EUNOIA JUNIOR COLLEGE
JC1 Promotional Examinations 2019
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME								
CIVICS GROUP	1	9	-			REGISTRATION NUMBER		

H2 Biology

9744/02

Paper 2
Structured Questions & Free Response Questions

04 October 2019
2 hours

Candidates are to **answer all questions** in section A in this question booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.

There are **two** sections in Paper 2, sections A and B.

Answer **all** questions.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
5	
Total	/80

This document consists of **17** printed pages and **1** blank page.

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Section A

Answer **all** the questions in this section.

1 Fig.1.1 is an electron micrograph of an animal cell.

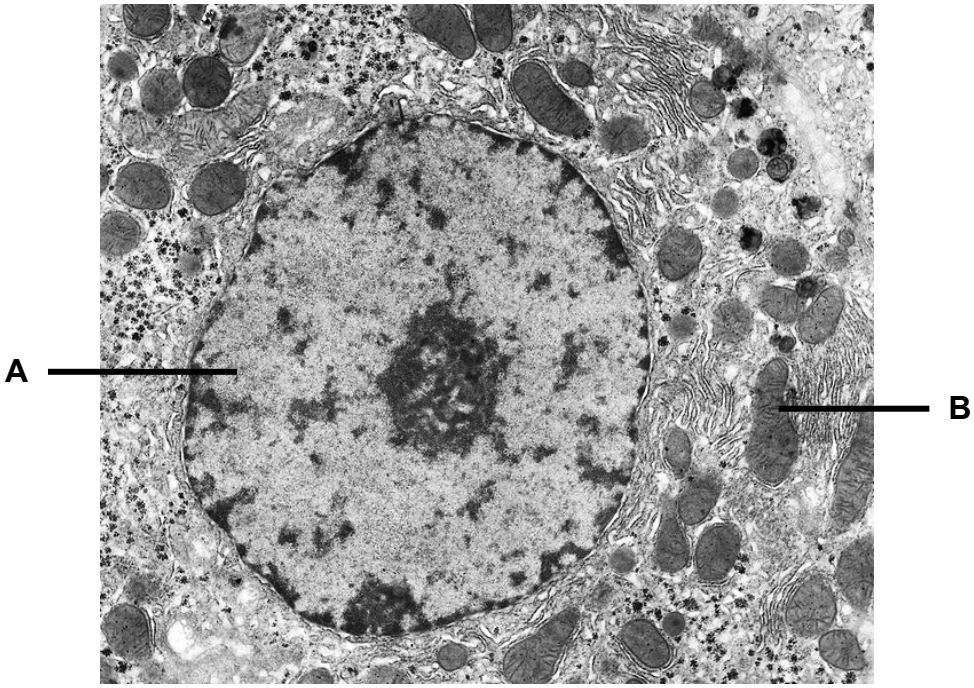


Fig 1.1

(a) (i) Identify the organelles **A** and **B** shown in Fig 1.1. [2]

A: nucleus
B: mitochondrion

Examiner's comments:
If the arrow is pointing at one organelle, use the singular term. For example, mitochondrion instead of mitochondria (plural).

(ii) Compare the structures of both organelles. [3]

Similarities:
1. **Both nucleus and mitochondrion are enclosed by a double membrane**
2. **Both contain DNA;**

Differences:
3. **Mitochondrion has a highly folded inner membrane forming cristae, while the inner nuclear membrane is not folded;**
4. **Nucleus has nuclear pores in its nuclear envelope, while mitochondrion does not have pores in its double membrane;**
5. **AVP**

Examiner's comments:
For comparison questions such as this, please compare point-to-point and do not write in chunks. Note that the nucleus is also bounded by a double membrane (nuclear envelope). If size is stated as a point of comparison, give an approximate range else the point of comparison (bigger vs. smaller) looks weak.

The nucleus does not contain 80s ribosomes. Only ribosomal subunits are synthesized in the nucleolus. Assembly of 80s ribosomes occurs in the cytoplasm.

Other accepted answers included:
- DNA in nucleus is linear v.s. DNA in mitochondrion is circular.

Protons are transported across the inner mitochondrial membrane through a transport protein depicted in Fig 1.2. This transport protein also serves as an enzyme that drives the synthesis of ATP from ADP and an inorganic phosphate ion (P_i).

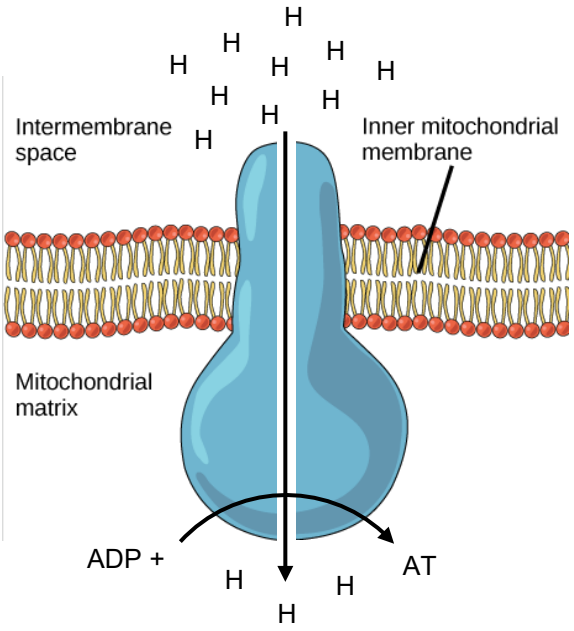


Fig 1.2

(b) Using Fig. 1.2,

(i) identify the type of transport protein. [1]

1. **Channel protein** **R: carrier protein / pump**

(ii) state and describe the process by which protons are transported across the inner mitochondrial membrane. [3]

1. **Facilitated diffusion;** **R: diffusion / osmosis / active transport**
2. **Protons move through the hydrophilic pore of the channel protein;**
3. **down their concentration gradient from intermembrane space to mitochondrial matrix;**

R: using energy / ATP hydrolysis

Examiner's comments:
Several students did not indicate the process of movement of protons – facilitated diffusion. Incorrect answers included active transport and passive diffusion. Protons are charged (not polar!) hence they are unable to move across the hydrophobic core of the phospholipid bilayer. Direction of movement from intermembrane space to matrix must also be stated.

[Total: 9]

2 Fig 2.1 shows an error occurring during the second meiotic division of primary spermatocytes of an unknown animal.

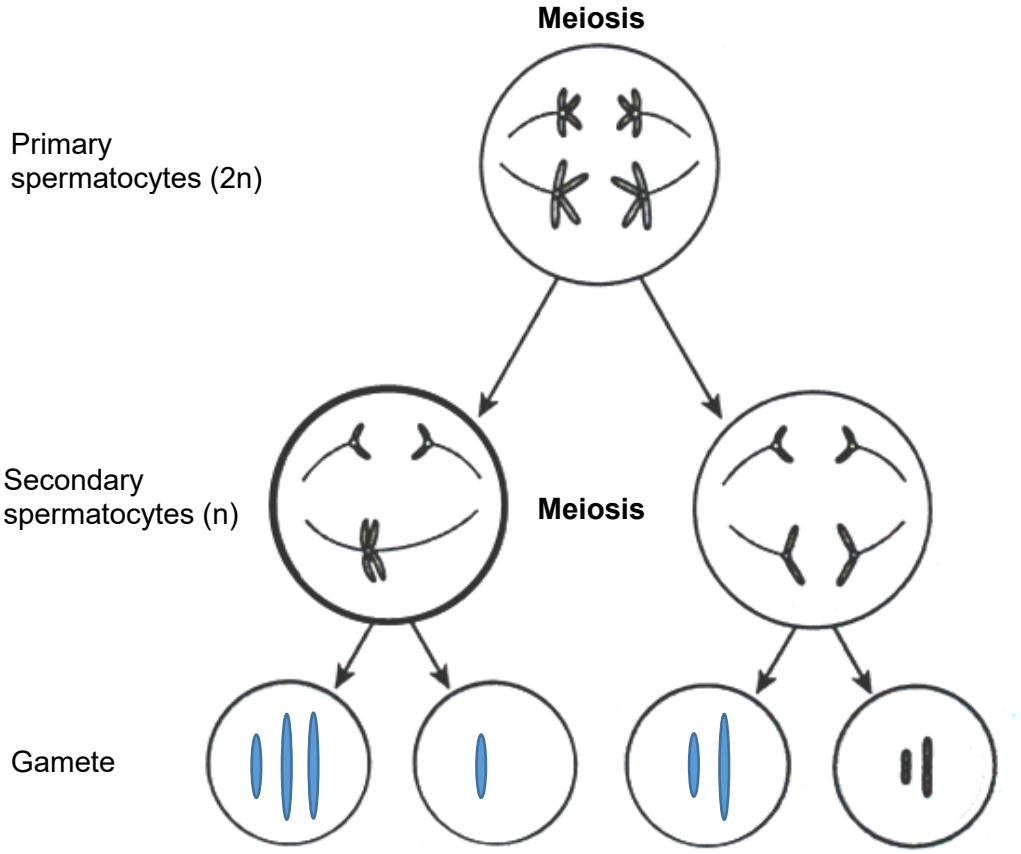


Fig. 2.1

(a) **(i)** Complete Fig 2.1 to show the correct structures and number of chromosomes within the gametes. [1]

n+1 and n-1 in the first two gametes, normal haploid (n) third gamete
R: metaphase chromosome (X-shaped), or if all gametes are haploid (n)

Examiner's comments:

- Many students drew a metaphase chromosome in either of the first two gametes, which is incorrect. Although there was a failure of centromere division during anaphase II, by the time telophase and cytokinesis have occurred, the proteins holding the centromeres together would have dissociated, and the two chromatids would separate into chromosomes in the same gamete.

(ii) Describe and explain how the error depicted in Fig 2.1 may have occurred. [3]

1. **Arising from a non-disjunction event;**
2. **due to failure of separation of sister chromatids during anaphase II;**
3. **Caused by centromeres failing to divide**
   OR improper / unequal shortening of kinetochore microtubules / spindle fibres;

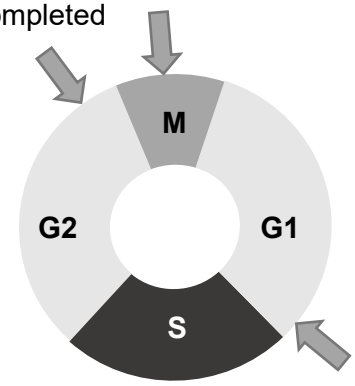
Examiner's comments:

- This question was generally well done, with most students able to explain how aneuploidy arises. However, many students did not identify the error as a non-disjunction event, and focussed instead on the consequences (aneuploidy), which was not asked for.

Testis cells undergo several rounds of mitosis to differentiate into primary spermatocytes.

Fig 2.2 shows the different phases of the cell cycle. Arrows indicate checkpoints of the cell cycle, and brief descriptions of the G1 and G2 checkpoint criteria are given. The M checkpoint occurs during metaphase of mitosis.

G2 checkpoint:
- DNA replication is completed
- cell size is adequate



G1 checkpoint:
- cell size is adequate
- sufficient nutrients and growth factors
- absence of DNA damage

Fig. 2.2

(b) (i) State the criteria for the cell to pass the M checkpoint. [1]

1. **Check for proper attachment of spindle fibres / kinetochore microtubules to the centromere of each chromosome;**

Examiner's comments:
- Many students stated the alignment of chromosomes along the metaphase plate, which though important, is not the key criteria of the M checkpoint.
- Some students also incorrectly stated that proper separation of homologous chromosomes to opposite poles of the cell, which only occurs during anaphase (after the M checkpoint).

(ii) With reference to Fig 2.2, describe how the dysregulation of cell cycle checkpoints could lead to cancer. [3]

1. **Dysregulation of cell cycle checkpoints means that cells will continue to divide despite failing to meet the criteria to satisfy each checkpoint;**
2. **For instance, mitosis proceeds even in absence of growth factors / presence of damaged DNA [quote at least one criterion from Fig 2.2];**
3. Thus, **uncontrolled cell division and accumulation of further genetic mutations over multiple rounds of DNA replication occurs could result in cancer.**

Examiner's comments:
- The first point on explaining what dysregulation of cell cycle checkpoints entails was poorly answered by most students.
- A common erroneous answer was to explain how dysregulation of each checkpoint could result in a different consequence that might lead to cancer.
- For this question, all three checkpoints simply serve to regulate the cell cycle, and a dysregulation of these checkpoints (due to spontaneous mutation or otherwise) would lead to uncontrolled cell division, despite the criteria not being met.

(c) Research has shown that colchicine exerts its effect by binding to tubulin molecules and preventing polymerisation of microtubules. As such, colchicine has been identified as a potential chemotherapeutic drug.

(i) Explain how colchicine may be used in the treatment of cancer. [3]

1. **Colchicine inhibits the formation of mitotic spindle / spindle fibres / kinetochore microtubules;**
2. **As such, no kinetochore microtubules / spindle fibres attach to chromosomes during prophase;**
3. **Mitosis cannot proceed / is arrested, thus preventing uncontrolled cell division;**

Examiner's comments:

- This question was generally well done, with most students being able to explain the effects of inhibiting microtubule polymerisation to prevent uncontrolled cell division.
- The first point, however, was commonly missed out in answers, and many students chose to quote that "colchicine prevents the polymerisation of microtubules" which does not explain its effect on the cell cycle – exactly which microtubules are affected?
- A few students mentioned that colchicine would prevent the formation of centrioles. Note that centrioles are already present in the cell, and serve as the microtubule organising centre (MTOC) from which spindle fibres are polymerised. Moreover, the spindle fibres will be far more adversely affected by colchicine, as they are rapidly polymerised and depolymerised.

(ii) Suggest an undesirable side effect of using colchicine in cancer treatment. [1]

1. **normal cells also cannot undergo cell division; (OWTTE)**
2. **AVP**

Examiner's comments:

- Most students were able to identify that normal non-cancerous cells would also be affected.
- Some students also mentioned downstream effects (such as poor wound healing, impaired growth, hair loss), which were also accepted.

[Total: 12]

3 Semi-conservative DNA replication results in the formation of genetically identical DNA molecules. Fig. 3.1 shows a replication fork involved in DNA replication.

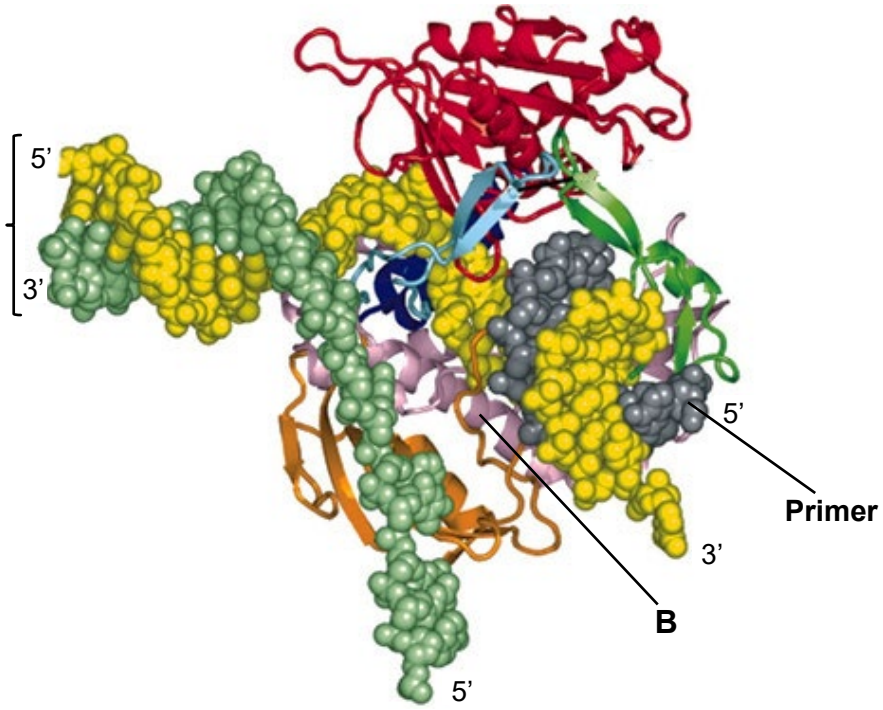


Fig. 3.1

(a) Describe two structural differences between helices A and B. [2]

1. A is made of **deoxyribonucleotides** monomers while B is made of **amino acid** monomers;
2. A has **phosphodiester bonds** joining monomers while B has **peptide bonds**;
3. In A, **hydrogen bonds** formed between **complementary base pairs** while in B, hydrogen bonds formed between **NH and CO groups**;
4. A is **double-stranded** while B is **single-stranded**;

Examiner's comments

- A number of students were not able to identify A and B correctly. E.g. some incorrectly identified A as a protein structure.
- Point for point comparison is required, but some candidates fell short of displaying such an answering skill and thereby were not able to score.

Mark Point 1:

- **R**: nucleotide bases.
- **R**: A contains deoxyribose, phosphate group and nitrogenous base while B contains amino acids as monomers. Monomer of A should be stated instead in order to make the comparison valid.

Mark Point 4:

- **R**: A has anti-parallel strands but B runs in one direction.

Others:

- **R**: A is bigger than B.
- **R**: A has directionality but B does not; B has directionality too, this is due to the presence of N and C terminus in a polypeptide chain.

(b) Explain why DNA replication is described as "semi-conservative". [2]

1. During DNA replication, DNA molecule is **unzipped** and the separated DNA strands each serve as a template for the synthesis of the a **complementary** **new DNA strand**;
2. The resulting **daughter DNA molecules** are hence each composed of **an original/parental DNA strand** and **a new/daughter DNA strand**;

Examiner's comments

Mark Point 1:

- Unwind is not the same as unzip.
- A number of students failed to mention that the new DNA strand formed is by complementary base pairing or that is complementary to the template DNA strand.
- **R**: a number of students lost the mark due to the mention that only one strand of DNA serves as a template during DNA replication.

Mark Point 1 & 2:

- A significant number of students were not able to differentiate between the terms "molecule" and "strand". A DNA molecule is composed of 2 DNA strands. It is therefore incorrect to say the following:
  - DNA strand is unzipped
  - DNA strand is made up of one parental strand and one new strand

(c) **(i)** Describe how a primer strand is synthesized. [3]

1. Separated **DNA strands** serve as **templates** for the synthesis of the **RNA** primer via **complementary base pairing**;
2. **Adenine, thymine, cytosine and guanine** on DNA template base pairs with **uracil, adenine, guanine and cytosine** on **ribonucleotides** respectively;
3. **Primase** catalyses the **formation of phosphodiester bonds** between **ribonucleotide** monomers;
4. Primer is synthesised in the **5' to 3'** direction;

Note: RNA or ribonucleotides marked for once in either points 1, 2 or 3.

Examiner's comments

- It is irrelevant to refer to the role of primers in the answer.
- It is also not important to mention helicase, topoisomerase and single-stranded binding proteins in the answer.

Mark Point 1:

- The keyword "template" is frequently missing in a number of students' answers.

Mark Point 2:

- Not frequently seen in answers.

Mark Point 3:

- It is incorrect to refer to primase as RNA primase. It is also incorrect to state that RNA polymerase or DNA polymerase synthesises the primer.
- **R**: Primase catalyse the formation of hydrogen bonds between complementary base pairs.

- Some students confused primers to be synthesised using DNA nucleotides instead of RNA nucleotides.

Mark Point 4:

- Not frequently seen in answers.

(ii) With reference to Fig. 3.1, explain if the primer is priming the synthesis of the leading strand or lagging strand. [2]

1. The primer is priming the synthesis of the **leading strand**;
2. This is because the leading strand is **synthesized towards the replication fork**;

Examiner's comments

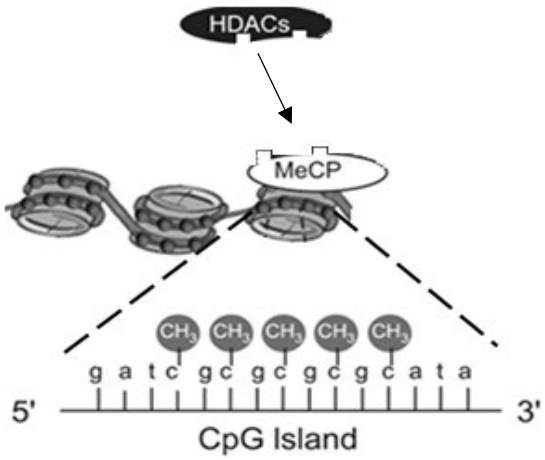
Mark Point 1:

- A number of students incorrectly stated lagging strand was being synthesised.

Mark Point 2:

- Most students incorrectly substantiated their answer using the idea of direction of DNA synthesis as 5' to 3'. Both leading and lagging strand are synthesised in 5' to 3' direction. Therefore, direction of synthesis of new DNA strand is not what makes it a leading or lagging strand.

CpG islands are regions of DNA where a cytosine nucleotide is followed by a guanine nucleotide in the linear 5' to 3' sequence. CpG islands are typically 300 to 3000 base pairs in length. These CpG islands have been found to be in or near approximately 40% of promoters of mammalian genes and can be methylated.



HDAC: Histone Deacetylase
MeCP: Methyl-CpG-binding protein

Fig. 3.2

(d) With reference to Fig. 3.2, explain the significance of the presence of CpG islands in regulating gene transcription. [4]

1. **Methyl-CpG-binding proteins** **bind** to the methylated CpG islands which recruit / **bind HDACs**;
2. HDACs **remove acetyl groups** from **histones** and this **restores the positive charge** on histones;
3. This **increases** the **electrostatic attraction** between **negatively charged DNA and histones** and **chromatin condenses**;

4. **RNA polymerase** and **general transcription factors** **cannot bind** to the **promoter** to form the **transcription initiation complex** and transcription of genes cannot occur;

Examiner's comments

Many students either failed to refer to Fig. 3.2 to construct their answers, or they failed to comprehend what was illustrated in Fig. 3.2.

Mark Point 1:

- A significant number of students incorrectly thought that MeCP was involved in carrying out methylation of the CpG island.
- Students were given the full name of MeCP but they failed to refer to it to understand the role of MeCP was as a binding protein, i.e. to bind to methylated CpG.
- **R**: active site of HDACs is complementary in conformation to MeCP and the active site therefore binds to MeCP. Students who wrote this failed to refer to their prior knowledge on the reaction catalysed by HDACs.
- **R**: Methylated of CpG island blocks RNA polymerase and general transcription factors from binding to the promoter to form the transcription initiation complex. Students who wrote this showed that they were not basing their answer on Fig. 3.2.

Mark Point 2:

- Some students incorrectly mentioned that acetyl groups were removed from DNA.
- Some students incorrectly thought that histones were negatively charged.

Mark Point 3:

- **R**: DNA condenses. As chromatin is made up of DNA coiled around histones, the terms "DNA" and "chromatin" are not interchangeable.

Mark Point 4:

- The idea of accessibility must be extended to whether **binding** of RNA polymerase and general transcription factors to the promoter occurs or not. This was lacking in a significant number of answers.
- Some students are still incorrectly referring to the "transcription initiation complex" as the "translation initiation complex".

The gene encoding insulin receptor is located on chromosome 19 and contains 22 exons.

There are two forms of the insulin receptor (IR) that differ by 12 amino acids. These two forms of the receptor are:

- IR-A, which binds insulin and insulin-like growth factor 2, and is expressed in the brain and ovary.
- IR-B, which binds only insulin, and is expressed in the skeletal muscle and liver.

Fig. 3.3 illustrates the pre-mRNA sequence and the mRNA sequences for the two forms of IR. The numbered boxes represent exons and the introns can be found between the exons in the *IR* pre-mRNA.

IR pre-mRNA:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

IR-A mRNA:

1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22

IR-B mRNA:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

Fig. 3.3

(e) **(i)** Explain how *IR-A* mRNA and *IR-B* mRNA are derived from *IR* pre-mRNA. [3]

1. **Alternative splicing**;
2. whereby **all introns** in the *IR* pre-mRNA **are removed** and **different combinations of exons are joined together** to form *IR-A* mRNA and *IR-B* mRNA;
3. *IR-A* mRNA contains all exons except for exon 11 while *IR-B* mRNA contains all 22 exons; (OWTTE)

Examiner's comments

Mark Point 1:

- A number of students incorrectly focused on the idea of splicing rather than alternative splicing.
- Some incorrectly stated that IR-A mRNA was formed via alternative splicing while IR-B mRNA was formed via splicing.
- The terms "IR-A" and "IR-A mRNA" are not interchangeable. The former refers to the IR-A protein, not the mRNA.

Mark Point 2:

- A significant number of students incorrectly stated that a "different combination of introns are excised" during alternative splicing.
- "Exons are spliced" has no meaning. The term splicing refers to both excision of introns and joining together of exons. In reference to exons, it is only correct to describe it as "exons are spliced together" or "exons are joined together".

Mark Point 3:

- **R**: exon 11 is removed and exons 10 and 12 are joined together.

(ii) Explain how *IR-A* and *IR-B* mRNA results in gene products with different specificity. [3]

1. *IR-A* mRNA and *IR-B* mRNA code for **different sequence of amino acids**;
2. Therefore, the **type and location** of **bonds** formed between **R groups** are **different**;
3. This gives rise to IR-A and IR-B which have **different 3D conformation** in their **binding sites**;
4. IR-A therefore can **bind both insulin and insulin-like growth factor 2** while IR-B can **bind insulin only**;

Examiner's comments

A number of students incorrectly focused on details of alternative splicing.

Mark Point 1:

- Must have this point to score full marks.

Mark Point 2:

- Not frequently seen in answers.

Mark Point 3:

- It is incorrect to refer to IR-A and IR-B as having active sites as they are not enzymes.
- It is also incorrect to refer to the binding site on IR-A and IR-B as receptor binding sites.

Mark Point 4:

- Not frequently seen in answers.

Prokaryotes and eukaryotes and exhibit differences in their control of gene expression.

Fig. 3.4 shows the *arg* operon found in *Escherichia coli*. In the absence of arginine, the operon is in the active state. In the presence of arginine, the expression of the structural genes decreases.

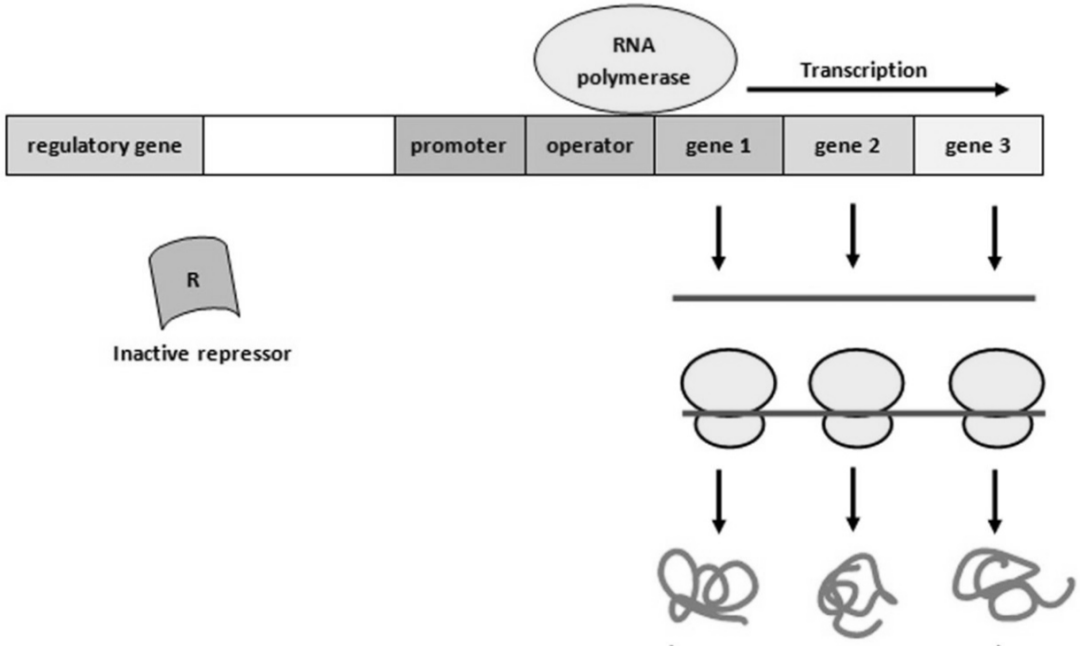


Fig 3.4

(f) **(i)** State which type of operon is the *arg* operon. [1]

Repressible operon;

Examiner's comments

A surprising portion of students did not seem to know that types of operon refer to either inducible operons or repressible operons.

R: lac operon / trp operon / repressive operon / repressed operon / repressor operon / inhibitor operon / anabolic operon / constitutively expressed operon

(ii) Describe how the *arg* operon is turned off. [3]

1. In **presence / excess of arginine**, arginine **binds** to the **allosteric site** of the **repressor**;
2. This **changes conformation** of the **DNA binding site** of the **repressor** and repressor is **activated**;
3. **Repressor** **binds** to the **operator** and **prevents RNA polymerase from binding to the promoter** and operon is turned off;

Examiner's comments

A number of students incorrectly mentioned that the gene product of arg operon was arginine, or incorrectly referred to arginine as a protein/polypeptide. These students did not know that arginine is an amino acid, synthesized by the enzymes coded by the arg operon.

Mark Point 1:

- A number of students failed to include the keyword "allosteric site".

Mark Point 2:

- The DNA-binding site is located on the repressor, not the operator.

Mark Point 3:

- Some students were confused between the terms "promoter" and "operator".
- It is incorrect to mention the terms "transcription initiation complex" and "general transcription factors" for prokaryotes. Answers which mention these terms will not therefore not have mark point 2 awarded. Students should note that these terms are only applicable to eukaryotes.

Besides regulating gene expression through operons, bacteria have other means to enhance their adaptability to the changing environment through gene transfer.

Fig. 3.5 shows one way in which bacteria can acquire new genetic material.

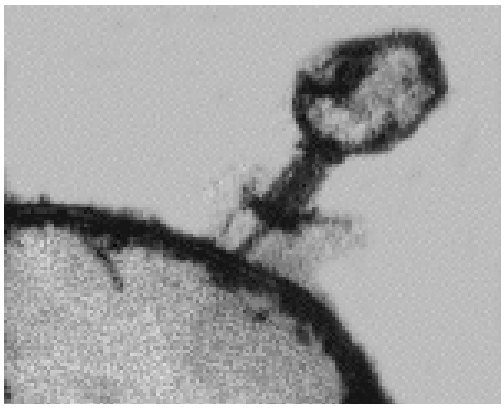


Fig. 3.5

(g) With reference to Fig. 3.5, describe the process which can allow a population of bacteria to acquire an advantageous allele. [3]

1. **Generalised transduction**;
2. A **lytic phage** **infects** a bacteria carrying the advantageous allele and **cleaves the bacteria chromosome**;
3. One of the progeny phage erroneously **packages** the advantageous allele into its capsid head and **injects** the advantageous allele into another bacteria during a subsequent infection;

OR

4. **Specialised transduction**;
5. A **temperate phage** **infects** a bacteria carrying the advantageous allele and **inserts its DNA/genome** into the bacterial chromosome, forming a **prophage**;
6. During activation of prophage, the **advantageous allele may be excised along with the prophage** and is **packaged** into the capsid head of a progeny phage and **injected** into another bacteria during a subsequent infection;

Examiner's comments

- A number of students were vague in their responses and mentioned "transduction" instead of a specific form of transduction.
- A large number of students failed to include the specific form of phage (i.e. lytic or temperate phage) in their answers. Mention of T4 or lambda phage was not accepted as it is not possible to identify the phage in the diagram.
- Mark point 2: it is incorrect to state that lysozyme cleaves bacterial DNA.
- Mark point 3: answers that seem to indicate that the entire bacterial genome was packaged into the phage capsid head are not accepted. This is because the bacterial genome is too big to be packaged into the phage capsid head.
- Some students failed to understand the concept of transduction and stated that the advantageous allele acquired by the recipient bacteria came from integrated phage genome.

Fig. 3.6 shows a classic experiment used to show that physical contact between bacterial cell is necessary for a mode of horizontal gene transfer to occur.

In the experiment, the researchers placed 2 different strains of bacteria in the U-tube, with a filter separating the two strains. Strain A is able to synthesise 3 essential amino acids (thr^+ leu^+ thi^+) but is unable to synthesise 2 other essential amino acids (met^- bio^-). Strain B is able to synthesise 2 essential amino acids (met^+ bio^+), but is unable to synthesise three others (thr^- leu^- thi^-). Minimum medium was also used in the experiment and only bacteria able to synthesise all 5 essential amino acids are able to grow on it.

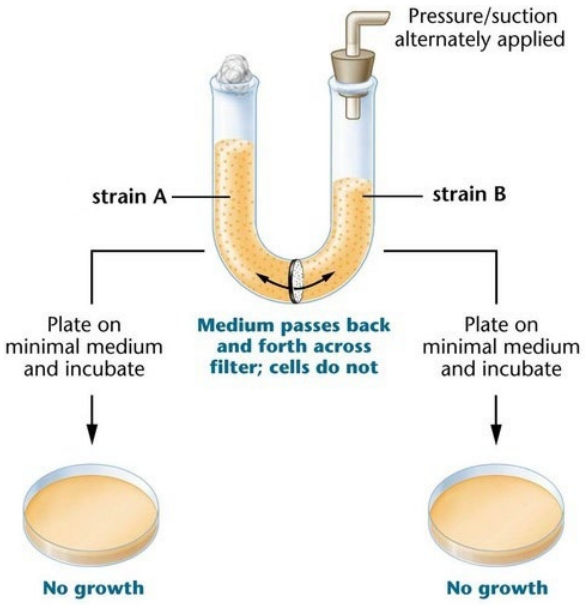


Fig. 3.6

(h) A student tried to replicate the experiment but did not get the result shown in Fig. 3.6. Instead, he observed a few bacterial colonies which are hybrids of strains A and B. He later realized that he accidentally forgot to add in DNase in the U-tube before carrying out the experiment.

Explain how the lack of DNase in the experiment resulted in the growth of hybrid bacterial colonies. [3]

1. Without DNase, **naked DNA fragments** released from dead bacteria **would not be degraded**;
2. These naked DNA fragments are **small enough to move through the filter** separating the two strains of bacteria;
3. And then **taken up by the other strain of bacteria** via **transformation**;

Examiner's comments

- A significant number of students failed to comprehend the role of DNase. DNase is an enzyme that cleaves DNA. It is therefore incorrect to link the absence of DNase with allowing the possibility of conjugation taking place.
- Mark point 1: many students failed to recognise the importance of the keyword "naked".
- Mark point 2: many failed to explain the passing of the naked DNA fragments across the filter based on the small size of these fragments.
- Mark point 3: the idea that the naked DNA fragment taken up by the recipient bacteria was from the **other** strain of bacteria was frequently lacking in answers.

[Total: 29]

4 Bacteriophages play an important role in regulating microbial ecology of many ecosystems because of their impact on bacteria.

Fig. 4.1 shows an electron micrograph of some bacteriophages.

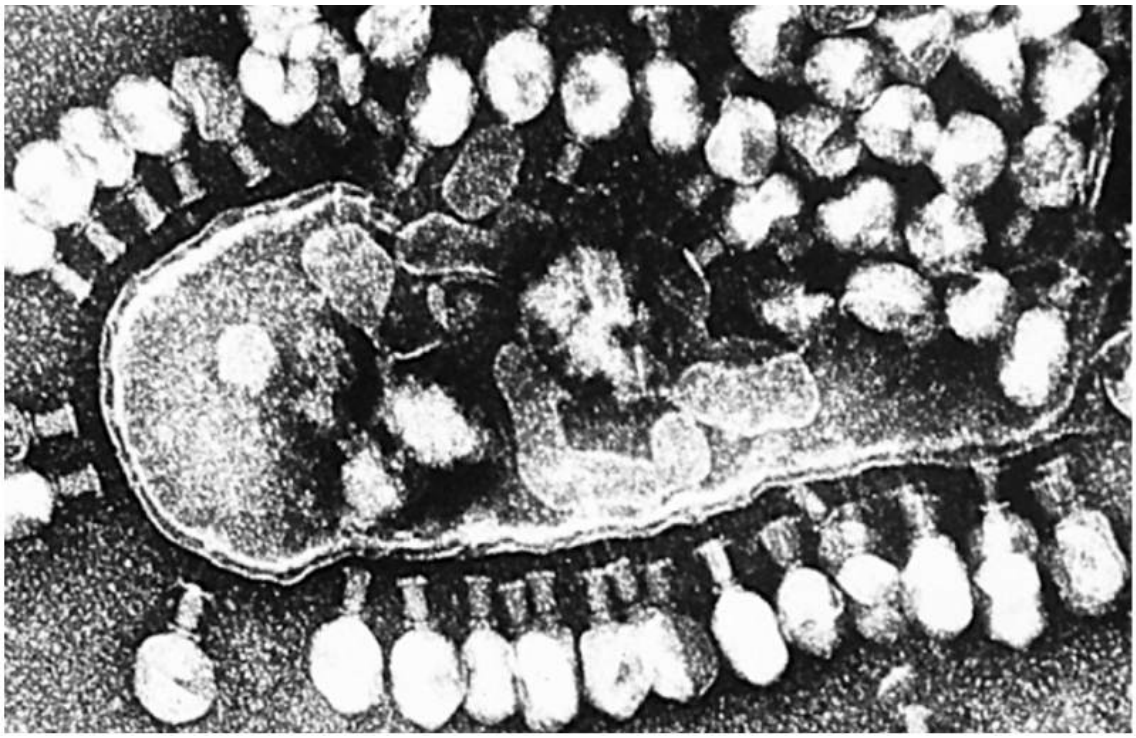


Fig 4.1

(a) **(i)** Identify the reproductive cycle shown in Fig. 4.1. [1]

Lytic cycle;

Examiner's comments:
- Most students could correctly identify the lysis of bacterium cell from the figure.
- Some students incorrectly stated lysogenic cycle, but went on to explain lysis in (ii).

(ii) Describe how newly synthesised phages are released from the bacterium. [2]

1. **Phage lysozymes hydrolyse / break down bacterial peptidoglycan cell wall;**
2. **Bacterium undergoes osmotic lysis, allowing release of phages into the surrounding medium;**

Examiner's comments:
- This question was very well done, and most students obtained full credit for mentioned lysozymes hydrolyse the bacterium cell wall, which causes lysis of the bacterial cell surface membrane.
- Some students had the misconception that the lysozymes hydrolyse / break down the cell surface membrane, or lysis of the cell wall, which are both incorrect.

Animal viruses, such as the influenza virus, undergo a different method of release as shown in Fig 4.2.

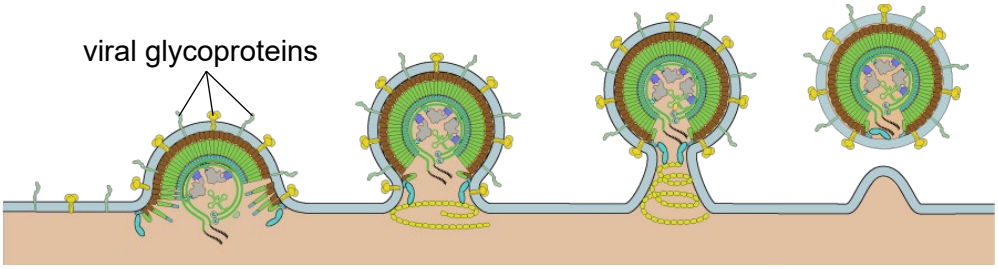


Fig 4.2

(b) Describe how viral glycoproteins become embedded in the viral envelope. [4]

1. **Viral proteins are glycosylated and embedded in the membrane of the rough endoplasmic reticulum;**
2. **Transport vesicles with embedded viral glycoproteins (R: containing viral glycoproteins) in the membrane bud off from rough endoplasmic reticulum, move towards Golgi apparatus;**
3. **Transport vesicle then fuses with *cis* face of Golgi apparatus and secretory vesicles with embedded viral glycoproteins bud off from the *trans* face of Golgi apparatus;**
4. **Secretory vesicles move towards and fuse with the host cell surface membrane, and viral glycoproteins are now embedded in the host cell surface membrane; (R: secretion of viral glycoproteins / exocytosis)**
5. **Host cell surface membrane with embedded viral glycoproteins wraps around nucleocapsid and becomes the viral envelope during release of virus via budding;**

Note to marker:
"embedded viral glycoproteins" mark once in points 1 to 4.
Mark point 5 must have for attainment of full marks.

Examiner's comments:

- This question was generally poorly done, with most students misinterpreting the question.
- Students who gained full credit were those who described, in detail, the endomembrane system of protein transport, as well as the budding of newly synthesised viruses to acquire the host cell surface membrane as its viral envelope.
- Some students focussed on the entry of influenza virus into the host cell, which is irrelevant to how the glycoproteins are synthesised and embedded.
- Some also spent the majority of their answer describing the synthesis of proteins (including translation of viral mRNA), which is not the focus of this question.
- The most common error was students using phrases such as "vesicle containing glycoproteins" or "proteins enter the lumen" instead of the correct conception that the proteins would **remain embedded** in membranes from synthesis by ribosomes at rER.
- Another common misconception was the host cell is a bacterium cell (this is also true for questions 4c below, and 5b on comparing HIV and influenza).
- Another common mistake was that the viral glycoproteins are recycled upon entry of the viral envelope fusing with the lysosome membrane, which then returns to the cell surface membrane for budding of newly synthesised viruses.

Different strains of influenza virus have different glycoproteins in their envelope. Over time, these may result in different flu epidemics, as shown in Fig 4.3.

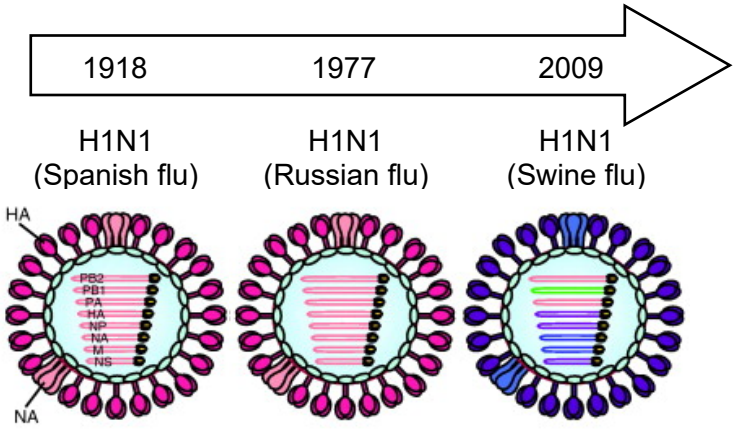


Fig 4.3

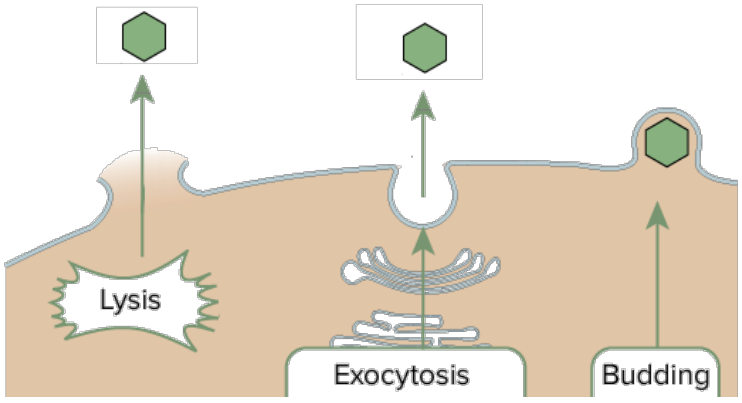
(c) Explain how different strains of H1N1 influenza virus may arise. [3]

1. **Antigenic drift results in accumulation of genetic mutations in the viral genome;**
2. **Resulting from the lack of proofreading ability of RNA-dependent RNA polymerase in influenza virus;**
   OR
   Influenza genome is single-stranded RNA, and hence, does not have any back-up copy to carry out gene repair mechanisms;
   OR
   Fast rate of influenza viral replication;
3. **Leading to changes in the viral genome / RNA sequence that alters the 3D conformation of the viral glycoprotein;**

Examiner's comments:

- When interpreting the information given for this question, students should realise that the glycoproteins of all viruses shown are of the same type: H1 and N1. This means that genetic reassortment can be ruled out as a possible cause, since influenza viruses carrying different glycoproteins are not shown, and hence, antigenic shift was not an acceptable answer.
- For students who correctly identified antigenic drift, most could explain why accumulation of mutations result in a different 3D conformation of the viral glycoproteins.

[Total: 10]



For Examiner's Use

Section B

Answer **all** the questions in this section.

5 (a) Polymers perform a variety of **functions** in living organisms.

Using **named examples**, relate the **structure** of **polymers** to their importance to cells. [11]

Need to **quote named example** of polymer for and their importance to cells.
R: lipids / phospholipids / triglycerides → these are not polymers
R: collagen → function at tissue level, to help tissues (e.g. skin, tendon, bone cartilage) withstand stretching

Also, to explain importance / function, need to link **structure → property → function**

Need to specify importance. e.g. in terms of:
energy storage, structural, specific enzymatic reaction / metabolic reactions, transport function storage of genetic information etc
Need to cover **at least 3 different areas of importance**

1. **Definition**:
   Polymer is a **macromolecule** comprise of **many monomers joined together**;

   Max 3 per named example:

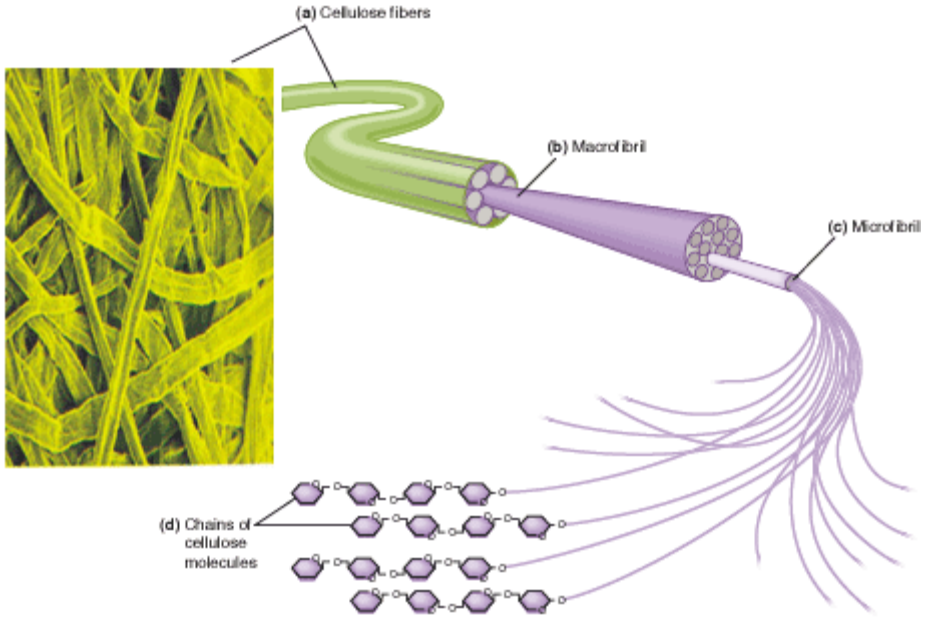
2. **Starch / glycogen + Energy storage** function; **(must have)**
   a) Starch / glycogen is a polymer of **α-glucose**;
   b) **Large**, hence **insoluble in water** and hence **does not affect water potential of plant / animal cells**; R: osmotic pressure
   OR
   c) Linking of α-glucose monomers via α-1,4 glycosidic bond results in a **helical** molecule, hence making starch a **compact** energy storage molecule;
   OR
   d) **α-1,4- glycosidic bond** in starch/glycogen can be **easily hydrolysed** by enzymes to supply glucose to cellular **respiration**;
   OR
   e) (amylopectin / glycogen) **branched / has many branch points** provides **many ends** for **faster hydrolysis** of amylopectin/glycogen to glucose by **enzymes**; R: easy hydrolysis / so that energy can be released quickly
   f) This enables rapid release of glucose for **respiration** to provide **ATP** (R: energy) to cells;

3. **Cellulose + Structural support** function; **(must have)**
   a) Cellulose is a polymer of **β-glucose**;
   b) **Large**, hence **insoluble in water** and forms the **cell wall** (mark once in answer) of plant cells; R: does not affect water potential of cells
   OR
   c) Relatively **fewer** **hydroxyl groups** are available **for hydrogen bonding with water** as many of OH groups are involved in **forming inter-chain hydrogen bonds**, hence **insoluble in water**; R: does not affect water potential of cells

   OR

d) As adjacent **β-glucose** monomers are **inverted / rotated 180°** with respect to each other, cellulose is a **straight** molecule and is able to lie **parallel** to other cellulose chains;

e) This therefore allows cellulose molecules bundle together to form **microfibrils**, which in turn bundle together to form **macrofibrils** and subsequently cellulose **fibres** → **high tensile strength** OR **extensive inter-chain hydrogen bonding** gives rise to **high tensile strength**; R: further meshwork of macrofibrils / microfibrils form a meshwork…



f) Cell wall of plant cells **prevents plant cell from bursting** when exposed to **high water potential in surroundings**; Note: need to state when will excessive water enter the plant cell. R: cellulose cell wall helps maintain turgidity of cell.

- **3/3f + 3a + 3b/c** OR **3/3f + 3d + 3e**
- **R**: β-1,4 glycosidic bonds are strong bonds that are not broken down by enzymes
- **R**: β-1,4 glycosidic bond provides cellulose with high tensile strength
- **R**: β-1,4 glycosidic bonds are very strong bonds as enzymes that catalyse the hydrolysis of these bonds are rare in nature
- A proportion of students tend to confuse details of cellulose with collagen.

4. **Hb + Oxygen transport** to cells in body: **(must have)**
   a) Haemoglobin a polymer of **amino acids**;
   b) Has **haem group** with an **iron ion** which **binds to O2**;
   c) Hb has **4 subunits** which exhibit **cooperative binding** of O2, allowing **efficient loading of O_2**;
   d) Amino acids with **hydrophilic R groups** are located on **exterior** while amino acids with **hydrophobic R groups** are located in the **interior**, allowing haemoglobin to be **soluble in water**;

5. **DNA + storage of genetic information / contains genes**; **(must have)**
   a) DNA is a polymer of **deoxyribonucleotides**;

b) Each DNA strand can serve as a **template** for synthesis of a **complementary** new DNA strand to produce **genetically identical DNA molecules**;
c) This results in **genetically identical cells** produced from **mitosis**;
OR
d) Genes code for _(specific enzyme)_ involved in _(specific reaction)_ ;

6. **mRNA + carrier of genetic code**: **(must have)**
   a) mRNA is a polymer of **ribonucleotides**;
   b) serves as a **template** for **ribosomes** to **translate** to form **proteins** used in the cell;

7. **tRNA + involved in bringing right amino acid for translation process**: **(must have)**
   a) tRNA is a polymer of **ribonucleotides**;
   b) **3' CCA stem** for **attachment** of a **specific amino acid** to form aminoacyl tRNA used in translation;
   c) **Anticodon complementary base pairs** with **codon on mRNA** during translation;

8. **rRNA + complexes with ribosomal proteins to form ribosomes**:
   a) rRNA is a polymer of **ribonucleotides**;
   b) rRNA serves as **peptidyl transferase** in large ribosomal subunit to catalyse the **formation of peptide bond** during **translation;**

9. Specific enzyme + role (catalyse formation / breakdown of ….):
   a) named enzyme which is a polymer of **amino acids**;
   b) **Specific sequence of amino acids** give rise to specific 3D conformation of **active site** which is **complementary in conformation and charge** to specific substrate;
   c) AVP: structure → property

10. Specific membrane transport protein + role:
   a) ….. is a polymer of **amino acids**;
   b) Structure → property;

11. Microtubules + movement of genetic material:
   a) a polymer of **amino acids**;
   b) **separates sister chromatids** during **anaphase of mitosis** / **anaphase II of meiosis**
   OR
   separates homologous chromosomes during **anaphase I of meiosis**
   OR
   Align chromosomes independently at **metaphase plate** during **metaphase of mitosis**;
   c) This gives rise to **genetically identical cells** after mitosis
   OR
   This gives rise to **haploid gametes** after meiosis;

QWC (1m)
At least 3 different types of biomolecular polymer stated to illustrate 3 different functions
Answer structure: well paragraphed etc

(b) Distinguish the structures and reproductive cycles of HIV and influenza virus. [9]

Structural differences (max 3m)

	Feature of comparison	HIV	Influenza virus
S1	Genome	**2 identical** single stranded RNA OR **Positive sense** RNA	**8 different** single stranded RNA OR **Negative sense** RNA ;
S2	Viral enzymes	Reverse transcriptase, Integrase, protease	RNA-dependent RNA polymerase, neuraminidase ;
S3	Capsid shape	Conical	Spherical ;
S4	Viral glycoproteins	gp120, gp41	Hemagglutinin and neuraminidase ;

Differences in reproductive cycle (max 5m)

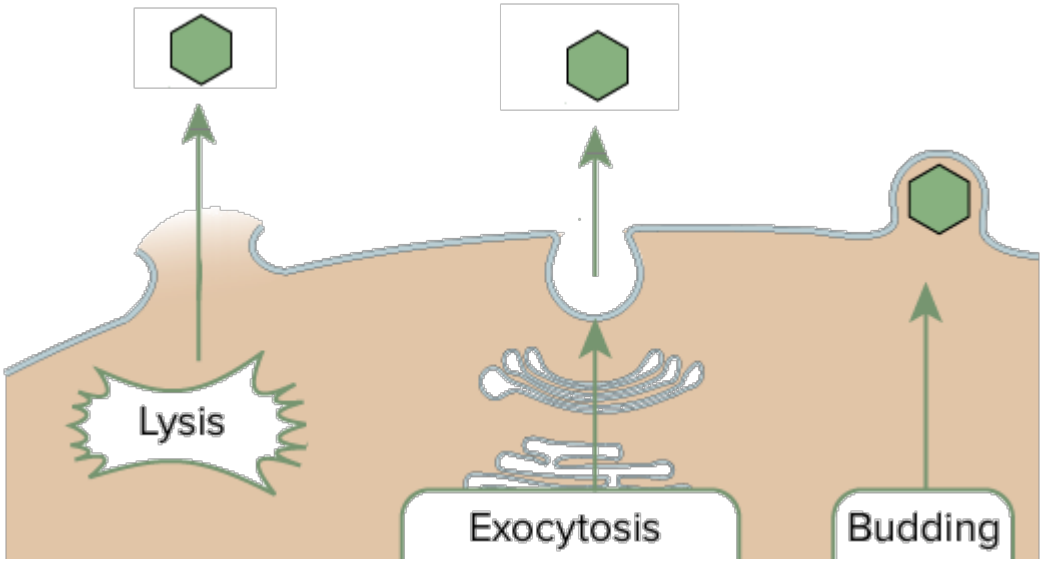
	Feature of comparison	HIV	Influenza virus
R1	Attachment of virus to host cell	Viral **gp120 binds** to **CD4 receptors** on **T helper cells**	Viral **hemagglutinin bind** to **sialic acid receptors** on **lung epithelial cells**;
R2	Entry of virus into host cell	HIV enters via **fusion** of viral envelope and host cell surface membrane	Influenza virus enters host cell via **endocytosis**;
R3	Integration of viral genome into host cell genome to form provirus	**Viral DNA is integrated** into host cell genome by viral integrase, forming a **provirus**	**Viral genome not integrated** into host cell genome and **no provirus** is formed;
R4	Enzyme involved in	**Host cell DNA polymerase** transcribes	**Viral RNA-dependent RNA polymerase**

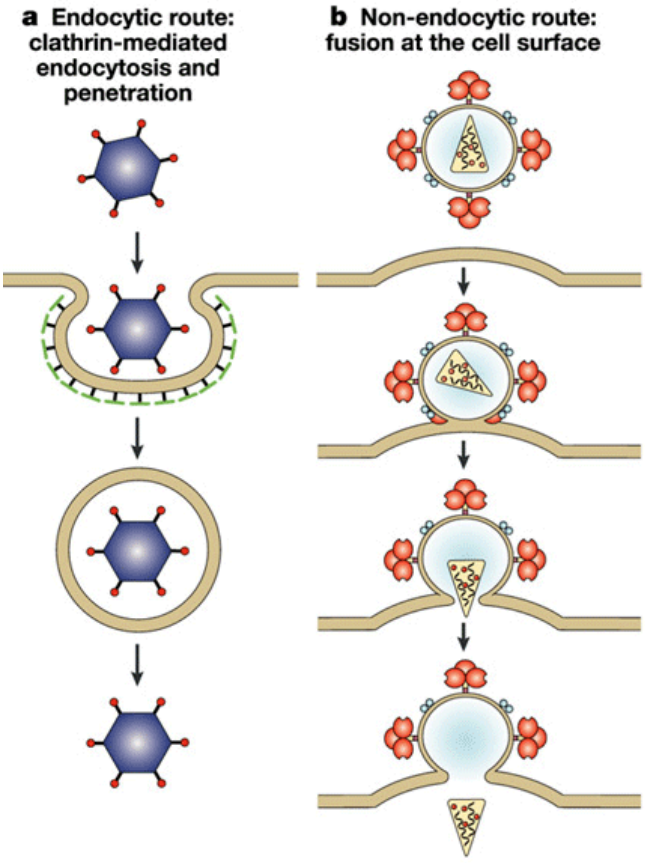
	replication of viral genome / formation of viral mRNA	provirus to form viral RNA genome / formation of viral mRNA	transcribes viral mRNA to form viral genome / formation of viral mRNA;
R5	Formation of functional viral proteins	**Some viral proteins are synthesized as polyproteins** which need to be cleaved by **viral protease** to form functional viral proteins	Viral proteins are not synthesized as polyproteins; OR Viral proteins are synthesized individually as functional proteins;
R6	Release of virus	HIV virus is **immediately released** from host cell after budding	**Neuraminidase cleaves sialic acid receptors** to release virus from host cell after budding;

QWC (1m)
Point for point comparison demonstrated.
Answer well-structured.

Examiner's comments:

- This question was quite poorly done, either due to lack of time or prerequisite knowledge.
- The incorrect notions that both viruses enter by endocytosis and exit by exocytosis are quite pervasive. Note that **endocytosis and fusion** of cell surface membrane are **different** processes altogether. Also, **budding off** (which includes evagination of the membrane followed by pinching off to form a separate compartment) is not the same thing as exocytosis (fusion of the vesicle membrane with the cell surface membrane to release contents).
- QWC was only given to students who structured their answers according to the question: structure and replication, and demonstrated clear point-for-point comparisons.




a Endocytic route: clathrin-mediated endocytosis and penetration
b Non-endocytic route: fusion at the cell surface
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