H

RAFFLES INSTITUTION

2024 Year 6 Preliminary Examination
Higher 2

CANDIDATE NAME

CIVICS GROUP | 2 | 4 | S | 0 | 3 |

INDEX NUMBER

BIOLOGY

9744/02

Paper 2 Structured Questions

18th September 2024

2 hours

Candidates answer on Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number, CT group & name in the spaces at the top of this page.
Write in a dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 9
2	/ 10
3	/ 10
4	/ 10
5	/ 10
6	/ 11
7	/ 10
8	/ 10
9	/ 10
10	/ 5
11	/ 5
Total	/ 100

This document consists of **25** printed pages.

Raffles Institution
Internal Examination

[Turn over

For Examiner's Use

Section A

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

1 Fig. 1.1 shows the structure of pancreatic ribonuclease (RNase A) which hydrolyses RNA.

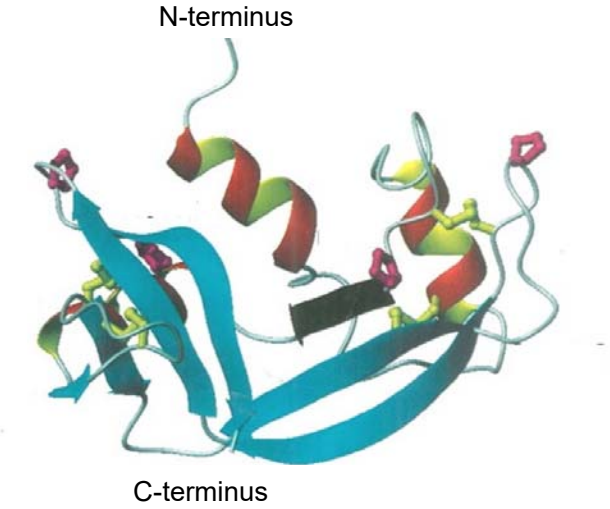

Fig. 1.1

(a) **(i)** Describe two features of RNase A that make it a globular protein.

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(ii) With reference to Fig. 1.1, describe two structural differences between RNase A and haemoglobin.

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…… [2]

For Examiner's Use

(b) Christian Anfinsen performed pioneering experiments on the folding of RNase A.

He found that RNase A is most stable between pH 2.0 and pH 4.5 at 100^0C.

Fig. 1.2 shows the changes in the protein structure when he added urea and mercaptoethanol to RNase A. The numbers represent the various positions of a particular amino acid in the protein.

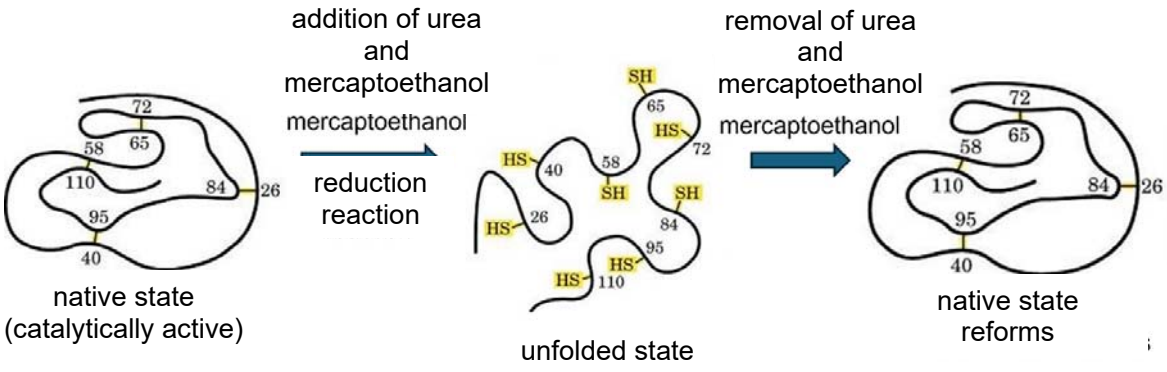

Fig. 1.2

(i) With reference to Fig. 1.2, explain why RNase A can withstand temperatures of up to 100^0C, but is only stable between pH 2.0 and pH 4.5.

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(ii) Renaturation does not commonly occur.

Suggest why RNase A is able to reform to its native state in this experiment.

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[Total:9]

2 Pancreatic cells were cultivated in a medium rich in radioactive amino acids and the locations of assimilated radioactive amino acids over time was ascertained using autoradiography.

When autoradiography was carried out, radioactive amino acids were detected as "autoradiographic grains".

Fig. 2.1 shows the changes in the percentage of autoradiographic grains in different regions of the cell as time elapsed.

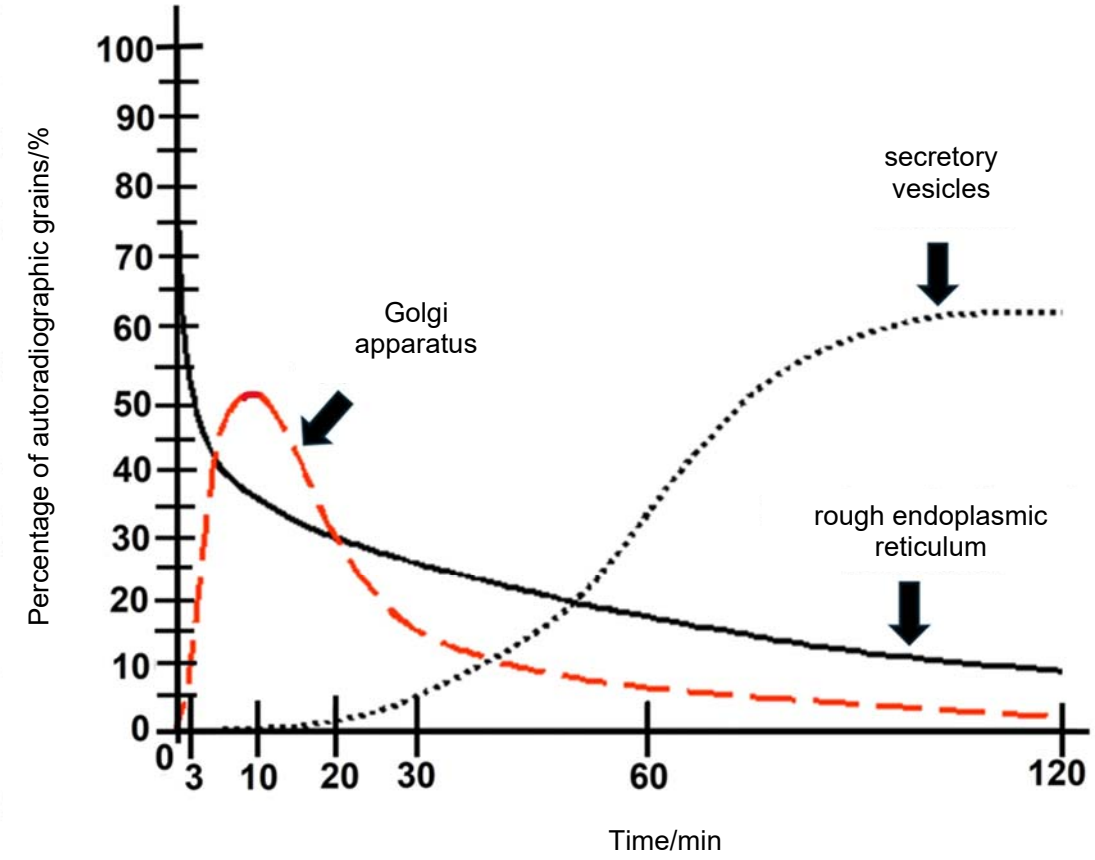

Fig. 2.1

(a) **(i)** With reference to Fig. 2.1, explain the changes in the first 10 min,

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…… [3]

(ii) With reference to Fig. 2.1, explain the changes in the Golgi apparatus and secretory vesicles from the 10th to 60th min.

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(b) Not all the proteins synthesised at the rough endoplasmic reticulum are secreted out of the cell.

Suggest two potential fates of these proteins.

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…… [2]

(c) Explain why pancreatic cells often have a lot of mitochondria.

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……[3]

[Total: 10]

For Examiner's Use

3 Cystic fibrosis (CF) is a disorder caused by a mutation in the cystic fibrosis transmembrane conductance regulator (*CFTR*) gene. The mutation affects the production of the CFTR protein responsible for regulating the flow of chloride ions (Cl^-) and bicarbonate out of cells, as shown in Fig. 3.1. Individuals with CF experience thick, sticky mucus buildup in various organs, leading to respiratory, digestive, and other health issues.

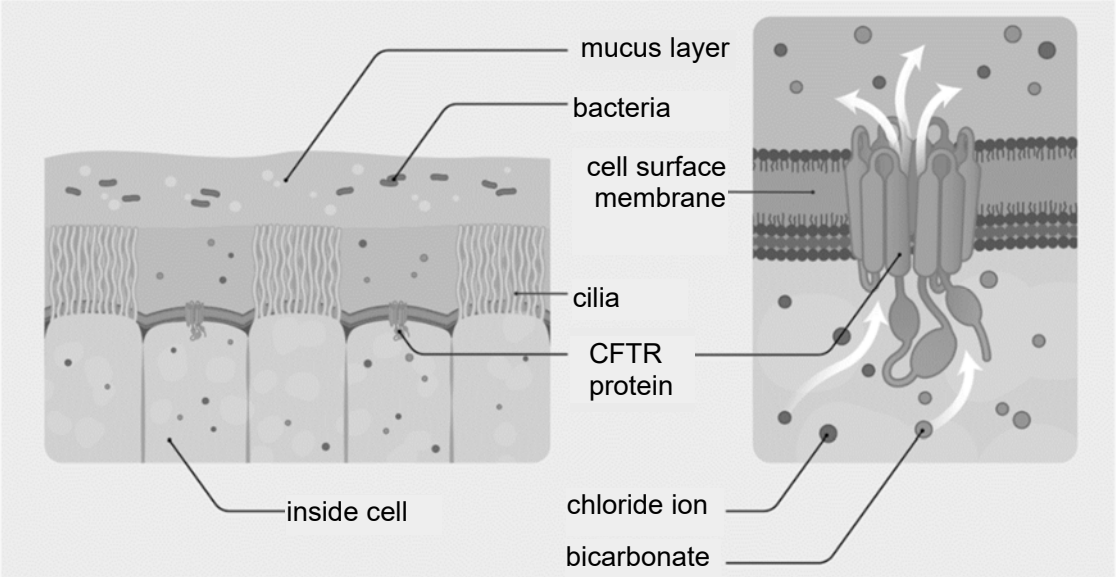

Fig 3.1

(a) CFTR protein regulates the transport of Cl^- across the cell surface membrane. The transport of Cl^- by epithelial cells expressing the normal *CFTR* allele was compared with that by epithelial cells expressing two different types of mutant *CFTR* alleles.

The results are shown in Table 3.1 where normal digestive function of the pancreas associated with a particular allele is indicated with a tick (✓) and the absence of normal functioning is indicated with a cross (✗).

Table 3.1

CFTR allele	percentage Cl^- transported in comparison with normal allele /%	normal digestive function in pancreas
normal	100	✓
mutation 1	6	✗**
mutation 2	50	✓

**Pancreatic insufficiency - pancreas no longer functions at a level needed to digest food.

(i) With reference to Fig. 3.1 and Table 3.1, explain which mutation has a more deleterious effect, causing greater harm to the individual.

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……[3]

(ii) With reference to the information given in Fig. 3.1 and Table 3.1, suggest and explain the type of gene mutations that may have occurred in the two mutant alleles.

mutation 1...

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mutation 2...

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.....[4]

(c) Some observations of the geographical distribution of CF showed that CF is more prevalent in populations with a history of exposure to infectious diseases like cholera or tuberculosis.

Other data have suggested that populations with a higher prevalence of CF also experienced lower mortality rates during epidemics of infectious diseases mentioned above.

Experimental studies on mice showed that mice heterozygous for CFTR allele have enhanced resistance to certain pathogens.

Suggest an explanation for the higher prevalence of CF in some areas.

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[Total: 10]

4 Operons are a well-known feature of prokaryotic genomes.

(a) Fig. 4.1 shows the structure of the tryptophan (*trp*) operon of *Escherichia coli*.

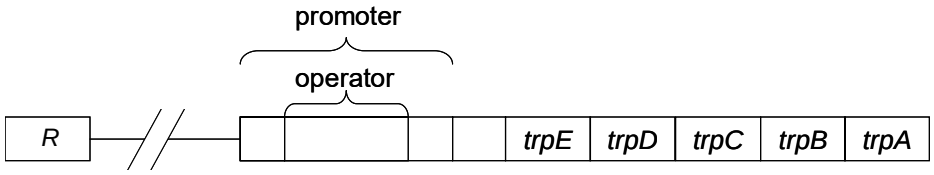

Fig. 4.1

(i) With reference to Fig. 4.1, briefly describe the function of *R*.

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…… [3]

(ii) There are 2 strains of bacteria. In strain 1 bacteria, an insertion of a single nucleotide occurred in *R*, while in strain 2 bacteria, the same mutation occurred at *trp C*.

Predict and explain the effects of the mutation in the two strains of bacteria when they are not supplied with tryptophan.

strain 1……

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strain 2……

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……[4]

For Examiner's Use

(b) Distinguish between repressible and inducible operons.

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[Total: 10]

For Examiner's Use

5 Hormone-sensitive breast cancers are fueled by the natural hormones such as estrogen. A type of breast cancer that is sensitive to estrogen is called estrogen receptor positive (ER-positive) breast cancer.

ER-positive breast cancer cells have receptors for the hormone estrogen. These cancers develop because of increased estrogen concentrations in the blood. Effective treatment of ER-positive breast cancers often involves the use of drugs such as Tamoxifen which has a similar structure to estrogen.

Fig. 5.1 shows the effect of estrogen and Tamoxifen on cell proliferation.

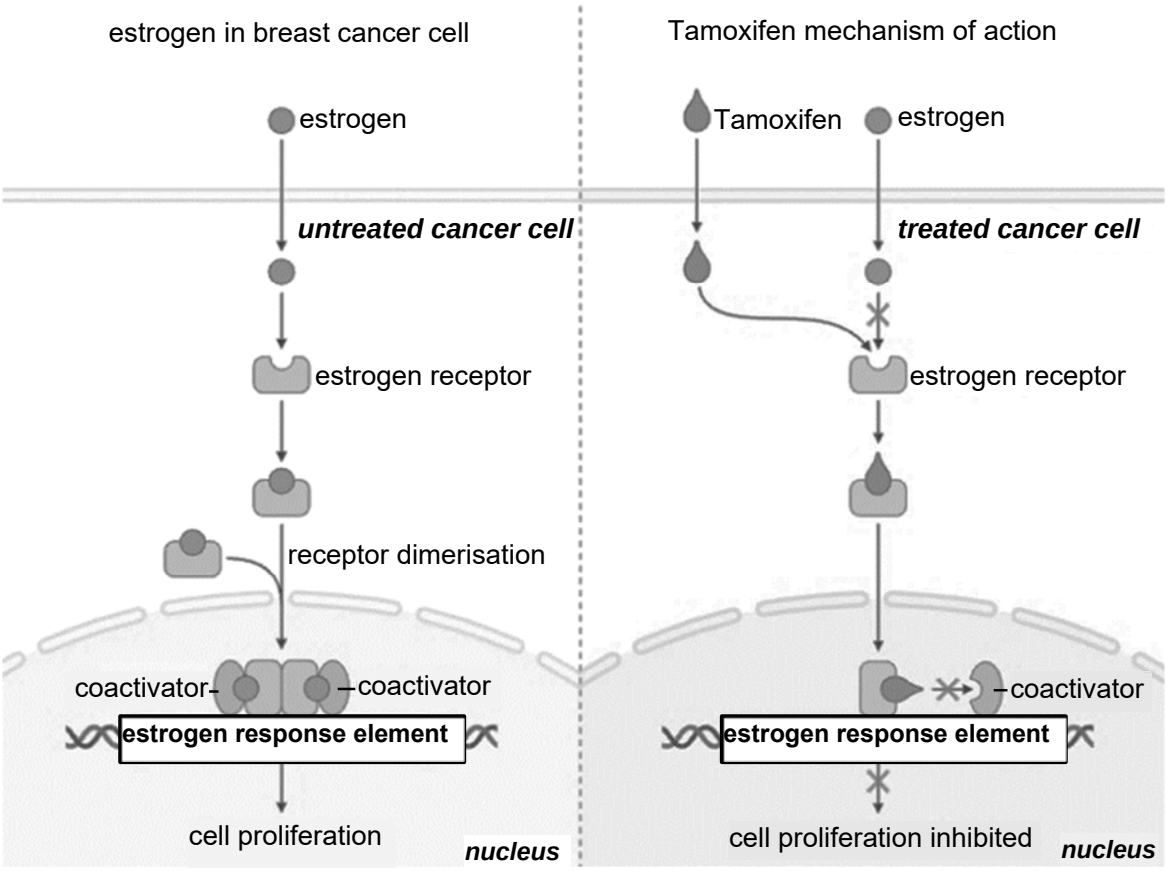

Fig. 5.1

(a) **(i)** With reference to Fig. 5.1, explain why estrogen is able to enter the cell.

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……[2]

(ii) Tamoxifen is considered an effective treatment of ER-positive breast cancers.

With reference to Fig. 5.1, explain how Tamoxifen works.

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……[4]

(b) Recent research has indicated that several cancers result from epigenetic changes that do not alter the base sequence but influence chromatin structure instead.

Treatment with certain drugs have been found to reverse the epigenetic changes that cause cancers.

Suggest how these drugs can reverse epigenetic changes that have occurred in tumour suppressor genes.

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……[4]

[Total: 10]

6 The body's immune system normally functions to protect itself by attacking pathogens like bacteria and viruses.

In autoimmune diseases, the immune system mistakenly attacks cells in the body instead. Rheumatoid arthritis is an autoimmune disease in which the immune system attacks the synovial membrane which is a layer of connective tissue that lines the cavities of joints, causing inflammation.

Fig. 6.1 shows both a healthy joint and an arthritic joint.

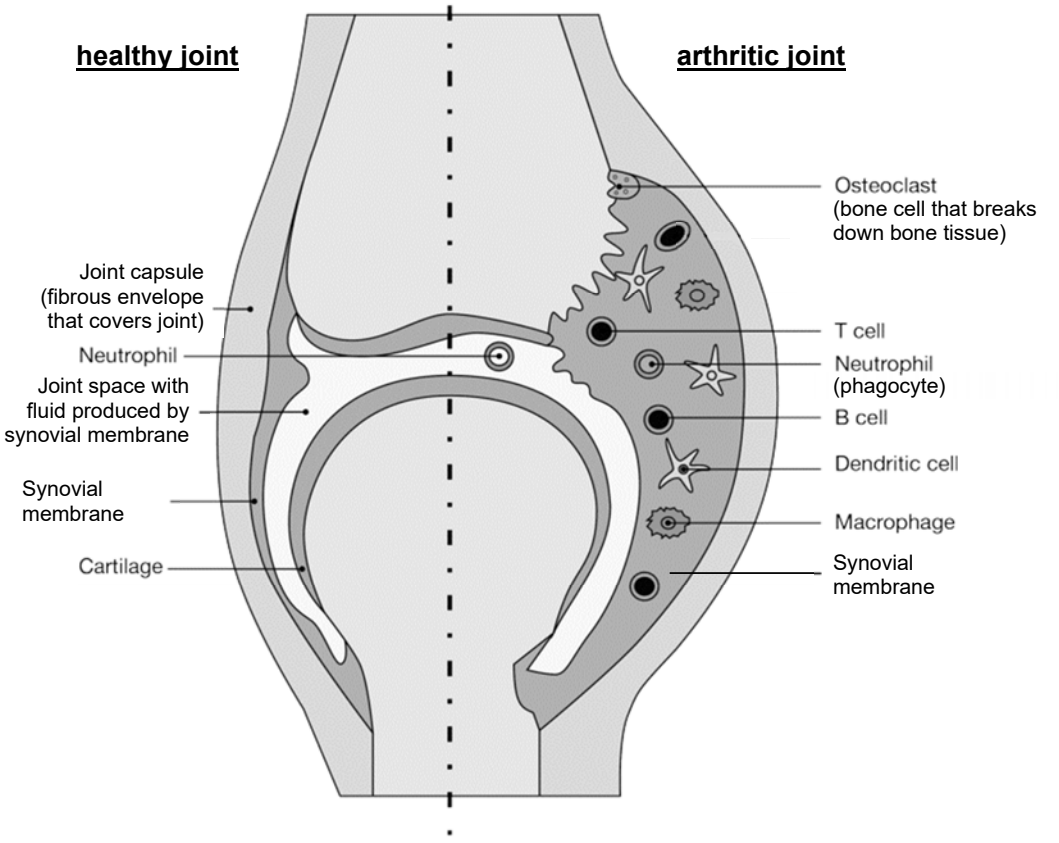

Fig. 6.1

(a) With reference to Fig. 6.1, outline the inflammatory response in the arthritic joint and its resultant effects.

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For Examiner's Use

(b) The dysregulation of the Janus Kinase-Signal Transducer and Activator of Transcription (JAK-STAT) pathway is associated with autoimmune diseases, including rheumatoid arthritis. JAKs are non-covalently associated intracellular non-receptor tyrosine kinases that transfer a phosphate group from ATP to other proteins.

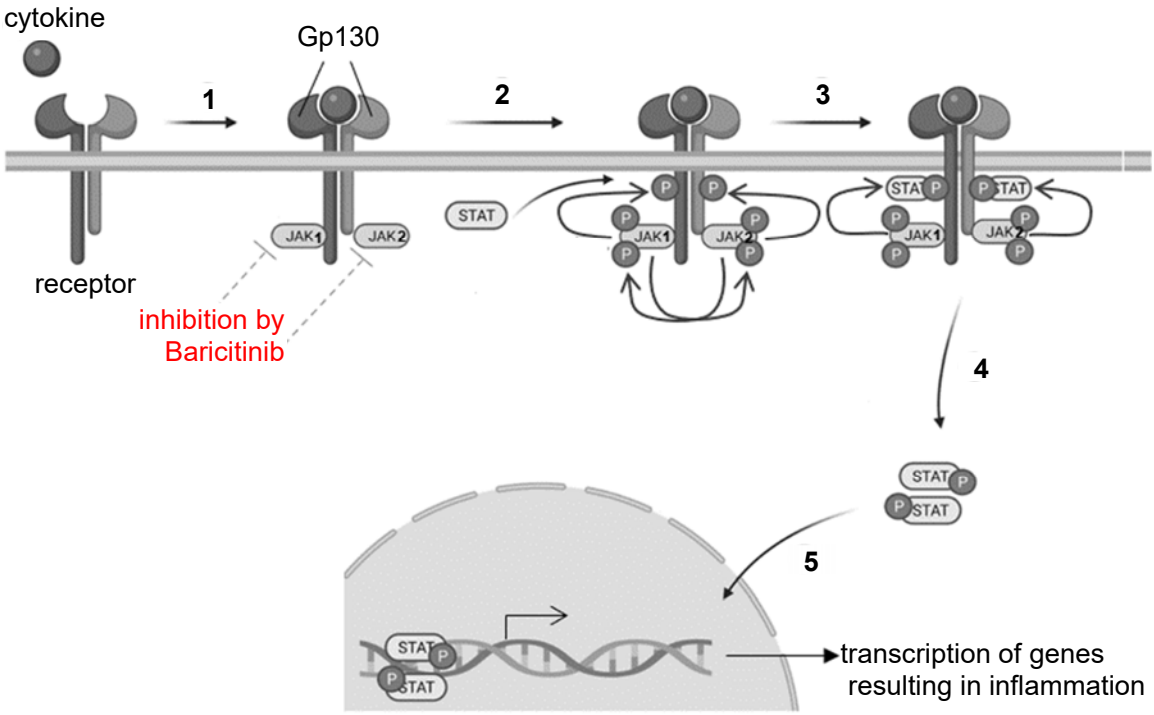

Fig. 6.2

With reference to Fig. 6.2,

(i) describe how the receptor is activated from stage **1** until the end of stage **2**,

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……[3]

(ii) explain how the phosphorylation of STAT allows for its dimerisation.

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……[2]

There are four different tyrosine kinases, namely JAK 1, JAK 2, JAK 3 and TYK2.

All four kinases are associated in different combinations with multiple receptors that are involved in numerous cytokine signaling pathways.

Baricitinib is a drug that inhibits these four kinases and is used in the treatment of rheumatoid arthritis, atopic dermatitis, alopecia and even COVID.

(c) Suggest and explain how Baricitinib inhibits JAK 1, JAK 2, JAK 3 and TYK2.

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(d) Identify the type of enzymes that can inactivate the receptor.

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[Total: 11]

7 Fig. 7.1 shows some structural features of a chloroplast and some processes that occur within it.

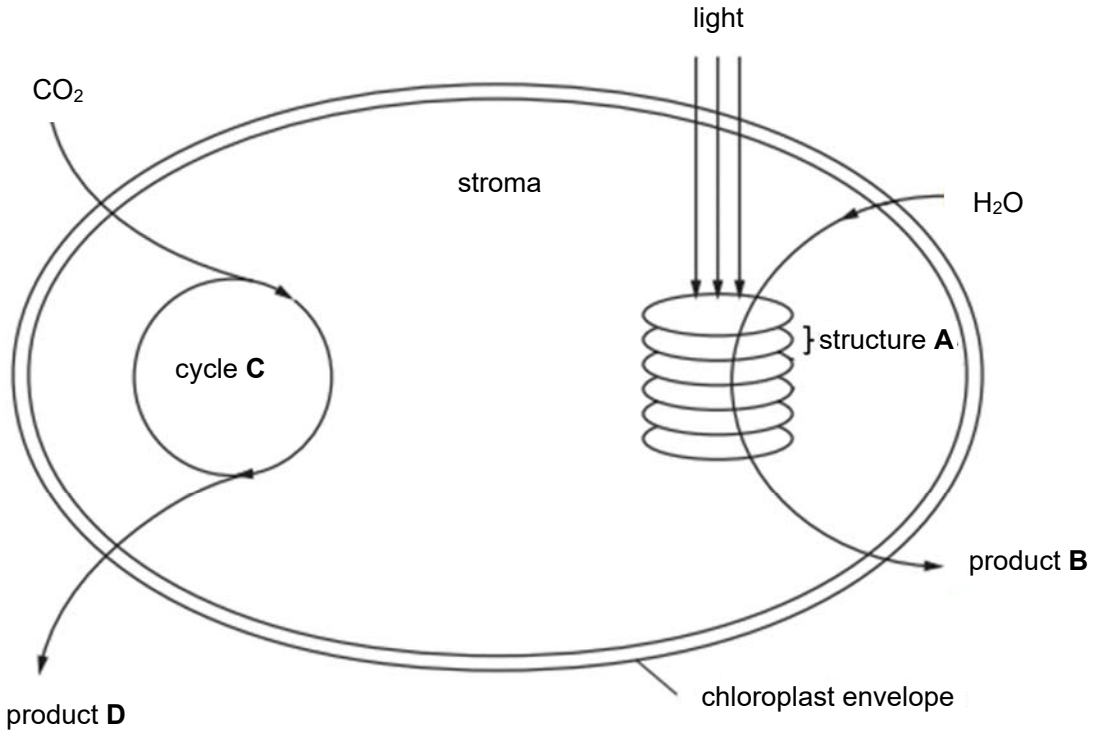

Fig. 7.1

(a) **(i)** With reference to Fig. 7.1, explain how structure **A** is related to its function.

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……[3]

(ii) With reference to Fig. 7.1, explain why pathway **C** is described as a cycle.

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……[2]

(iii) Identify the products of photosynthesis labelled **B** and **D** in Fig. 7.1.

B: ……

D: …… [2]

(b) Compare the chloroplast envelope and a mitochondrial envelope.

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……[3]

[Total: 10]

For Examiner's Use

8 Nail patella syndrome is a rare genetic syndrome characterised by unusual changes in one's nails, kneecaps and bones. It is caused by mutations in the *LMX1B* gene that encodes for a transcription factor that plays a vital role in early embryonic development.

Fig. 8.1 shows the transmission of the nail patella syndrome along with ABO blood type. Individuals suffering from the nail patella syndrome are shaded, and the blood type of each individual is also stated.

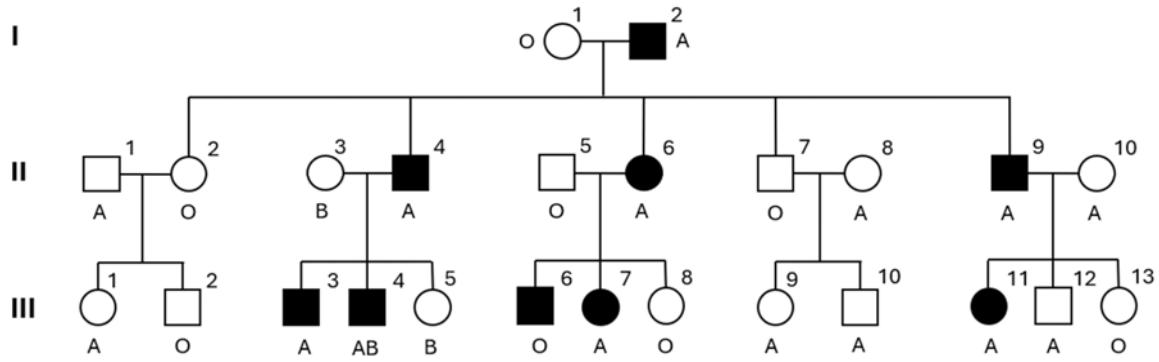

Fig. 8.1

(a) With reference to Fig. 8.1, justify why nail patella syndrome is an autosomal dominant disease.

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……[4]

(b) The gene coding for the ABO blood type is located on the same chromosome as the *LMX1B* gene.

(i) Assuming crossing over does not occur, show the cross between **II-3** and **II-4** to produce offspring **III-3**, **III-4** and **III-5**, using a genetic diagram.

[5]

(ii) Identify an individual in generation **III** that is formed as a result of crossing over.

……[1]

[Total: 10]

For Examiner's Use

9 The family of Camelidae comprises two major subfamilies, namely *Camelinae* (Old World Camelids) and *Laminae* (New World Camelids).

The old world camelids include two domesticated species, the dromedary (*C. dromedarius*) and the bactrian camel (*C. bactrianus*). Both species are referred to as large camelids and distributed into different regions of the world. *C. dromedarius* is located mainly in the hot areas of Middle East and Africa whereas *C. bactrianus* inhabits the cold zones of Central Asia and China.

The new world camelids comprise four main species located in South America and are commonly known as small camelids. Two species, the llama (*Lama glama*) and the alpaca (*Vicugna pacos*), have been domesticated whereas the other two species, namely the guanaco (*Lama guanicoe*) and the vicuna (*Vicugna vicugna*), are wild species.

A classification and map distribution of members of the Camelidae family is shown in Fig. 9.1.

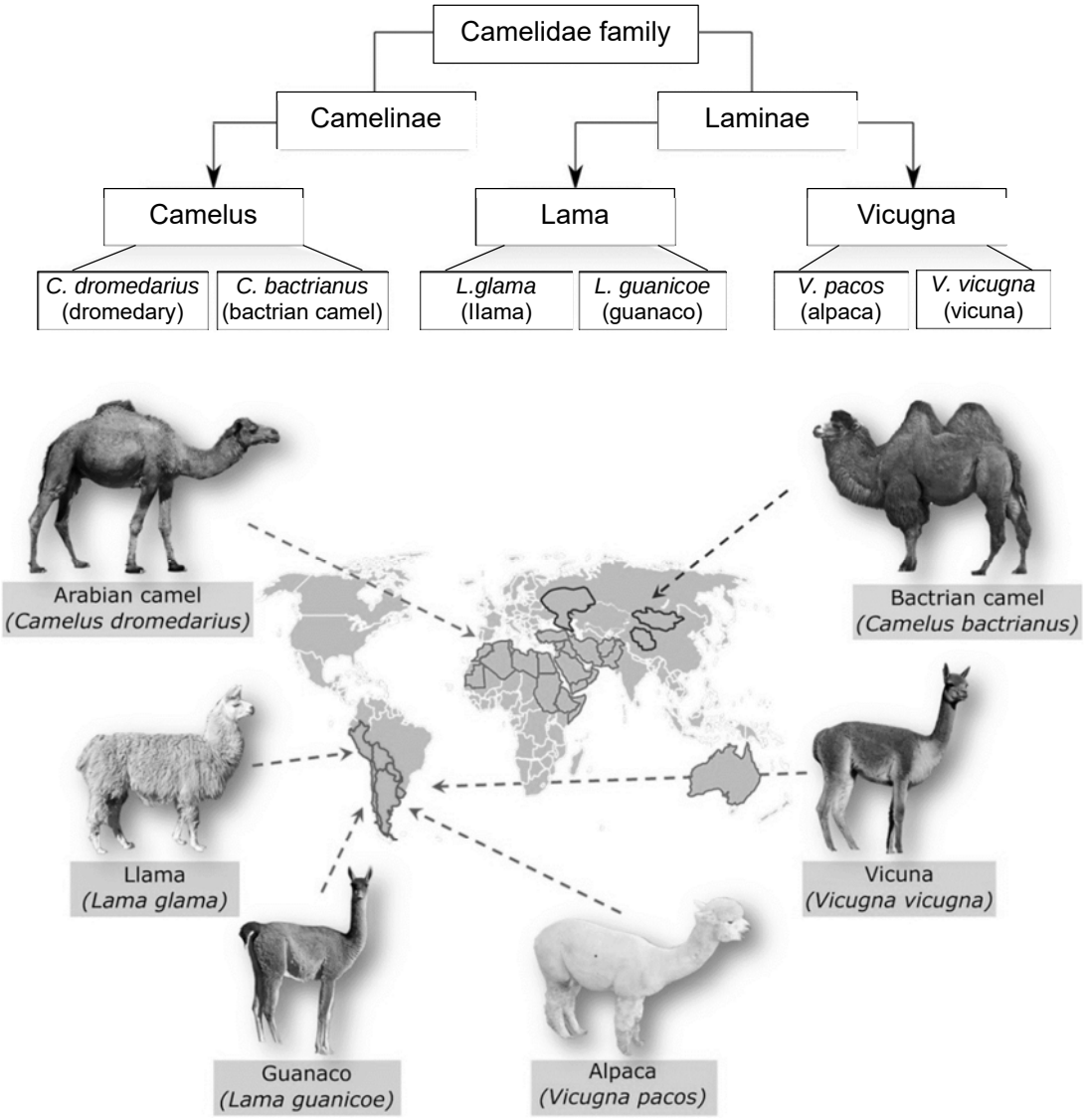

Fig. 9.1

(a) Explain how all the camel species today arose from one common ancestor.

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……[4]

Fig. 9.2 shows the characteristics of the ancestors of the *Camelidae* family that were constructed based on fossils that were found.

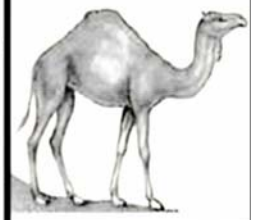
Age	Paleocene 65 million years ago	Eocene 54 million years ago	Oligocene 33 million years ago	Miocene 23 million years ago	Present
Organism					
Skull and teeth					
Limb bones					

Fig. 9.2

(b) With reference to Fig. 9.2, describe how fossils can serve as evidence of evolution.

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……[2]

(c) Recently, a giant camel fossil has been found in the Arctic. Fig. 9.3 shows the shards of a camel tibia (one of the bones in the lower leg) that was unearthed.

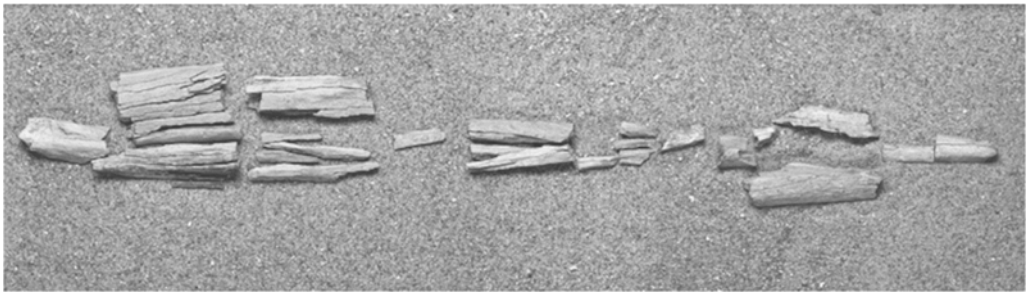

Fig. 9.3

To investigate further, scientists took collagen, a dominant protein found in bone, from the fossils, and compared this with collagen found in other fossils and modern animals.

One of the research scientists said, "These biomolecules tell us that it is an ancestor of modern camels."

(i) Suggest why it was necessary to investigate further despite having fossil evidence of the camel ancestor.

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(ii) Explain why collagen was a good choice for the study described above and how the findings could help to conclude that the fossil found is from an ancestor of camels.

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……[3]

[Total: 10]

10 When a person first becomes infected with the Human Immunodeficiency Virus (HIV), both the innate and adaptive immune responses are triggered.

(a) Describe how the innate immune response differs from the adaptive immune response.

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……..[2]

HIV can infect both non-dividing and dividing T cells, including helper T cells and memory T cells.

The onset of disease, which can occur many years later, coincides with a severely lowered primary and secondary immune response, owing to greatly reduced numbers of T cells in the body.

(b) Suggest and explain how the destruction of memory T cells will contribute to a lowered secondary immune response.

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……[3]

[Total: 5]

For Examiner's Use

11 Climate change has a negative impact on coral reef ecosystems. Coral bleaching is a major threat to reefs.

Fig. 11.1 shows coral bleaching and recovery.

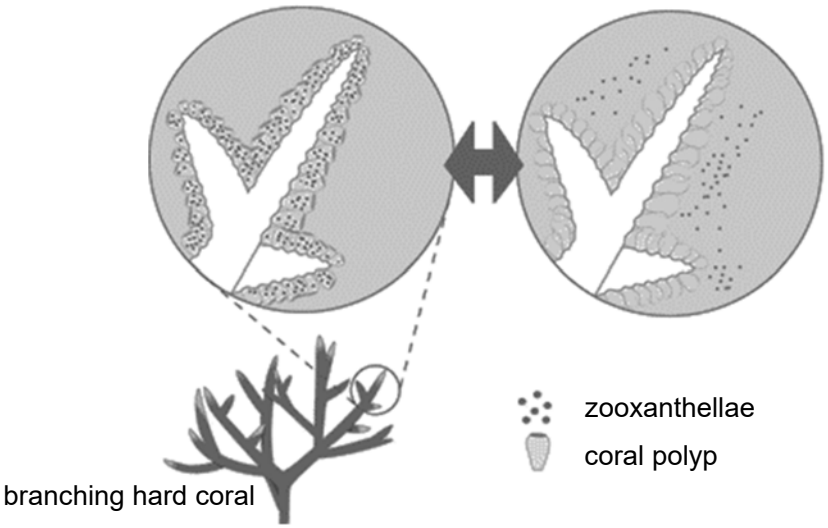

Fig. 11.1

(a) With reference to Fig. 11.1, explain how a rise in ocean temperature leads to bleaching and eventual death of corals.

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……..[2]

Artificial reefs are widely used to regenerate coral reef ecosystems by providing a surface for the mobile larvae of the corals to settle on and subsequently develop into coral polyps.

Scientists investigated the settlement of coral larvae and growth of coral polyps on four different types of artificial coral skeletons.

Equal numbers of coral larvae were introduced into four separate tanks, each containing one type of artificial coral skeleton.

The percentage of larvae attached to each type of coral skeleton was recorded over a 14-day period, and the growth rate of those that attached was determined.

Fig. 11.2 shows the percentage of larvae attached to each type of coral skeleton material.

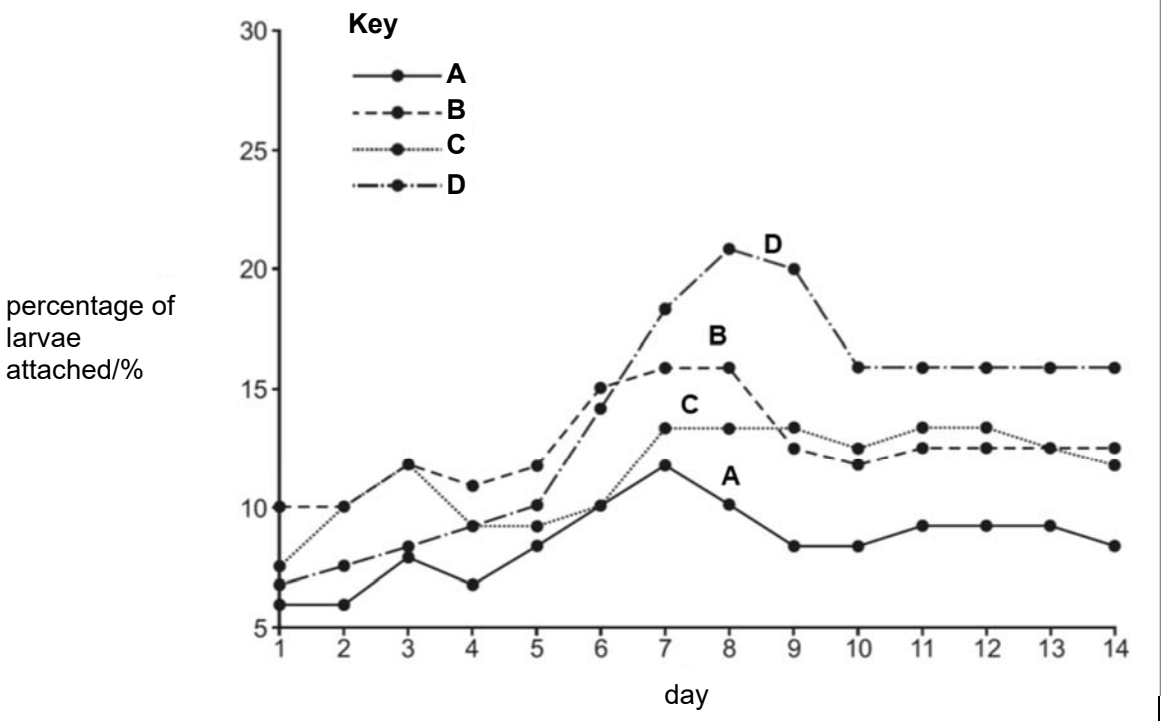

Fig. 11.2

Table 11.1 shows the mean growth rate of attached coral larvae.

Table 11.1

coral skeleton material	mean growth rate of coral polyps / mm^2 per week
A	0.078
B	0.230
C	0.211
D	0.162

(b) Using the results shown in Fig. 11.2 and Table 11.1, state and explain which of the materials **A-D** is best to use for coral regeneration.

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[Total: 5]

End of Paper