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DUNMAN HIGH SCHOOL

Preliminary Examination

Year 6

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-Response Questions

26 September 2025

2 hours

Candidates answer on the Question Paper and Answer Booklet.

Additional Materials: Answer Booklet

READ THESE INSTRUCTIONS FIRST:

Write your name, centre number, index number and class at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Sections A

Answer **all** questions in the spaces provided on the Question Paper.

Sections B

Answer any **one** free-response question in the Answer Booklet provided.

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

You may lose marks if you do not show your working or if you do not use appropriate units.

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

For Examiner's Use	
Section A / 50	
1	32
2	9
3	9
Section B / 25	
4 / 5	25
Total	75

This document consists of **18** printed pages and **2** blank pages.

Section A: Long Structured Questions

Answer **all** questions.

- 1 Hawaii is located in the central Pacific Ocean, approximately between 19° and 22° North latitude, placing it within the tropics. It experiences a warm tropical climate all year round. This positioning influences its unique ecosystems and diverse flora and fauna, including native species like the Hawaiian honeycreepers.

Epidermal cells of Hawaiian honeycreepers possess the Epidermal Growth Factor Receptor (EGFR), which plays a crucial role in their feather development. Like in other birds, EGFR helps in regenerating damaged tissues and maintaining feather quality, which is essential for their survival and adaptation to environmental changes.

Fig. 1.1 shows EGF binding to EGFR on the surface of a cell. A specific region on each EGFR functions as an enzyme.

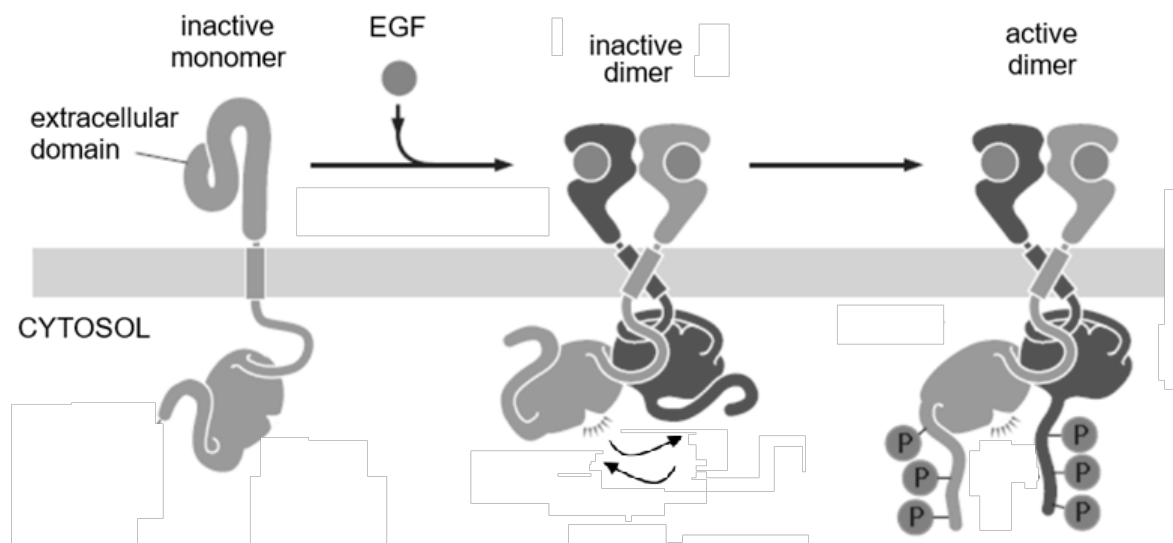


Fig. 1.1

- (a)(i) Name the enzyme found on EGFR and describe the reaction catalysed by the enzyme. Be as precise as possible.

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..... [2]

- (ii) Suggest why having a mutated EGFR can increase the susceptibility of the Hawaiian honeycreepers to infections by pathogens.

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..... [1]

The EGFR and insulin receptor exhibit a high degree of similarities.

(b)(i) Describe the insulin signaling pathway after the insulin receptor is fully activated.

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..... [2]

RAF and RAS are two examples of proteins involved in signal transduction. RAF can be activated by phosphorylation, or by direct interaction with its allosteric site.

RAS protein is known to activate RAF by direct interaction instead of phosphorylation.

(ii) Suggest why RAS does not activate RAF by phosphorylation.

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..... [1]

In some Hawaiian honeycreepers, slower feather regeneration was observed.

Scientists hypothesised that this may be due to reduced *EGFR* expression caused by increased histone deacetylation. To test this, they measured histone acetylation levels and *EGFR* mRNA expression in four populations of honeycreepers exposed to varying levels of feather damage through moulting. Table 1.1 shows the level of histone acetylation in the four populations and Fig. 1.2 shows the mRNA expression in each population.

Table 1.1

population	histone acetylation level / a.u.
A	1.23
B	2.56
C	4.39
D	4.38

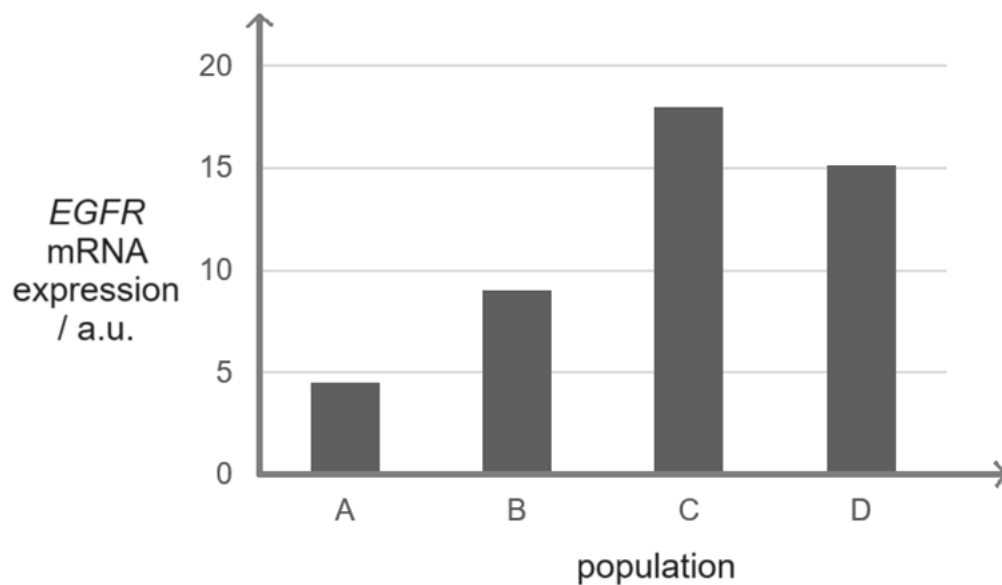


Fig. 1.2

(c)(i) With reference to Table 1.1 and Fig. 1.2, explain how histone acetylation may regulate the expression of the *EGFR* gene in Hawaiian honeycreepers.

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[3]

- (ii) Discuss whether the data in Table 1.1 and Fig. 1.2 fully support the hypothesis that histone deacetylation is responsible for reduced *EGFR* expression in some populations.

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..... [3]

The *FEGF1* gene, located downstream of *EGFR*, contains non-coding sequences believed to regulate *EGFR* gene expression in Hawaiian honeycreepers.

Fig. 1.3 shows the schematic representation of the *FEGF1* gene. In a recent study, scientists found that some birds with rapid feather regrowth had mutations in intron 2 of *FEGF1*, allowing regulatory proteins to bind. These regulatory proteins control the transcription of the *EGFR* gene.

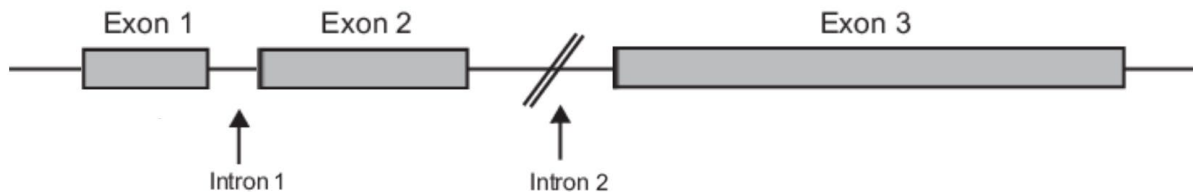


Fig. 1.3

- (d) Suggest how mutations to intron 2 of the *FEGF1* gene could result in faster feather regrowth.

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..... [4]

In the forests of Hawaii, climate change has led to warmer temperatures and increased rainfall, which in turn has expanded the range of *Plasmodium relictum*, a parasitic protozoan that causes avian malaria.

Avian malaria is a mosquito-borne disease of birds. The local Hawaiian honeycreeper birds, especially the liwi and Apapane, are particularly susceptible to this pathogen due to their long-term isolation and lack of prior exposure to such diseases. This outbreak of avian malaria exhibits symptoms such as anemia, respiratory distress, and organ failure in the honeycreeper population.

Table 1.2 shows the mean rate of oxygen consumption per gram of body mass in Hawaiian honeycreepers infected and uninfected with *P. relictum*, measured over a 12-hour period at a constant ambient temperature of 27 °C.

Table 1.2

Time (h)	Mean rate of oxygen consumption / a.u.	
	Uninfected Hawaiian honeycreepers	Infected Hawaiian honeycreepers
0	33.27	23.13
4	33.48	22.92
8	33.65	22.71
12	33.70	22.63

- (e) Using Table 1.2, explain how infection with *P. relictum* may affect the metabolism of Hawaiian honeycreepers.

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..... [3]

The immune system of Hawaiian honeycreepers responds to *P. relictum* by identifying the parasite as non-self antigens.

Fig. 1.4 is a diagram of a protein in the cell surface membrane of a macrophage from the Hawaiian honeycreepers. Macrophages use these proteins in antigen presentation. Non-self antigens bind to these proteins and are involved in the activation of specific T lymphocytes during the immune response.

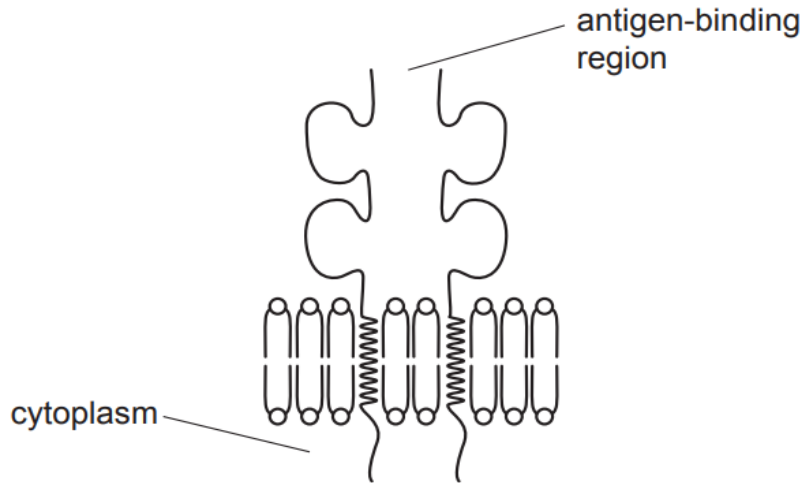


Fig. 1.4

(f)(i) Explain what is meant by a non-self antigen.

..... [1]

Macrophages partially digest these pathogens and present antigens to T lymphocytes during immune responses.

(ii) With reference to Fig. 1.4, explain how a specific immune response against these pathogens is possible.

..... [4]

Hawaiian honeycreepers do not occur naturally in other parts of the world. Although at least 56 species of Hawaiian honeycreepers have been documented, only 18 of them survive today with the most recent extinction occurring in 2004.

Fig. 1.5 shows the phylogenetic tree of the Hawaiian honeycreeper species, including the Hawaii Creeper, that was constructed based on their mitochondrial genomes. The four grey vertical bars indicate the times when the four Hawaiian Islands were formed.

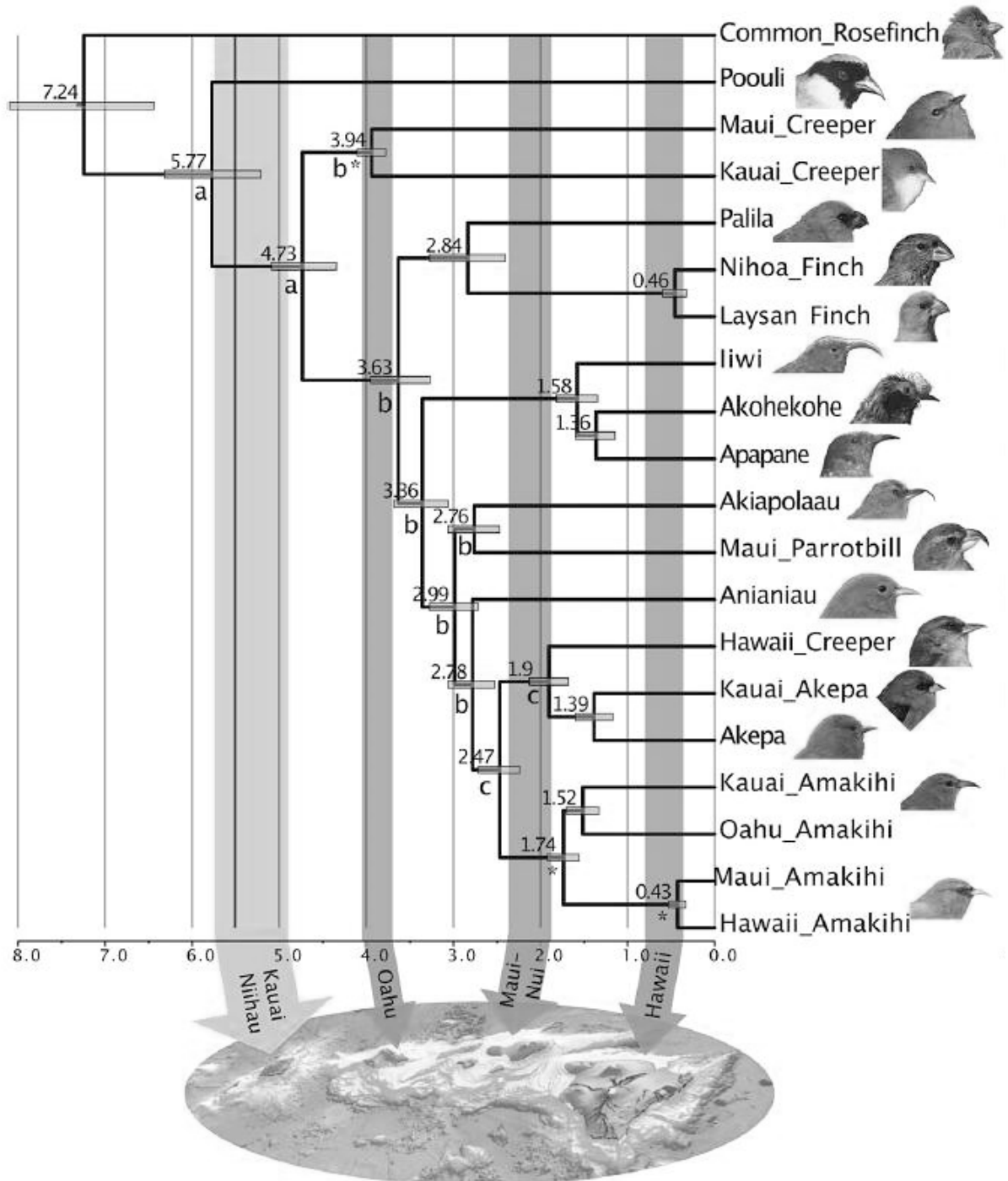


Fig. 1.5

- (g)(i)** The Hawaii Creeper, while endemic to Hawaii, did not originate there. With reference to Fig. 1.5, explain how the Hawaii Creeper appears in Hawaii.

[3]

A spectrogram shows the frequencies that make up a sound and how they change over time. The courtship songs of four Hawaiian honeycreeper species were recorded.

Fig. 1.6 shows the spectrograms of common rosefinch, palila, poouli and akepa. The song consists of an opening whistle, followed by a buzz, the complex syllables and then the simple trill.

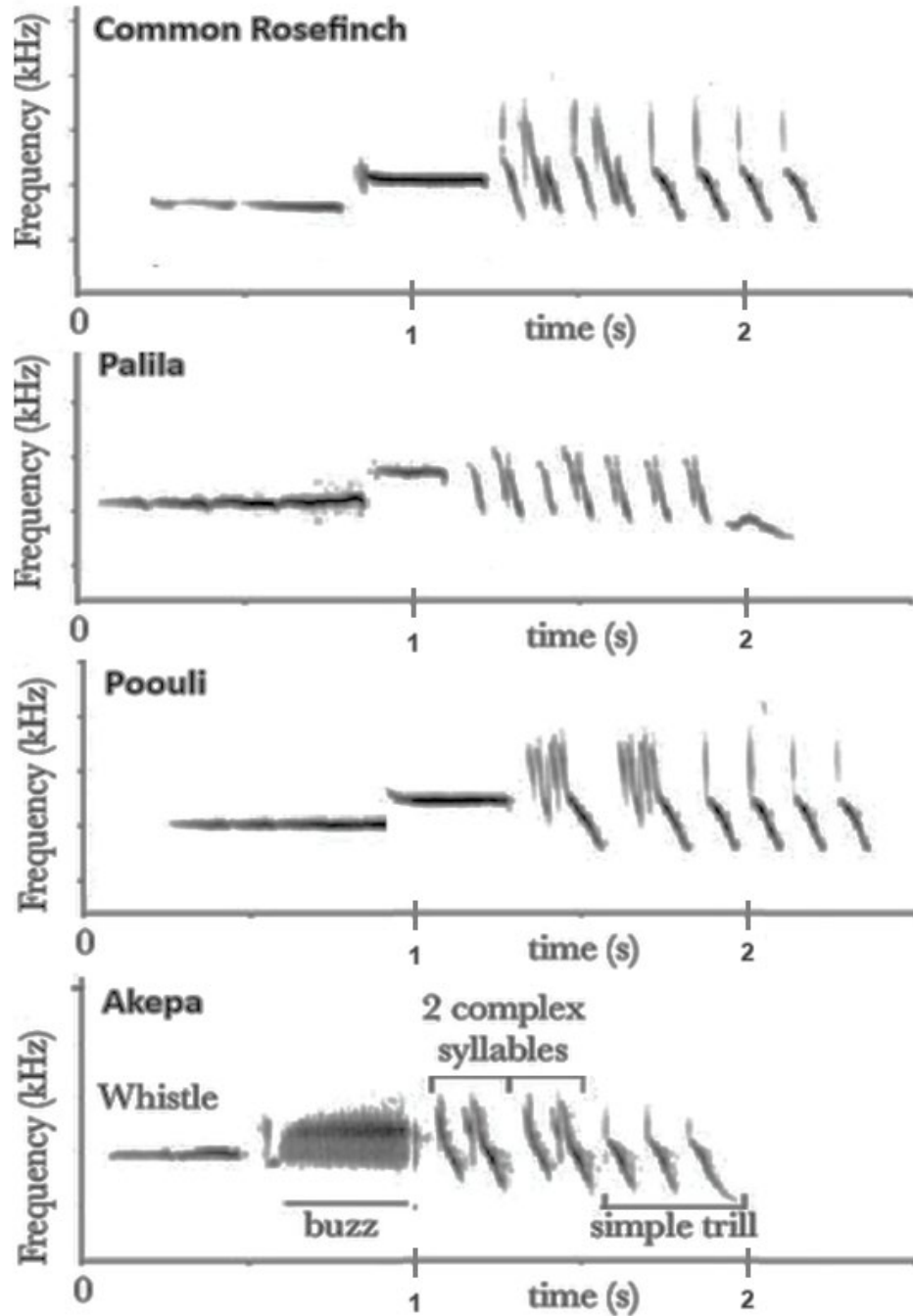


Fig. 1.6

- (ii) With reference to Fig. 1.6, explain which species of Hawaiian honeycreeper has the most similar courtship song as the common rosefinch.

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..... [2]

Avian malaria has devastating effects on the Hawaiian honeycreepers, leading to high mortality rates and threatening their survival. As these native bird populations decline, biodiversity in Hawaii suffers.

- (h)(i) Name two Hawaiian honeycreeper species that are more susceptible to avian malaria.

..... [1]

- (ii) Explain how global warming can increase the prevalence of avian malaria.

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..... [2]

Total: [32]

- 2 A study was carried out to determine the factors that affect the replication of influenza virus. In a single-cell analysis, one viral-infected cell was transferred to each well on a 384-well plate as shown in Fig. 2.1. As the virus replicates in the cell, the viral particles are released from the cell into the well.

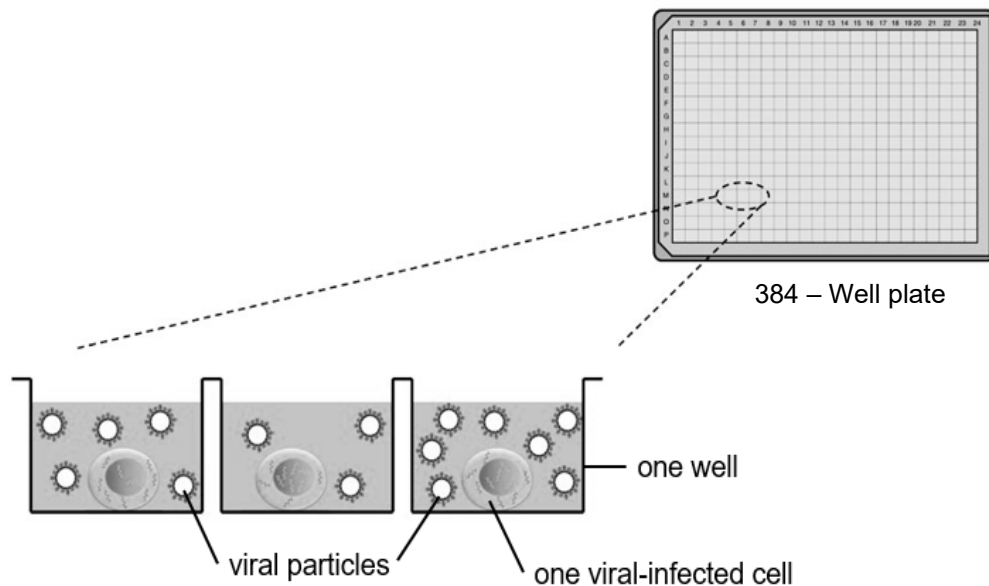


Fig. 2.1

To ensure that the cells placed in the wells are all infected by the influenza virus, the scientists also measured the infection of the cell and the state of the cell after exposure to the virus.

Fig. 2.2 shows the proportion of cells infected and the proportion of cells undergoing apoptosis on the plate.

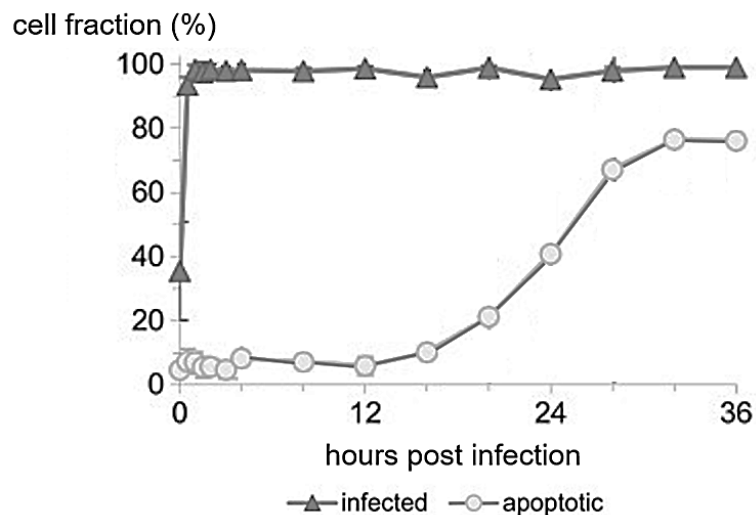


Fig. 2.2

The virus yield per cell, which is the number of infectious viral particles released from each cell, was determined. The diameter of each infected cell was also measured. The results are shown in Fig. 2.3 and Fig. 2.4. The first bar on the left of the histogram in Fig. 2.3 indicates the fraction of cells that shows no release of viruses.

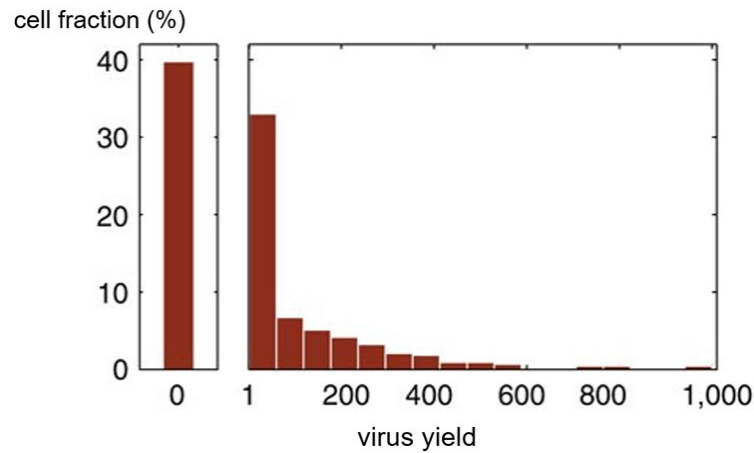


Fig. 2.3

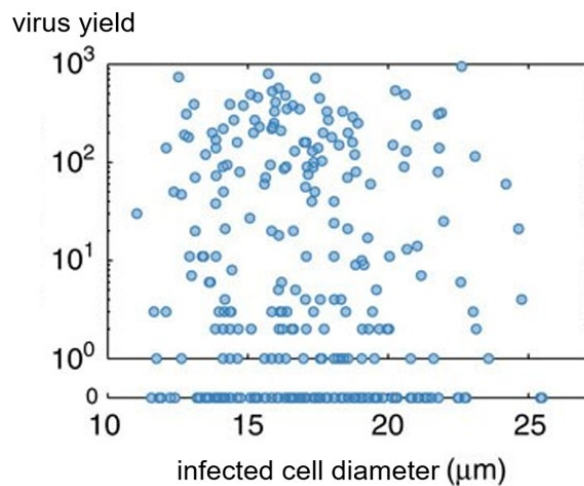


Fig. 2.4

- (a) With reference to Fig. 2.4, comment on the relationship between the diameter of the viral-infected cell and the virus yield.

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..... [2]

- (b) Given the formula of the surface area of a sphere is $4\pi r^2$, calculate the area of the cell surface membrane of a viral-infected cell with a diameter of 15 μm .

Show your workings and present your answer in nm^2 .

[2]

- (c) The diameter of each virus is 120 nm. Calculate the virus yield per cell. Show your workings and present your answer in 2 s.f..

[2]

- (d) The observed maximum number of viral particles released from each viral-infected cell as shown in Fig. 2.3 and Fig. 2.4, differs from the maximum possible number of viral particles released as shown from calculations in (c).

With reference to all the information provided, suggest a reason for this difference.

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..... [3]

Total: [9]

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- 3 A diagram of a chromosome from a dividing cell is shown in Fig. 3.1.



Fig. 3.1

- (a)(i) On Fig. 3.1, add a label line and the letter **G** to show the location on the chromosome of an area that helps to prevent the loss of genes. [1]

- (ii) State **one** other function of this region of the chromosome.

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..... [1]

- (iii) Compare the structures of telomeres and centromeres.

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..... [2]

- (b) Telomere length is maintained in most eukaryotic cells by telomerase. The core components of this ribonucleoprotein enzyme include a protein catalytic subunit (TERT), and an RNA subunit as shown in Fig. 3.2. The RNA subunit contains a short template sequence essential for the synthesis of telomeric repeats.

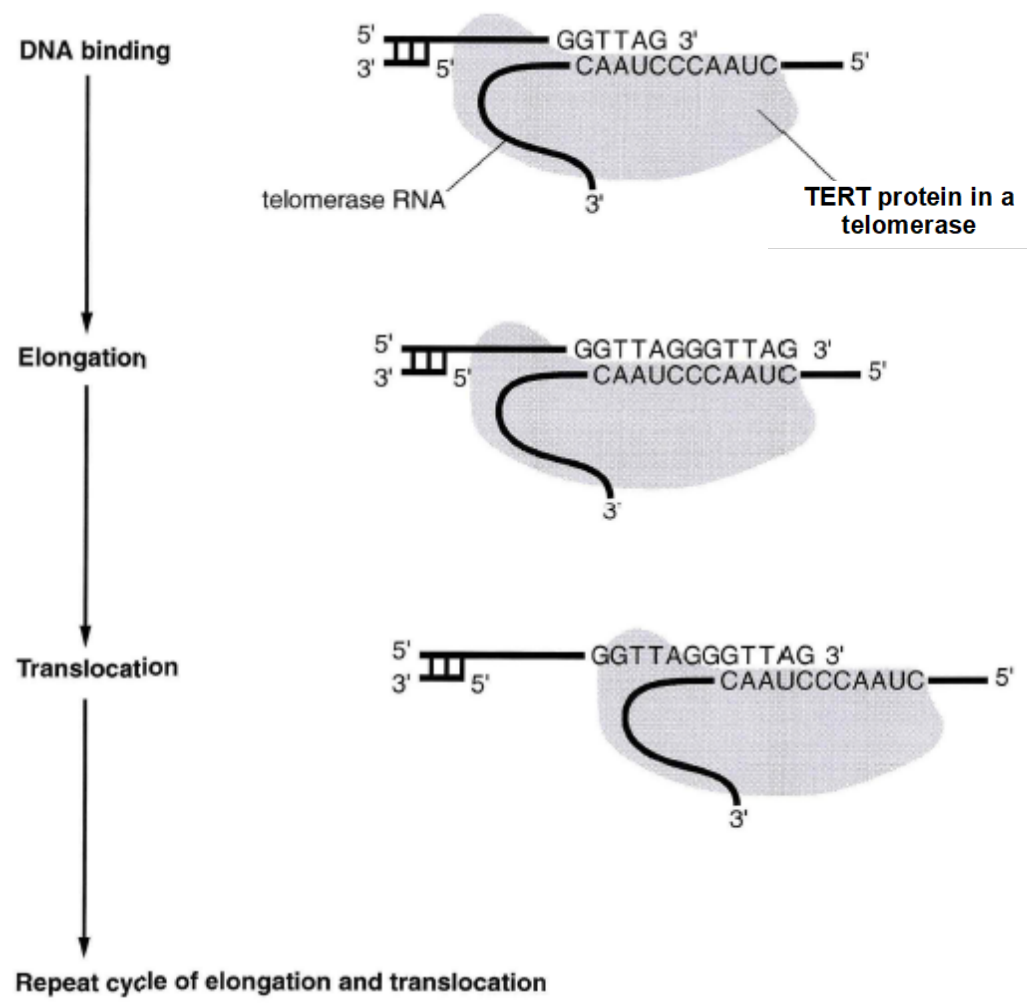


Fig. 3.2

With reference to Fig. 3.2, explain the role of the TERT protein and RNA subunit in telomerase involved in the lengthening of telomeres.

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[3]

- (c) Telomerase activity is observed to be high in embryonic stem cells but not in adult stem cells. Cancer cells are also known to exhibit high levels of telomerase activity.

The high levels of telomerase activity in cancer cells could be due to mutations which involve the *TERT* locus where the *TERT* gene is located, as shown in Fig. 3.3 and Fig. 3.4.

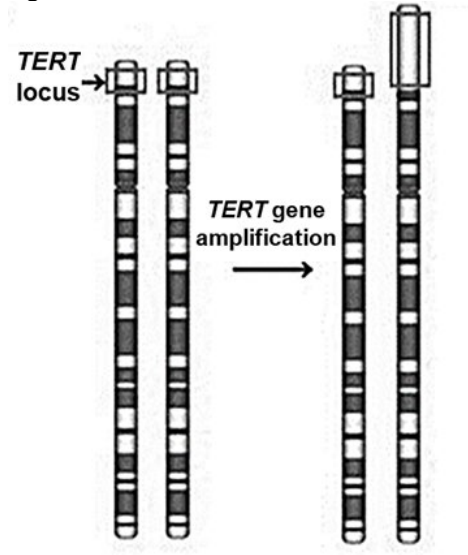


Fig. 3.3

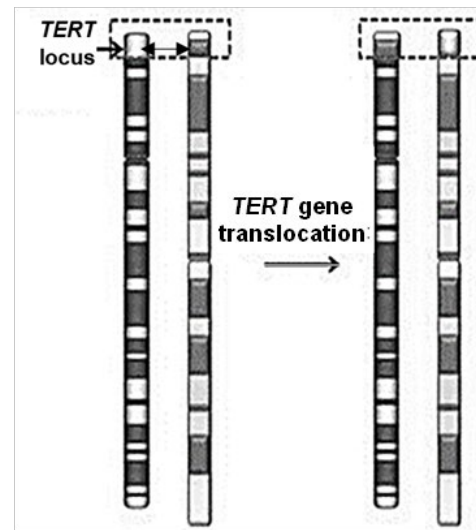


Fig. 3.4

Suggest how the mutations that involve the *TERT* locus shown in the Fig. 3.3 and Fig. 3.4 could result in the high levels of telomerase activity in cancer cells.

Fig. 3.3

..... [1]

Fig. 3.4

..... [1]

Total: [9]

Section B: Free-Response Questions

Answer **one** question.

Write your answers in the Answer Booklet provided.

Your answers should be illustrated by large, clearly labelled diagrams, wherever appropriate.

Your answer must be in continuous prose, where appropriate.

A **NIL RETURN** is required.

- 4 (a) Describe the action of glucagon on liver cells in the regulation of blood glucose concentration. [10]
- (b) Cycles play important roles in both natural and man-made biological processes. Explain the significance of cycles in biology. [15]
- 5 (a) Discuss whether all living organisms on Earth depend on phosphate. [10]
- (b) With reference to examples relevant to prokaryotes, eukaryotes and viruses, outline different ways in which molecules can enter cells. [15]

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Paper 2 Suggested Answers

- 1 (a)(i) **Tyrosine kinase**;
Tyrosine kinase **adds a phosphate group from an ATP molecule to the own / other receptor at the tyrosine residues on their intracellular tail via auto/crossphosphorylation.**;
- (a)(ii) Mutated EGFR **affects the feather development** of the honeycreepers, **weakening their first line of defense.**
- (b)(i) 1. **Insulin receptor substrate (IRS) binds to the receptor, allowing phosphorylation of tyrosine residues on IRS, activating it.**;
2. Activated IRS thereby **increases the expression of GLUT4 / increases the transportation of GLUT4** from Golgi apparatus for **insertion** into the cell surface membrane.;
3. **Increasing rate of glycolysis / glycogenesis OR decreasing rate of gluconeogenesis / glycogenolysis.**;
- Max 2
- (b)(ii) RAS protein is **not a protein kinase / is unable to catalyse phosphorylation.**;
- R! RAS does not bind complementarily to RAF (Note: RAS can activate RAF by direct interaction).
- (c)(i) 1. As **histone acetylation increases from 1.23 a.u. in A to 4.39 a.u. in C**, the **EGFR mRNA expression increases from 4.5 a.u. to 18 a.u.**;
2. **Acetylation of histone tails neutralises the positive charge on lysine residues**, reducing histone-DNA interaction and allowing for a **more open / looser conformation of chromatin / euchromatin.**;
3. This allows **easier access for RNA polymerase and general transcription factors** to bind to the promoter to form the **transcription initiation complex, increasing transcription** of EGFR.;
- (c)(ii) 1. **Yes**, the general trend supports the hypothesis that **lower acetylation correlates with lower EGFR expression** (Note: data quoted in (c)(ii) hence not required).;
2. But **not fully**, as **populations C and D have similar acetylation levels at 4.39 a.u. and 4.38 a.u. respectively**, but they have relatively **different EGFR mRNA expression at 18 a.u. and 15 a.u.**;
3. This suggests that **additional regulatory mechanisms**, e.g. transcriptional / post-transcriptional / translational / post-translational level are involved.;
- (d) 1. Mutation results in **intron 2 acting as enhancers.**;
2. This allows **activator proteins to bind to the enhancer, bending DNA.**;
3. DNA bending brings the **bound activators closer to the promoter of EGFR**, thereby recruiting **RNA polymerase and general transcription factors** to form.
4. This **increases the rate of formation of transcription initiation complex, and rate of transcription of EGFR**, leading to faster feather regrowth;

- (e)
1. Infected Hawaiian honeycreepers show a **consistently lower oxygen consumption** than uninfected ones + **quote any 1 data.**;
 2. This suggests a **reduced rate of aerobic respiration / oxidative phosphorylation.**;
 3. Thereby leading to **less ATP production.**;
- (f)(i) **Foreign + protein that stimulates an immune response / production of antibodies / activation of lymphocytes;**
(A! glycoprotein / polysaccharide / molecule / foreign antigen)
- (f)(ii)
1. CD4 T cells have **specific T cell receptors** that recognise and bind to the **complementary to the antigen presented on antigen-binding region** (following Fig. 1.2, otherwise known as MHC class II complex) **on macrophage**;
 2. Upon binding, the **CD4 T cells gets activated** to undergo **clonal expansion**, and **differentiates** to form **helper T cells.**;
 3. Helper T cells **secrete cytokines** to **activate B cells** to undergo **clonal expansion** and **differentiate into plasma cells and memory B cells.**;
 4. Helper T cells **secrete cytokines** to **activate CD8 T cells** to undergo clonal expansion and **differentiate into cytotoxic T cells and memory T cells.**;
 5. **Cytotoxic T cells** bind to infected cells and destroy / kill them by **releasing perforin, granzymes and granulysin.**;
 6. The production of **memory T cells** that **quickly divide by mitosis, proliferate and undergo differentiation** to develop into **large numbers of T cells** upon **re-exposure** to the same antigen ;
 7. The production of **memory B cells** that **quickly divide by mitosis, proliferate and undergo differentiation** to develop into **large numbers of plasma cells** upon **re-exposure** to the same antigen ;

Max 4

- (g)(i)
1. **Founder effect.**;
 2. It **emerged in Maui-Nui** and when Hawaii was formed later, it **colonised Hawaii**;
 3. This may be due to honeycreepers having **reduced competition** for resources / **better resources / environment** available in Hawaii / chance events;

- (g)(ii) **Poouli.**;

Same duration of whistle and buzz, both are **1s** long.;

OR

The number of complex syllables / simple trills are similar.;

- (h)(i) **liwi and Apapane.**;

- (h)(ii) Global warming leads to **higher temperatures** and thus **higher rate of development / shorter life-cycles / higher metabolic rate of mosquitoes.**;

OR

Global warming can also lead to **increase in rainfall**, increasing **stagnant pools of water** available for mosquitoes to **lay eggs** / for eggs to hatch.;

The **increase in number of vectors** will **increase the spread of *P. relictum***, and thus the prevalence of avian malaria.;

- 2 (a) There is **no correlation** between the cell diameter and the number of infectious viral particles per cell ;
The number of infectious viral particles **can range from 0 per cell, to about 1000 per cell regardless of the cell diameter from 12 to 25.5µm** ;
- (b) Conversion of units: $15\text{ }\mu\text{m} = 15\,000\text{ nm}$
Radius = $15000\text{ nm} / 2 = 7500\text{nm}$;
- Area = $4\pi r^2 = 4\pi (7500)(7500) = 706858347\text{ nm}^2 = 710000000\text{ nm}^2$ (2 s.f.) ;
- (c) Area of viral envelope = $4\pi r^2 = 4\pi (60)(60) = 45239\text{ nm}^2$;
- $706858347\text{ nm}^2 / 45239\text{ nm}^2 = 15624 = 16000$ (2 s.f.) ;
- (To consider ECF from (b))
- (d) [Data] Fig 2.3a / Fig 2.3b shows a maximum actual number of 1000 / slightly less than 1000 (for 15 µm cell diameter) infectious viral particles per cell, much smaller than the maximum possible number calculated in (c) ;
- [Reason] The viral infected cell **underwent apoptosis before** all the viral particles can fully assemble / yielding more viral particles ;
- [Data of reason] From Fig. 2.2, the graph shows that from 12 hours to 32 hours post infection, the fraction of the cells which are apoptotic increases from 5% to 75% ;
-

- 3 (a)(i) Draw a label line, must be pointing to one correct region ;



- (a)(ii) Telomeres protect and stabilize the terminal ends of the chromosomes from exonuclease attack / Telomeres prevent fusion of the ends of linear chromosomes ;

Length of telomeres determines life span of cells / Regulate replicative cell senescence – if telomere shortened to critical length, will lead to apoptosis ;

In cells where telomerase enzyme is present - telomeres provides the recognition site for telomerase to recognise and bind to lengthen DNA / provide RNA template for telomerase activity ;

Max 1

- (a)(iii) Similarities Max 1

- S1. Both are made up of repeating sequences/ **repetitive DNA** ;
- S2. Both are made up of non-coding sequences/ are **non-coding** ;
- S3. Both are **associated with proteins** ;

Differences Max 1

- D1. Telomere is found at the **ends of linear chromosomes** while centromeres are found at **a point along the chromosomes / not at the ends** of chromosomes ;
- D2. Telomeres has a **recognition site for telomerase** to bind while centromere **does not have such a recognition site** ;
- D3. Centromeres contain **binding site for kinetochore** proteins to bind while telomeres contain **binding sites for telomere binding proteins** ;
- D4. Telomeres occur **in two regions** on a chromosome while centromere occurs at **only one region** on a chromosome ;
- D5. Telomeres has a single-stranded overhang while centromere is completely double-stranded ;

- (b) Role as enzyme

TERT active site is **complementary in shape to a telomeric DNA sequence** ;

Telomerase catalyse formation of **phosphodiester bond between deoxyribonucleotides** added to the 3' end of the telomere ;

Telomerase **moves** telomere / DNA template from **5' to 3'** and synthesize another repeat, **elongating the telomere** ;

Role as RNA template

RNA subunit in telomerase has **RNA sequence CAAUC** which is **complementary to telomeric DNA sequence GTTAG** ;

RNA subunit acts as a **template to extend the 3' end of the telomere DNA** ;

Max 3, at least 1pt from each section

- (c) [Fig. 3.3] Gene amplification resulting in **more copies of the TERT gene**, therefore the **expression of more TERT proteins** and **increased telomerase activity** ;

[Fig. 3.4] Translocation resulting in the TERT gene under the control of a **strong promotor, increasing the expression of TERT gene** / production of more TERT proteins and **increasing telomerase activity** ;

Q4(a) Describe the action of glucagon on liver cells in the regulation of blood glucose concentration. [10]

1. glucagon **binds to G-protein linked receptors** in cell surface membrane (of liver cell) ;
2. binding of glucagon **causes a change in the shape** / conformation, of the receptor ;
3. conformational change in the receptor **activates an associated G-protein** by causing the **exchange of GDP for GTP** on the alpha subunit, which then dissociates and activates downstream signaling pathways.
4. **activated G-protein** / G α subunit) **binds to and activates** the enzyme **adenylyl cyclase**, which is also embedded in the liver cell membrane.
5. Adenylyl cyclase **catalyzes the conversion of ATP into cAMP**, a small intracellular signaling molecule.
6. (cAMP is) **second messenger** ;
7. (cAMP) **activates protein kinase A (PKA)**;
8. activation of PKA **sets off** a chain reaction of enzyme activations / a **phosphorylation cascade**) ;
9. where each step **amplifies the original signal** from glucagon.;
10. One of the key enzymes **activated by PKA is phosphorylase kinase**, ;
11. which in turn **activates glycogen phosphorylase**. ;
12. Glycogen phosphorylase is responsible for **catalyzing the breakdown of glycogen into glucose-1-phosphate** ;
13. Glucose produced in the liver **exits** the hepatocyte by **facilitated diffusion**, contributing to an **increase in blood glucose concentration**. ;
14. transport of glucose out of the liver cell is mediated by **GLUT2 transporters**, which allow passive movement of glucose down its concentration gradient into the bloods ;
15. ref. to glucagon can also **stimulate gluconeogenesis** ;

QWC: 2 points each from (pt1-pt11) and (pt12-pt15)

Q4(b) Cycles play important roles in both natural and man-made biological processes. Explain the significance of cycles in biology. [15]

A. Cell Cycle (Max 5)

[Overview and Phases]

1. The cell cycle is a sequence of events from the formation of a **cell to its division into daughter cells**, which then repeat the cycle ;
2. It includes **interphase**, **nuclear division (mitosis/meiosis)**, and **cytokinesis** ;

[Processes and Significance]

3. During **interphase**, the cell grows, synthesises proteins and organelles, and replicates its DNA (S phase), preparing for division.
4. **Mitosis** ensures production of genetically identical daughter cells — essential for growth, repair, and asexual reproduction.
5. **Meiosis**, on the other hand, produces haploid gametes necessary for sexual reproduction.
6. In **cytokinesis**, cytoplasmic contents are divided between the two daughter cells.
7. **Significance**: After fertilisation, the diploid zygote undergoes mitosis, ensuring all body cells carry the same genetic material for development.

B. Krebs Cycle

[Process and Cyclical Nature]

8. Begins when **acetyl-CoA** (from pyruvate via the link reaction) combines with **oxaloacetate (4C)** to form **citrate (6C)** ;
9. Through a series of **oxidative decarboxylation and dehydrogenation** reactions, citrate is **converted back to oxaloacetate**, completing the cycle ;

Products and Significance:

10. In each turn: produces **1 ATP (via substrate-level phosphorylation)**, **3 NADH**, **1 FADH₂**, and **2 CO₂**.
11. **Significance**: NADH and FADH₂ carry electrons to the **electron transport chain (ETC)**, where the bulk of ATP is generated — vital for cellular energy.

C. Calvin Cycle

[Phases and Reactions]

12. **Carbon Fixation**: CO₂ combines with **RuBP** to form an unstable 6C compound, splitting into two molecules of **3-phosphoglycerate (GP) (3C)** ;
13. **Reduction**: GP is reduced to **glyceraldehyde-3-phosphate (G3P)** using **NADPH** and **ATP** from the light-dependent reactions ;
14. **Regeneration**: Some G3P is used to regenerate **RuBP**, enabling the cycle to continue ;

[Significance]

15. For every 3 CO₂, 1 G3P exits to eventually form **glucose**, which can be used to synthesise **starch**, **cellulose**, or for respiration ;
16. The cycle **regenerates NADP⁺**, maintaining the balance needed for light-dependent reactions.

D. Electron Transport Chain & Cyclic Photophosphorylation**[Process]**

17. In **cyclic photophosphorylation**, a photo-excited **electron** from **P700 (Photosystem I)** travels down the **ETC** and **returns** to P700, forming a cycle ;
18. Energy from the ETC is used to pump protons and synthesise **ATP via chemiosmosis** ;

[Significance]

19. Only **ATP** is produced (no NADPH or O₂), making it useful when ATP demand is high but NADPH is not needed ;

E. Polymerase Chain Reaction (PCR)**[Cycle Stages]**

20. **Each cycle consists of denaturation, annealing, and elongation** ;

[Cyclical Amplification and Significance]

21. Each cycle **doubles** the number of DNA molecules ;
22. After **n cycles**, **2ⁿ** copies are produced ;

Significance:

23. Enables rapid **amplification** of specific DNA sequences — essential in diagnostics, forensic science, and genetic research ;

QWC: 1 point from section E + 3 other sections

Q5(a) Discuss whether all living organisms on Earth depend on phosphate [10].

[Cell Membrane]

1. Cells of all living organisms have **cell membrane**.;
2. All cells need phosphate for synthesis of **phospholipids**.;
3. Which helps to **regulate molecules** entering / leaving cells or organelles
4. This contributes to **fluidity of membranes**, allowing for processes such as phagocytosis

[Nucleic Acids]

5. Genetic code relies on **nucleic acids**.;
6. Backbone of nucleic acids is a **sugar-phosphate backbone**.;
7. Therefore, without nucleic acids, there will be **no storage of information**.;

[Energy Storage]

8. Most energy are stored in the bonds of ATP.;
9. ATP is more energy-rich than ADP.;

[Cell Signalling]

10. Phosphates are involved in cellular signaling and regulation.;
11. Can activate / inactivate many enzymes.;

QWC: At least 1 points from any 3 sections.

Q5(b) With reference to examples relevant to prokaryotes, eukaryotes and viruses, outline different ways in which molecules can enter cells [15].

[Simple Diffusion]

1. **Small, non-polar** molecules can enter cells through **simple diffusion, down a concentration gradient.**;
2. Ref to any relevant example. (E.g. O₂ and CO₂ diffusing across the phospholipid bilayers of prokaryotic / eukaryotic cells).;

[Facilitated Diffusion]

3. **Polar / charged** molecules can enter cells through **facilitated diffusion, through protein channels / carriers, down a concentration gradient.**;
4. Ref to any relevant example. (E.g. Glucose entering eukaryotic cells via GLUT transporters).;

[Osmosis]

5. **Water molecules** can enter cells through **osmosis, down a water potential gradient.**;
6. Ref to any relevant example. (E.g. water molecules moving into root hair cells in plants).;

[Active Transport]

7. Molecules can enter cells via **active transport, against a concentration gradient, with the use of ATP / proton motive force.**;
8. Ref to any relevant example. (E.g. Electron carriers serving as proton pumps during respiration in eukaryotic mitochondria or in prokaryotic cell membrane / during photosynthesis in eukaryotic plant cells).;

[Bulk Transport - Endocytosis]

9. Substances can be **engulfed** into the cells, through **endocytosis via membrane invagination**, such as phagocytosis, pinocytosis, receptor-mediated endocytosis.; (R! exocytosis as the question is focused on entry of substances into the cells)
10. Ref to any relevant example. (E.g. uptake of extracellular fluids and solutes by animal cells).;

[Viral-entry Mechanisms]

11. Some viruses enter host cells by **directly fusing** with the host's cell membrane.
12. Ref to any example. (E.g. HIV fuses with the membrane of CD4 T cells to release viral components into the cell).;
13. Some viruses enter the host cells through **receptor-mediated endocytosis.**;
14. Ref to any relevant example. (E.g. entry of influenza virus by receptor-mediated endocytosis / uptake of extracellular fluids and solutes by animal cells).;
15. Certain viruses can **inject their genetic material** into host cells without entering the cell themselves.;
16. Ref to any relevant example. (E.g. a bacteriophage attaches to the surface of a bacterial cell and injects its DNA through the bacterial cell wall and membrane).;

QWC: At least 1 point + example each, for eukaryotes and viruses.