

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names											
Pearson Edexcel Level 3 GCE		Centre Number <table border="1"><tr><td></td><td></td><td></td><td></td><td></td></tr></table>						Candidate Number <table border="1"><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
Thursday 4 June 2020													
Morning (Time: 1 hour 45 minutes)		Paper Reference 9BI0/01											
Biology B Advanced Paper 1: Advanced Biochemistry, Microbiology and Genetics													
You must have: Calculator, HB pencil, ruler			Total Marks										

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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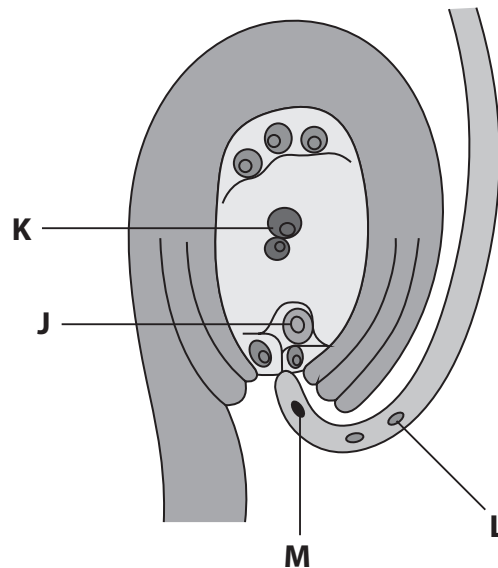
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Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

- 1 The diagram shows a pollen tube entering the embryo sac of a flowering plant.



Complete the table to give the name of each labelled structure and the number of sets of chromosomes that each structure contains.

(4)

Structure	Name of structure	Number of sets of chromosomes
J	<i>egg cell (female gamete)</i>	<i>one (haploid, n)</i>
K	<i>polar nucleus</i>	<i>one (haploid, n)</i>
L	<i>male gamete</i>	<i>one (haploid, n)</i>
M	<i>pollen tube nucleus</i>	<i>one (haploid, n)</i>

(Total for Question 1 = 4 marks)



2 The table shows two differences between blood plasma and tissue fluid.

Blood plasma	Tissue fluid
Has a higher protein content	Has a lower protein content
Contains more dissolved oxygen	Contains less dissolved oxygen

(a) State how tissue fluid is formed.

(1)

High hydrostatic pressure at the arteriole end of the capillary forces fluid (plasma) out of the capillaries into the spaces between the cells.

(b) Explain the differences between blood plasma and tissue fluids shown in the table.

(2)

Blood plasma has a higher protein content because plasma proteins (e.g. albumin) are too large to pass out through the capillary walls, so they stay in the blood.

Tissue fluid contains less dissolved oxygen because oxygen has diffused from the tissue fluid into the cells, where it is used in respiration.

(c) Some of the tissue fluid is not reabsorbed into the blood capillary.

Describe what happens to the tissue fluid that is not reabsorbed into the blood capillary.

(2)

The tissue fluid that is not reabsorbed drains into the lymphatic vessels (lymphatic system), where it is called lymph.

The lymph is carried through the lymph vessels and returned to the blood by draining into the (subclavian) veins near the heart.

(Total for Question 2 = 5 marks)



3 Mosquitoes transmit a number of diseases, including malaria.

The photograph shows a mosquito, *Anopheles gambiae*.

This mosquito transmits malaria.



Source: © Sinclair Stammers / Science photo library

(a) (i) State the genus of this mosquito.

(1)

Anopheles

(ii) Mosquitoes belong to the class Insecta.

Some of the insects in this class are subdivided into a group called Diptera.

What is the name of the classification group that includes Diptera?

(1)

- ☐ A Family
- ☐ B Genus
- ☒ C Order
- ☐ D Phylum

(iii) Which of the following organisms causes the symptoms of malaria?

(1)

- ☐ A *Anopheles gambiae*
- ☒ B *Plasmodium falciparum*
- ☐ C *Puccinia graminis*
- ☐ D *Salmonella enterica*



(b) From 2010 to 2015 there was a 29% decrease in the number of deaths from malaria. This was due to prevention and control measures.

(i) Explain **one** implication of a named method of controlling malaria.

(2)

Using mosquito nets (insecticide-treated bed nets) over beds to stop mosquitoes biting people at night.

One implication is that nets are too expensive for many people in poor areas and are not always available, so not everyone can be protected.

(ii) In 2015, the number of deaths from malaria was 429 000.

Calculate the number of deaths from malaria in 2010.

(2)

percentage of 2010 deaths in 2015 = $100 - 29 = 71\%$

deaths in 2010 = $429\,000 \times 100 \div 71 = 604\,225$

Answer *604 225*

(c) In 2015, the number of cases of malaria was 211 million. This increased to 216 million cases in 2016.

Give the change in the number of cases of malaria in standard form.

(1)

change = $216\text{ million} - 211\text{ million} = 5\text{ million}$

Answer *5×10^6*



(d) Scientists are researching new methods of controlling malaria.

One group used a procedure called gene drive.

This procedure resulted in female mosquitoes that could not bite or could not lay eggs.

One of the scientists said:

'It will still be at least 5 to 10 years before we consider testing any mosquitoes with gene drive, but now we have some encouraging proof that we're on the right path.'

Explain why this group are sharing the results of their research.

(2)

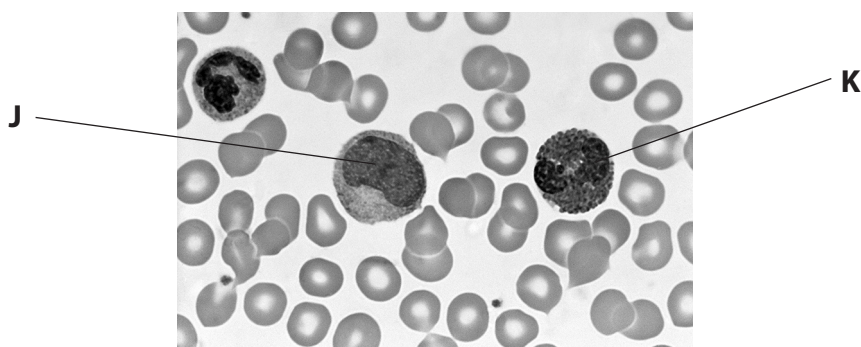
They want other scientists to validate their results, so the results are seen as reliable before any testing on wild mosquitoes.

By sharing, other members of the scientific community can check, repeat, discuss and criticise their work (peer review), and use it to develop the research further.

(Total for Question 3 = 10 marks)



- 4 The photograph shows a blood smear from a healthy person, as seen using a light microscope.



Source: © biophoto associates/science photo library

- (a) (i) Which row of the table identifies the cells labelled **J** and **K**?

(1)

	Cell J	Cell K
☐ A	eosinophil	lymphocyte
☐ B	lymphocyte	neutrophil
☒ C	monocyte	eosinophil
☐ D	neutrophil	monocyte

- (ii) Which is the approximate ratio of erythrocytes to leucocytes in this blood smear?

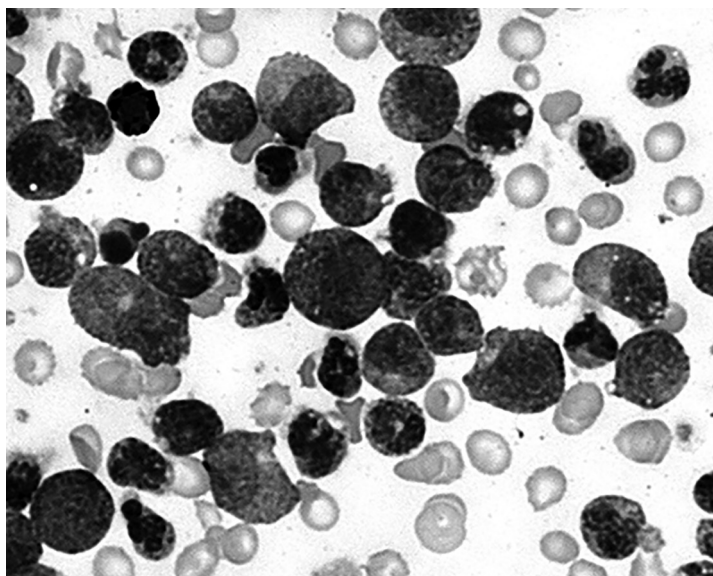
(1)

- ☐ **A** 1:50
☐ **B** 3:50
☐ **C** 50:1
☒ **D** 50:3



(b) Chronic myelogenous leukaemia (CML) is a blood disorder.

The photograph shows a blood smear from a person with CML, as seen using a light microscope.



Explain why a blood smear can be used to diagnose CML.

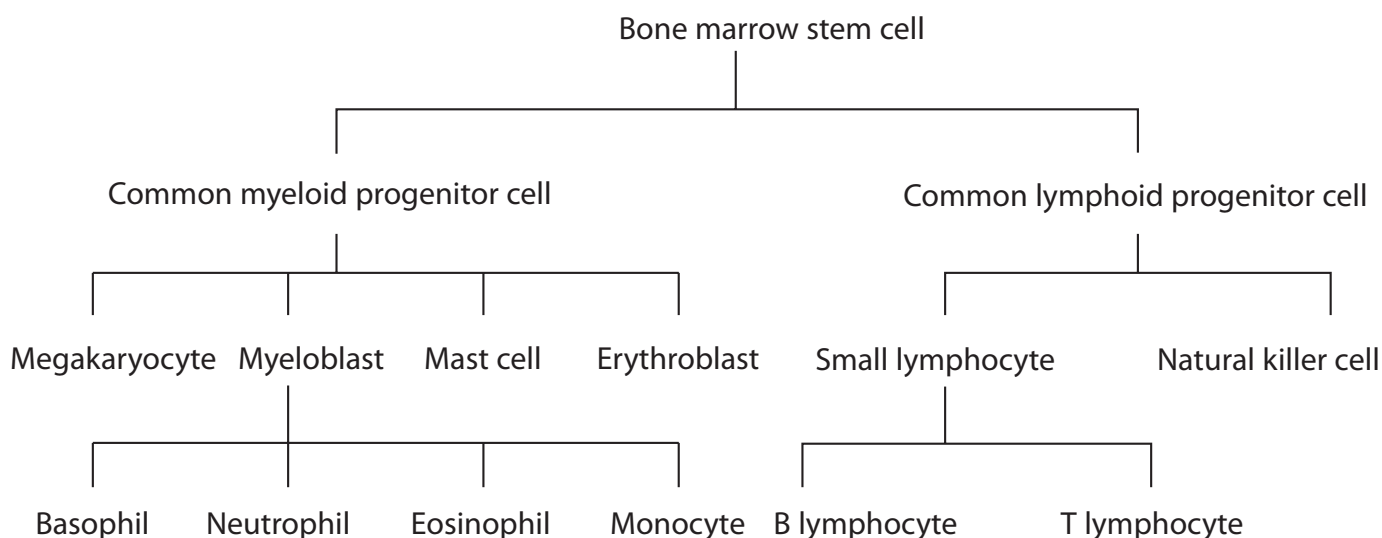
(2)

From a blood smear the numbers of erythrocytes (red blood cells) to leucocytes (white blood cells) can be counted and determined.

These numbers can then be compared to a normal (healthy) blood smear: in CML there are many more leucocytes and fewer erythrocytes than normal.



(c) The diagram shows some stages in the production of blood cells from bone marrow stem cells.



Explain how a bone marrow stem cell differentiates into either a common myeloid progenitor cell or a common lymphoid progenitor cell.

(4)

The stem cell differentiates by epigenetic modification of its DNA.

For example, DNA methylation (adding methyl groups to cytosine) or histone methylation switches genes off, as transcription is prevented, whereas histone acetylation switches genes on, so transcription can take place.

House-keeping genes, needed in both cell types (e.g. for respiration), remain switched on.

In a common myeloid progenitor cell, the genes needed only in common lymphoid progenitor cells become permanently switched off, and the myeloid genes are switched on (and the converse in a lymphoid cell).

So only certain mRNA is transcribed and translated, causing proteins to be made that are specific to that cell type.

(Total for Question 4 = 8 marks)



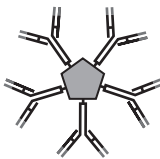
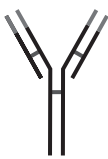
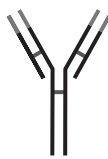
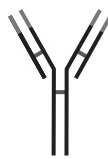
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- 5 The rubella virus stimulates the production of antibodies in humans but usually causes only mild infections.

However, infection of pregnant women can cause serious problems for the developing fetus.

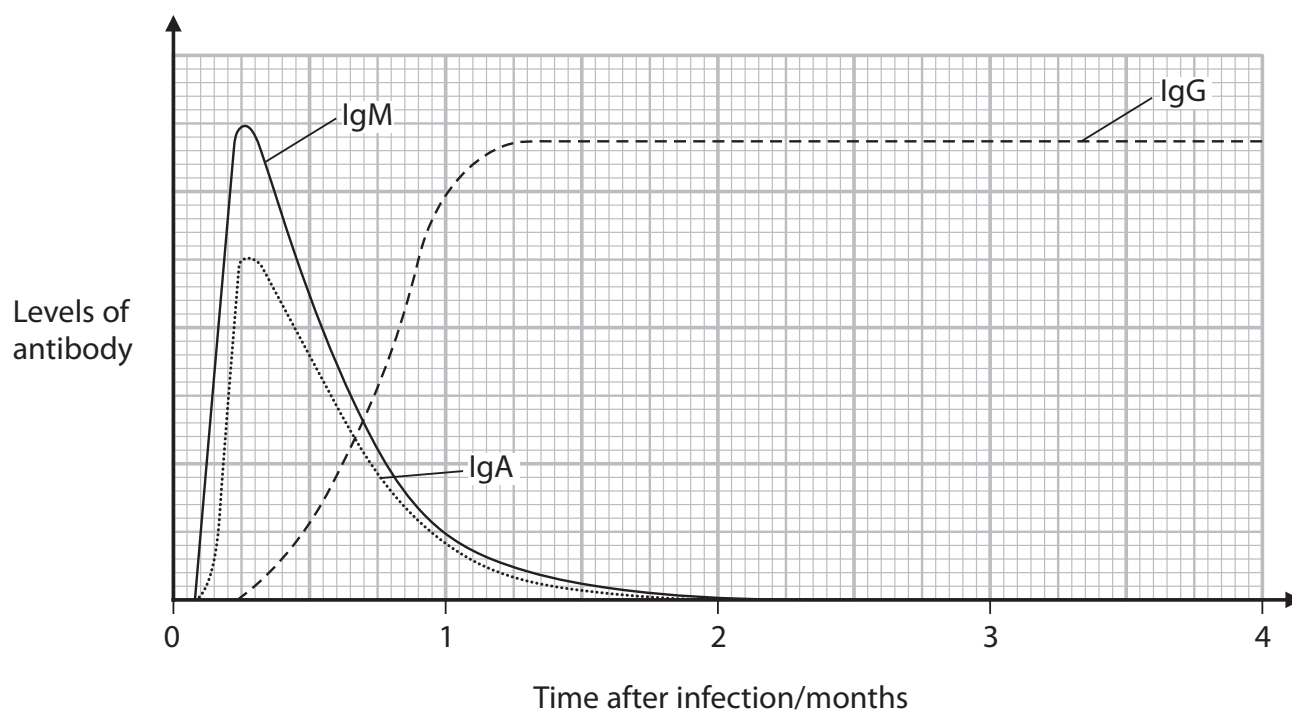
*(a) Antibodies can be divided into five classes.

The table gives some information about these classes of antibody.

Information	Class of antibody				
	IgM	IgA	IgG	IgD	IgE
Shape					
Number of antigen binding sites	10	4	2	2	2
Can cross the placenta	no	no	yes	no	no
Other details	secreted into the blood	secreted into mucus, tears, saliva, colostrum ¹	secreted into the blood	attached to the surface of B cells	involved in allergy and parasitic infections

¹ Colostrum is the first type of milk produced by the mother following birth.

The graph shows the levels of three of these classes of antibody produced in response to infection with the rubella virus.



Analyse the information in the table and the graph to assess the role of these five classes of antibody in the immune response to the rubella virus.

(6)

The graph shows IgM and IgA are produced early in the response, peaking within about 0.3 months, while IgG rises later and persists for months. IgM has ten antigen-binding sites, so it causes agglutination of many viruses at once, giving a fast primary response. IgA has four binding sites, so it can also agglutinate viruses and acts in opsonisation to enhance phagocytosis by phagocytes. It is secreted into mucus, tears and saliva, so it prevents entry of the virus through the eyes and nose, and in colostrum it gives passive immunity to a newborn baby.

IgG persists in the body for months, providing immunity to the virus. With two binding sites it causes agglutination and opsonisation, enhancing phagocytosis. It is the only class that can cross the placenta, giving the fetus passive immunity against rubella.

IgD is attached to the surface of B cells, so it is involved in B cell activation by binding the virus antigen to the B cell; activated B cells then differentiate into plasma cells that produce antibodies.

IgE is not involved, because rubella infection is not a parasitic infection and does not cause an allergic response.



(b) Vaccination against rubella has helped to reduce the incidence of infection.

Explain the importance of vaccinating as many people as possible against rubella.

(2)

Vaccinating as many people as possible results in herd immunity, so there are fewer infected people to pass the virus on to uninfected people.

This protects people who cannot become immune, e.g. those allergic to the vaccine, immunosuppressed people and pregnant women, so fewer fetuses are harmed.

(Total for Question 5 = 8 marks)



- 6 Norovirus is a single-stranded RNA, non-enveloped virus.

Norovirus is the most common cause of gastroenteritis.

- (a) The table shows some features used to classify viruses.

Which box in each row shows how these viruses are classified?

(3)

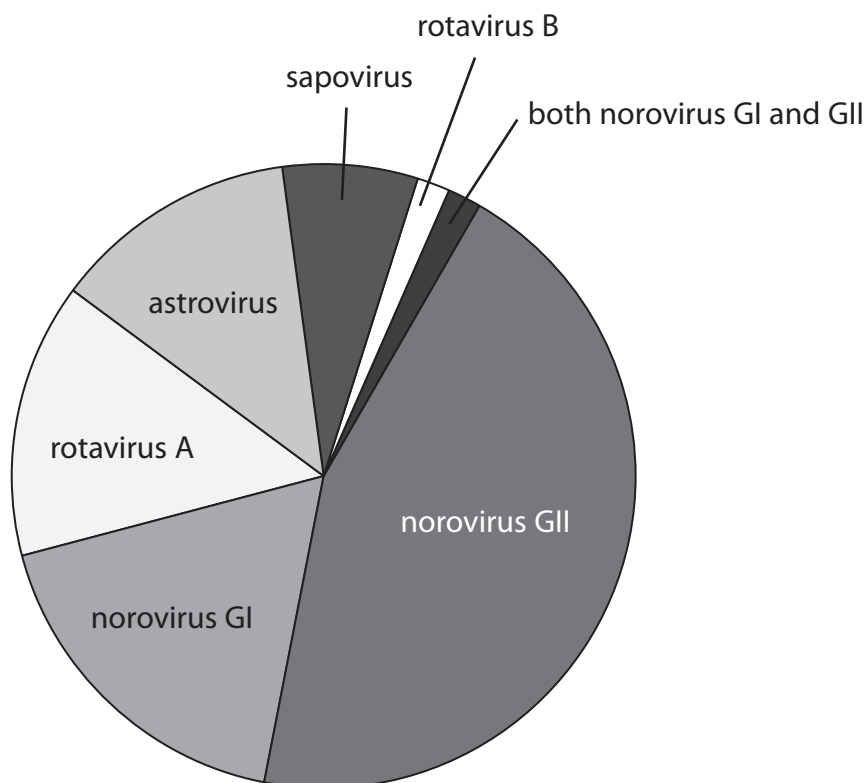
Virus	Classification of viruses			
	DNA enveloped	DNA non-enveloped	RNA enveloped	RNA non-enveloped
Ebola	☐	☐	☒	☐
λ (lambda) phage	☐	☒	☐	☐
Tobacco mosaic	☐	☐	☐	☒



(b) One study into the causes of gastroenteritis involved 162 patients.

This study found that 24.7% of these gastroenteritis cases were caused by viruses.

The pie chart shows the proportion of the different types of virus identified as causing these gastroenteritis cases.



Estimate the total number of gastroenteritis cases caused by noroviruses.

(3)

$$\text{cases caused by viruses} = 162 \times 24.7 \div 100 = 40$$

$$\text{noroviruses (GI + GII + both)} \approx 65\% \text{ of pie chart}$$

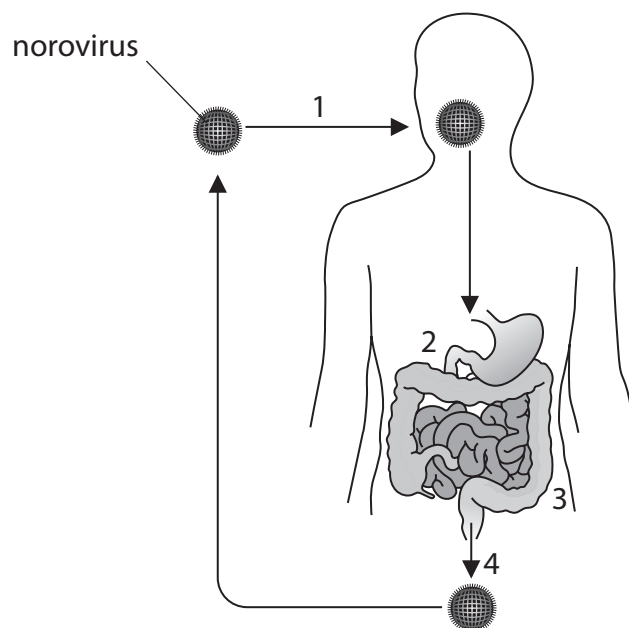
$$\text{norovirus cases} = 40 \times 65 \div 100 = 26$$

Answer 26 cases



(c) Norovirus is usually spread through the faecal-oral route.

The diagram shows the pathway that norovirus takes through the body.



- 1 The norovirus is transmitted in contaminated food or water.
- 2 The norovirus passes through the stomach and into the small intestine.
- 3 Some noroviruses are taken up by the cells of the small intestine.
- 4 Some noroviruses pass out of the body in the faeces.

This process only takes a few hours.

Describe what happens inside the cells of the small intestine that have taken up the norovirus.

(3)

The viral RNA is released into the cell and the host cell's ribosomes and enzymes are used to make (replicate) more viral RNA.

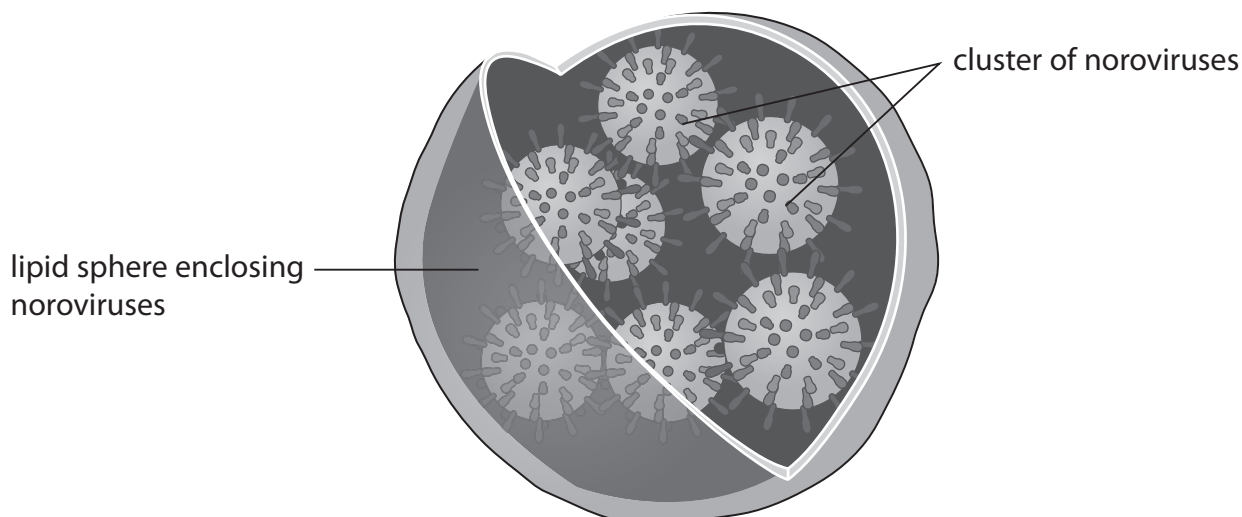
The viral RNA is translated to make viral proteins, including capsid proteins.

The RNA and capsid proteins are assembled into new virus particles, which are then released from the cell.

- (d) Noroviruses can infect an animal as individual viruses or as a cluster of viruses inside a lipid sphere.

A cluster of viruses inside a lipid sphere is called a stealth sphere.

The diagram shows a stealth sphere.



- (i) Animals infected with stealth spheres develop gastroenteritis very quickly and with severe symptoms.

Animals infected with individual noroviruses develop gastroenteritis more slowly and with less severe symptoms.

Analyse the information to explain these findings.

(3)

A stealth sphere delivers many viruses to a cell at once, rather than one virus at a time, so more viruses enter cells.

The lipid sphere can fuse with and pass through the cell surface membrane, so there is no need to bind to cell receptors; it also protects the viruses from enzymes, stomach acid and the immune system (phagocytes).

So more cells are infected quickly and virus particles are not destroyed, so symptoms develop faster and are more severe.

- (ii) Scientists are hoping that new treatments for norovirus infections can be developed to target the stealth sphere.

Analyse the information to explain how targeting the stealth sphere could be used to treat these infections.

(2)

A drug could target the lipid sphere so that the lipids are broken down, e.g. by an enzyme that breaks down lipid.

This releases the viruses so they are exposed to the immune system, and fewer virus particles arrive at the cells in one go.

(Total for Question 6 = 14 marks)



7 Lipids and carbohydrates are used as respiratory substrates.

The respiration of lipids generates more ATP than the respiration of carbohydrates.

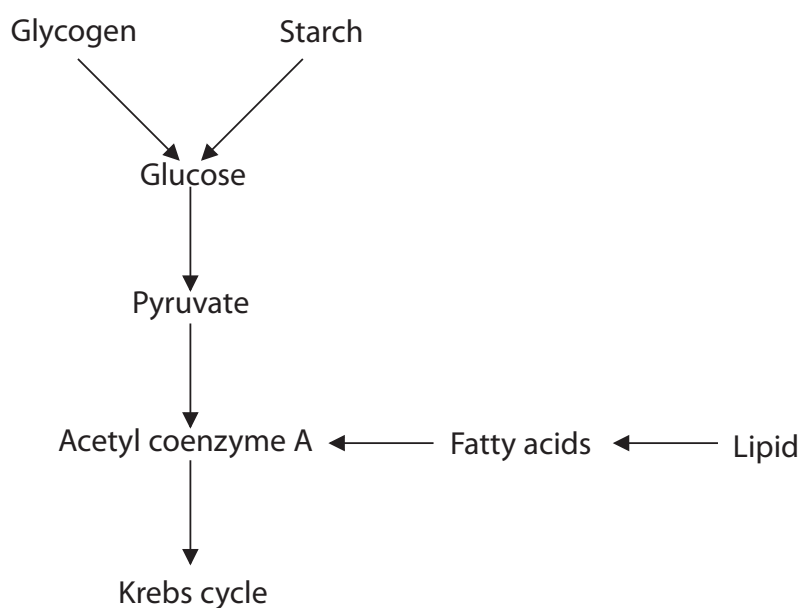
(a) The table shows bonds that may be found in carbohydrates and lipids.

Which box in each row shows whether the bond may be found in these molecules?

(3)

Bond	Molecule that bond may be found in			
	carbohydrate only	lipid only	both carbohydrate and lipid	neither carbohydrate nor lipid
covalent	☐	☐	☒	☐
ester	☐	☒	☐	☐
hydrogen	☒	☐	☐	☐

(b) The diagram shows some steps in the respiration of carbohydrates and lipids.



(i) Where in a cell does the conversion of pyruvate to acetyl coenzyme A take place?

(1)

- ☐ **A** cytoplasm
- ☒ **B** matrix
- ☐ **C** stroma
- ☐ **D** tonoplast



(ii) Explain why lipids can be respired only in aerobic conditions.

(3)

Fatty acids are broken down into acetyl coenzyme A, which must enter the Krebs cycle; in anaerobic conditions pyruvate is used to reoxidise NADH, so there is no Krebs cycle.

With no oxygen there is no terminal electron acceptor at the end of the electron transport chain.

So reduced NAD and reduced FAD (NADH, FADH₂) cannot be reoxidised, so there is no oxidised coenzyme to bind hydrogen ions (protons) and electrons, and the Krebs cycle and fatty acid breakdown stop.

(c) The electron transport chain uses hydrogen ions to generate ATP.

Explain why the respiration of lipids generates more ATP than the respiration of carbohydrates.

(2)

A lipid molecule contains a higher proportion of hydrogen atoms than a carbohydrate, so more reduced NAD and reduced FAD are produced.

So more hydrogen ions are pumped into the intermembrane space, producing a larger proton gradient, so more pass through ATP synthase by chemiosmosis (oxidative phosphorylation).

(d) The respiratory quotient (RQ) can indicate which substrate is being used in respiration.

The formula used to calculate RQ is

$$\text{RQ} = \frac{\text{volume of carbon dioxide produced}}{\text{volume of oxygen used}}$$

(i) State why the RQ for carbohydrate is 1.0.

(1)

When carbohydrate is respired, the volume of carbon dioxide produced is the same as the volume of oxygen used.



- (ii) The table shows the formula for calculating the volume of oxygen used and the volume of carbon dioxide produced in the respiration of lipids.

The number of carbon atoms in the lipid is represented by n .

Volume of oxygen used / a.u.	Volume of carbon dioxide produced / a.u.
$4.5n + 3.75$	$3n + 6$

Calculate the RQ for a lipid containing 21 carbon atoms.

(2)

$$\text{oxygen used} = (4.5 \times 21) + 3.75 = 98.25 \text{ a.u.}$$

$$\text{carbon dioxide} = (3 \times 21) + 6 = 69 \text{ a.u.}$$

$$\text{RQ} = 69 \div 98.25 = 0.70$$

Answer 0.70

- (e) Explain why an insect has an RQ of 1.0 at rest and an RQ of 0.7 during flight.

(3)

At rest the insect is respiring carbohydrate (RQ 1.0), as respiration of carbohydrate provides enough energy for the insect at rest.

During flight the insect requires much more energy (ATP) for muscle contraction.

So it has to respire lipid (RQ 0.7) to provide this extra energy, as lipids release more ATP per gram than carbohydrates.

(Total for Question 7 = 15 marks)



8 Skin flora include bacteria that live on the skin.

Different parts of the body have different types of bacteria present.

Skin flora are beneficial as they inhibit the growth of pathogenic bacteria on the skin.

Skin flora compete for nutrients and space or secrete toxic chemicals.

(a) The following are types of bacteria found in the female genital tract:

- *Escherichia coli*
- *Klebsiella* species
- *Lactobacillus* species
- *Staphylococcus* species.

(i) Describe how these types of bacteria present in the female genital tract could be identified.

(4)

Take a sample (swab) from the female genital tract and culture it on agar plates.

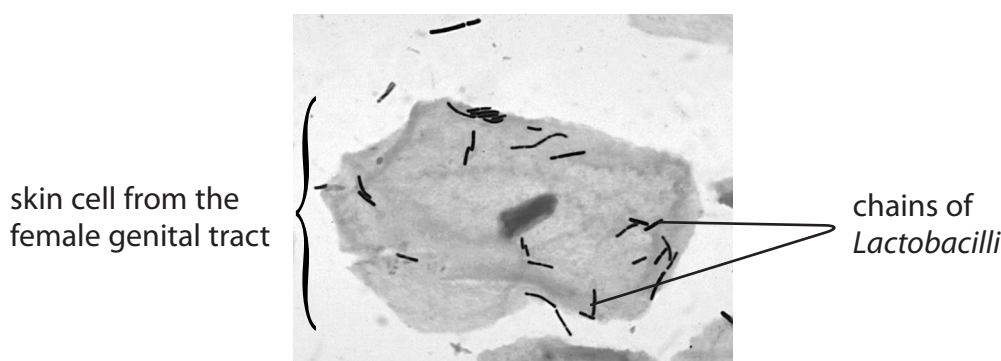
Grow the bacteria on selective or indicator media, e.g. MacConkey agar, so only certain bacteria grow or colonies change colour (E. coli ferments lactose).

Grow the bacteria on media containing different types of antibiotics to see which antibiotics each type is sensitive to.

Use Gram staining, cell shape (rods or cocci, e.g. Staphylococcus in clusters), colony shape and colony colour, and use antibodies or DNA profiling (PCR) to confirm each species.



- (ii) The photograph shows *Lactobacilli* on a skin cell from the female genital tract.



Source: © Janice Carr Content Providers (s): CDC/Dr. Mike Miller

Lactobacilli metabolise glycogen into lactic acid.

Explain how *Lactobacilli* inhibit the growth of pathogenic bacteria in the female genital tract.

(3)

Lactobacilli grow on the skin cells, so they occupy the space and prevent pathogenic bacteria from growing there.

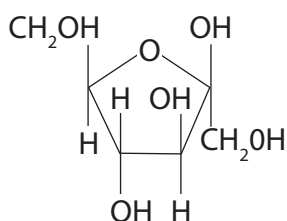
They use the glycogen, so less glycogen (glucose, energy) is available for the pathogenic bacteria.

They produce lactic acid, which lowers the pH and inhibits the growth of pathogenic bacteria, as the low pH (below their optimum) denatures the enzymes of the pathogenic bacteria.

- (b) Sperm cells are released into the female genital tract in seminal fluid.

Seminal fluid contains fructose instead of glucose.

The diagram shows the structure of fructose.



(i) Compare and contrast the structure of fructose with the structure of glucose.

(3)

Similarities: both are hexoses with the formula $C_6H_{12}O_6$ (six carbon atoms), and both contain covalent bonds.

Differences: glucose has a hexagon (six-membered) ring, whereas fructose has a pentagon (five-membered) ring.

Glucose has one CH_2OH group but fructose has two CH_2OH groups.

(ii) Explain the advantages of the presence of fructose in seminal fluid.

(3)

Fructose acts as a respiratory substrate (energy source) for the sperm, as respiration produces ATP.

The sperm need ATP for movement (tail contraction) through the female genital tract to reach the egg.

Using fructose rather than glucose reduces competition for carbohydrates with the skin cells and bacteria of the genital tract, which may not use fructose.

(Total for Question 8 = 13 marks)



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- 9 The photograph shows a wombat, an animal that lives in dry parts of Australia.



Source: © Blue Gum Pictures/Alamy Stock Photo

Wombats are herbivores, feeding on grasses, leaves and bark. Wombats also dig in the soil for roots.

They have behavioural and physiological adaptations to survive periods of severe drought.

The effect of drought on the health of wild wombats was investigated.

Changes in body mass, body condition and the chemical constituents of stomach contents and faeces were recorded.

These changes were related to the changes in the quality and quantity of the food of wombats.

- (a) Explain why drought affects the quality and quantity of the food of wombats.

(5)

In a drought there is less water in the soil for plants to take up, so plants wilt or die.

So fewer mineral ions are taken up and transported to the rest of the plant, e.g. less nitrate so less amino acid and protein made, and less magnesium so less chlorophyll, so plants are less nutritious.

There is less water for photolysis in the light-dependent reaction, so less photosynthesis.

So less GALP is produced in the light-independent reaction (Calvin cycle), so less NPP (plant biomass) for wombats to eat.



(b) The table shows some of the measurements made in this investigation.

Measurement	Before drought	10 months into drought	14 months into drought	2 months after rain
Body condition index	0.92	0.86	0.76	0.85
Body mass / kg	26.4	25.1	21.2	25.2
Organic matter in stomach / g kg ⁻¹ dry matter	946	732	704	822
Mineral ion content in stomach	low	high	high	low
Moisture content of faeces / g kg ⁻¹ wet mass	815	603	522	748

(i) The body condition was expressed as a body condition index (BCI).

The BCI can be calculated using the formula

$$BCI = \frac{\text{body mass of wombat}}{\text{mass-for-length of wombat (Y)}}$$

The mass-for-length (Y) of a wombat can be calculated using the formula

$$Y = (\text{body length} \times 0.73) - 34.5$$

A wombat before the drought had a body length of 86.4 cm and a mass of 26.4 kg.

Calculate the BCI of this wombat.

(2)

$$Y = (86.4 \times 0.73) - 34.5 = 28.572$$

$$BCI = 26.4 \div 28.572 = 0.92$$

Answer 0.92



*(ii) Analyse the data to explain the results of this investigation.

(6)

During the drought body mass decreased from 26.4 kg to 21.2 kg after 14 months, so the body condition index also decreased (from 0.92 to 0.76). This is because less nutritious plant material was available, so the wombats used their fat and protein stores.

Organic matter in the stomach decreased from 946 to 704 g kg⁻¹, because less plant material was available to eat in the drought.

The mineral ion content in the stomach increased from low to high, because the wombats foraged more for roots by digging, and therefore soil was consumed with the roots.

The moisture content of faeces decreased from 815 to 522 g kg⁻¹, as the plant material did not contain as much water, so the wombat had to conserve water by reabsorbing more water from its faeces.

2 months after rain the measurements started returning to normal (body mass 25.2 kg, BCI 0.85, organic matter 822, minerals low, faeces moisture 748), as the quality and quantity of plant material increased.

(Total for Question 9 = 13 marks)

TOTAL FOR PAPER = 90 MARKS



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