

Cells – A2 Biology

1. No.1

0 1 . 1

Give the **three** structural features found in **all** virus particles **and** describe the function of **one** of these features.

[2 marks]

1 DNA (Genetic material)

2 Capsid

3 Attachment proteins that bind to cell receptors

Function of **one** named feature Capsid protects the genetic material of the virus.

0 1 . 2

Explain why viruses are described as acellular and non-living.

[2 marks]

They are not made of cells and do not carry out metabolic reactions.

Viruses have no cell surface membranes and do not carry out life processes such as nutrition.

0 1 . 3

Give **one** reason why antibiotics are **not** effective against viruses.

[1 mark]

The viruses don't have a cell wall which antibiotics can act on.

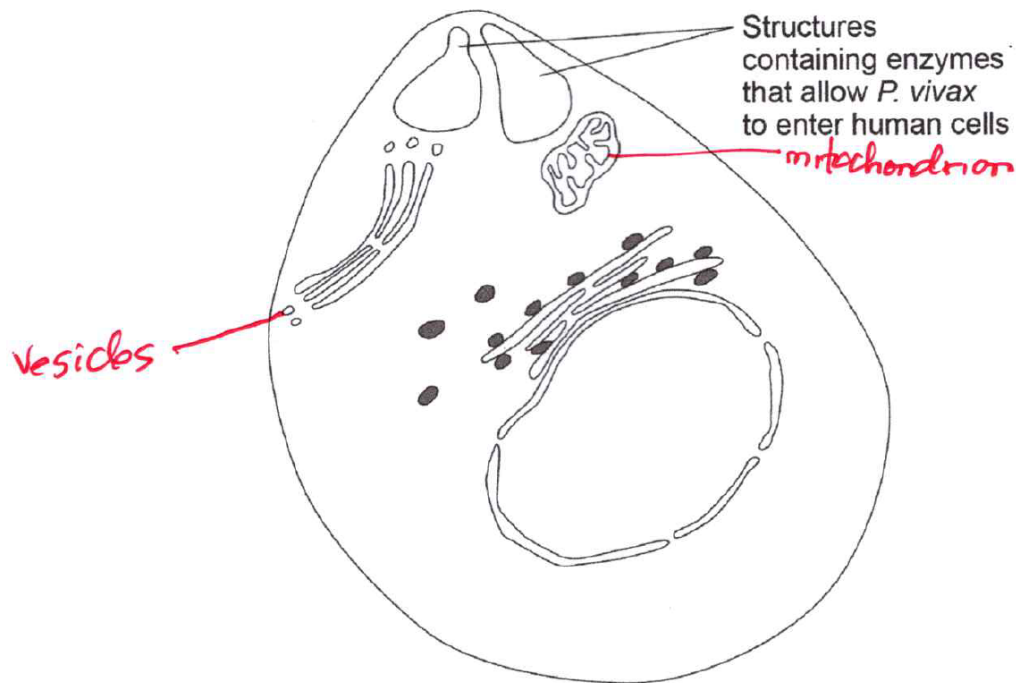
2. No.3

0 3 . 1

The human disease, malaria, is caused by infection with a single-celled eukaryotic organism.

Figure 2 shows a diagram of *Plasmodium vivax*, one of the species that can cause malaria.

Figure 2



Other than the Golgi apparatus, name **one** structure in **Figure 2** which shows that *P. vivax* is a eukaryote.

[1 mark]

vesicles

endoplasmic reticulum

mitochondrion

0 3 . 2

Describe **two** functions of the Golgi apparatus in a eukaryotic cell.

[2 marks]

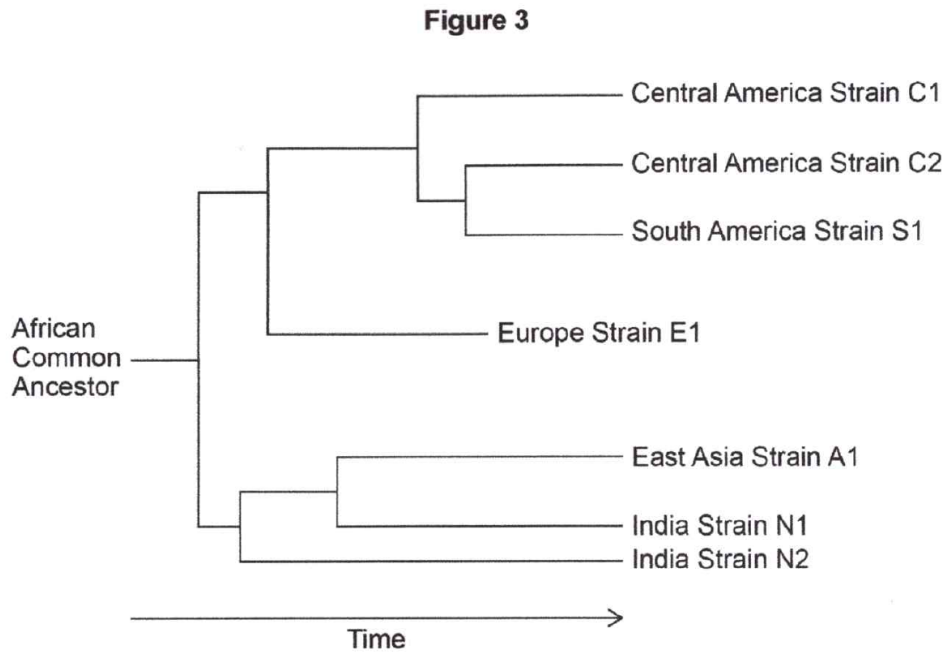
1 Modify and package proteins that are destined for export to the outside of the cell

2 Transport glycoproteins to cell surface membrane.

P. vivax evolved from a common ancestor in Africa. As humans migrated around the world, new strains of *P. vivax* evolved.

P. vivax is now extremely rare in Africa but there are several different strains of *P. vivax* in other parts of the world.

Figure 3 shows a phylogenetic diagram of the evolution of these different strains.



0 3 . 3

What does **Figure 3** suggest is the order of human migration out of Africa?

Central American strain is the most distant to the African ^{Common} ancestor
 Tick (✓) **one** box.
Indian strain is the closest to African ancestor in the phylogenetic tree [1 mark]

Europe, India, East Asia, Central America, South America

☐

India, East Asia, Europe, South America, Central America

☐

India, Europe, East Asia, Central America, South America

☒

South America, Central America, East Asia, Europe, India

☐

0 3 4

There are an estimated 229 million cases of human malaria worldwide per year. 94% of these cases are found in Africa, but are not caused by *P. vivax*. *P. vivax* does cause 61% of the cases of human malaria outside Africa.

Use this information to calculate the number of cases worldwide caused by *P. vivax* each year.

causes outside Africa = $(1 - 0.94) \times 229 \text{ million} = 13.74 \text{ million}$ [1 mark]
 Cases caused by *P. vivax* = $13.74 \times \frac{61}{100} = 8.3814 \text{ million}$
 $8.3814 \times 1000,000$
 $\approx 8.4 \times 10^6$

Answer _____ cases of malaria

0 3 5

In Africa today, most of the human population are resistant to malaria caused by *P. vivax*.

Use your knowledge of natural selection to explain why this resistance is so common in Africa.

[4 marks]

Mutation produced allele for resistance to Malaria
 Those with the allele for resistance are less likely to get malaria. They survive and reproduce to pass on the allele. This increases allele frequency within the population over many generations.
 This allele confer resistance to Malaria to those that have it.

3. No.9

0 9

Dengue fever is a human disease caused by the dengue virus.

Scientists designed an ELISA test to detect antibodies to the dengue virus in a patient's blood sample.

Figure 10 shows a diagram of this test and some information about how it works.

Figure 10

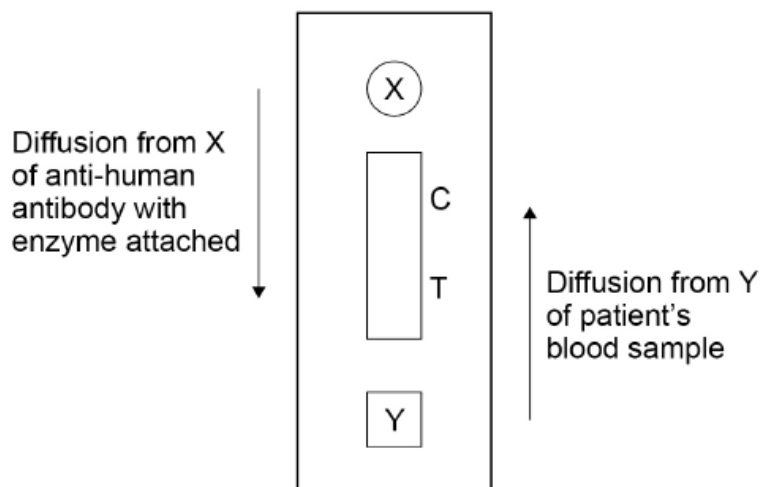
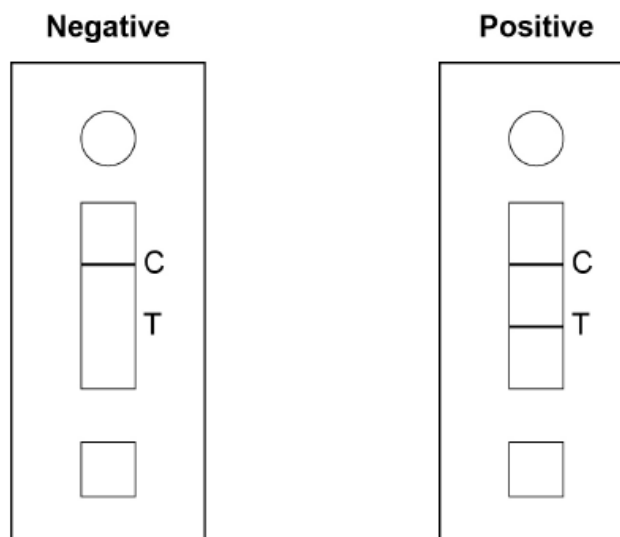


Figure 11 shows the negative and positive results that were produced 20 minutes after the use of the test shown in Figure 10.

Figure 11



09.1

Suggest what is on the test at line T and explain what causes the line to appear in a positive test.

[2 marks]

Enzyme binds with substrate at T to form enzyme-substrate complex. The complex forms a colour that is visible as a line at T. The substrate is colourless but complex is coloured.

09.2

A line at C shows that the test has worked.

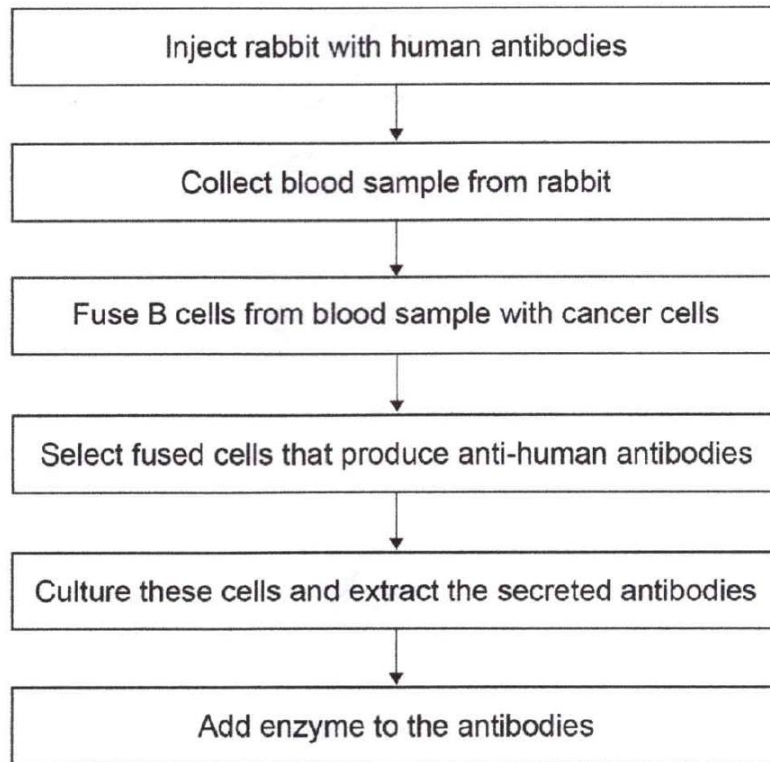
Suggest one reason why a line at C shows the test has worked.

[1 mark]

Blood sample diffused above T in the test.

Figure 12 shows a flowchart of how the anti-human antibodies with enzyme attached are produced.

Figure 12



09.3

Suggest why the fused cells allow continuous production of monoclonal antibodies.

[2 marks]

Cancer cells replicate rapidly by mitosis.
The B cells produce monoclonal antibody

09.4

Evaluate the ethics of the production process shown in **Figure 12**.

[1 mark]

Production of monoclonal antibodies is harmful but it produces medicine that stops human suffering.

Early identification of dengue fever can be difficult as many other diseases produce the same symptoms. Early identification is important because people suffering with dengue fever can become ill very quickly and may need hospital treatment.

Scientists compared the effectiveness of three diagnostic tests for dengue fever.

- Laboratory-based test – a patient's blood sample is sent from the doctor's clinic to a laboratory for testing.
- Current test used in the doctor's clinic.
- New test to be used in the doctor's clinic – the ELISA test shown in **Figures 10 and 11** (on page 24).

The scientists' results are shown in **Table 3**.

A blood sample from each patient with confirmed dengue fever at each time after onset of symptoms was tested with all three diagnostic tests.

Table 3

Time after onset of symptoms / days	Number of confirmed dengue fever patients tested	Number of positive results		
		Laboratory-based test	Current test	New test
1–2	14	10	0	6
3–4	38	28	6	24
5–7	18	8	14	14

09.5

The scientists recommend that the new test is used for the identification of dengue fever in all countries around the world.

Discuss this recommendation. Use all the information given.

[3 marks]

The method is better than current at early detection but not as good as the lab-based.

The new test is better than lab based as from 5 days. The new test is cheaper and quicker.

New test and lab-based give better total of positives than current.

09.6

The dengue virus causes damage to capillaries so that blood proteins move out of the capillaries into the tissue fluid.

Explain how this would affect the return of tissue fluid into the capillaries.

[2 marks]

Loss of blood proteins in the capillaries increases water potential of blood at the capillaries. So, less water returns to blood at capillaries by osmosis. So, more water leaves blood by osmosis.

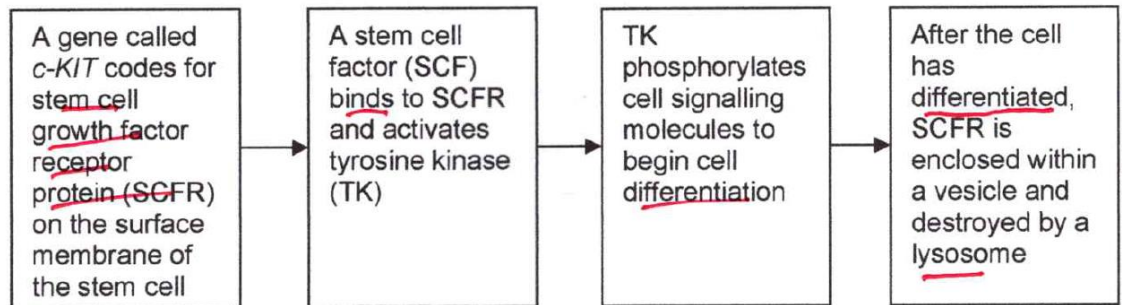
4. No.4

0 4

Following a body injury, bone marrow stem cells move to the site of damage and undergo cell differentiation.

Figure 5 shows how this differentiation occurs.

Figure 5



0 4 . 1

Suggest how SCFR is destroyed by a lysosome.

[2 marks]

The vesicle fuses with a lysosome so that hydrolytic enzymes ^{at lysosome} digest SCFR

After a heart attack, cardiomyocytes (cardiac muscle cells) die, and become infarcted tissue. Infarcted tissue cannot contract.

Stem cells in bone marrow cannot move to the infarcted tissue and differentiate into cardiomyocytes.

Scientists used laboratory rats to investigate if bone marrow stem cell transplants could be used to repair infarcted tissue resulting from a heart attack.

They split the rats into three groups.

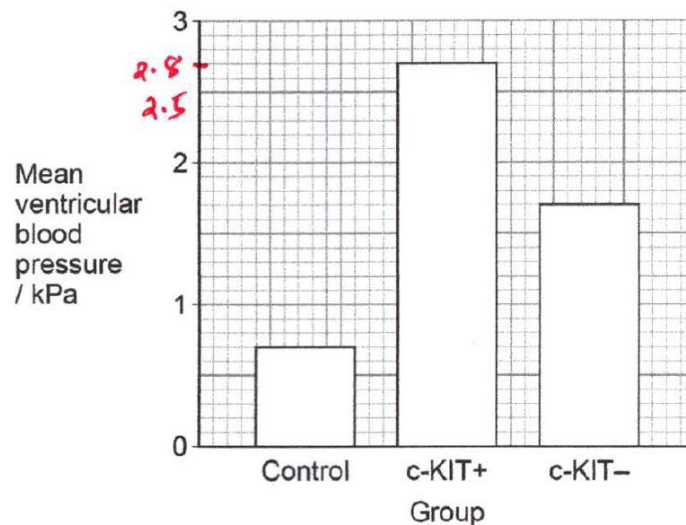
- **Control** group did not get a transplant of bone marrow stem cells.
- **c-KIT⁺** group got a transplant of bone marrow stem cells with a functioning *c-KIT* gene.
- **c-KIT⁻** group got a transplant of bone marrow stem cells with **no** functioning *c-KIT* gene.

After 9 days, the scientists measured the mean ventricular blood pressure of each of the three groups.

Figure 6 shows their results.

The differences between the groups were all statistically significant.

Figure 6



0 4 2

Using all of the information, suggest explanations for the results for the **Control** group and the **c-KIT-** group shown in **Figure 6**.

[4 marks]

Control Cardiomyocytes have not been replaced.
This is why contraction of the ventricle is weak.
A small number of Cardiac muscles are still
alive. So, pressure at ventricles remains
low. Pressure is not zero because not all
Cardiac muscles became infarcted.

c-KIT- Mean ventricular pressure is higher
than control because some stem cells must
have been able to differentiate. This shows
that c-KIT is not the only gene responsible
for differentiation. So, SCF must be binding
to something other than SCFR.

0 4 . 3

Nine days after transplantation, the **c-KIT+** group showed that 68% of infarcted tissue was made up of new cardiomyocytes. The control group had no new cardiomyocytes.

Assuming that mean ventricular blood pressure is directly proportional to the number of cardiomyocytes, calculate the percentage of infarcted tissue that was made up of new cardiomyocytes in the c-KIT- group.

[2 marks]

New : old
68 : 32

New cardiomyocytes = 68%
Mean ventricular pressure proportional to the number of cardiomyocytes = $P \propto \text{cardiomyocytes}$
 $P_1 = KC$ where $K = \text{constant}$
 $P_2 = K \times \frac{68}{100} C = 0.68 KC$
 $\frac{P_2}{P_1} = \frac{0.68 KC}{KC} = 0.68 = \frac{68}{100} = \frac{34}{50}$
% infarcted tissue $\frac{68}{100} = \frac{34}{50}$ Answer 34 %

All new cardiomyocytes produced:

- Connexin-43, a channel protein that allows electrical impulses to pass between cardiomyocytes
- GATA-4, a transcriptional factor that stimulates the expression of genes for actin and myosin.

0 4 . 4

Suggest how production of Connexin-43 and GATA-4 could give the result seen in the **c-KIT+** group in **Figure 6** (on page 13).

Do **not** include details of transcription or translation in your answer.

[2 marks]

Connexin-43 it allows impulses to pass to the bottom of the ventricles. It allows diffusion of ions between cardiomyocytes.

GATA-4 It causes more binding of myosin to actin. This leads to formation of more actin-myosin bridges.

5. No.6

0 6 . 1

Give **two** types of cell that can stimulate an immune response.

[2 marks]

- 1 Antigen-presenting cells
- 2 Abdominal body cells

An autoimmune disease causes the immune system to attack healthy body tissues. Scientists investigated the immune responses of healthy mice and mice with autoimmune disease.

The chemical OXA causes an immune response in mice and can make their skin swell. Mice had olive oil applied to their left ear and OXA in olive oil applied to their right ear.

The immune response was recorded in two ways:

- the cellular response by measuring the mean increase in ear thickness 24 hours after exposure to OXA
- the humoral response by measuring the mean concentration of anti-OXA antibody in blood 14 days after exposure to OXA.

Table 2 shows the results of this investigation. The values in the brackets show ± 2 standard deviations. A value of ± 2 standard deviations from the mean includes over 95% of the data.

Table 2

Type of mice	Sex of mice	Mean increase in ear thickness / $\text{cm} \times 10^{-3}$	Mean concentration of anti-OXA antibody / arbitrary units
Healthy	Male	17.9 (± 4.1)	16 (± 3)
	Female	18.5 (± 2.9)	14 (± 4)
Autoimmune disease	Male	25.9 (± 4.5)	14 (± 2)
	Female	16.7 (± 3.0)	26 (± 7)

0 6 . 2

Suggest and explain **one** reason why olive oil was applied to the left ear of the mice.

[1 mark]

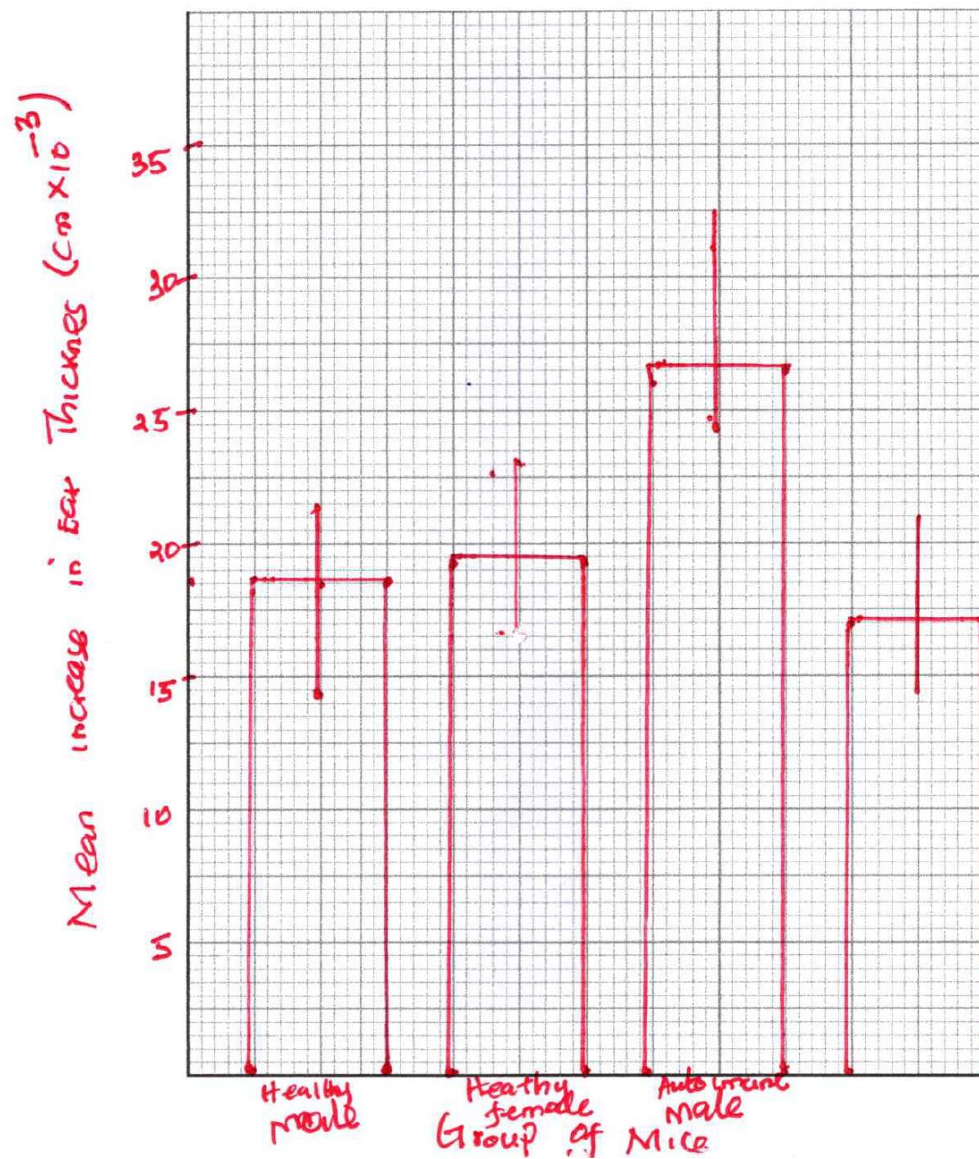
it was used as control experiment, to show that it is OXA affecting the immune response

06.3

Plot a suitable graph for mean increase in ear thickness for each group of mice in Table 2.

Include the data for ± 2 standard deviations on your graph.

[3 marks]



0 6 . 4

What can you conclude about the effects of autoimmune disease on the cellular response and the humoral response in male and female mice?

Use the data to justify your conclusions.

[3 marks]

- Male to female cellular response has no significant difference because the standard deviations overlap. There is significant increase in cellular response in autoimmune male compared with autoimmune female because standard deviations do not overlap.
- There is significant increase in humoral response in autoimmune female compared with autoimmune male as standard deviations do not overlap.

0 6 . 5

Some studies have shown that in humans, oestrogen has the opposite effect on two different autoimmune diseases. Oestrogen:

- accelerates the progression of systemic lupus erythematosus (SLE)
- prevents the progression of rheumatoid arthritis (RA).

The scientists investigated the effect of oestrogen on the immune response in healthy mice and mice with autoimmune disease.

Table 3 shows the scientists' results.

Table 3

Type of mice	Effect of oestrogen on humoral response	Effect of oestrogen on cellular response
Healthy	No effect	No effect
Autoimmune disease	Increase in response	Decrease in response

A student studying these data made the following conclusions.

1. In humans, SLE is caused by an overproduction of antibodies.
2. In humans, RA is caused by an overproduction of cytotoxic T cells (T_C cells).

Evaluate the student's conclusions.

[4 marks]

- Oestrogen increases the humoral response that produces antibody. Production of more antibodies could increase the progression of SLE. Oestrogen decreases cellular response and this will slow down progression of RA. Mice and humans are mammals, so the effect is similar in both. This makes conclusions valid.
- However, investigation was done in mice and not humans; so, results would be different. Decrease in cellular response could also mean fewer antigen presenting cells and not just T_C cells. This makes the conclusions invalid.

06.6

In mice, one type of autoimmune disease is inherited as a dominant allele. Would the Hardy-Weinberg principle hold true for a population of mice, some of which had this autoimmune disease?

Explain your answer.

[2 marks]

- No. Mice with autoimmune disease will be unlikely survive and reproduce. It will be selected against naturally
- Hardy-Weinberg principle would hold because allele frequency remain constant as long as mice's ability to reproduce is not affected.

6. (7.2)

07

Write an essay on one of the topics below.

07

2

The importance of membranes in the functioning of cells.

[25 marks]

- Cell membranes separates cell's internal from the external one. This maintains cell structural integrity. This barrier prevents entry of toxic materials into the cell.
- Cell membranes are selectively permeable. So, they control of materials into and out of cell. The transport channel proteins regulates flow of ions into cell.
- Cell membranes contain receptors that bind with signalling molecules. This initiates chain reaction of events within the cell. This allows the cell to respond to changes in the external stimuli.
- Membranes are essential for passive transport, active transport and exocytosis. Passive transport allows the molecules to move down their concentration gradient.

→ In active transport, ^{transport} proteins use ATP to move molecules against their concentration gradient.

Endocytosis and exocytosis involve absorption and release of molecules across cell membrane.

This shows that cell membranes support cellular transport.

- Among eukaryotes, internal membranes create compartments (organelles) for different processes. The mitochondria's membrane supports ATP production. Membranes of endoplasmic reticulum enable protein and lipid synthesis.

- Cell membranes provide structural support and maintain flexibility of the cell. It allows cell to change shape and divide.

- In prokaryotes, surface area to volume ratio is very high. So, materials such as oxygen diffuse across cell membrane into the cell.

- Absorption of end products of digestion occurs across cell membranes of the micro-villi and epithelium lining cells inside the villi.

- To generate action potential, the cell membranes of the axon allows movement of Na^+ outside of axon. This causes a wave of depolarisation.

- During protein synthesis, the pores on the nuclear envelope allows for mRNA to leave nucleus and go to cytoplasm where ribosomes is located.

- Cell membrane regulates flow of glucose into and out of cell. This affects water potential inside the cell.

- At the synapse, arrival of action potential causes the vesicles to move and fuse with the ^{membrane of} pre-synaptic neuron. Then, the vesicles burst open to release neuro-transmitter across the synapse.