



Oxford Cambridge and RSA

Thursday 9 June 2022 – Afternoon

AS Level Biology B (Advancing Biology)

H022/02 Biology in depth

Time allowed: 1 hour 30 minutes



You can use:

- a ruler (cm/mm)
- a scientific or graphical calculator



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

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First name(s)

Last name

StemUp Model Solution

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for a correct method, even if your answer is wrong.

INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [].
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE

- Read each question carefully before you start your answer.

Answer **all** the questions.

- 1 **Fig. 1.1** shows a prepared slide of onion cells in different stages of mitosis, viewed using a light microscope.

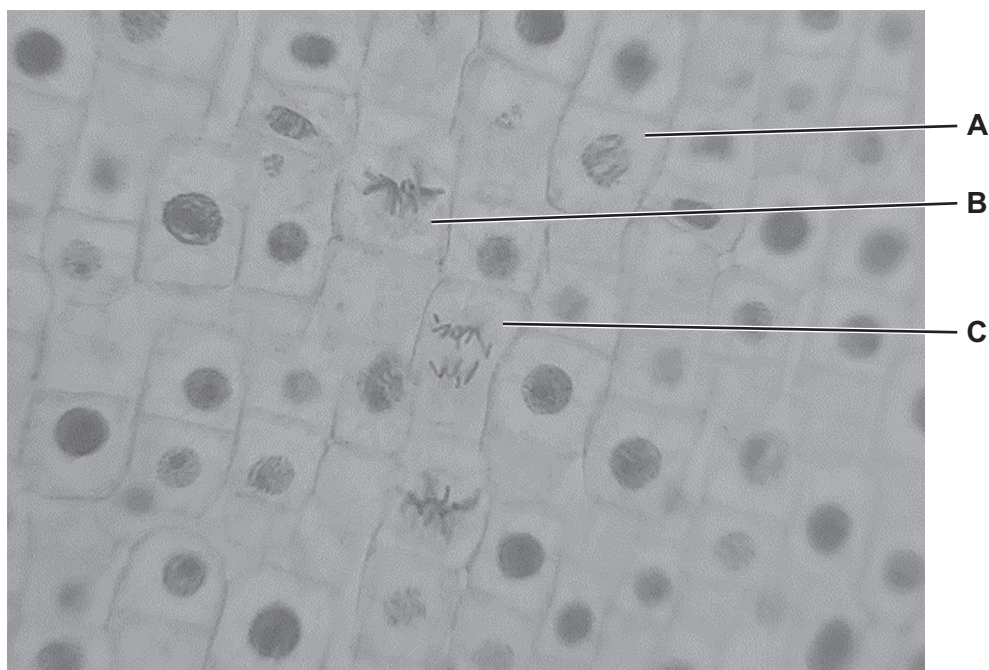


Fig. 1.1

- (a) (i) Name the stages of mitosis taking place in cells **A** and **B**.

A *Prophase*

B *Metaphase*

[2]

(ii) Fig. 1.2 shows a student's drawing of the cell labelled C in Fig. 1.1.

Onion cell $\times 400$

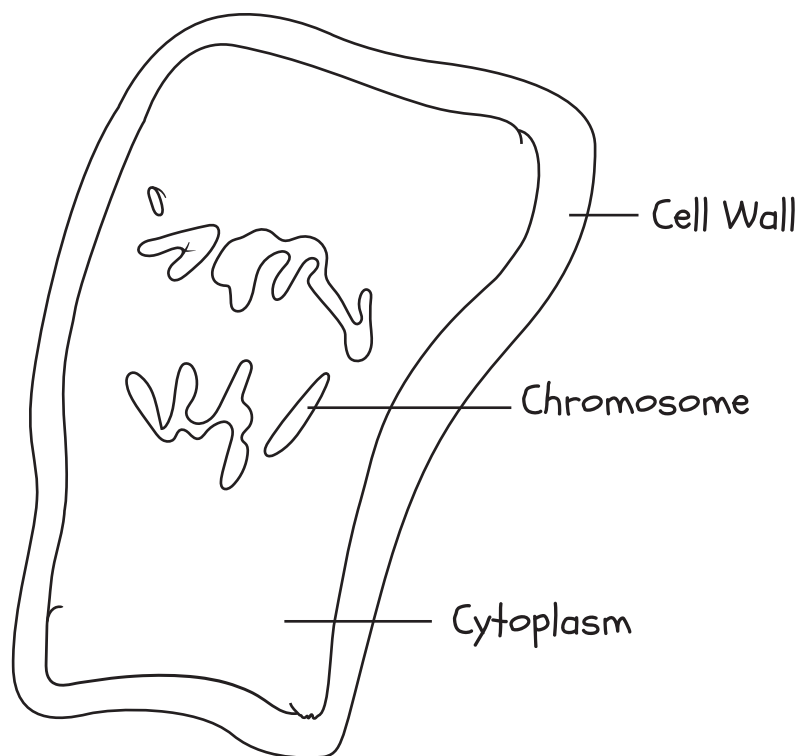


Fig. 1.2

Give **two** improvements the student could make to their drawing.

- 1 *Draw continuous single lines and do not sketch or shade.*
- 2 *Draw the cell wall thinner and keep the proportions of the cell and chromosomes accurate.*

[2]

(b) Fig. 1.3 shows the cell cycle in an onion cell.

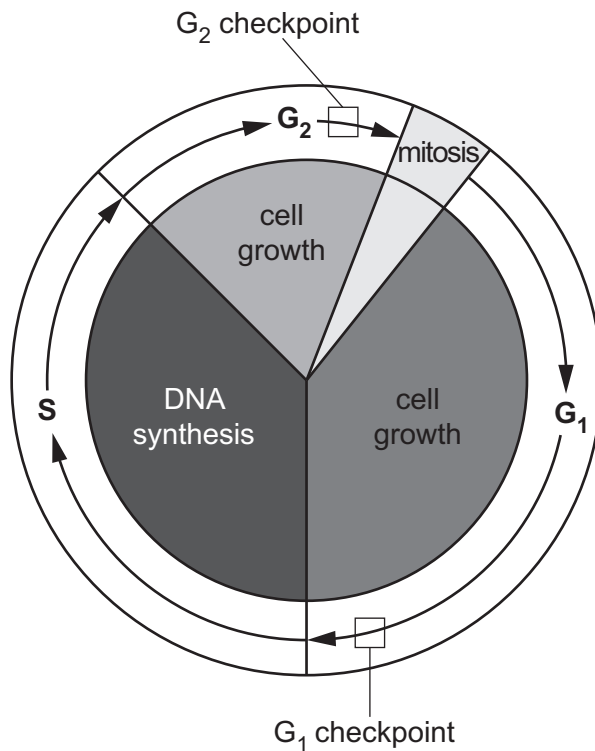


Fig. 1.3

Mitosis in an onion cell occurs once in 24 hours and lasts for 80 minutes.

Metaphase takes approximately 6.5 minutes to complete.

Calculate the percentage of the cell cycle which is spent in metaphase.

$$24 \text{ hours} = 1440 \text{ minutes}$$

$$(6.5 \div 1440) \times 100 = 0.45138\ldots$$

$$\text{Metaphase} = \dots\dots\dots 0.45 \dots\dots\dots \% \text{ [2]}$$

(c) There are two main checkpoints in the cell cycle, the G_1 checkpoint and the G_2 checkpoint.

Explain how each of the checkpoints can ensure the cell develops normally.

G_1 ..Checks the cell is large enough and has sufficient nutrients, energy
..reserves and proteins before DNA replication.....

G_2 ..Checks the cell size, that DNA has replicated fully and that there is no
..DNA damage before mitosis.....

[2]

- (d) The cell cycle is controlled by proteins. These proteins can initiate apoptosis.

Describe the sequence of events that occurs during apoptosis.

The cell shrinks and the nucleus condenses (pyknosis) as chromatin
condenses.
The cell membrane forms blebs, and the nucleus breaks up into fragments
(karyorrhexis); the cell breaks into membrane-bound fragments.
Phosphatidylserine is exposed on the outer surface of the membrane, which
signals to macrophages, so the fragments are engulfed by phagocytosis.

[3]

2 Lenticels appear as small brown patches on the surface of some fruit.

A researcher wanted to investigate if water availability affected the number of lenticels on the surface of apples.

They chose nine apple trees of one variety and watered each tree with a specific volume of water every day for twelve weeks.

After twelve weeks they counted the total number of lenticels that developed on the surface of one apple from each tree.

This was repeated with a second variety of apple.

Fig. 2.1 shows the number of lenticels found on the surface of the two varieties of apple.

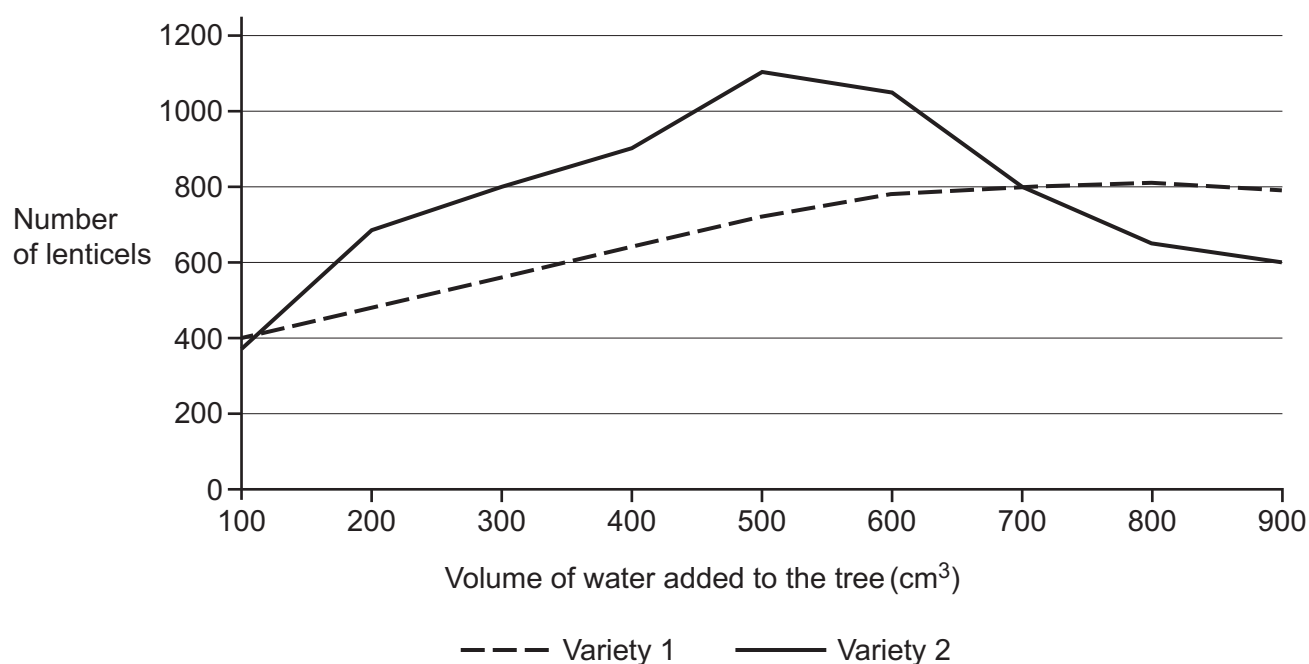


Fig. 2.1

- (a) (i) Using **only Fig. 2.1**, what conclusions can be drawn about the effect of water availability on lenticel number for these two varieties of apple?

As the volume of water increases, the number of lenticels increases for both varieties (then decreases at the highest volumes).

Below 700 cm³ variety 2 has more lenticels, but above 700 cm³ variety 1 has more, e.g. at 900 cm³ variety 1 has more lenticels than variety 2.

[2]

- (ii) Another researcher suggested that:

‘Adding a known volume of water to the tree is **not** a suitable method of investigating the effect of water availability on lenticel development.’

Evaluate this claim.

Suitable to some extent, as a known volume allows a quantitative comparison between trees.

Not suitable, because water availability is also affected by soil moisture, so the volume added is not the water available. Not all of the water added will be taken up by the trees, as some drains away or evaporates.

The rate of transpiration also affects how much water each tree takes up, and other variables (e.g. humidity, tree size) were not controlled, so the claim is largely justified.

[4]

- (iii) Explain why any difference in lenticel number shown in **Fig. 2.1** should not be described as a **significant** difference.

Only one apple was counted per tree, so there is no evidence of replicates and no means were calculated.

So no statistical test (such as a t-test) was carried out, and significance cannot be judged.

[2]

- (iv) During this investigation, the trees were kept in a laboratory at 20 °C.

State **two** other variables that must also be controlled in this investigation **and** suggest how they could be controlled.

1 *Light intensity: use the same lamp at a fixed distance from each tree.*

.....

2 *Humidity: use a dehumidifier with a humidistat (or wind speed: use a fan at a constant speed).*

..... [2]

- (v) The researcher compared the number of lenticels on apples of each variety. A more accurate method would be to compare the density of lenticels per apple.

Suggest how the researcher could measure lenticel density **and** explain why this would be a more accurate way to compare the effect of water availability on the two varieties. You can assume that the apples are spherical.

Measure the diameter of each apple, calculate the surface area ($4\pi r^2$) and divide the number of lenticels by the total surface area.

This is more accurate because apples vary in size and surface area, so a larger apple would have more lenticels anyway.

..... [2]

(b)* Compare and contrast gaseous exchange in stomata and lenticels.

Similarities: in both, gas exchange is by diffusion down a concentration gradient between the air spaces in the plant and the atmosphere. Both exchange O_2 and CO_2 , both lose some water vapour, and in both the rate is affected by environmental conditions.

Differences: stomata are mainly on leaves (lower epidermis), lenticels mainly on bark and fruit. Stomata are more numerous with a greater surface area, so more gas exchange (and water loss) occurs through them; stomata are sunken, lenticels raised.

Stomata have guard cells, which use ATP to pump ions in, so turgor pressure changes open them in the light and close them in the dark. Lenticels have no guard cells, use no ATP and have no turgor changes, so stay open all the time.

Stomata mainly let CO_2 in for photosynthesis in daylight, whereas lenticels mainly allow gas exchange for respiration (O_2 in, CO_2 out).

[6]

Additional answer space if required.

3 Tuberculosis (TB) is a disease caused by the bacterium *Mycobacterium tuberculosis*.

Fig. 3.1 shows the number of TB cases in the UK and the total population of the UK from 2001–2019.

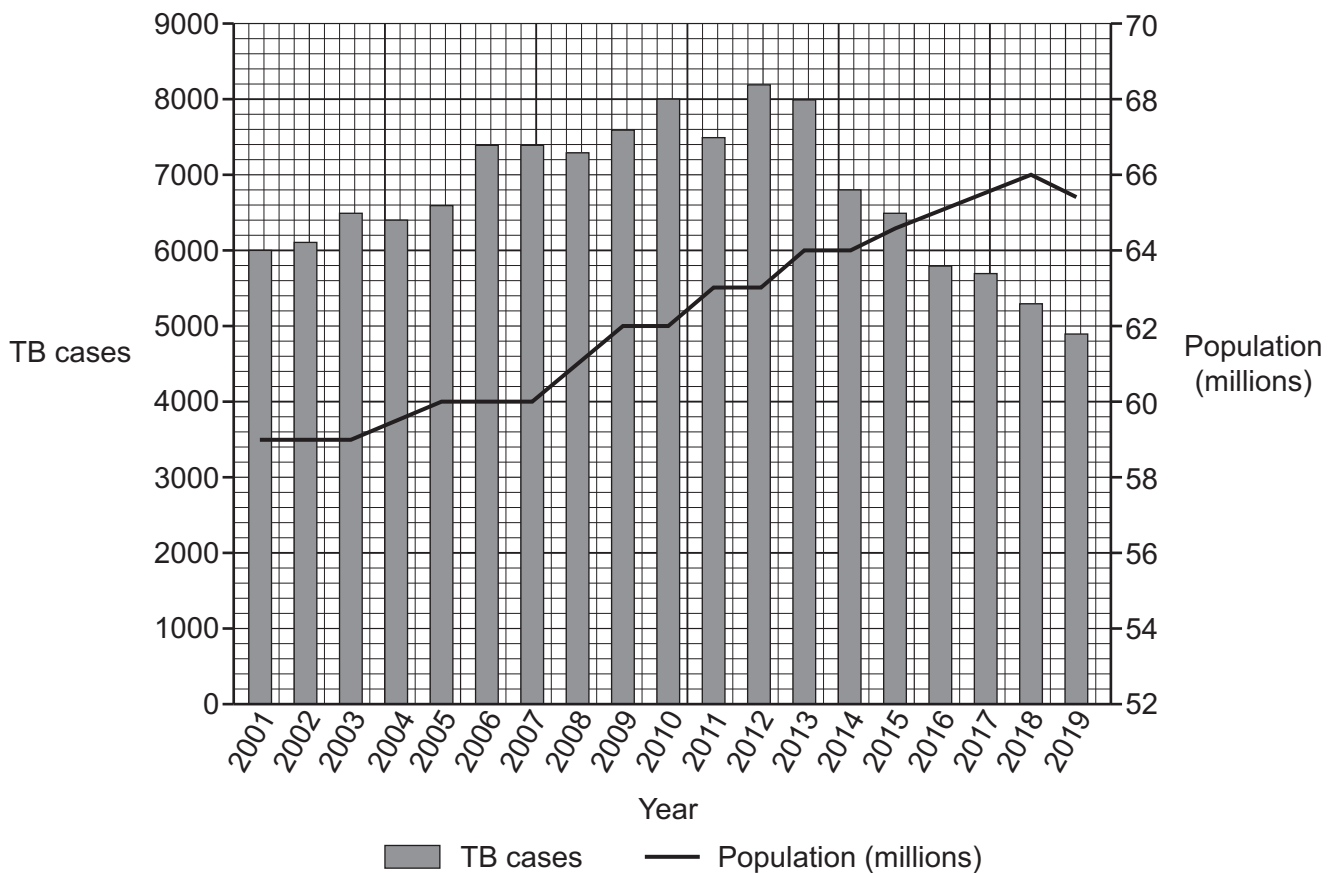


Fig. 3.1

(a) (i) Using **Fig. 3.1**, calculate the incidence rate of TB in 2018 per 100 000 of the population.

2018: 5300 cases, population 66 million

$$(5300 \div 66\,000\,000) \times 100\,000 = 8.03$$

Incidence rate = ...8..... per 100 000 people [2]

- (ii) Some people claim that TB will be eradicated from the UK by the year 2050.

Comment on whether the data in **Fig. 3.1** supports this claim.

Yes, if the current trend continues: cases fell from about 8200 in 2012 to 4900 in 2019.

No, because the decrease appears to be slowing down and might reach a plateau, so eradication by 2050 is uncertain.

[2]

- (b) TB is a notifiable disease and is reported to Public Health England (PHE).

State **three** ways that PHE can use data about the spread of TB to reduce the incidence of the disease.

- 1 *Screen the population (especially high-risk groups) for TB.*
 - 2 *Notify and trace the contacts of infected people, and isolate cases.*
 - 3 *Increase the vaccination programme (BCG) and educate people about how TB is transmitted.*
- [3]

(c) Treating TB requires a long course of antibiotics.

Fig. 3.2 shows the outcome after 12 months of treatment with antibiotics, by sex and age, for a group of patients suffering from TB.

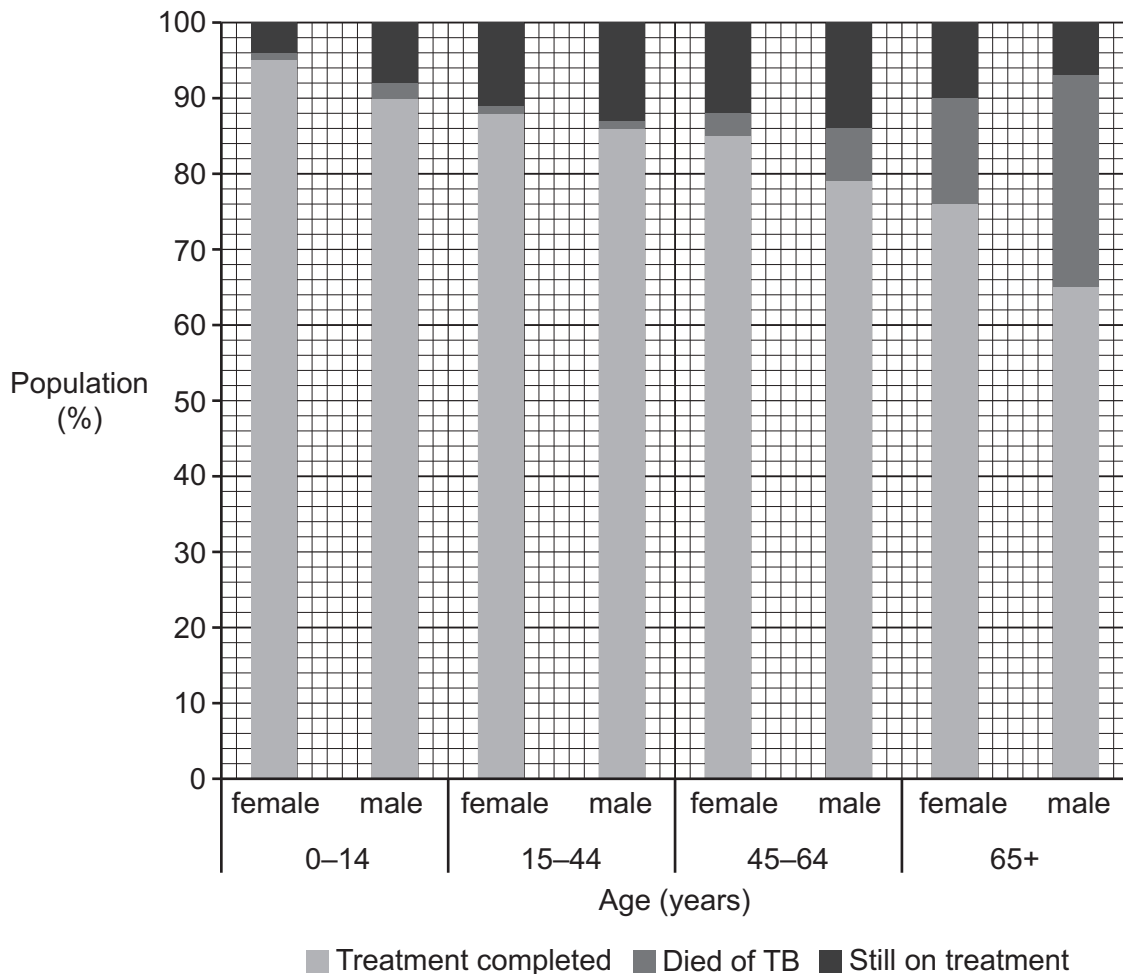


Fig. 3.2

- (i) Calculate how many times more likely an individual aged 65+ is to die from TB compared to an individual aged 0-14 years old.

You can assume that the number of males and females is the same in each age group.

$$65+: (90 - 76) + (93 - 65) = 14 + 28 = 42$$

$$0 \text{ to } 14: (96 - 95) + (92 - 90) = 1 + 2 = 3$$

$$42 \div 3 = 14$$

Likelihood = ...14..... times [2]

- (ii) Give **two** reasons why comparing age groups in this way may not be a valid method.

1 *The number of people in each age group could be different.*

2 *Lifestyle and compliance with treatment differ between age groups.*

[2]

- 4 In the first year of life, a baby will be given a vaccination against meningitis B.

There are two types of meningitis B vaccine. Both are inactivated vaccines.

- (a) (i) Explain why it is not possible to contract meningitis B from an inactivated vaccine.

The pathogen has been killed, so it cannot replicate; it only contains the antigens. [1]

- (ii) There are currently no live vaccines for meningitis B.

Explain one advantage **and** one disadvantage of using a live vaccine.

Advantage *It can replicate, so more antigen is formed, giving a greater, longer-lasting immune response.*

Disadvantage *Possible infection or greater side effects, especially if immunocompromised (e.g. HIV).* [2]

- (b) Give one reason for **and** one reason against giving vaccines to healthy babies when they are under one year old.

For *Babies have a weak immune system and have not developed many immune cells, so are at high risk.*

Against *The vaccine causes pain and the baby cannot give consent.* [2]

- (c) (i) Some premature babies are unable to have the meningitis B vaccine.

Explain why it is important for premature babies that as many other babies as possible are vaccinated against the disease.

Herd immunity: vaccinating the majority reduces the chance of the disease spreading to them. [1]

- (ii) One reason that premature babies may not be given the meningitis B vaccine is that they can be born suffering from protein deficiency.

Babies born with protein deficiency may not be immune following vaccination.

Suggest why these babies may not be able to produce an immune response to the vaccine.

Proteins are needed to make antibodies, so fewer antibodies would be produced.
Proteins are also needed to make new lymphocytes (B and T cells), so clonal expansion is limited and memory cells will not be produced. [2]

(d)* Scientists produce new vaccines for different communicable diseases every year.

Explain the potential problems faced by these scientists when developing new types of vaccine.

Type of pathogenic material: a whole-organism vaccine must have antigens similar to the pathogen. Live vaccines must be attenuated, but there is a potential risk of the attenuated pathogen causing disease. Dead (inactivated) or antigen-only vaccines trigger a weaker immune response, so boosters may be needed. A toxoid can only be used when the pathogen produces a toxin.

Problems with the pathogen: many pathogens have high mutation rates, so their antigens vary (antigenic variability) and a vaccine soon becomes ineffective. The mode of transmission may be unknown, the pathogen may not cause symptoms in everyone, and some pathogens go through different stages in their life cycle with different antigens.

Problems with making the vaccine: development is time consuming and costly, and requires clinical trials with volunteers. There may be side effects from the immune response, the general health of the target group must be considered, production must be scaled up, and there are ethical issues such as animal testing and access in developing countries. [6]

Additional answer space if required.

.....

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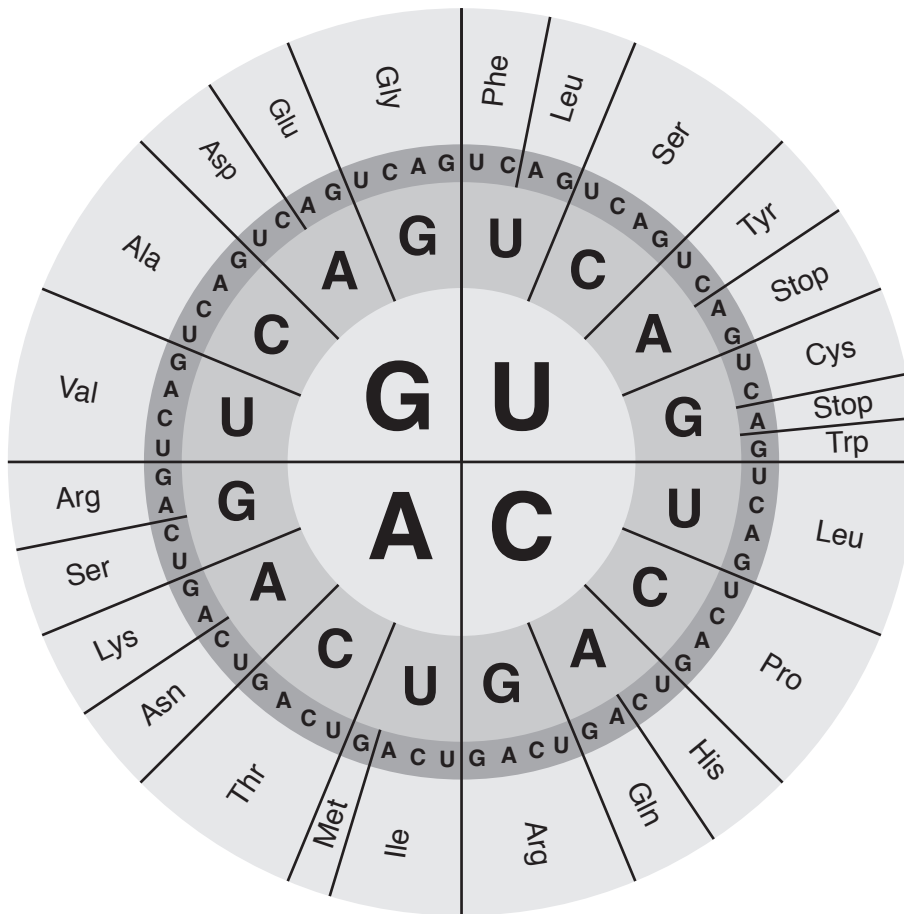
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- 5 Amino acids are coded for by codons in the mRNA sequence.

The diagram shows the mRNA codons and the corresponding amino acids.



- (a) The table below shows an mRNA sequence and some of the amino acids coded for by that sequence.

Complete the table with the correct amino acids.

mRNA sequence	AUG	GUG	CAC	CUG	ACU	CCU	GAG	GAG	AAG	UCU
Amino acids	Met	Val	His	Leu	...Thr...	...Pro...	Glu	Glu	...Lys...	Ser

[1]

- (b) (i) Each amino acid is coded for by a 'triplet' code.

There are 64 different triplet combinations.

Explain how this number is calculated.

There are 4 different bases (A, U, G and C) and each codon contains 3 bases.

So the number of combinations is $4^3 = 4 \times 4 \times 4 = 64$.

[2]

- (ii) Only 20 different triplet combinations would be required to code for the 20 amino acids commonly found in living organisms.

Explain what the remaining 44 combinations are used for.

The code is degenerate: more than one codon codes for the same amino acid.

Some are stop codons, which stop the ribosome translating the mRNA.

[2]

- (c) Selenocysteine is an unusual amino acid that is coded for by the codon UGA.

It can be produced by *Escherichia coli* (*E. coli*) when grown in the absence of sulfur atoms and in the presence of selenium atoms.

Suggest the likely effect on a protein made by *E. coli* if the conditions are right for selenocysteine formation.

UGA is normally a stop codon, so translation would continue and the protein would have an increased length.

This produces a different protein with a changed primary sequence and tertiary structure, so its function may change.

[2]

6 Fig. 6.1 shows the structure of a phospholipid.

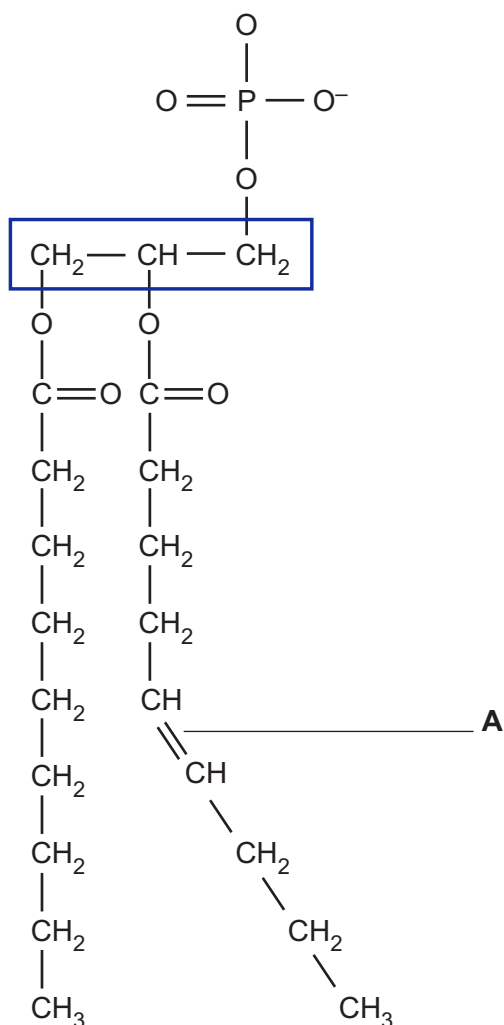


Fig. 6.1

- (a) (i) Draw a box **on Fig. 6.1** around the region of the phospholipid that is glycerol. [1]
- (ii) Label **A** in **Fig. 6.1** shows a double bond between carbons.

Describe the effect this double bond between carbons has on the properties of this molecule.

It makes the fatty acid unsaturated with a kink, so the phospholipids pack less tightly and the membrane is more fluid. [1]

(b) Fig. 6.2 shows the percentage mass of two different lipids found in eukaryotic membranes.

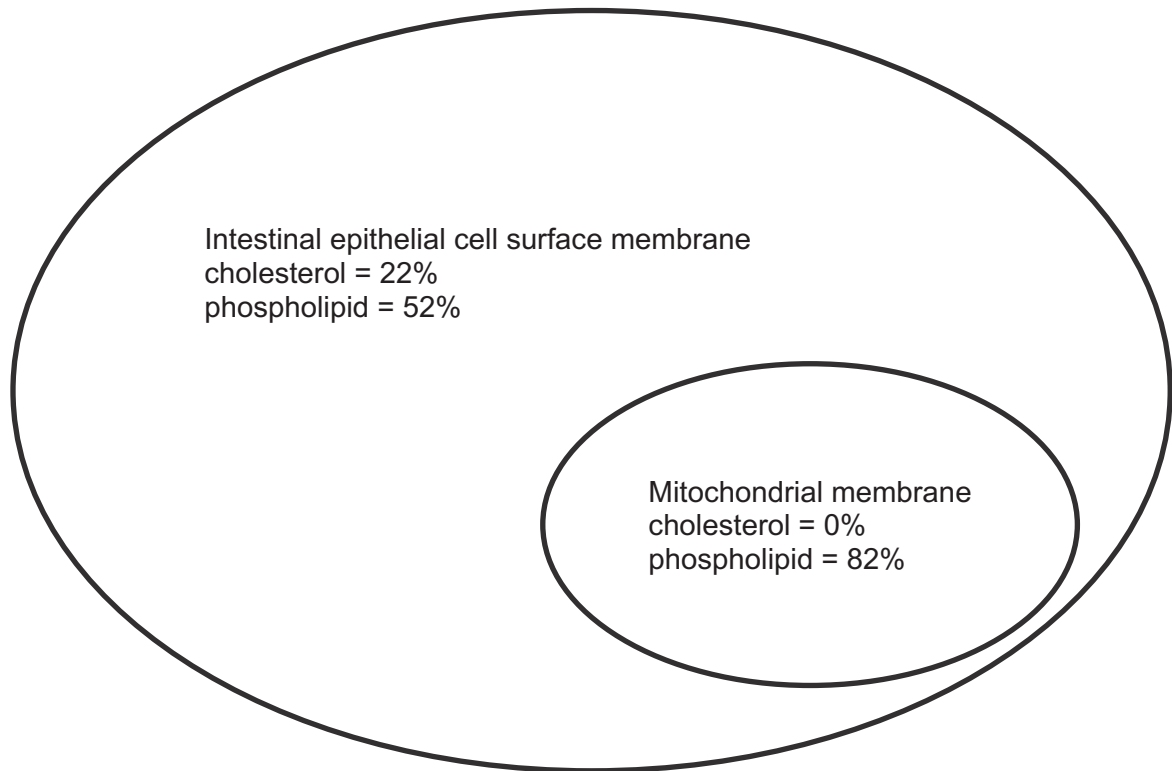


Fig. 6.2

- (i) Explain why the cell surface membrane of an intestinal epithelial cell contains cholesterol but the mitochondrial membrane does not.

Cholesterol regulates fluidity and stabilises the membrane; the cell surface membrane is exposed to the outside of the body so needs this.
Mitochondria are organelles within the cell, and their membrane is less fluid and flexible, so it does not need cholesterol.

[2]

- (ii) Counting the number of each type of lipid molecule would be too difficult to do accurately.

Suggest **one** other reason why calculating the percentage mass of the lipids would be more accurate than counting the number of each type of lipid molecule.

The lipids have different sizes and masses, so mass gives a better idea of their proportion.

[1]

- (c) The rate of active transport of a molecule across a membrane is dependent on a number of different factors.

State **and** explain **two** factors that can increase the rate of active transport across a membrane in the epithelial cell.

1 ..*Increased number of carrier proteins in the membrane.*.....

Explanation ..*More molecules can be moved across the membrane at the same time.*.....

2 ..*Increased oxygen availability, giving increased ATP production.*.....

Explanation ..*Increases the rate of aerobic respiration, and active transport requires ATP (energy).*.....

[4]

END OF QUESTION PAPER

[illegible]

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