogenic clover plants at various places in the field.

Table 2

Population density of slugs	Number of acyanogenic clover plants per m^2	Number of cyanogenic clover plants per m^2
Very low	26	10
Low	17	26
High	0	10
Very high	0	5

(e) Explain the proportions of the two types of clover plant in different parts of the field.

_____

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_____

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(4)

(Total 15 marks)

Q40.

(a) Meiosis results in cells that have the haploid number of chromosomes and show genetic variation. Explain how.

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(6)

(b) In mice, two genes affecting coat colour are on different chromosomes.
One gene controls whether there is any black pigment in the hairs. The dominant allele of this gene, **B**, results in black fur. The recessive allele, **b**, results in white fur. The second gene controls banding of the fur. The dominant allele, **A**, causes a yellow band to develop on each hair. The resulting coat colour is called agouti. The recessive allele, **a**, results in hairs with no bands on them. This gene has no effect on mice with white fur; white mice do not develop bands, even if they have the **A** allele.

Breeders performed many crosses in which agouti mice were crossed with white mice, homozygous for both genes. They expected agouti, black and white mice in the offspring in a 1 : 1 : 2 ratio.

(i) Complete the genetic diagram to show how this ratio of phenotypes would be produced.

Parental phenotypes Agouti White

Parental genotypes

Gamete genotypes

Offspring genotypes

Offspring phenotypes

(4)

(ii) The actual numbers of offspring with each phenotype were

Agouti	34
Black	35
White	51

The x^2 test can be used to test the hypothesis that there is no significant difference between these results and the expected 1 : 1 : 2 ratio. Complete the table to calculate the value of x^2 for these results.

Colour of offspring	Observed (O)	Expected (E)	(O - E)	$(O - E)^2$	$\frac{(O-E)^2}{E}$
Agouti	34				
Black	35				
White	51				
			$\sum \frac{(O-E)^2}{E}$ =		

(2)

(iii) The table shows values for x^2 at different levels of probability and for different degrees of freedom.

Degrees of freedom	Probability, p				
	0.2	**0.1**	**0.05**	**0.02**	**0.01**
1	1.64	2.71	3.84	5.41	6.64
2	3.22	4.61	5.99	7.82	9.21
3	4.64	6.25	7.82	9.84	11.35
4	5.99	7.78	9.49	11.67	13.28
5	7.29	9.24	11.07	13.39	15.09

What should the breeders conclude about the significance of their results? Explain your answer.

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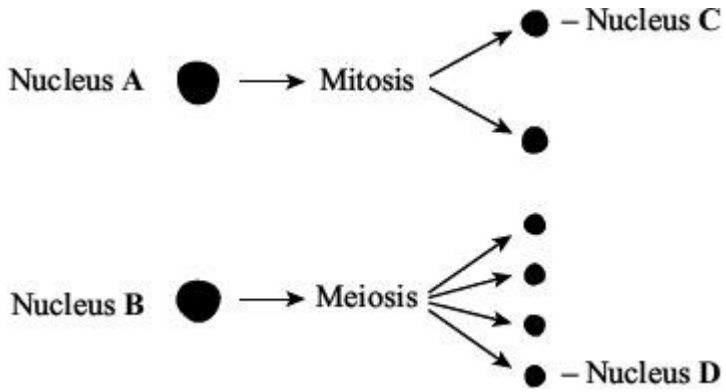
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(3)

(Total 15 marks)

Q41.

(a) Nucleus **A** and nucleus **B** come from the same organism. The diagram shows these nuclei immediately before division and the nuclei formed immediately after their division. The table gives information about some of the nuclei shown in the diagram.



Nucleus	Number of chromosomes	Mass of DNA / arbitrary units
A	8	600
B	8	600
C		
D		

Complete the table for nuclei **C** and **D**.

(2)

(b) A student investigated the process of meiosis by observing cells on a microscope slide. The cells on the slide had been stained.

(i) Name an organ from which the cells may have been obtained.

_____

(1)

(ii) Explain why a stain was used.

_____

_____

(1)

(Total 4 marks)

Q42.

Finches are small birds. Fourteen species of finch are found on the Galapagos Islands.

(a) What is a species?

_____

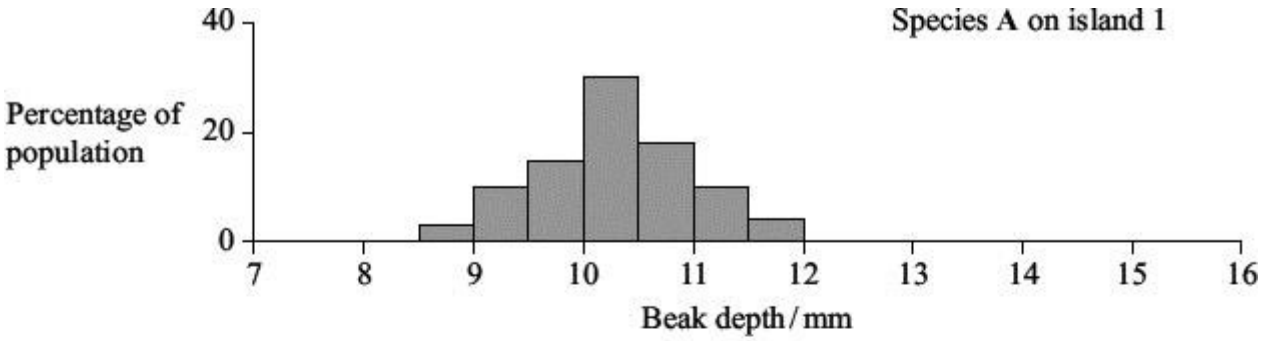
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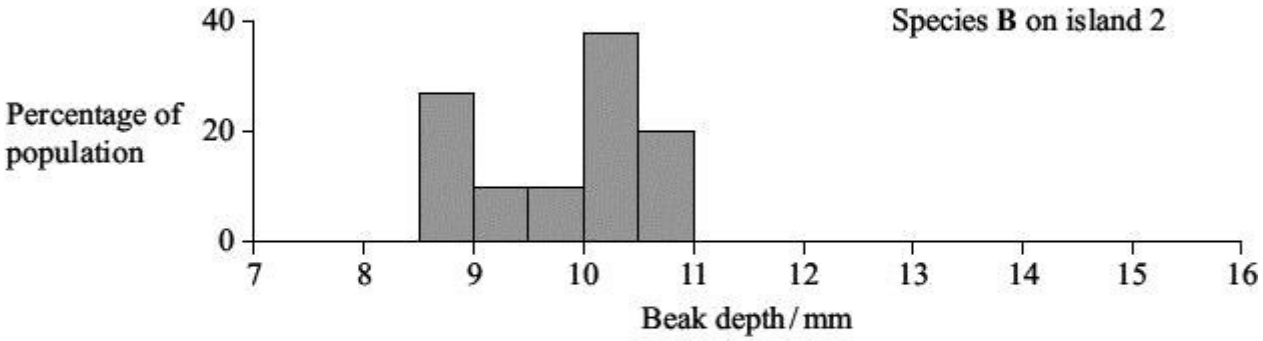
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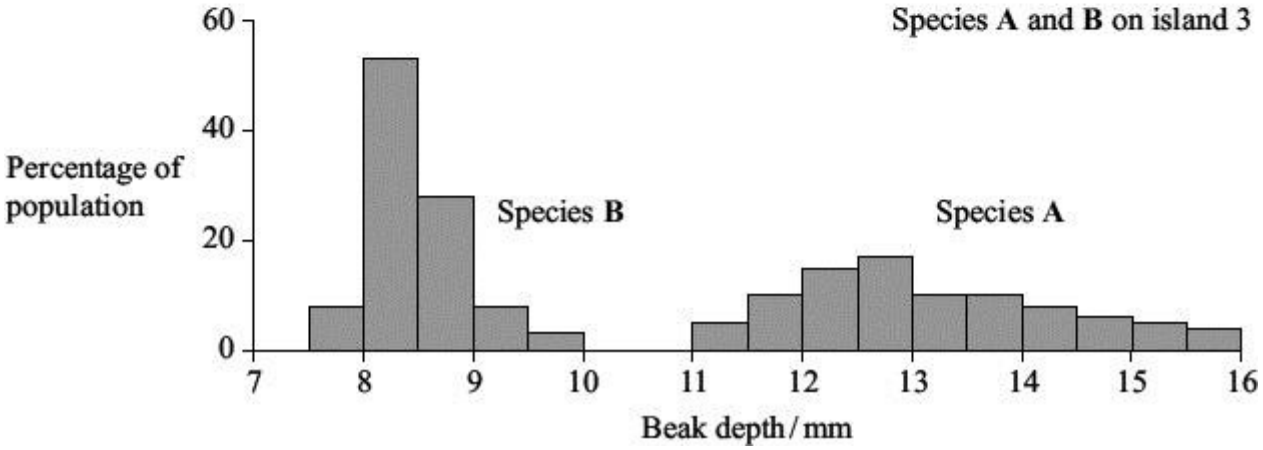
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(2)

(b) Measurements were made of the beak depth of two species of finch (species **A** and species **B**) on different islands. Species **A** is found on island 1, species **B** is found on island 2. Both species are found on island 3. They are thought to have colonised island 3 from islands 1 and 2 respectively. The graphs show the ranges of beak depths of the two species on the different islands.







What type of natural selection took place in the populations of both species after they had colonised island 3? Explain your answer.

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_____

(3)

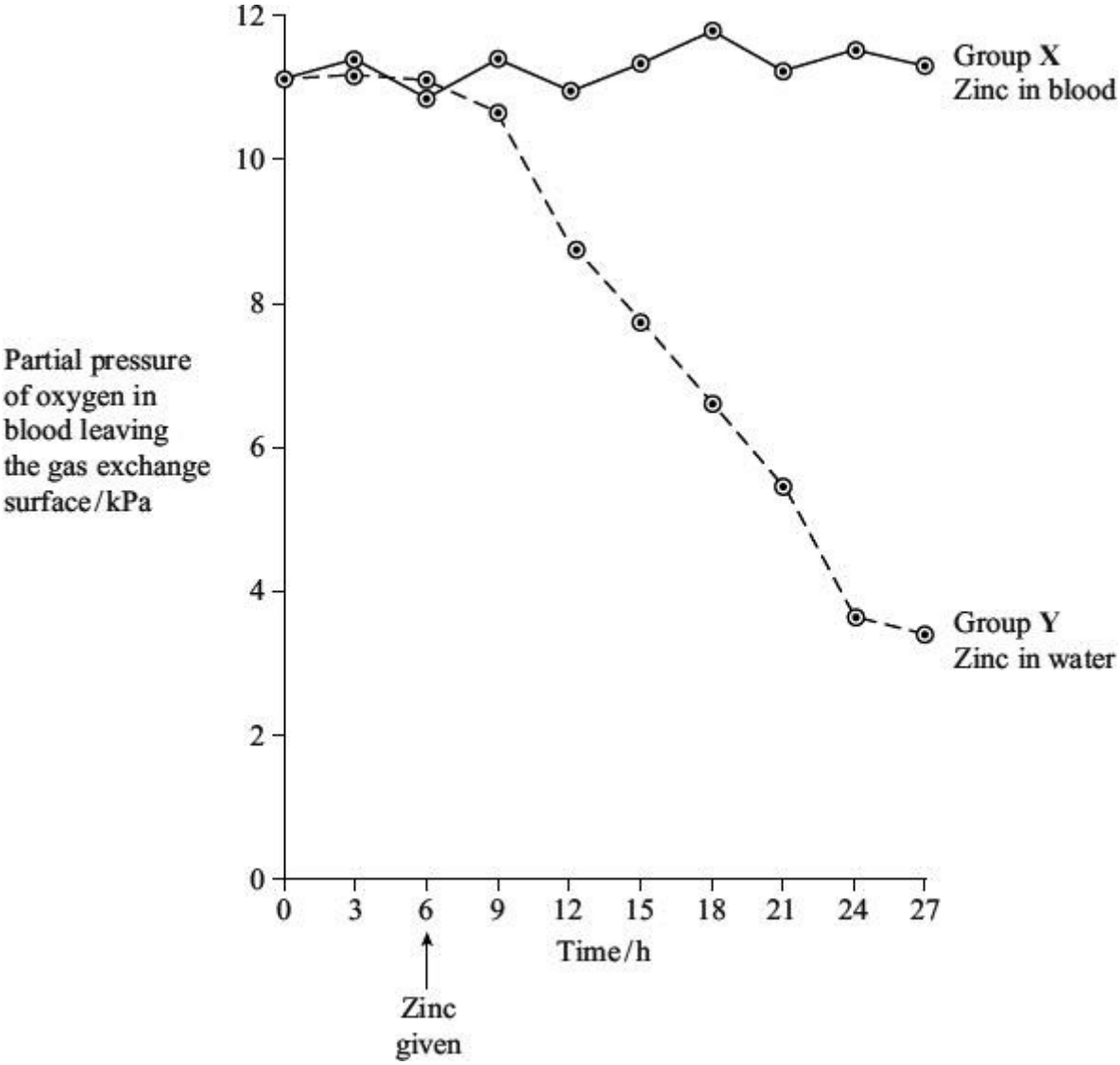
(Total 5 marks)

Q43.

Ions of metals such as zinc often pollute rivers. The effect of zinc ions on gas exchange and respiration in fish was investigated. Fish were kept in tanks of water in a laboratory.

The fish in one group (**X**) had a solution of a zinc compound injected directly into their blood and were then put in a tank of zinc-free water. A second group (**Y**) was not injected but had the solution of the zinc compound added to the water in the tank.

The partial pressure of oxygen in the blood of both groups of fish was then monitored. The results are shown in the graph.



(a) During this investigation, the water temperature in the tanks was kept constant. Explain why changes in the water temperature might lead to the results of the investigation being unreliable.

_____

_____

(1)

(b) The results from the two groups were compared using a statistical test.

(i) Suggest a null hypothesis that could be tested.

_____

(1)

(ii) Explain why it is important to use a statistical test in analysing the results of this investigation.

_____

_____

_____

_____

(2)

(c) Two suggestions were made to explain the results shown in the graph.

A Zinc ions reduce the rate at which oxygen is taken up from the water and passes into the blood.

B Zinc ions reduce the ability of haemoglobin to transport oxygen.

Which of these suggestions is the more likely? Explain the evidence from the graph that supports your answer.

_____

_____

_____

_____

(2)

(d) During the investigation, the pH of the blood was also monitored. It decreased in group **Y**. Suggest an explanation for this decrease in pH.

_____

_____

_____

_____

_____

_____

(3)

(e) Leaves were collected from sycamore trees growing in a polluted wood and the concentration of some metal ions in samples of these leaves was measured. Woodlice were then fed with the leaves. After 20 weeks, the concentration of the ions in the bodies of the woodlice was measured. Some of the results are shown in the table.

	Concentration of ions / µg g^{-1}			
	Copper	Cadmium	Zinc	Lead

Leaves	52	26	1430	908
Woodlice	1130	525	1370	132

(i) Which of the elements shown in the table is concentrated most by the woodlice? Use suitable calculations to support your answer.

(2)

(ii) Suggest what happens to most of the lead ions in the leaves eaten by the woodlice.

_____

_____

(1)

(iii) Explain the difference in the copper ion concentration between the leaves and the woodlice.

_____

_____

_____

_____

(2)

(f) Yorkshire fog is a species of grass. Two varieties of Yorkshire fog were studied. One variety was tolerant to arsenic, while the other variety was not. In a series of investigations, it was found that

- Arsenic-tolerant plants grow in soil which contains a high concentration of arsenic.
- Arsenic-tolerant plants growing in soil containing high concentrations of arsenic and phosphorus-containing compounds have very low concentrations of arsenic in their cells. They also have low concentrations of phosphates in their cells. Arsenic and phosphorus are chemically similar.
- Plants that are not tolerant to arsenic grow poorly on soil which has a high concentration of both arsenic and phosphorus-containing compounds.
- Tolerance to arsenic in Yorkshire fog is caused by a single gene with the allele, **a**, for tolerance recessive to the allele, **A**, for non-tolerance.

(i) What caused the allele for tolerance to first arise?

_____

_____

(1)

(ii) Give **two** functions of phosphates in plant cells.

1. _____

_____

2. _____

_____

(2)

(iii) Arsenic-tolerant Yorkshire fog plants are very rare in areas with low concentrations of arsenic in the soil, even where the soil has a high concentration of phosphate. Explain why they are unable to compete in these conditions with plants that are not tolerant to arsenic.

_____

_____

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_____

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_____

(3)

(Total 20 marks)

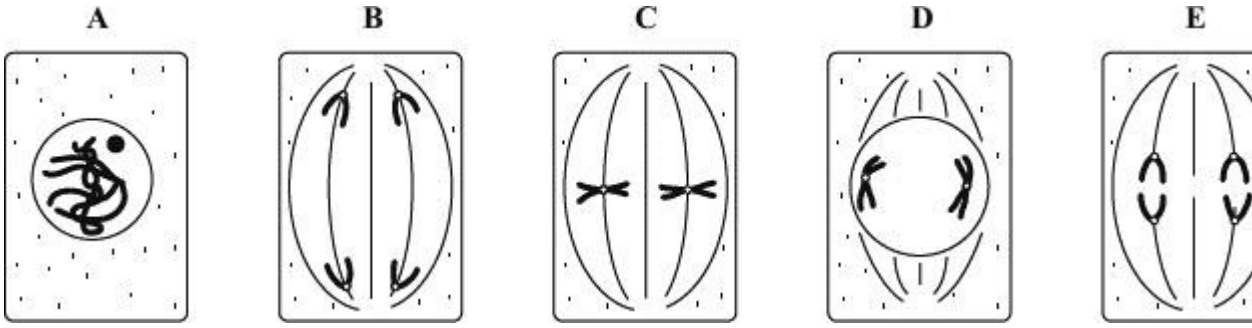
Q44.

(a) In which phase of the cell cycle does DNA replication take place?

_____

(1)

(b) The diagrams show five stages of mitosis.



List the stages **A** to **E** in the correct sequence, beginning with the earliest stage.

_____ _____ _____ _____ _____

(1)

(c) Describe the role of the spindle during mitosis.

_____

_____

_____

_____

(2)

(d) Meiosis also occurs during the life cycle of organisms. What is the importance of meiosis?

_____

_____

_____

_____

(2)

(Total 6 marks)

Q45.

There is evidence that the first photosynthetic organisms were primitive water-dwelling bacteria. The very first of these lived near the surface of the water in lakes and contained a purple pigment that absorbed light most strongly in the green region of the spectrum. Later, other bacteria evolved that lived on the top of sediment at the bottom of the lakes (**Figure 1**). Gene mutations had enabled these bacteria to synthesise chlorophyll instead of the purple pigment present in the bacteria living near to the surface. Chlorophyll absorbs light most strongly in the blue and red regions of the spectrum (**Figure 2**).

Figure 1

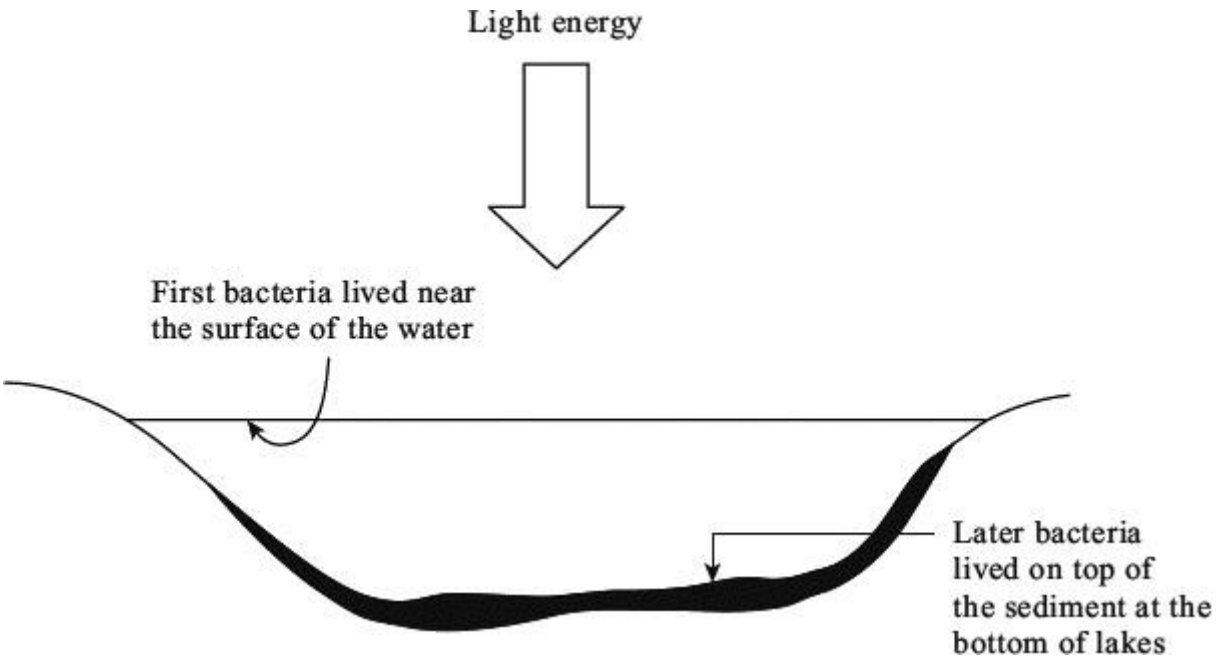
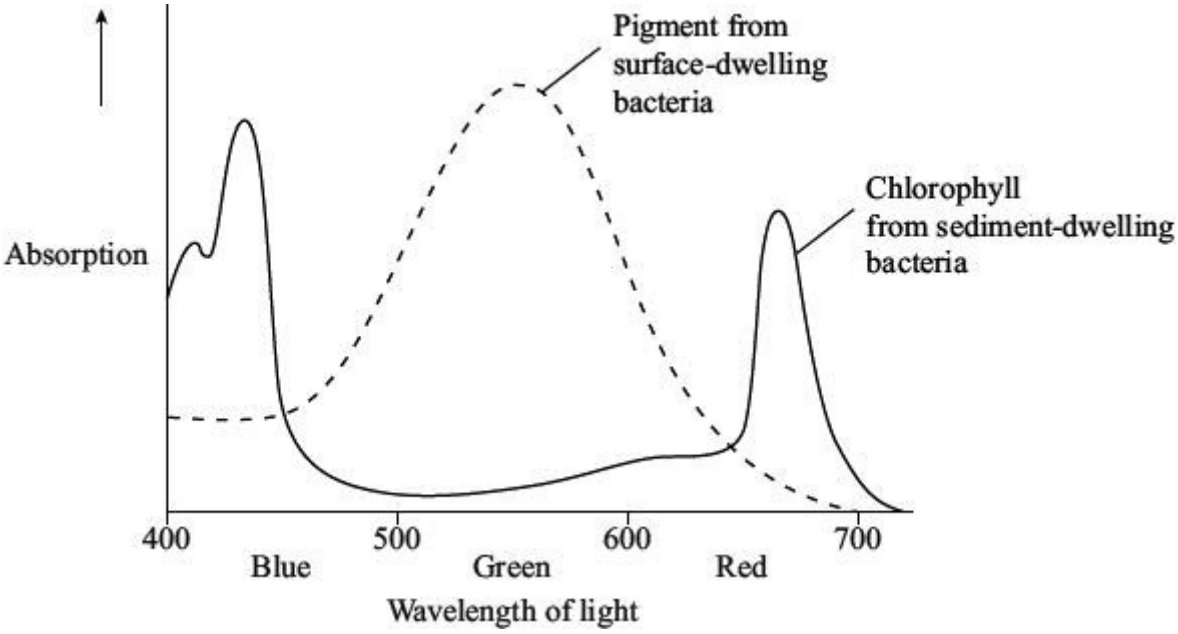


Figure 2



(a) Describe how light energy absorbed by chlorophyll molecules is used to synthesise ATP.

(5)

(b) Use **Figure 2** to explain how natural selection would favour the evolution of sediment-dwelling bacteria containing a different photosynthetic pigment from those living near the surface of the water.

_____

_____

_____

_____

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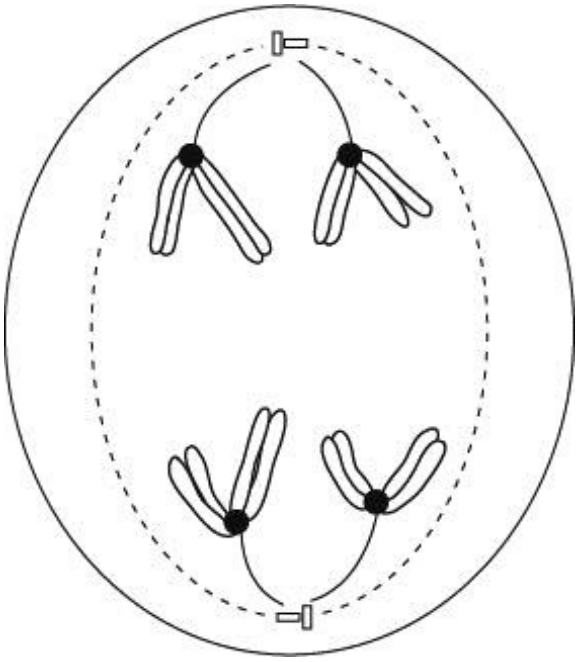
_____

(6)

(Total 11 marks)

Q46.

(a) The diagram shows a cell undergoing cell division.



Identify the type and stage of cell division shown. Give evidence from the diagram to support your answer.

_____

_____

_____

_____

_____

_____

(3)

(b) Describe how crossing over occurs during meiosis I.

_____

_____

_____

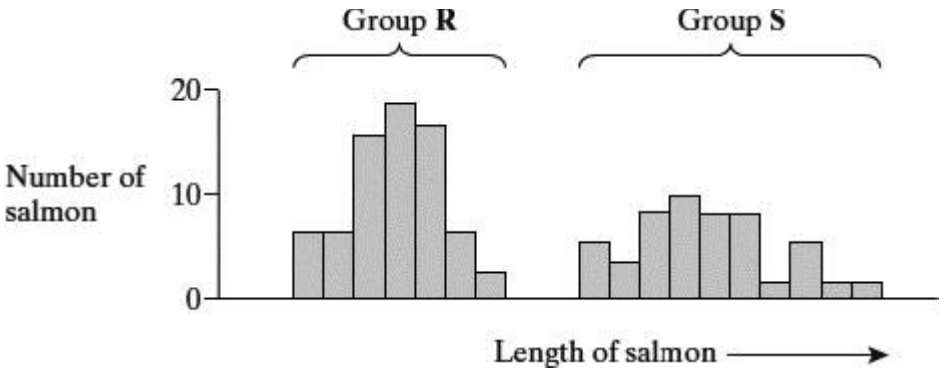
_____

(2)

(Total 5 marks)

Q47.

The graph shows the variation in length of 86 Atlantic salmon.



(a) Give **two** possible causes of this variation that result from meiosis during gamete formation.

1. _____

_____

2. _____

_____

(2)

(b) When comparing variation in size between two groups of organisms, it is often considered more useful to compare standard deviations rather than ranges. Explain why.

_____

_____

_____

_____

(2)

(Total 4 marks)

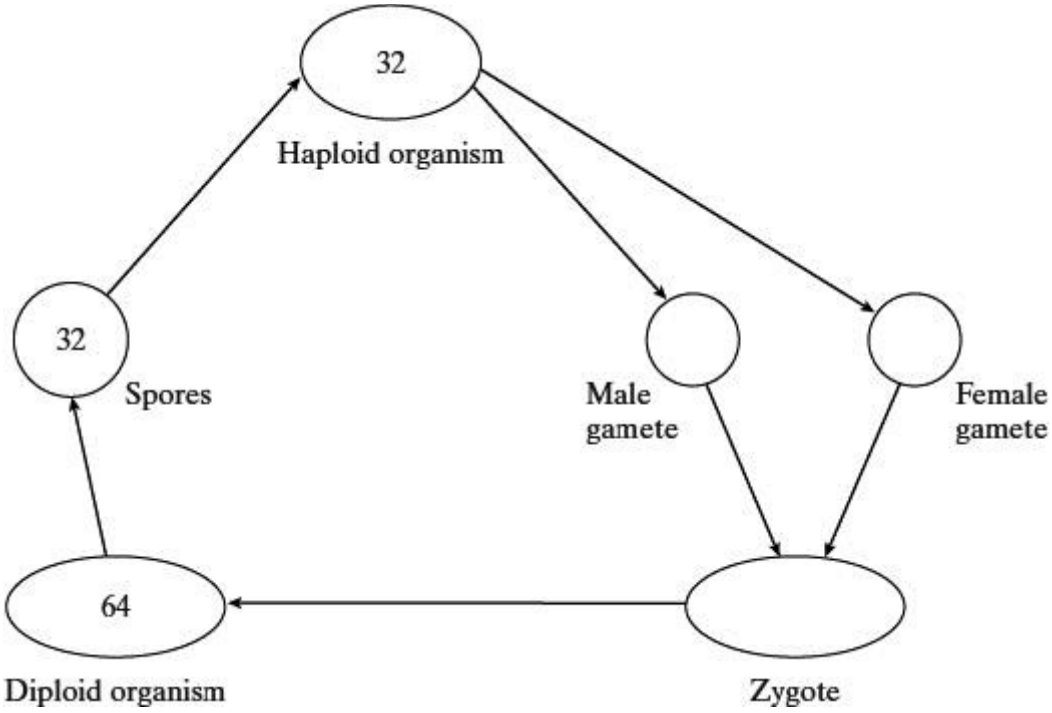
Q48.

(a) Complete the table to describe some of the events during the cell cycle.

Stage of cell cycle	Main event which takes place
Metaphase	
	Chromosomes coil and shorten
	Daughter chromosomes move to poles of the cell
S-phase	
	Nuclear envelope re-forms

(5)

(b) The diagram shows the life cycle of an organism. The numbers show how many chromosomes are present in one cell at each stage of the life cycle.



(i) Name the type of cell division that must be involved in producing the spores.

_____

(1)

(ii) How many chromosomes are there in a male gamete from this organism?

_____

(1)

(Total 7 marks)

Q49.

Division of the nucleus by meiosis produces haploid cells from a diploid cell. Nuclei produced by mitosis have the same number of chromosomes as the parent nucleus.

(a) What is the biological importance of reducing the chromosome number when the cell divides by meiosis?

_____

_____

_____

_____

(2)

(b) The table gives one difference between meiosis and mitosis. Complete the table by giving **three** further differences.

	Meiosis	**Mitosis**
1	Reduces the chromosome number	Maintains the same chromosome number as in the parent nucleus
2		
3		
4		

(3)

(Total 5 marks)

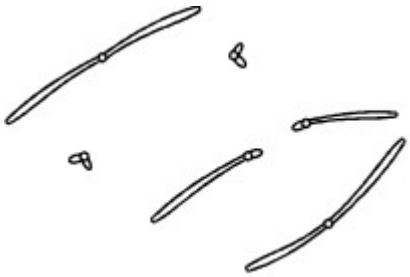
Q50.

(a) Give **one** process which occurs in the nucleus of a cell during interphase which is necessary before cell division can take place.

_____

(1)

(b) The diagram shows the chromosomes from a cell with a diploid chromosome number of six.



Draw a diagram to show the chromosomes from one of the resulting cells if

(i) the cell divides by **mitosis**;

(2)

(ii) the cell divides by **meiosis**.

(2)

(c) Explain **one** advantage of cells lining the human gut dividing very frequently.

_____

_____

(1)

(Total 6 marks)

Q51.

(a) Describe what happens to chromosomes in meiosis.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(b) Meiosis results in genetic variation in the gametes which leads to variation in the offspring formed by sexual reproduction. Describe how meiosis causes this variation and explain the advantage of variation to the species.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(c) An old form of wheat, emmer wheat (*Triticum turgidum*), has a diploid chromosome number of 28 (2n = 28). A wild wheat, einkorn wheat (*Triticum tauschii*), has a diploid chromosome number of 14 (2n = 14). These two species occasionally crossed and produced sterile hybrid plants. Due to an error during cell division, one of these hybrid plants formed male and female gametes with 21 chromosomes. Fusion of these gametes resulted in viable offspring. These plants were a new species, *Triticum aestivum* (2n = 42), our modern bread wheat.

(i) How many chromosomes would there have been in each of the cells of the hybrid plant produced by crossing *Triticum turgidum* with *Triticum tauschii*?

_____

(1)

(ii) Explain why *Triticum aestivum* is fertile while the majority of hybrid plants were not.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Q52.

(a) Explain **one** way in which the behaviour of chromosomes during meiosis produces genetic variation in gametes.

_____

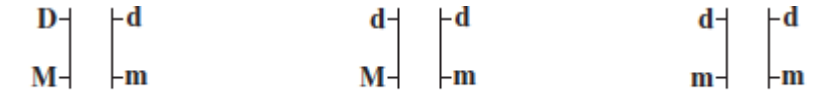
_____

_____

_____

(2)

(b) In mosquitoes, the sex of an individual is determined by one gene. Males have the genotype **Mm** and females **mm**.
Another gene is carried on the same chromosome. Normal males and females are homozygous **dd** for this gene. Abnormal males have a dominant **D** allele.
The possible genotypes are shown below. The vertical lines represent homologous chromosomes.



During meiosis, allele **D** causes the homologous chromosome carrying the **m** allele to disintegrate. Cells lacking this chromosome do not develop further.

Complete the genetic diagram to show how allele **D** is transmitted from an abnormal male to his offspring.

Parental phenotypes Abnormal male Normal female

Parental genotypes



Gametes _____ _____

Offspring genotype(s) _____

Offspring phenotype(s) _____

(3)

(Total 5 marks)

Q53.

(a) (i) What is the role of RNA polymerase in transcription?

_____

_____

(1)

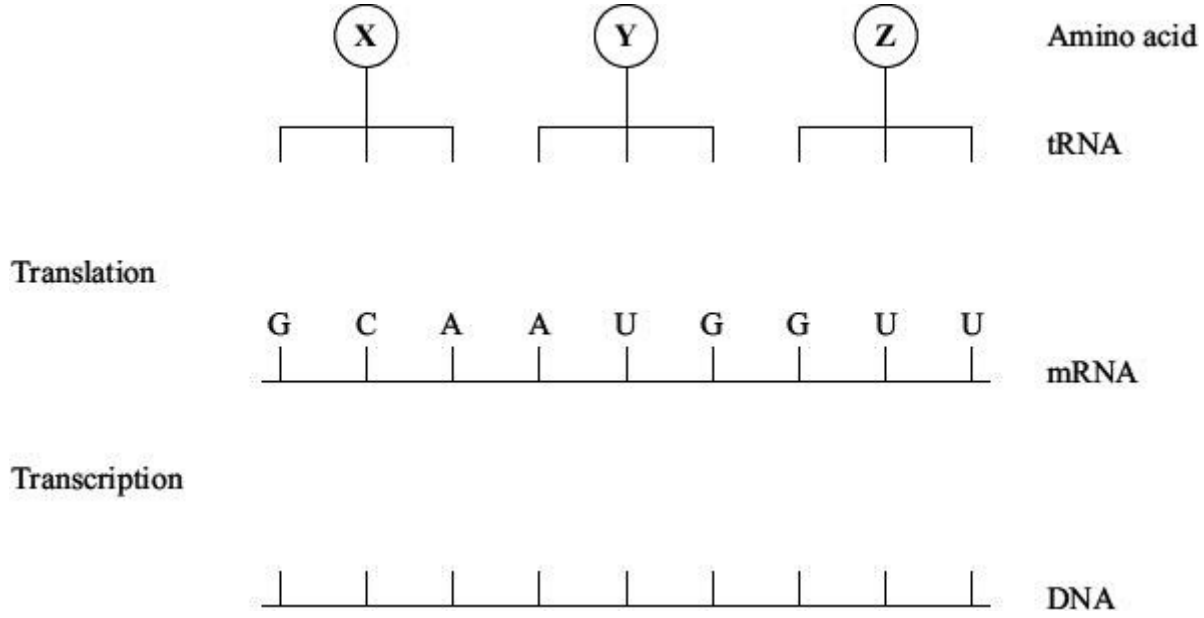
(ii) Name the organelle involved in translation.

_____

(1)

(b) **Figure 1** shows some molecules involved in protein synthesis.

Figure 1



Complete **Figure 1** to show

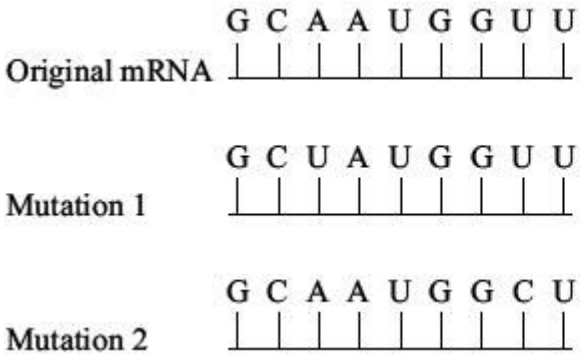
(i) the bases on the DNA strand from which the mRNA was transcribed;

(ii) the bases forming the anticodons of the tRNA molecules.

(2)

Figure 2 shows the effects of two different mutations of the DNA on the base sequence of the mRNA. The table shows the mRNA codons for three amino acids.

Figure 2



Amino acid	mRNA codon
methionine	AUG
valine	GUC GUU
alanine	GCA GCC GCU

(c) Name the type of mutation represented by mutation 1.

_____

(1)

(d) Use the information in the table to

(i) identify amino acid **X** in **Figure 1**;

_____

(1)

(ii) explain how each mutation may affect the polypeptide for which this section of DNA is part of the code.

Mutation 1 _____

_____

_____

_____

(2)

Mutation 2 _____

_____

_____

_____

(2)

(Total 10 marks)

Q54.

(a) Apart from increasing genetic variation, explain why meiosis is important in organisms which reproduce sexually.

_____

_____

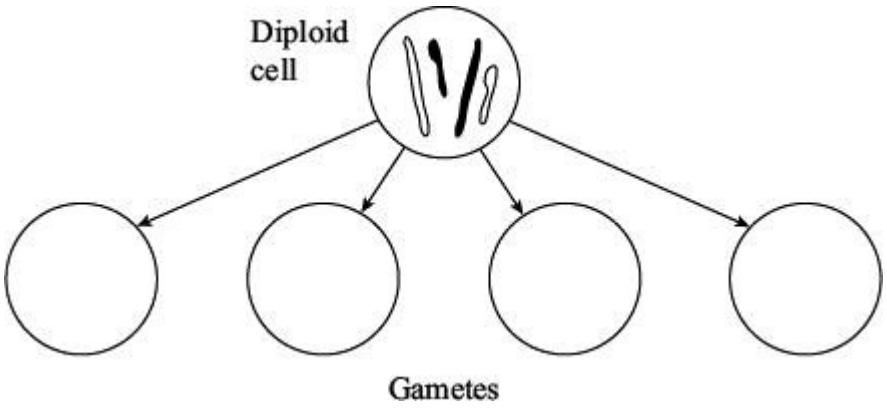
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(2)

(b) **Figure 1** shows the chromosomes in a diploid cell.

Figure 1

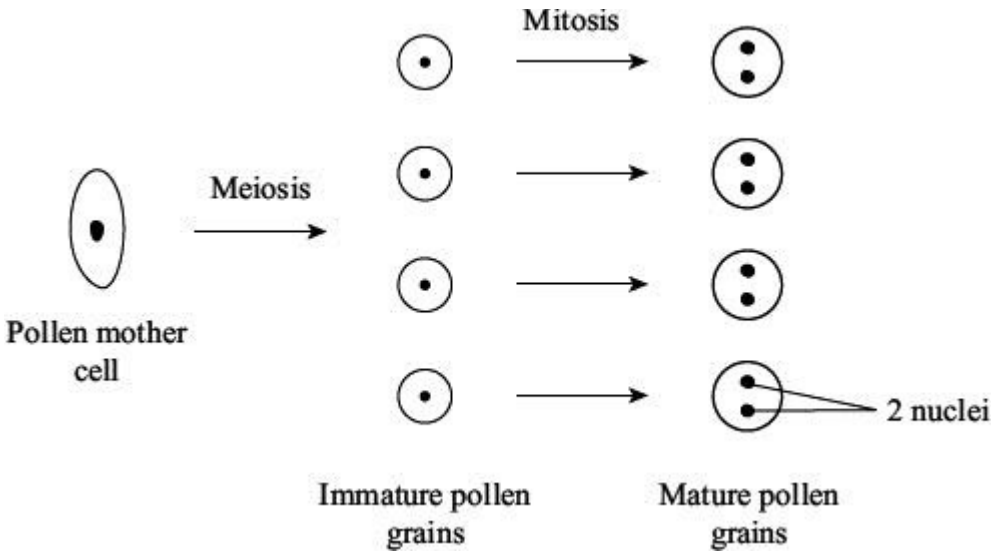


Complete **Figure 1** to show the four different combinations of these chromosomes in the gametes produced by meiosis.

(2)

(c) **Figure 2** shows the main stages in the production of pollen grains in a flowering plant.

Figure 2



The diploid number of chromosomes in this plant is sixteen. How many chromosomes would there be in

(i) the nucleus of an immature pollen grain;

_____

(ii) one of the nuclei of a mature pollen grain?

_____

(2)

(d) In tissues that produce gametes, there is a greater proportion of cells undergoing meiosis in male tissue than in female tissue. Suggest **one** advantage of this.

_____

_____

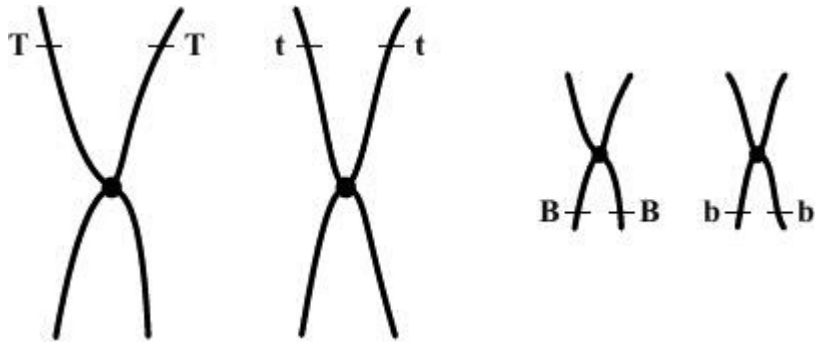
(1)

(Total 7 marks)

Q55.

(a) **Figure 1** shows two pairs of chromosomes from a plant cell. The letters represent alleles.

Figure 1



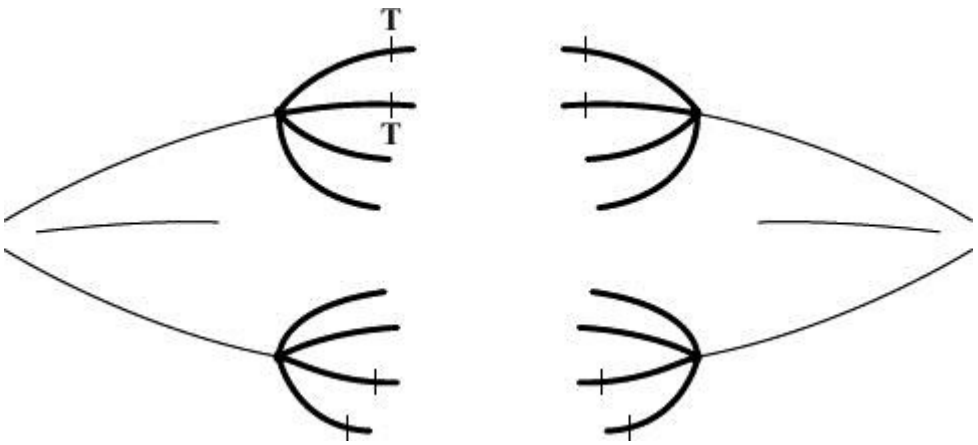
(i) Give all the different genotypes of the gametes which could be produced by this plant.

_____

(1)

(ii) **Figure 2** shows the same chromosomes on the spindle during meiosis. Complete the labelling of all the chromosomes to show the arrangement of the alleles that would result in the production of a gamete with the genotype **TB**.

Figure 2



(1)

(iii) One chromosome has two copies of allele **T**. What occurs during meiosis

which results in only one copy of the allele **T** being present in a gamete?

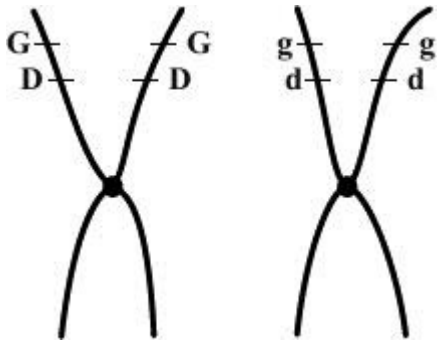
_____

_____

(1)

(b) **Figure 3** shows another pair of chromosomes from the same plant cell. The table shows the numbers of gametes with each genotype produced by this plant.

Figure 3



Genotype of gametes	**GD**	**gd**	**Gd**	**gD**
Number of gametes	1096	1124	210	230

(i) Describe what happens during meiosis, which results in the new combinations of alleles, **Gd** and **gD**.

_____

_____

_____

_____

_____

_____

(3)

(ii) Suggest why there are fewer gametes with genotypes **Gd** and **gD** than **GD** and **gd**.

_____

_____

(1)

(Total 7 marks)

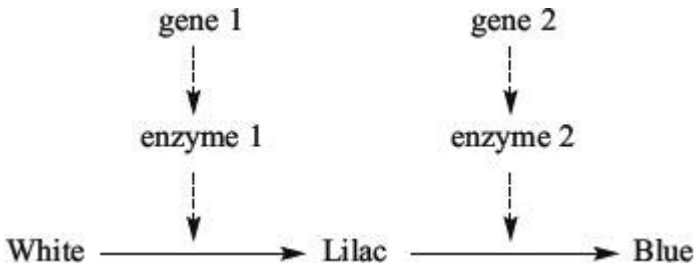
Q56.

(a) Name **one** mutagenic agent.

_____

(1)

(b) In flax plants the flowers are white, lilac or blue. The diagram shows the pathway by which the flower cells produce coloured pigments.



(i) A deletion mutation occurs in gene 1. Describe how a deletion mutation alters the structure of a gene.

_____

_____

_____

_____

(2)

(ii) Describe and explain how the altered gene could result in flax plants with white-coloured flowers.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(iii) Electrophoresis was used to separate the enzymes involved in this pathway. When extracts of the differently coloured flax petals were analysed, four different patterns of bands were produced. In the table, only bands that contain functional enzymes are shown.

Result of electrophoresis	Colour of petal
	White

Complete the table to give the colour of the petal from which each extract was taken.

(2)

(Total 9 marks)

Q57.

New alleles arise as a result of mutations in existing genes. These mutations may occur during DNA replication.

(a) Explain what is meant by an allele.

_____

_____

(1)

(b) Explain how DNA replicates.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) Explain why a mutation involving the deletion of a base may have a greater effect than one involving substitution of one base for another.

_____

_____

_____

_____

_____

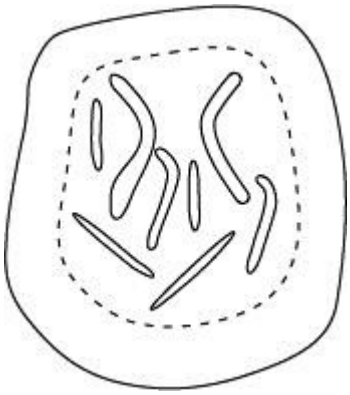
_____

(3)

(Total 8 marks)

Q58.

The diagram represents a cell from a fruit fly in which the diploid number is eight.



(a) Draw a diagram to show

(i) this cell during anaphase of mitosis;

(2)

(ii) the chromosomes in a gamete produced from this cell by meiosis.

(2)

(b) Explain why meiosis is important in sexual reproduction, apart from producing gametes that are genetically different.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q59.

Two pairs of alleles **A** and **a**, and **B** and **b** are found on one pair of homologous chromosomes. A person has the genotype **AaBb**. **Figure 1** shows the chromosomes at an early stage of meiosis. The position of two of the alleles is shown.

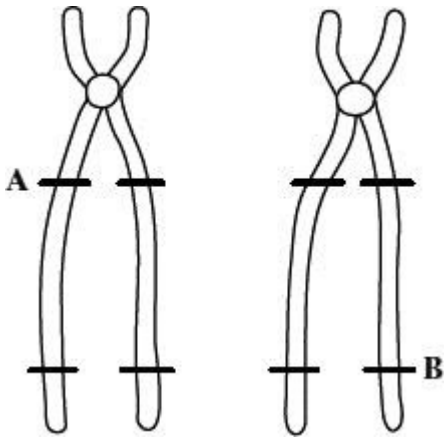


Figure 1

(a) Complete **Figure 1** to show the alleles present at the other marked positions.

(1)

Crossing over occurs as shown in **Figure 2**.

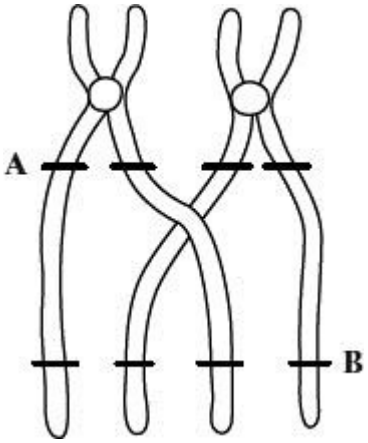


Figure 2

(b) What term is used to describe the pair of homologous chromosomes shown in **Figure 2**?

_____

(1)

(c) From **Figure 2**, give the genotypes of the gametes produced containing the chromatids

(i) that have **not** crossed over;

_____

(ii) that have crossed over.

_____

(2)

(d) Give **two** processes, other than crossing over, which result in genetic variation. Explain how each process contributes to genetic variation.

Process _____

Explanation _____

_____

Process _____

Explanation _____

_____

(4)

(Total 8 marks)

Q60.

(a) During meiosis, one chromosome from each homologous pair goes to each of the cells produced. Explain why this is important.

_____

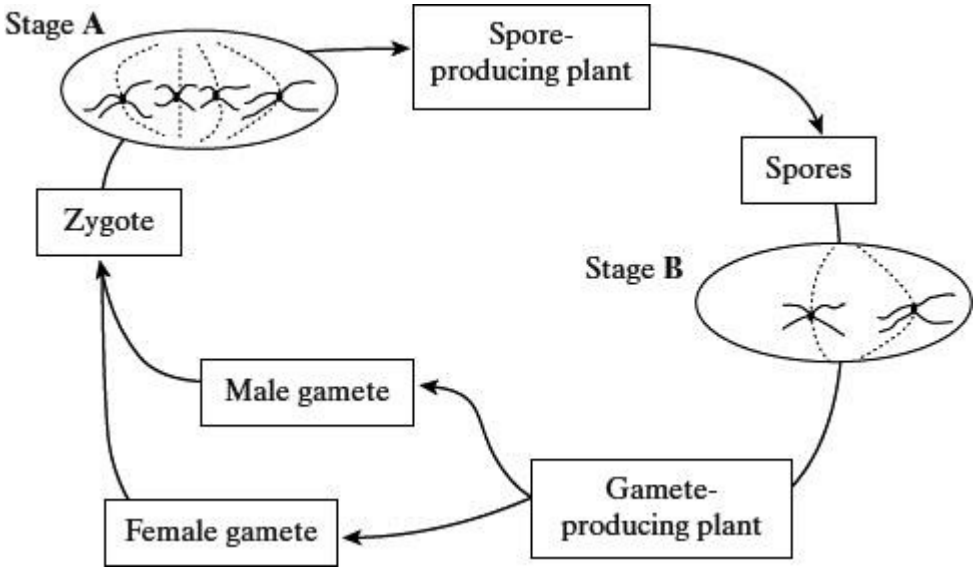
_____

_____

_____

(2)

(b) The diagram shows the life cycle of a fern plant. Drawings of the chromosomes during cell division are shown for the stages that give the spore-producing plant and the gamete-producing plant.



(i) What is the diploid number of chromosomes in this fern plant?

_____

(1)

(ii) Explain the difference in the number of chromosomes at stages **A** and **B**.

_____

_____

(1)

(iii) Are the male and female gametes produced by mitosis or meiosis?

Explain your answer.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q61.

(a) Explain how crossing over can contribute to genetic variation.

_____

_____

_____

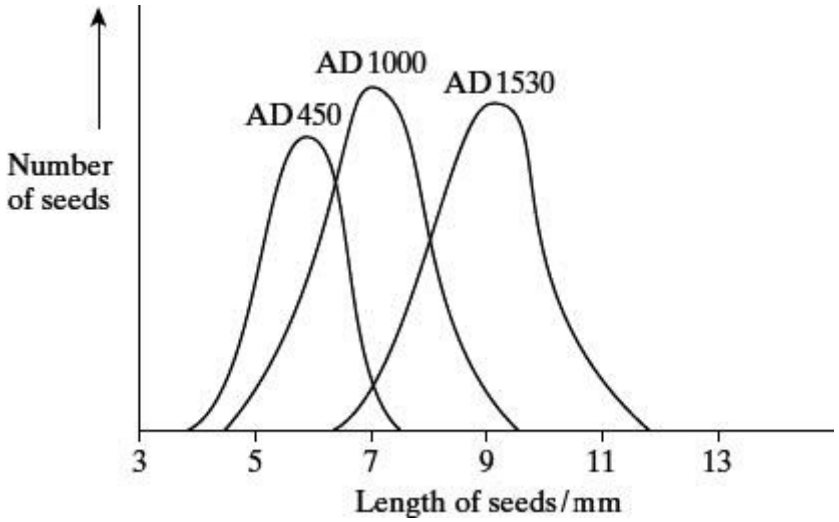
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_____

_____

(3)

(b) Maize seeds were an important food crop for the people who lived in Peru. The seeds could be kept for long periods. Each year, some were sown to grow the next crop. Archaeologists have found well-preserved stores. The graph shows the lengths of seeds collected from three stores of different ages.



(i) Within each store the maize seeds showed a range of different lengths. Explain **one** cause of this variation.

_____

_____

_____

_____

(2)

(ii) Use your knowledge of genetics and selection to explain the changes in the mean length of the seeds between AD 450 and AD 1530.

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 9 marks)

Q62.

The National Vegetable Research Station stores a collection of seeds from many species and varieties of vegetables. These include old and rare varieties.

(a) Why is it important to keep seeds from old and rare varieties of vegetables?

_____

_____

_____

_____

(2)

(b) Every few years, seeds of each variety in the collection are germinated and grown into mature plants. New seeds obtained from these plants are added to the collection.

(i) Suggest why it is necessary to obtain new seeds every few years.

_____

_____

(1)

(ii) Within each variety, the scientists cross plants with different genotypes. Explain the advantage of this.

_____

_____

_____

_____

(2)

(Total 5 marks)

Q63.

(a) Explain the importance of meiosis in the life cycles of organisms which reproduce sexually.

_____

_____

_____

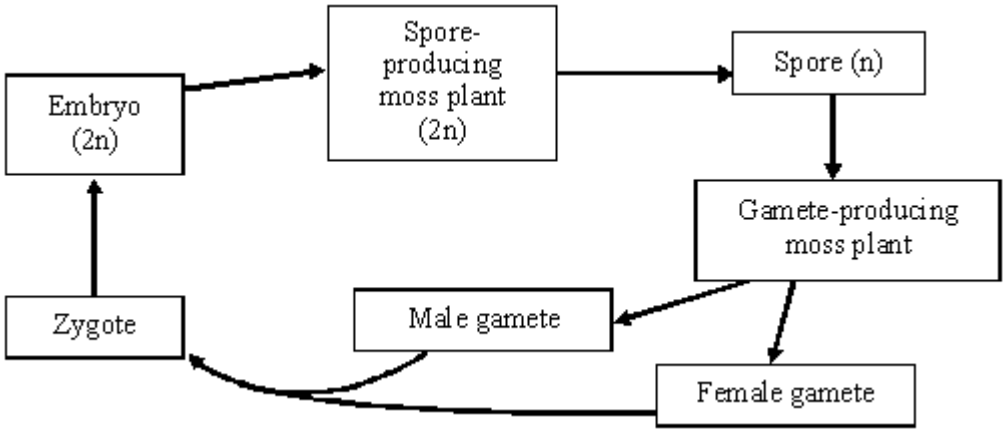
_____

_____

_____

(3)

(b) The diagram shows the life cycle of a moss plant.



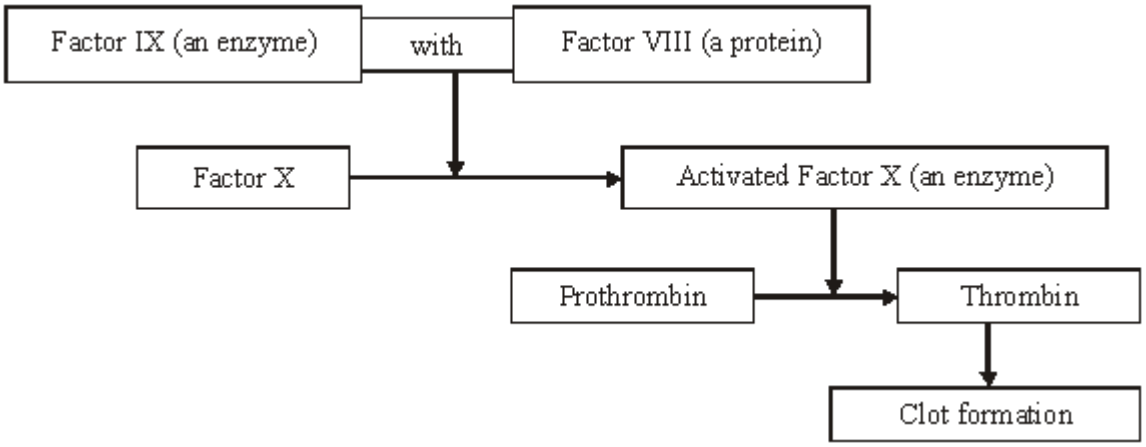
On the diagram mark with an **M** where meiosis takes place.

(1)

(Total 4 marks)

Q64.

The diagram shows part of the metabolic pathway involved in the clotting of blood in response to an injury.



Haemophilia is a condition in which blood fails to clot. This is usually because of a mutant allele of the gene for Factor VIII.

(a) Explain how mutation could lead to faulty Factor VIII.

_____

_____

_____

_____

(2)

(b) Use information in the diagram to explain how faulty Factor VIII causes haemophilia.

_____

_____

_____

_____

(2)

(c) A boy had haemophilia caused by faulty Factor IX. When his blood was mixed with blood from a haemophiliac with faulty Factor VIII, the mixture clotted. Suggest an explanation for clotting of the mixture.

_____

_____

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_____

(2)

(Total 6 marks)

Q65.

Figure 1 and **Figure 2** show the chromosomes from a single cell at different stages of meiosis.

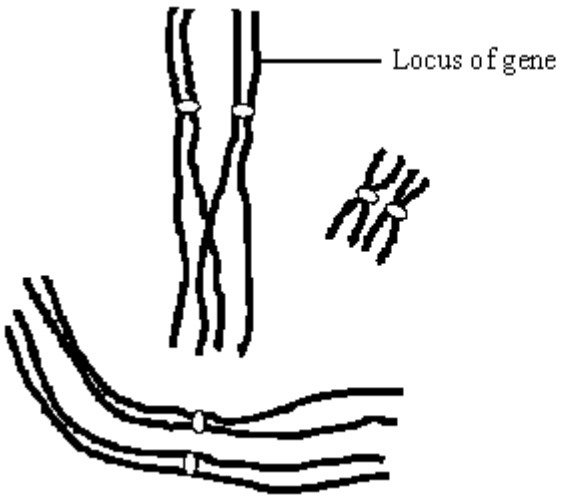


Figure 1

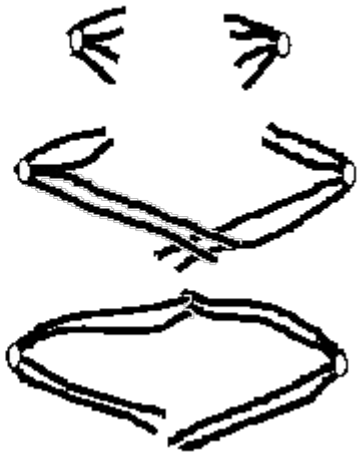


Figure 2

(a) What is the diploid number of chromosomes in the organism from which this cell was taken?

_____

(1)

(b) Describe what is happening to the chromosomes at the stage shown in

(i) **Figure 1**;

_____

_____

_____

_____

(2)

(ii) **Figure 2**.

_____

_____

_____

_____

(2)

(c) (i) The genotype of this organism is **Bb**. The locus of this pair of alleles is shown in **Figure 1**.

Label **two** chromosomes on **Figure 2** to show the location of the **B** allele and the location of the **b** allele.

(1)

(ii) How many genetically different gametes can be produced by meiosis from a cell with the genotype, **Bb Cc Dd**? Assume these genes are located on different pairs of homologous chromosomes. Show your working.

_____

(2)

(Total 8 marks)