JC1 2023
H1 PROMOTIONAL EXAMINATION
ANSWERS

SECTION A: MCQ

1	**A**	6	**A**	11	**D**
2	**B**	7	**D**	12	**B**
3	**D**	8	**A**	13	**B**
4	**A**	9	**D**	14	**D**
5	**C**	10	**B**	15	**B**

1 Fig.1.1 shows a cell releasing insulin in response to glucose uptake.

The uptake of glucose through Glucose Transporter 2 (GLUT2) causes a rise in ATP levels in the cell.

This closes the potassium channel and in turn causes calcium channel to open. The influx of calcium ions leads to the release of insulin.

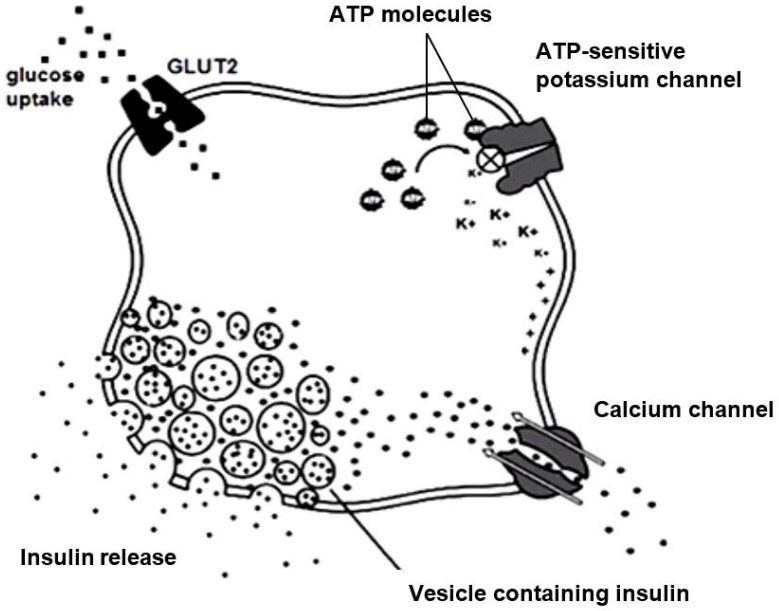


Fig. 1.1

(a) (i) With reference to Fig. 1.1., describe **two** differences in the way insulin and glucose are transported across the cell surface membrane. [2]

Any 2

1. **Transport of insulin involves the secretory vesicles, but the transport of glucose involves transport / carrier proteins.**

2. **Insulin is released when the secretory vesicles fuse with the cell surface membrane, but glucose enters the cell when they bind to [QF] GLUT2 which undergoes conformational change to facilitate the transport of glucose.**

3. **Glucose is transported down a concentration gradient but not insulin.**
4. **Transport of insulin requires energy from ATP (R: active transport) but not the transport of glucose.**

Feedback / comment

1. **Candidates had difficulty recalling the different types of transport across the membrane. While most knew that glucose is transported via facilitated diffusion, most did not realize from the Fig. that insulin is released / secreted via exocytosis (i.e., involving secretory vesicles).**

2. **Transport protein could either be channel protein or carrier protein. Note that glucose is transported into the cell via carrier protein and not channel protein.**

(ii) Explain how the membrane proteins in Fig. 1.1 are able to transport the substances across the cell surface membrane. [2]

1. **The membrane proteins are transmembrane proteins**

2. **with hydrophilic channel to shield polar molecules (e.g., glucose) and charged ions (e.g., calcium ions) [1]**

Note: If no reference to glucose / potassium ions / calcium ions = ½ mark

3. **from hydrophobic core of phospholipid bilayer / cell surface membrane. This helps to transport them across the membrane.**

Extra point:

4. **Potassium channels have binding sites for ATP to bind to such that they are closed and prevent K^+ ions from leaving the cell. This will help calcium channels to open.**

Feedback / comment

1. **Candidates were mostly unable to relate to the property of membranes and the properties of substances that are transported across the membrane.**
2. **Candidates should use the information presented in the figure to answer (i.e., QF the types of substances in Fig. 1.1).**

(b) Suggest with a reason how a secretory cell will differ in terms of organelles from a non-secretory cell. [1]

Any one

1a) There will be more mitochondria.
1b) Reason: To produce more ATP for the synthesis of proteins / movement of vesicles / exocytosis [any 1 example]

2a) There will be more rough endoplasmic reticulum.
2b) Reason: Attachment of more ribosomes on its surface to synthesise more proteins.

3a) There will be more Golgi apparatus. (Note: Uppercase G for Golgi).
3b) Reason: So that more proteins can be modified, sorted and packaged for secretion.

Feedback / comment

1. **Transport proteins are not organelles.**
2. **Reason was often lacking in the answers. Candidates are reminded to answer both parts of the question.**

Fig. 1.2 shows an organelle in a eukaryotic cell.

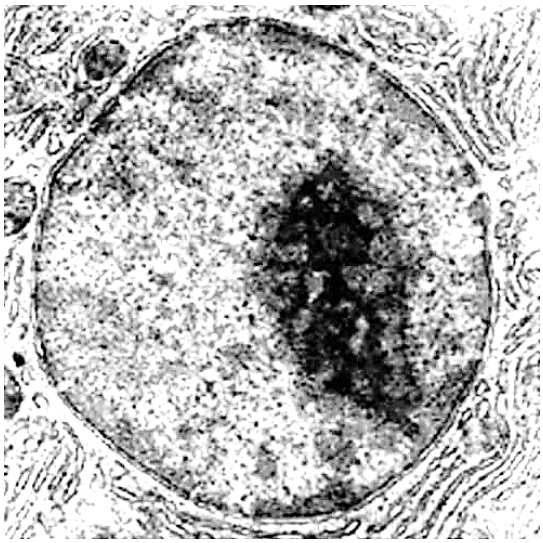


Fig. 1.2

(c) With reference to Fig. 1.2; explain why the organelle cannot be a lysosome. [1]

Any one

1. **Nucleus is a double-membrane bound organelle while lysosome is a single membrane-bound organelle.**
2. **Presence of a prominent nucleolus in the nucleus which is absent in a lysosome.**
3. **Presence of nuclear pores which are absent in the lysosome.**

Feedback / comment

Most candidates were able to identify the organelle as nucleus, and answer in terms of the structural difference, as seen in Fig. 1.2, between nucleus vs lysosome.

[Total: 6]

2 **(a)** Fig. 2.1 shows the photomicrograph during one stage of mitosis occurring in a root tip cell of a diploid flowering plant. The diploid number is 14.

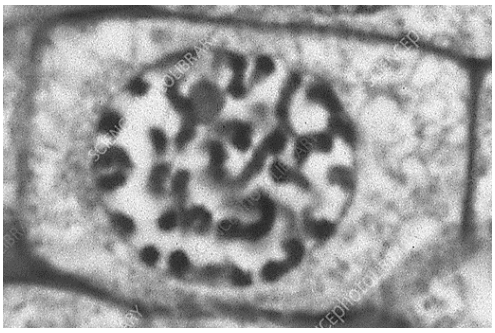


Fig. 2.1

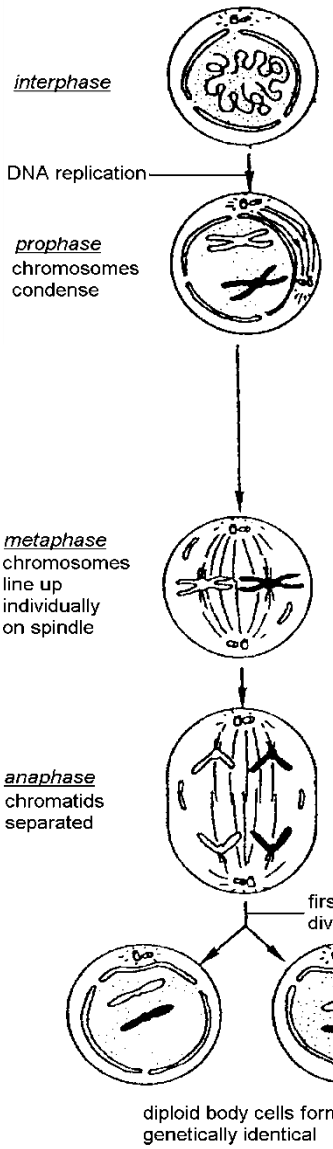
Complete Table 2.1 to show the number of chromosomes found in the cell at the end of a given stage of the cell cycle. [2]

Table 2.1

stage	no. of chromosomes per cell
G1	14
S phase	**14**
cytokinesis	**14**

Feedback / comment

1. More than half of the candidates were able to gain at least one mark. Some students who drew the chromosomes were able to gain full credit.



Interphase: G1
No. of chromosomes per cell = 2 (i.e., 2 unduplicated

[End of] Interphase: S
No. of chromosomes per cell = 2

Prophase
No. of chromosomes per cell = 2

Metaphase
No. of chromosomes per cell = 2

Anaphase
No. of chromosomes per cell = 4

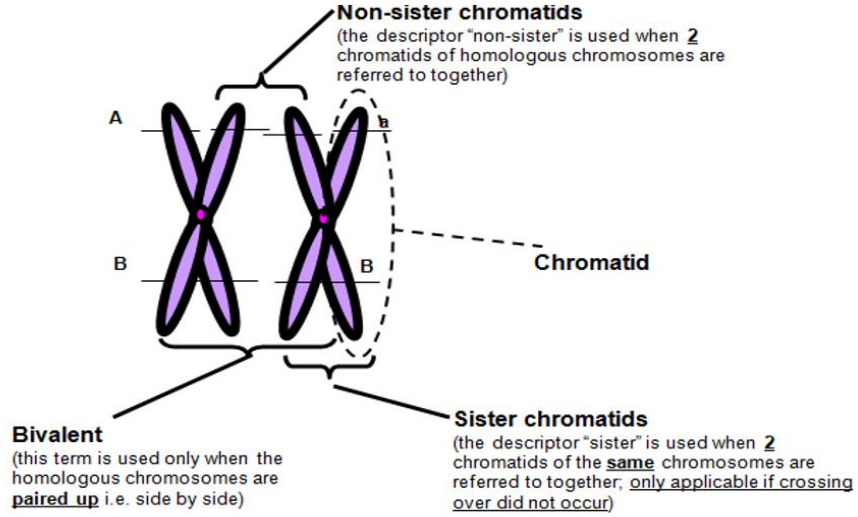
Note: Telophase marks the end of mitosis.
Telophase: No. of chromosomes per cell = 4
No. of chromosomes per nucleus = 2

[End of] Cytokinesis
No. of chromosomes per cell = 2

For STQ 2a
No. of chromosomes per cell = 14

For STQ 2a
No. of chromosomes per cell = 14

(b) Outline **one** difference between a pair of homologous chromosomes and sister chromatids of a chromosome. [1]

Feature	A pair of homologous chromosomes	Sister chromatids
1) Genetic similarity	Not genetically identical to each other [1/2]	Genetically identical to each other before crossing over [1/2]
Explanation for point 1 A diploid individual inherits one homologous chromosome from his father and one homologous chromosome from his mother. Hence, the pair of homologous chromosomes are genetically different / not identical. On the other hand, a pair of sister chromatids (of a duplicated chromosome) is the result of DNA replication. Hence, they are genetically identical.		
2) Physical connection / attachment	Not connected to each other	Connected to each other at the centromere
3) Anaphase I	Separate	Do not separate
4) Alleles at corresponding gene loci.	Same number and type of genes but have different alleles for the same genes. Max ½ mark if "may" is missing from answer.	Same number and type of genes and have same alleles for the same genes.
Explanation: It is possible for the homologous chromosomes to have the same alleles for the same genes. In Fig 17 of Cell cycle notes (page 19), the pair of homologous chromosomes have different alleles for gene A/a but the same alleles for gene B/b.  		
Explanation for point 4 For the pair of homologous chromosomes, the corresponding alleles of one gene may be identical (i.e., homozygous for the particular gene) or they may be different (i.e., heterozygous for the particular gene). On the other hand, a pair of sister chromatids will always have identical alleles for every gene because they are the result of DNA replication.		
5) Crossing over	Crossing over occurs during prophase I. Max ½ mark if "prophase I" is missing.	No crossing over.

Feedback / comment

1. Mixed performance for this question. A few candidates have misconceptions regarding point 1 and 4. Point 1 and 4 are related to each other.

(c) (i) Describe the characteristics of embryonic stem cells. [2]

Any four

1. **Capable of dividing and renewing themselves.**
2. **Pluripotent**
3. **and can differentiate into almost any cell type to form any organ or type of cell.**
4. **Are unspecialized.**
5. **are able to give rise to specialized cells.**
6. **They are not totipotent but are multipotent.**

Feedback / comment

1. Candidates had difficulty recalling the characteristics of embryonic stem cells and no candidates were able to gain full credit.

(ii) State the challenges of using embryonic stem (ES) cells for research or medical treatment and explain how induced pluripotent stem cells (iPSCs) may overcome each of these challenges. [3]

1. **Obtaining ES cells destroy / kill human embryos which may be regarded as living human beings. Obtaining iPSCs do not involve killing human embryos so there is no ethical issue.**
   Note: Need to refer to the destruction of embryos during the process of extracting ES cells + idea that embryos might be considered as living human beings.
   R: Destruction of ES cells.

2. **ES cells may cause immune rejection in the patients as they are foreign cells. iPSCs are derived from the patient and so the patient will not have any immune rejection.**
   Note: Need to mention the idea of "immune" rejection, and not merely donor rejection.

3. **Obtaining ES cells may take a long time as a suitable donor need to available. Obtaining cells from patients to create iPSCs are faster / do not need to wait.**
   Note: Need to mention the idea that iPSCs are derived from the patient at least once in point 2 or 3.

Feedback / comment

1. Several candidates erroneously mentioned the destruction of embryonic stem (ES) cells instead of embryos. If ES cells are destroyed, they cannot be used for research or medical treatment.

2. Another error is the idea that ES cells might turn cancerous but not iPSCs. Note that there is always a risk that stem cells, including iPSCs, might turn cancerous.

3. Note that iPSCs are derived from specialized adult cells and not stem cells (refer to Stem cell notes, page 17).

[Total: 8]

3 A student carried out an investigation into the mass of product formed in an enzyme-controlled reaction at three different temperatures. Only the temperature was different for each experiment. The results are shown in Fig. 3.1.

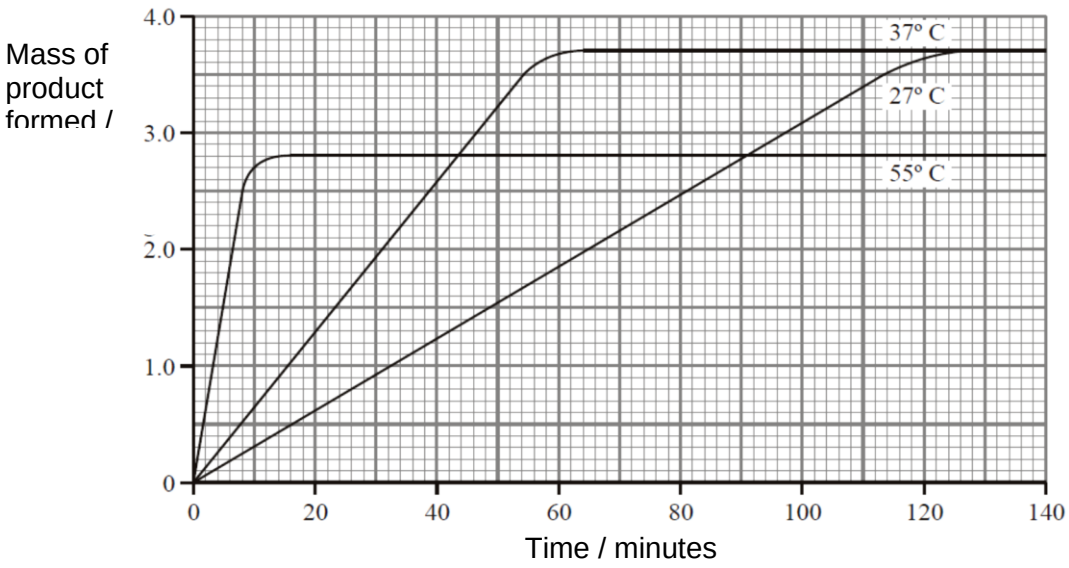


Fig. 3.1

(a) Use your knowledge of enzymes to explain

(i) why the initial rate of reaction was highest at 55 °C; [2]

1. **Highest temperature of the 3 temperatures.**
2. **Enzymes and substrates have highest kinetic energy**
3. **Highest / increased successful collisions between enzyme and substrate**
4. **Highest number of enzyme-substrate complexes formed per unit time.**
   Note: must mention highest at least once.

Feedback / comment

1. In the context of this question, there must be comparison such as reference to 55ºC as being the highest of the 3 temperatures, substrate and enzyme having the highest kinetic energy, etc.

(ii) the shape of the curve for 55 °C after 20 minutes. [3]

1. **[QF] After 20 minutes, amount of product formed remains at 2.8 mg.**

2. **Above optimum temperature,**
3. **atoms in the enzyme to vibrate more,**
4. **resulting in breaking of hydrogen bonds and hydrophobic interactions.**

5. **The enzyme was denatured / loss of tertiary structure.**
6. **Shape of active site changed.**
7. **Shape of active site no longer complementary to shape of substrate**

Feedback / comment

1. Candidates were able to understand that high temperature denatured the enzyme but the points were often incomplete.

   Note that for 55ºC, the enzyme was denatured and hence not all substrates were converted to products.

(b) Explain why the curves for 27 °C and 37 °C level out at the same value. [1]

1. [State / QF] Same amount of product formed at 3.7 mg
2. [Explanation] All substrate changed into product.

Feedback / comment
1. Few candidates understood that the reaction has been completed and hence, the mass of products remained the same.

The enzyme is found to have the structure as shown in Fig. 3.2.

Fig. 3.2

(c) Describe structure **A** found in the enyzme. [2]

1. It is alpha helix / an extended spiral spring.
2. Stabilized by hydrogen bonds
3. between –C=O and –NH groups / peptide linkages within polypeptide chain
4. 3.6 amino acid residues in one complete turn

Feedback / comment
1. Generally, well done as most candidates were able to recognize structure A as the secondary structure of protein.
2. One candidate mentioned peptide bonds which is included if one is describing the primary structure.

[Total: 8]

4 A diagram of a chromosome from a dividing cell is shown in Fig. 4.1.

Fig. 4.1

(a) Before a cell divides, DNA replication takes place via semi-conservative replication.

State **two** ways how DNA replication differs from transcription. [2]

Important reminders:

1. **Students MUST use comparative term "whereas" or "while" to connect the 2 contrasting statements.**
   Reject: if students use "and" or "comma"
   E.g. The enzyme used in DNA replication is DNA polymerase while the enzyme used in transcription is RNA polymerase.
2. **MUST write "D" & "R" clearly.**
3. **Reject any differences where students just list all the different proteins.**
4. **Some students confused transcription with translation.**

	FEATURE	DNA REPLICATION	TRANSCRIPTION
1	Enzyme involved	DNA polymerase	RNA polymerase
2	Raw materials	Deoxyribonucleotides	Ribonucleotides
3	Template	Both strands of DNA molecule	Only template strand of the DNA
4	Base pairing	Adenine with thymine and vice versa Cytosine with guanine and vice versa Reject : if students only mention thymine in DNA	Adenine on DNA with uracil on RNA Thymine on DNA with adenine on RNA Cytosine with guanine and vice versa
5	Proofreading property on enzyme involved	DNA polymerase carry out 3' to 5' exonuclease on daughter strand, ensuring precise complementary base pairing / proofreading of daughter strand	RNA polymerase does not carry out 3' to 5' exonuclease proofreading of RNA transcript.
6	Product(s)	2 DNA molecules Reject : 2 strands OR daughter strand	mRNA, tRNA or rRNA
7	Products destination	Products remain in the nucleus.	All products leave nucleus via nuclear pore
8	Enzymes involved in unwinding DNA	Helicase	RNA polymerase
9	Requirement of primers	DNA polymerase require primers to start the process of DNA replication	RNA polymerase does not require primers to start the process of transcription
10	Start site	DNA replication starts at the origin of replication	Transcription starts at the promoter

(b) The chromosome shown in Fig. 4.1 consists of one long DNA molecule associated with histone proteins.

Name one stage of mitosis in which a chromosome would have the same general structure as the chromosome shown in Fig. 4.1. [1]

Note : MUST be a stage AFTER sister chromatids have separated.

- **Anaphase OR telophase**

(c) Name the stage in the cell cycle during which the cell divides to produce two genetically identical daughter cells. [1]

- **Cytokinesis**

Blood stem cells are actively dividing cells found in the bone marrow of a human being.

(d) **State** **one** role of blood stem cells in a human body. [1]

1. **Blood cells** are **continually replaced** by **division and differentiation of blood stem cells**.
2. **Lymphoid and myeloid stem cells** ensure **constant renewal of blood cells.**
3. **Lymphoid stem cells differentiate** to form **white blood cells** / **T lymphocyte** and **B lymphocytes**
4. **Myeloid stem cells differentiate** to form **red blood cells** and **other types of white blood cells**

(e) Lung cancer can be caused by carcinogens. Benzopyrene, a compound found in tar from tobacco smoke is known to interfere with DNA replication.

It brings about gene mutation via transversion mutation or transition mutation. Both cause the newly synthesised strand to have an incorrect base.

(i) A transversion mutation is when a pyrimidine is used in the newly synthesised strand instead of a purine, or the other way round.

Name the **two** possible bases that could be used instead of cytosine in a transversion mutation. [1]

Important reminders:

1. **The mutation is at the DNA level – uracil should not be a possible answer!**
2. **Cytosine is a pyrimidine – therefore your answer must list purines.**
3. **Must spell out in full.**

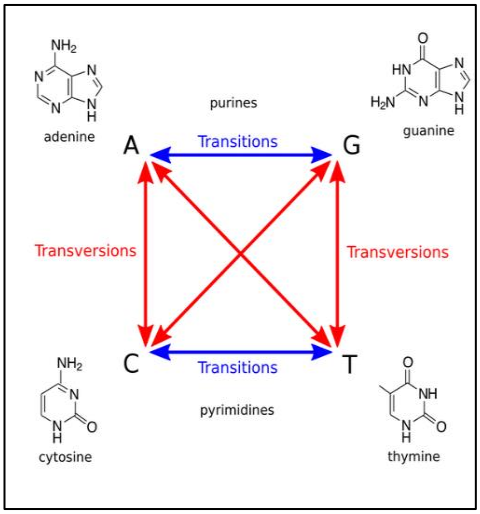
1. **adenine and**
2. **guanine ;**

(ii) A transition mutation is when a purine is replaced by an incorrect purine or a pyrimidine is replaced by an incorrect pyrimidine.

Suggest why transversion mutations are less likely to occur than transition mutations. [2]

Note:
- **MUST KNOW:**
- **Purine: 2 rings**
- **Pyrimidine: 1 ring**
- **Purine always base-pair with pyrimidine**

- **Wrong reasoning when students consider the chance of occurrence based on the total number of bases in pyrimidines vs purines.**
- **Wrong focus when students consider the chance of occurrence based on number of hydrogen bonds.**



1. **purines have two rings and pyrimidines have one ring ;**

2. **(a) purine base-pairs with pyrimidine to**
   (b) maintain constant width between 2 DNA strands
   Note : Reject constant length

3. **two purines or two pyrimidines change / distort the double helix constant width in a transversion event**

4. **so transversion event more likely to be detected by DNA polymerase during DNA repair mechanism and remove wrong nucleotide**

(iii) It has been observed that the carcinogens in cigarette smoke can also cause the deletion of a nucleotide base from the promoter of a gene.

State the role of promoter in a gene. [1]

- **Specifies transcription start site** on the template strand of DNA.
  OR
- **RNA polymerase** and **general transcription factors** bind to promoter to **initiate transcription**

The process of protein synthesis takes place in both cancerous and non-cancerous cells. Many types of nucleic acids are involved in the process.

(f) State **one** way in which the structure of DNA differs from the structure of messenger RNA. [1]

Reject any differences that does not refer to structure

Any one

Feature	DNA	RNA
1. Monomer	▪ deoxyribonucleotide.	▪ ribonucleotide.
	Reject: DNA nucleotides VS RNA nucleotides, because it is just repeating stating the terms DNA & RNA.	
2. Sugar	▪ deoxyribose sugar	▪ ribose sugar
3. Nitrogenous bases	▪ Adenine ▪ Thymine ▪ Cytosine ▪ Guanine	▪ Adenine ▪ Uracil ▪ Cytosine ▪ Guanine
	Note : No marks given if students only mention thymine verses uracil	
4. Number of strand	▪ It is usually double-stranded	▪ It is usually single-stranded
5. Types	▪ 1 form as a double helix	▪ It exist at least in 3 forms: – Mrna – tRNA – rRNA
6. Length OR	▪ Longer	▪ Shorter
7. Size	▪ It is a large molecule.	It is a smaller molecule than DNA

(g) At the start of translation, amino acid activation takes place whereby an amino acid attaches to its specific tRNA molecule. This process requires an enzyme, aminoacyl tRNA synthetase.

Explain why a particular amino acid needs to be linked to a specific tRNA molecule. [2]

1. tRNA carries a (a) specific amino acid to the (b) ribosome during translation
2. anti-codon of tRNA forms complementary base pairs with codons on the mRNA
3. which allows for correct sequencing of amino acids on the polypeptide chain.

(h) Suggest **one** possible effect of gene mutation in the cell during the synthesis of proteins. [1]

Important reminders:

1. **Focus is on effects of gene mutation, NOT types of gene mutation**
2. **Stating "nonsense mutation", "silent mutation" & "frameshift mutation" is incomplete regarding the effect during synthesis of protein.**
3. **Reject: "results in a different protein"**
   Reason: A non-functional protein is NOT a different protein.

Any one

1. A non-functional protein is produced
2. change in primary structure / amino acid sequence, of polypeptide / protein ;
3. A truncated protein is produced

[Total: 13]

5 **(a)** Outline how photosynthesis converts light energy to chemical energy stored in the form of carbohydrates. [10]

1. Photosynthesis occurs in the chloroplasts of plant cells.

Light reaction

2. During the light reaction (or photophosphorylation) stage of photosynthesis [1]
3. Light energy is absorbed
4. by photosynthetic pigments / (e.g., chlorophyll)
5. that are embedded in the thylakoid membranes of chloroplasts.
6. The absorbed light energy is converted to chemical energy stored in the products NADPH and ATP. [1] (If only one product → ½ mark)
7. O_2 is the by-product of the light reaction.
8. It is released from the photolysis of water.

Dark reaction

9. The products of light reaction (i.e., NADPH and ATP) are used for the dark reaction [1]
10. that occurs in the stroma of chloroplasts.
11. Together with CO_2 from air
12. and ribulose-1,5-bisphosphate from stroma,
13. they are used to produce triose phosphate (or glyceraldehyde-3-phosphate).
14. Triose phosphate molecules can be converted to organic compounds,
15. such as glucose
16. which in turn combine to form starch.

Hence, light energy is converted to chemical energy in carbohydrates (e.g., starch grains) stored in the chloroplasts.

QWC [1]
Paragraphing + light and dark reaction are addressed.

Feedback / comment
1. Candidates were able to relate to light and dark reactions although details were lacking in most scripts.
2. Candidates are reminded to write the essay in paragraphs as part of quality of written communication (QWC).

(b) Distinguish between transcription and translation. [5]

FEATURE	TRANSCRIPTION	TRANSLATION
1. Location of process	In the nucleus	On ribosomes in the cytoplasm
2. Template	DNA template strand	mRNA
3. Reading of template	DNA template read in the 3' to 5' direction	mRNA read in the 5' to 3' direction
4. Complementary base pairing	Between ribonucleotides and deoxyribonucleotides on DNA	Between codons on mRNA and anticodons on tRNA
5. Raw material	Ribonucleotides	Amino acids

6. Enzyme	**RNA polymerase catalyses formation of phosphodiester bonds between ribonucleotides**	**Peptidyl transferase in large subunit of ribosome catalyses formation of peptide bonds between amino acids.**
7. Products	**mRNA, tRNA, rRNA**	**Polypeptide chain**
8. Involvement of ribosomes	**No**	**Yes**
9. Involvement of tRNA	**No**	**Yes**

QWC [1]

1. **Paragraphing or draw complete table.**
2. **Must be point to point comparison.**

Feedback / comment

1. This was poorly done. Candidates are encouraged to understand and revise the processes thoroughly.

2. Paragraphing and point to point comparison for differences were mostly lacking.

[Total: 15]

6 **(a)** Explain the significance of mitosis and meiosis. [10]

Mitosis [max 5 marks]

1. **Mitosis maintains genetic stability of an organism or a cell from one generation to the next.**
2. **Two genetically identical daughter cells formed.**
   OR
   Daughter cells have the same number and type of chromosomes as the parent cell.

3. **Replication of DNA occurs in the parent cell.**
4. **before mitosis begins/ during S phase of interphase**
5. **and halved after cytokinesis.**

6. **Chromosomes are arranged at the equator of the cell during metaphase.**
7. **Sister chromatids separate during anaphase to opposite poles**
8. **and are evenly distributed between the two nuclei during telophase.**

9. **Mitosis occurs during the growth and development of a multicellular organism.**
10. **Mitosis occurs during the replacement of cells of worn-out tissues of the body.**
11. **Mitosis is the basis of asexual reproduction.**
12. **Production of offspring that are identical to parents allows a population to rapidly colonise / spread in a habitat.**
13. **Mitosis occurs during an immune response.**

Meiosis [max 4 marks]

14. **Meiosis gives rise to genetic variation between gametes.**
15. **This is due to crossing over**
16. **between homologous chromosomes.**
17. **and the independent assortment of bivalents / homologous chromosomes.**

18. **Both crossing over and independent assortment of homologous chromosomes will lead to new combination of alleles.**

19. **Meiosis prevents doubling of chromosome numbers.**
20. **Reference to meiosis producing four haploid gametes, which are genetically non-identical.**
21. **Reference to each gamete with half the number of chromosomes of the parent cell**
22. **Upon fusion of gametes / sexual fertilization**
23. **Diploid number (2n) is restored in the zygote.**

QWC [1]
Paragraphing + significance of mitosis and meiosis are addressed.

Feedback / comment
1. Generally, candidates who attempted this question could address both parts although some details are lacking.

(b) Distinguish between gene and chromosomal aberration. [5]

	Gene mutation	Chromosomal mutation
1. Changes to DNA	A change in sequence of DNA	A change in structure or number of chromosomes
2. Number of gene loci affected	Involves only one gene locus	Involves a multiple gene loci
3. Mechanism involved in the mutation	Brought about by deletion, insertion, or substitution of one or more nucleotides	Brought about by deletion, duplication, inversion or translocation of several gene loci on a chromosome. Due to non-disjunction during meiosis I or meiosis II
4. How it gives rise to genetic variation	By forming new alleles. Some new alleles may result in new proteins with a novel functions.	By reshuffling of alleles on a chromosome
5. Changes to chromosome number	Does not change chromosome number.	Changes chromosome number through polyploidy or aneuploidy
6. Frequency	More frequent	Less frequent
7. Evolutionary importance	Of evolutionary importance because acquisition of new alleles increases gene pool for natural selection to operate	Generally of lower evolutionary importance because it only reshuffles alleles already existing in the gene pool However, polyploidy may give rise to new species in some cases.

QWC [1]
1. **Paragraphing or draw complete table.**
2. **Must be pt to pt comparison.**

Feedback / comment
1. Except for one candidate, the candidates fared poorly for the question. Both parts were detailed separately without any point-to-point comparison. [Total: 15]