TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

H2 BIOLOGY **9744/03**

Paper 3 Long Structured and Free-response Questions

18 September 2023
2 hours

SUGGESTED ANSWERS

No	Oh dear, where did I go wrong? ☹	Affected Questions	I can improve by doing the following! ☺
1	I **don't understand** what the question wants from me.		• Identify topic(s) related to the question. • Analyse the preamble and/or diagram carefully. • Unpack the command term (e.g. explain, describe)
2	I don't know / can't remember the **conceptual facts**.		• Review my study techniques – what is effective and what is not? • Approach my tutor / peers for advice.
3	I did not give the **essential keywords** / wrong keyword.		• Reflect on why the missing words / phrases were essential in addressing the question.
4	My answers are **incomplete** / not of enough depth.		
5	I **misinterpreted** the questions / data, hence wrote the wrong answer / out-of-point answer		• Read the preamble carefully. • Paraphrase the question in my own words. • Unpack the command term (e.g. explain, describe)
6	I did not **contextualize my answers** to the question. That is, I did not make use of the information in the preamble / stimulus / figure.		• When the question revolves around a specific example, use the contextual information to craft the answers.
7	I did not **cite data** / I did not include the units for data / did not cite meaningful data for both axes.		• Cite complete data: both x & y axes, with units. • Examine the trend of the graph. If appropriate, divide the graph into ≥ 2 parts for meaningful citation of data.
8	I did not **organize my answers** properly, especially for comparison questions / essay questions.		• For comparison questions, ensure each sentence focuses on one feature. Use comparative words (e.g. but, whereas, while) • For essay questions, organise each major idea in a separate paragraph.
9	I did not manage to attempt the question due to **insufficient time.**		• Look through the whole paper and first attempt questions I am more confident in. • Be concise & succinct. Do not write excessively. • When I am stuck at a question, move on.
10	I was not able to **apply the conceptual facts** to this kind of 'suggest' questions.		• Identify topic(s) that the question is related to and draw links to the concept. • Examine any hint(s) / information in the preamble to suggest biologically sensible ideas.

Section A
Answer all questions in this section.

QUESTION 1

(a) The pituitary gland is located in the brain of mammals. Prolactin, a hormone from the pituitary gland, stimulates cells in the mammary glands of female mammals so that the cells are able to secrete milk.

(i) State the potency of the stem cells that produce pituitary cells. [1]
[Stem cell] [HI-1]

- Multipotent

(ii) With reference to the information provided, explain how the stem cells in pituitary gland stimulate cells in the mammary gland to secrete milk. [3]
[Stem cell and context] [HI-2]

1. Stem cells in the pituitary gland undergo cell division and **differentiation** to produce specialized cells that **secrete hormones / prolactin**.

2. the hormones **travel via bloodstream…**

3. …and **bind to prolactin receptor** on mammary cells to lead to signal transduction to stimulate the mammary cells to secrete milk.

(iii) Cells in the mammary glands that have been stimulated by prolactin need more glucose.

State **one** reason why those cells need more glucose. [1]
[Resp] [HI-2]

1. Glucose is a respiratory substrate used to **synthesise ATP** for the **production/secretion of milk**. *(reject: synthesise/produce energy)*

2. Glucose is a substrate to form milk sugar/ lactose.

3. Glucose is a component found in milk

(b) Female mammals produce milk to feed new-born offspring.

Secretory Immunoglobulin A (SIgA) is the main antibody found in breast milk of humans. It is secreted from IgA-producing plasma cells into cavities within the mammary glands to form milk with other components.

(i) Explain how newly synthesised SIgA in the IgA-producing plasma cells reach the cavities within the mammary glands. [4]
[Cell] [KU-2]

1. Newly synthesised SIgA antibody **enters the ER lumen** for **biochemical modifications**
2. **ER vesicles** carrying SIgA **bud off** from rER…
3. … and travel towards the ***cis* face** of Golgi apparatus and **fuse** with the **membrane** of the **Golgi apparatus**.
4. SIgA may undergoes **further biochemical modification** in GA.
5. Through **repeated budding and fusion of vesicles** to transport SIgA from the *cis* face to *trans* face
6. At the ***trans* face** of the Golgi apparatus, SIgA is **sorted** and **packaged** into a **secretory vesicle** which **buds off** from the Golgi apparatus.
7. The secretory vesicle **moves towards the cell surface membrane** and **fuse** with it to secrete SIgA out of the cell via **exocytosis**.

(ii) The antibodies and other components in the breast milk provide immediate protection to newborns in fighting infections. However, this is not a long-term protection.

Explain why antibodies such as SIgA in breast milk will not produce long-term protection to newborns. [2]
[Immunity] [KU-1]

1. **Passive immunity**
2. which does not elicit immune response

Or

Antibodies came from other source/the mother

3. Antibodies remains in the blood only for a short time / eventually degraded

(c) β-catenin signalling pathway involving WNT as a ligand is important in regulating cell proliferation during mammary gland development. When WNT binds to the Frizzled receptor embedded on the cell surface membrane, β-catenin is activated which translocates into the nucleus to upregulate the transcription of target genes. Fig. 1.1 shows the signalling pathway with and without WNT.

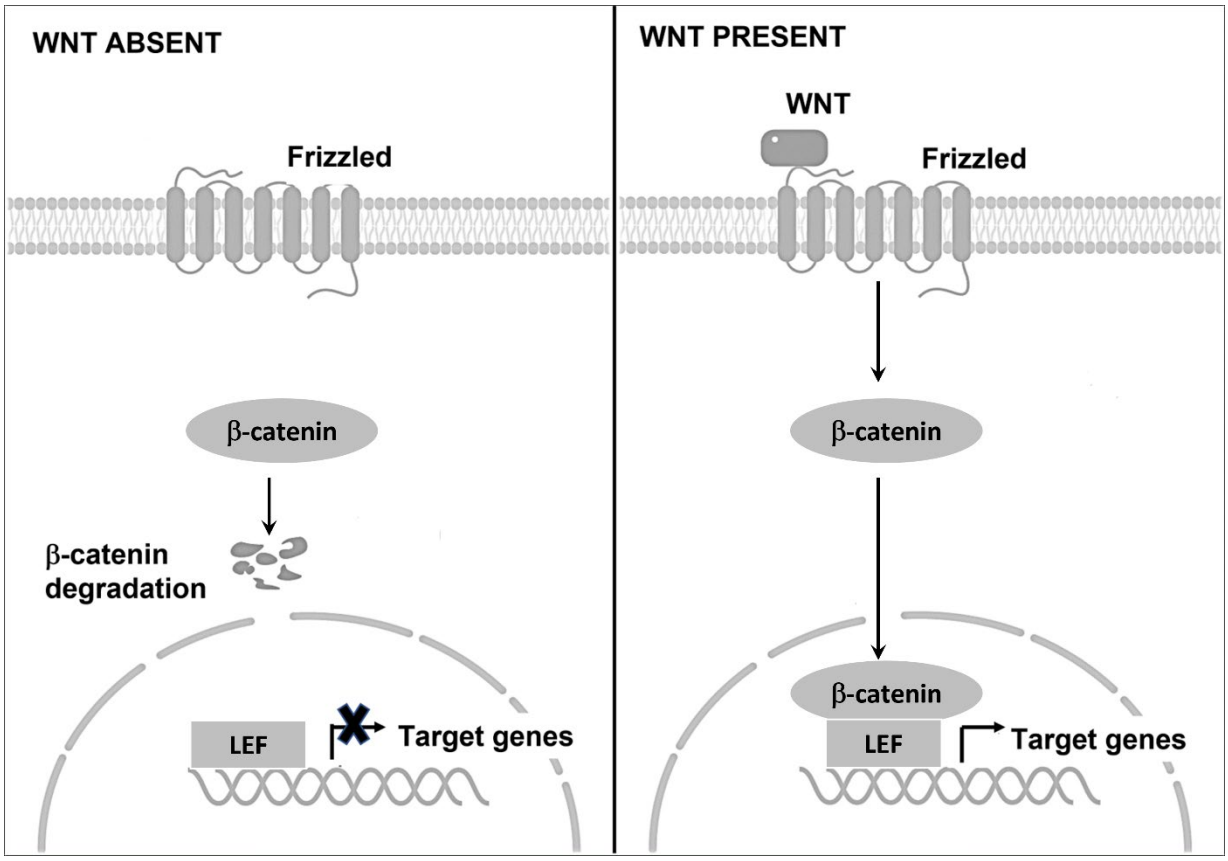


Fig. 1.1

(i) The shape of Frizzled receptor is characteristic of a particular group of transmembrane receptor proteins.

Name this group of proteins. [signalling] [HI-1] [1]

- G-protein linked receptors / G-protein coupled receptors

(ii) Suggest how β-catenin is degraded in the absence of WNT. [2]
[OCGE] [HI-2]

1. β-catenin is **tagged** by **ubiquitin**…
2. Which is then recognised and **degraded by proteasome**

(iii) Cell surface membrane is made up of phospholipid molecules.

Explain why triglycerides are **not** suitable as a component of cell surface membranes. [2]
[Bio Mol] [KU-2]

1. Triglyceride is **hydrophobic/non-polar**
2. Hence it is unable to **form hydrogen bonds** with water
3. *Idea of* Both cytoplasm and extracellular matrix are aqueous, triglyceride cannot form a bilayer to interact with

(d) One of the target genes in WNT/β-catenin signalling pathway is *cyclin D1* gene. Fig. 1.2 shows the percentage of β-catenin activity and cyclin D1 protein level during the mitotic cell cycle of a mammary gland cell.

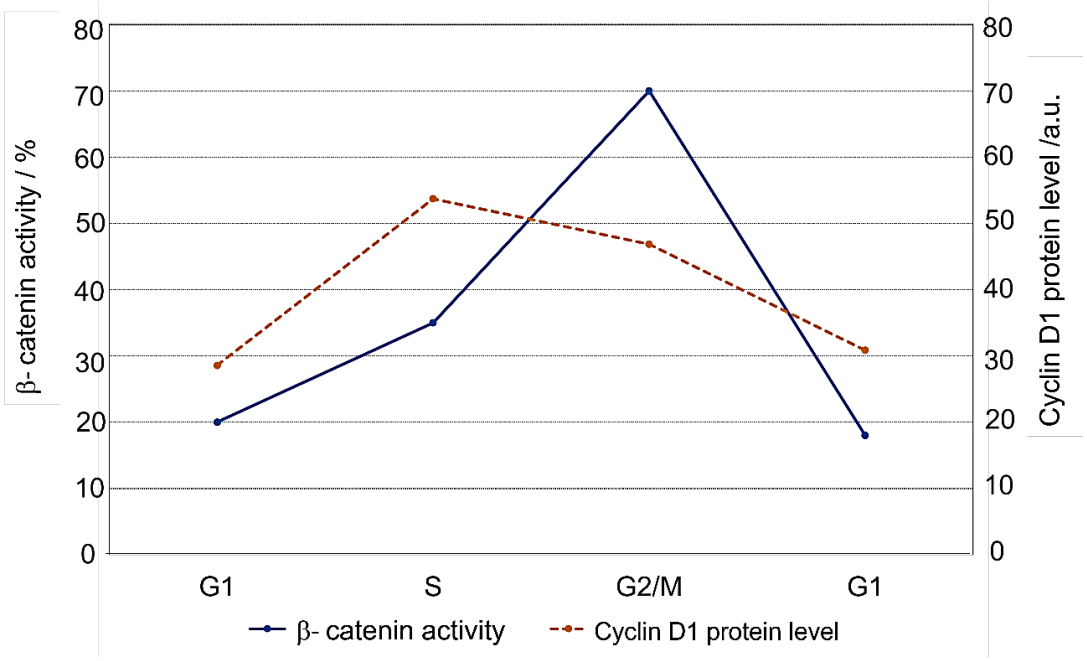


Fig. 1.2

With reference to Fig.1.1 and Fig.1.2, describe and explain the effect of β-catenin on *cyclin D1* gene expression from G1 to S **and** mitosis of mammary gland cell. [4]
[data response] [HI-2]

[effect on *cyclin D1* gene expression]

1. *[Describe]* As β-catenin activity level **increases from 20% to 35%** from **G1 to S** phase, cyclin D1 protein level **increases from 29 a.u. to 52 a.u**.

2. *[explain]* β-catenin acts as a **activator/transcription factor** which bind to/forms a complex with **LEF** to **increase/activate** *cyclin D1* gene expression.

[effect on mammary gland cell]

3. *[Describe]* β-catenin activity level **increases from 20% to 70%** from **G1 to G2/M** phase and peaks at G2/M.

4. *[explain] idea that* β-catenin activate/upregulate genes involved in promoting mitosis of mammary gland cell.

(e) The dysregulation of the β-catenin signalling pathway is frequently linked to breast cancer. A young scientist conducted an experiment to compare the amount of β-catenin protein in breast cancer cells and normal cells to determine if *β-catenin* gene expression is high in breast cancer.

(i) Explain why the amount of β-catenin protein is used as an indicator of breast cancer rather than the amount of *β-catenin* DNA. [2]

[OCGE] [KU-2]

1. *Idea that* β-Catenin protein level may **vary** due to **differential gene expression**

2. DNA amount is the **same** for both cancer and normal cells / both have 2 copies of the gene/ diploid

(ii) β-catenin is encoded by the *CTNNB1* gene. While *CTNNB1* mutations are rare in breast cancer, they are found in many other types of cancer. Table 1.1 displays a mutation that is often seen in *CTNNB1*.

Table 1.1

Name of mutation	Change in DNA		Change in β-catenin	
	Nucleotide present in *CTNNB1*	Nucleotide present after mutation	Amino acid before mutation	Amino acid after mutation
K354T	Adenine (A)	Cytosine (C)	Lysine (Lys)	Threonine (Thr)

With reference to Table 1.1, explain the meaning of a gene mutation. [HI-1] [2]

1. Gene mutation **K354T /mutation in *CTNNB1* changes** the nucleotide sequence **in DNA from A to C**

2. causing **change in amino acid sequence** of β-Catenin **from Lys to Thr.**

(f) Breast cancer is the most prevalent cancer among women in Singapore today. The age-standardised incidence rate of breast cancer per 100,000 women has significantly increased from 23.8 in 1975 to 70.7 in 2018.

(i) Calculate average annual percentage increase in age-standardised incidence rate of breast cancer from 1975 to 2018. Show your working. [HI-1] [2]

Percentage increase from 1975 to 2018: (70.7 – 23.8) ÷ 23.8 x 100% = 197% [1]
From 1975 to 2018: 44 years
Average annual percentage increase: 197% ÷ 44 = 4.48% [1]

https://pages.uoregon.edu/rgp/PPPM613/class8a.htm

average annual percentage increase ……4.48……**%**

(ii) The likelihood of surviving breast cancer is largely determined by the stage at which it is identified. Stage I indicates that the cancer is small and localized within the organ where it originated, and stage IV indicates that it has spread to other areas of the body. Table 1.2 illustrates the five-year survival rate for breast cancer based on the stage of detection.

Despite the efforts to promote Singapore's national breast cancer screening program, the screening uptake rate remains low at approximately 40%.

Table 1.2

Cancer stage at detection	Five year survival rate / %
Stage I	88
Stage II	74
Stage III	41
Stage IV	15

With reference to Table 1.2, state the importance of breast cancer screening **and** suggest why breast cancer screening rate remains low in Singapore. [4]

[state the importance of breast cancer screening]

1. Five year survival rate is the **highest at 88%** at **stage I** and **lowest at 15%** at **stage IV**.
2. The **earlier** the detection, the **greater** the chance of survival.

[suggest why breast cancer screening rate is low]

3. fear of procedural pain and fear of radiation from mammograms
4. high costs
5. Perception of low susceptibility to breast cancer
6. Personal challenges such as no time, shyness
7. Poor knowledge of benefits of screening
8. AVP

[Total: 30]

QUESTION 2

Vibrio cholerae is the bacterium that causes cholera by infecting intestinal epithelial cells.

The organism does not enter the cell but instead it secretes a toxin, choleragen which enter and cause damage in the cell. Choleragen is produced after *V. cholerae* has penetrated the mucus lining and attached to intestinal epithelial cells.

This toxin binds to and acts on cystic fibrosis transmembrane conductance regulator (CFTR) protein and causes large quantities of water and chloride ions to be lost from the gut epithelial cells. This results in severe diarrhoea and may lead to death if untreated.

Choleragen is composed of two subunits:

- subunit **A** consists of one polypeptide
- subunit **B** consists of five identical polypeptides
- the polypeptide in subunit **A** is different from the polypeptides in subunit **B**.

(a) Two genes, *ctxA* and *ctxB*, are needed to produce choleragen. Only one strand of the DNA forming gene *ctxA* is involved in the production of subunit **A**. Only one strand of the DNA forming gene *ctxB* is involved in the production of subunit **B**.

(i) Explain why only one strand of the DNA of each gene is involved in the production of the subunits. **[KU-2]** [2]

1. **[compulsory]** Only **one** DNA strand is used the **template strand** **for transcription** to form mRNA that is single-stranded.

2. *idea that* mRNA, is in turn used as template to produce the subunit (s) / polypeptide(s).

or

idea that transcribing the other DNA strand would result in different mRNA / polypeptide chain sequence.

(ii) *ctxA* and *ctxB* genes are observed to be transcribed in opposite directions.

Suggest why the direction of transcription of the two genes differs. **[KU-3]** [2]

1. ***Idea that*** **Different strands** was used as **template** for transcription.

2. **Promoter** is oriented in the **opposite direction / found on 3' end of the gene**.

3. Since the strands (used) are **antiparallel**, the two strands are **read in 3'→5' direction in opposite orientations**.

(b) CFTR protein is a channel protein that when open, allows the diffusion of chloride ions out of the epithelial cells down its concentration gradient. Chloride ions control the flow of water throughout the body, including the water that normally keeps mucus thin and slippery. If chloride ions are trapped in cells, the mucus outside the cells becomes thick and sticky, as shown in Fig. 2.1.

One of the most common causes of this defect is a mutation of the CFTR gene, *ΔF508,* which results in a deletion of phenylalanine at position 508 of the amino acid sequence.

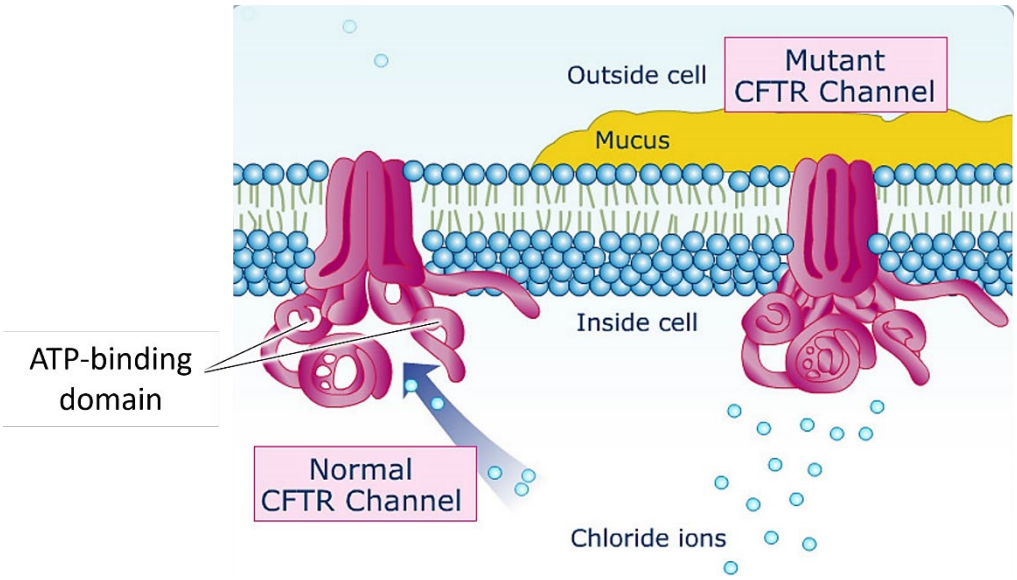


Fig. 2.1

(i) Explain how the deletion of a phenylalanine residue results in thick and sticky mucus outside the cells. **[HI-2]** [3]

1. Deletion of a phenylalanine result in a **different / shorter primary structure / amino acid sequence**.

2. This **alters the folding** of the polypeptide chain, hence **changes the tertiary structure / conformation** of CFTR protein.

3. CFTR is **no longer complementary to Cl^-** / CFTR **closes**, hence **reduced/no Cl^- transported out** of the cell,…

4. … resulted in **decreased in water potential inside the cell** / **higher water potential outside the cell → water moves into the cell via osmosis**, causing mucus to be less watery outside.

   Accept: No / less water release to maintain water potential gradient across the membrane, hence thick mucus outside /

(ii) With reference to Fig. 2.1, suggest the role of ATP in opening the channel. **[HI-2]** [1]

- **Binding of ATP to ATP-binding domain induces a conformational change** in the CFTR channel.

(c) In an experiment carried out in 1994, it was shown that when mice that were heterozygous for ∆*F508* were exposed to cholera toxin, they lost 50% less water than homozygous dominant mice also exposed to cholera toxin.

This supported a suggestion that the selective advantage of carrying the ∆*F508* allele may serve as protection from the effects of cholera.

(i) Suggest how the ∆*F508* allele might be expected to convey a selective advantage in areas of the world where cholera is common. **[HI-3]** [3]

1. Amount of water loss depends on, density / activity of CFTR protein (channels).
2. People **heterozygous** for the ΔF508 allele have **fewer functional CFTR proteins / reduced CFTR function**.
3. Hence, **fewer binding sites for cholera toxin** to act on, reducing toxins' effects.
4. Hence, **lower concentration of chloride ions transported out** of the cells.
5. **Less water loss** (to maintain water potential).
6. The effect of cholera is reduced, hence these **ΔF508 allele carriers** are **more likely to survive** cholera / confers to **heterozygous advantage**.

In 2000, a further experiment to investigate the possible link between the Δ*F508* allele and the severity of cholera in humans was conducted. To do this, the effect of prostaglandin was measured in fifteen human subjects including:

- some who had cystic fibrosis (homozygous for Δ*F508*)
- some who were carriers (heterozygous for Δ*F508*)
- a control group who did not have cystic fibrosis and did not carry Δ*F508*.

Prostaglandin is a chemical that increases water loss from epithelial cells by increasing chloride secretion through the CFTR protein.

The results are shown in Fig. 2.2.

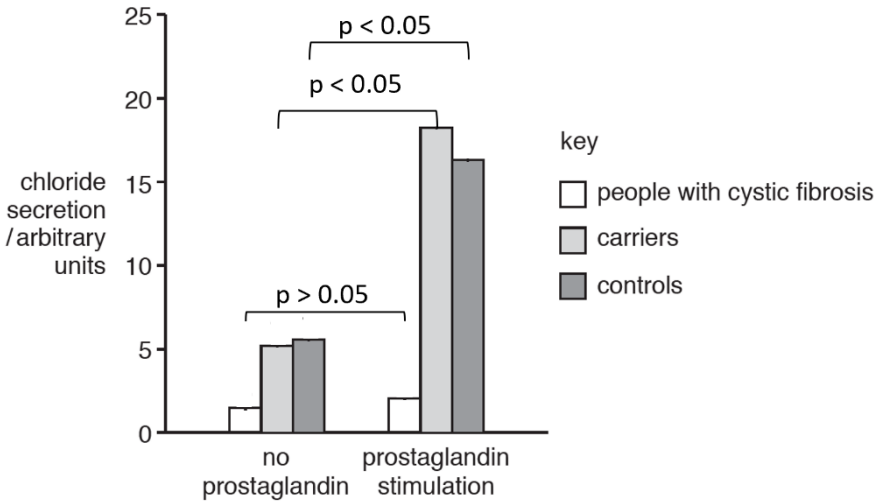


Fig. 2.2

(ii) Describe the results obtained in the study carried out in 2000. **[HI-2]** [3]

1. Prostaglandin stimulation **increased chloride secretion** in **both carriers and controls**.

2. In **carriers**, chloride secretion increased from **5a.u. to 18 a.u**. **(A: 18 – 18.5),** and in **controls**, chloride secretion increased from **(A: 5.5 – 6) 6a.u. to 16a.u (A: 16 – 16.5)**.

3. The **increase** in chloride secretion **in carriers and control** is statistically **significant**, as p < 0.05)

4. In CF patients, chloride secretion **increased very slightly** from **(A: 1 – 1.5),1.5a.u. to 2a.u. (A: 1.5 – 2),**/ remains **relatively constant at 1.5a.u (A: 1 – 1.5).**

5. The slight **increase** in chloride secretion **in CF patients** is statistically **insignificant**, as p> 0.05)

(iii) Suggest why prostaglandin was used to increase water loss from epithelial cells in the 2000 study. **[HI-2]** [1]

1. To mimic the effect of cholera.
2. Dangerous / unable / unethical to give actual cholera toxin to people.
3. Prostaglandin concentration can be controlled.
4. *Idea that* prostaglandin is not affected by immune system / no long term effects.

(d) Most people who have recovered from cholera rarely become ill again from the disease. In these people, antibodies have been identified that will bind either to the cholera toxin, or to the bacterial flagellum, or to the main bacterial cell.

Explain why each antibody is specific to its target. **[KU-2]** [3]

1. Each antibody consists of different **antigen-binding site / variable regions complementary in shape to specific antigen / epitopes** (in context of, flagellum / whole cell / toxin).

2. Each of these antibodies are secreted by **different plasma cells** differentiated from…

3. …**different B cells** that has receptors that binds specifically to the different antigens/epitopes.

4. ***Idea that*** The **variation / range of B cells with different receptors / antigen-binding site** is due to the process of **somatic recombination**, …

5. ….where **different V, D and J segments of heavy chain gene** and **V and J segments of light chain gene** are **recombined**.

(e) Viruses that infect bacteria are called bacteriophages. Some bacteriophages that infect the cholera pathogen cause lysis of the bacterium.

(i) Suggest what happens to the structure of a bacterial cell to cause lysis. **[KU-2]** [1]

1. Cell wall breaks / damaged / weakened / detail of change to cell wall / give example (cross links break down, quantity of peptidoglycan decreases).

2. Cell membrane ruptures / loses structure.

(ii) Some scientists believe that bacteriophages could be used to treat people who are infected with cholera.

Suggest a property of the bacteriophages that would make this possible. **[HI-2]** [1]

1. Specific in their action and hence **infect only *V. cholerae*** / **cholera bacteria** / **do not infect human (cells)**.

2. Do not give side effects / allergic responses (to humans). Likely to remain active / infective in human cells / within gut.

3. **Able to replicate inside *V. cholerae***, to **produce more** bacteriophage for treatment.

[Total: 20]

Section B
Answer **ONE** question.

Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in parts (a) and (b), as indicated in the question.

QUESTION 3

(a) Living organisms consist of diverse elements, including carbon, hydrogen, oxygen, nitrogen, and phosphorus. These elements play vital roles in upholding the continuity and viability of life.

Discuss the importance of nitrogen in living organisms. [13]

[KU-2]

[Nucleic acids]

1. All living organisms have nucleic acids to store genetic code.
2. Nitrogen is found in the **nitrogenous base** of a **nucleotide**
3. Needed to form **some hydrogen bonds** for **complementary base paring** with another nucleotide.
4. DNA: contains genetic information needed to synthesise proteins for cells to function
5. mRNA: conveys genetic information from nucleus to the cytoplasm
6. tRNA: carries amino acids to the ribosome for synthesis of polypeptide
7. rRNA: forms part of ribosome, the translation machinery
8. rRNA: peptidyl transferase that catalyses the formation of peptide bond for protein synthesis
9. telomerase RNA: forms part of telomerase, where it is a template for extension of telomere
10. snRNA: part of spliceosome, needed for RNA splicing to produce mature mRNA

[ATP- nucleotide] **[max 5]**

11. All living organisms rely on ATP as its energy source
12. ATP releases **energy** upon hydrolysis/breaking of phosphate bond **/ ATP**
13. For **phosphorylation** of hexose/glucose during glycolysis
14. (a) To convert **glycerate-3-phosphate to 1,3-bisphosphoglycerate** in Calvin cycle
    (b) To **regenerate RuBP** from triose phosphate
15. For **active transport** of substances against concentration gradient
16. Named example: e.g. pump protons from cytosol into lysosomes to maintain acidic pH
17. For movement of vesicles within the cell **along the microtubules**
18. For the extension of pseudopodia during phagocytosis
19. As a substrate for adenyl cyclase to produce the second messenger cyclic AMP (cAMP)

[GTP-nucleotide]

20. (a)The replacement of GDP with GTP activates G protein
    (b) Involved in the translocation of ribosome during translation
    (c) Involved in the formation of triphosphate bridge during the addition of 5' methylguanosine cap.

[proteins]

21. All living organisms rely on proteins to carry out the cellular functions
22. Nitrogen is found in **amino group / some R groups** of amino acid
23. (a) forms **peptide bond** between the adjacent amino acids
    (b) Forms **hydrogen bond** between O of CO and H of NH at the peptide backbone region in **secondary structure**
24. R-groups are involved in **forming bonds** in **stabilizing the tertiary and quaternary structure**
25. Ref to named proteins, in structure vs function
    (a) e.g. collagen → structural support
    (b) Ref to globular enzymes → active sites @ antibody + specific antigen binding sites / Hb + binding sites / GPLR/RTK/ membrane-bound proteins

[Role of Phospholipids containing nitrogen in Choline]

26. All living organisms have cell membranes for compartmentalisation which…
27. …sometimes requires choline which contains nitrogen to form **phospholipids**
28. Membranes are **fluid**, + eg. (for substances to be transported in and out of cell / phagocytosis, etc)

[NADP]

29. Name a specific role of NADP in photosynthesis (e.g. NADP acts as the final electron acceptor in photophosphorylation")

[NAD/FAD]

30. Name a specific role of NAD/FAD in respiration (e.g. NADH donate electrons to ETC in oxidative phosphorylation")

QWC: At least 3 or more groups discussed.

(b) The origin of viruses is a subject of extensive debate within the virology community. One hypothesis, known as the regressive hypothesis, proposes that viruses may have emerged from more complex, free-living organisms that gradually lost genetic information over time as they adopted a parasitic strategy for reproduction.

Outline the features of viruses that support regressive hypothesis **and** explain the role of viruses in evolution in living organisms. [12]
[Cell-KU2, OCPG and Evolution -KU-3]

[Outline the features of viruses that support regressive hypothesis]

1. Viruses contain genetic material / DNA or RNA
2. Viral **genome is small** which only carries a few essential genes
3. Viruses are **obligate intracellular parasites** / rely on the host cell's to reproduce
4. Viruses **do not contain organelles** and cytoplasm **/ do not have cellular organisation**
5. Viruses lack enzymes and **cannot carry out metabolic processes on their own**,
6. **Some viruses** have a **membrane,** obtained from the host cell

[explain the role of viruses in evolution - max 10]

[genetic variation]

7. Viruses can **introduce genetic variations** in hosts which can be passed down to their offspring and hence contribute to evolution in host population.

[prokaryotes]

8. **Bacteriophages** can introduce genetic variation in **prokaryotes** via **generalized/ Specialised transduction**
9. The transducing particle carry bacterial genes from the first host to the 2nd bacteria host…
10. …allowing **homologous recombination**

[eukaryotes]

11. Some viruses can **cause mutations** in the host genome, e.g. EBV virus is associated with Burkitt's lymphoma
12. Retroviruses such as HIV, can **integrate their genetic material** into the host organism's genome, causing **genetic variation** in the hosts

[act as selection pressure]

13. Viruses can act as a **selection pressure**
14. e.g. [eukaryotes] influenza / AIDS / Covid-19 / cancer caused by viruses
15. e.g. [prokaryotes] T4 bacteriophage act as **selection pressure** to bacteria

16. **Individuals with advantages alleles /** resistant to viral diseases are at **selective advantage**, and will be able to **survive** and **reproduce**…

17. to **pass on the advantages alleles** to **fertile and viable** offspring

18. **Bacteria with bacteriophage resistant alleles** are at **selective advantage**, and will be able to **survive** and **reproduce**…

19. to **pass on the bacteriophage resistant alleles** to **viable** new daughter bacteria cells

20. Individuals/bacteria with disadvantages allele are at a selective disadvantage and will be selected against.

21. Overtime, there will be a **change in allele frequencies**, with **increase in the frequency of advantages alleles** in the population.

QUESTION 4

(a) Enzymes play fundamental roles in cells to maintain optimal function and to survive in its environment.

Discuss the importance of enzymes in cells, to life. [13]

[KU-2]

(A) **Enzyme structure and function**

1. Enzyme has a globular structure with an **active site** **complementary** to the shape of **substrate**.
2. Enzyme **lowers the activation energy** to speed up the rate of reaction in cell
3. Rate of enzyme activities is affected by **enzyme concentration, substrate concentration, temperature and pH** of the environment.
4. Enzyme activities are also regulated by end product inhibition / allosteric regulation (including phosphofructokinase and ATP)

Functions of enzymes in cells → 1 mark for process + named enzyme

(B) Enzymes in DNA replication -general

5. DNA helicase, DNA polymerase, RNA primase, DNA ligase, AVP
6. **Impt:** this allows the cells to divide into two genetically identical daughter cells / genetic stability

(C) Enzymes in gene expression -general

7. Transcription – RNA polymerase
8. Post-transcriptional modification – GTP capping enzyme / spliceosome / poly(A)-polymerase
9. Amino acid activation – aminoacyl tRNA synthetase
10. Translation –peptidyl transferase
11. **Impt:** These enzymes allow the cells to produce proteins to carry out cellular processes

(D) Enzymes controlling gene expression

12. At DNA level: e.g. Histone acetyltransferase, histone deacetylase, DNA methyltransferase, etc
13. Post-translational modification – enzymes involved in glycosylation, kinase for phosphorylation.
14. **Impt:** To ensure that different genes are expressed / proteins are produced to meet the changes to the environment

(E) Enzymes controlling cell cycle

15. Regulation of cell cycle– cyclin-dependent kinase
16. Cell division, spindle formation and cytokinesis;
17. **Impt:** prevent uncontrolled cell division

(F) Enzymes in cell signalling

18. Cell signalling – adenylyl cyclase, enzyme cascades, kinases, phosphorylases etc;
19. **Impt:** allows regulation and coordination of cellular activities in signaling pathways

(G) Enzymes in photosynthesis and respiration

20. Role of enzymes in respiration - ATP synthase and phosphorylation, named enzymes in glycolysis and Krebs cycle;
21. **Impt:** Ensures that the cell is able to produce ATP which provides energy for the cellular processes

22. Role of enzymes in photosynthesis – ATP synthase (mark once) / NADP reductase/RUBISCO/ water splitting enzymes
23. **Impt:** allows the cells to harvest light energy to convert into chemical energy

(H) Enzymes in eukaryotes (others)

24. Immunity
    - Somatic recombination – recombinase
    - Enzymes involved in somatic hypermutation and class switching to produce wide range of B-cells
25. **Impt:** Ensures effective immune system to protect the body from infection.

26. Role of enzymes in carbon dioxide and oxygen transport in red blood cells e.g. carbonic anhydrase;
27. Enzymes involved in muscle contraction
28. Intracellular digestion – named enzymes in single celled organisms, cell death, lysosomes (proteases, lipases) etc;
29. Cell wall synthesis - Cellulose synthase
30. AVP;

(I) Enzymes in Prokaryotes

31. Enzymes involved in breaking down metabolites in prokaryotes e.g. b-galactosidase
32. Impt: this helps the bacterial cells to be able to utilize different catabolite for energy

33. Breaks down antibiotics – development of resistance
34. Impt: this helps the bacterial cells to survive under different environment / selection pressure

QWC: At least 3 or more groups discussed. These groups must show linking to importance of these intracellular enzymes to life.

(b) Explain the three modes of natural selection **and** discuss which mode(s) of selection might lead to the formation of new species, including circumstances under which this may take place. [KU-2]

[Three modes of natural selection] [max 6]

- **Accept diagram if it accurately depicts definition**

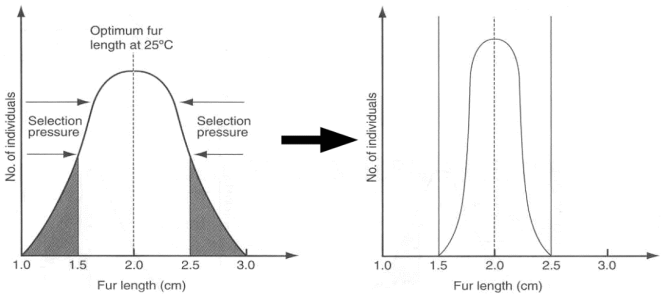
Stabilising Selection [at least 1]

1. Occurs when the **environment remains constant**.

2. Selection pressure selects for the **intermediate phenotype**, while the **extreme phenotypes** are **selected against**.

3. E.g. birth weight in humans. Babies born with very low or very high birth weights are at greater risk of health problems, so the average birth weight remains relatively stable.

4.



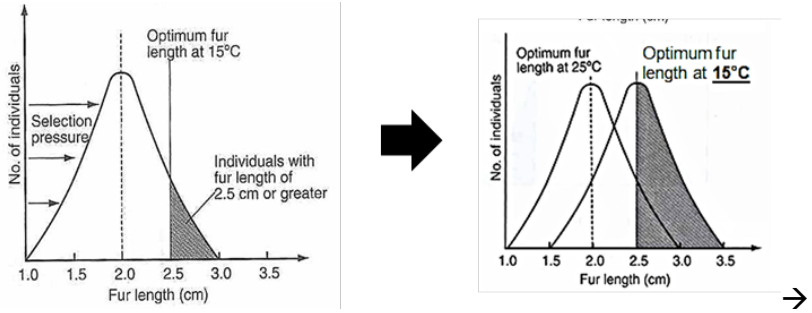
Directional Selection **[at least 1]**

5. There is **gradual changes in environmental conditions**.

6. The selection pressure tends to **select for phenotypes at one extreme** of the range of phenotypes. [reject: select for one extreme phenotype]

7. E.g. evolution of longer necks in giraffes. As trees became taller, giraffes with longer necks were better able to reach the leaves and therefore more likely to survive and reproduce. Over time, the population shifted towards longer-necked individuals.

8.



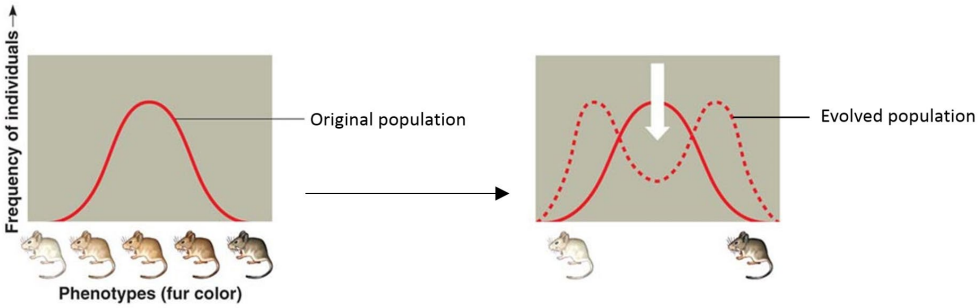
Disruptive Selection **[at least 1]**

9. Selection pressure **selects for phenotypes at both extreme** [reject: select for 2 extreme phenotypes] out of a range of phenotypes.

10. It occurs when **selection pressure is exerted on the middle range** of variation for a particular trait.

11. E.g. dark and light-colored oysters. Both dark-colored oysters and light-colored oysters have camouflage advantages. Light-colored oysters will blend with the rocks and dark-colored oysters can hide under the rock shadow.

12.



[Selection leading to speciation] – at least 1

13. **Disruptive selection** are **most likely** to lead to speciation, …

14. as it involve the change in environment/selection pressure, which select for two extreme populations [mark once]

15. This increases the rate of allele frequency changes and the chance of accumulation of genetic differences.

16. **Both directional and disruptive selection** result in the **change in allele frequencies** of the population.

    Eventually, may lead to speciation if isolation mechanisms are involved:

[Circumstances required to lead to speciation] – at least 1

17. **Geographical isolation**, where populations are separated by physical barrier.
18. **Behavourial isolation** – occurs when two populations are capable of interbreeding but have differences in courtship rituals or other behavourial strategies that prevents mating.
19. **Habitat isolation** – where populations located in the same geographical area but are separated / confined to their habitat/niches.

20. **Physiological isolation** leading to reproductive isolation, where existence of biological factors (barriers) impede members of two population from interbreeding and producing viable, fertile offspring. **[max 2 elaboration]**

    a. **Mechanical isolation** - The incompatibility of the anatomical structure of the reproductive organs prevents the transfer of gametes between species.
    b. **Gametic isolation** – Inability of sperm from one species/population to recognise egg from another species/population.
    c. Reduce hybrid viability /fertility
    d. **Temporal isolation** – where different population have different mating seasons or flowering seasons / may also become **sexually mature at different times** of the year, hence decreasing the possibility of reproduction.

21. These isolation mechanisms **reduces gene flow** between the isolated populations.

22. Overtime, when **sufficient genetic differences / mutations accumulates**, …

23. …and the **separated populations** can **no longer interbreed to produce fertile and viable offspring**, speciation has occurred.

24. **Geographical isolation** separating the populations can lead to **allopatric speciation**,

25. …while **other isolation mechanisms** separating the population can lead to **sympatric speciation.**

26. On the other hand, stabilising selection reduces the genetic variation within the population (as it favours intermediate phenotypes), limiting the rate of natural selection.

😊 END OF PAPER 3 😊