H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2025 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE NAME	
CLASS	INDEX NUMBER

BIOLOGY 9744/02

PAPER 2
SHORT STRUCTURED QUESTIONS

22 AUGUST 2025
FRIDAY

Candidates answer on the Question Paper.
No Additional Materials are required.

2 HOURS

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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	/ 9
3	/ 11
4	/ 10
5	/ 10
6	/ 9
7	/ 10
8	/ 10
9	/ 10
10	/ 7
11	/ 5
Total	**/100**

This document consists of **31** printed pages and **1** blank page.

Answer **all** the questions.

1 Stem cells are found throughout the human body. $Lgr5^+$ stem cells are found in the lining of the small intestine.

Fig. 1.1 is a flow chart showing stages in the development of one of the daughter cells produced by the mitotic division of an $Lgr5^+$ stem cell.

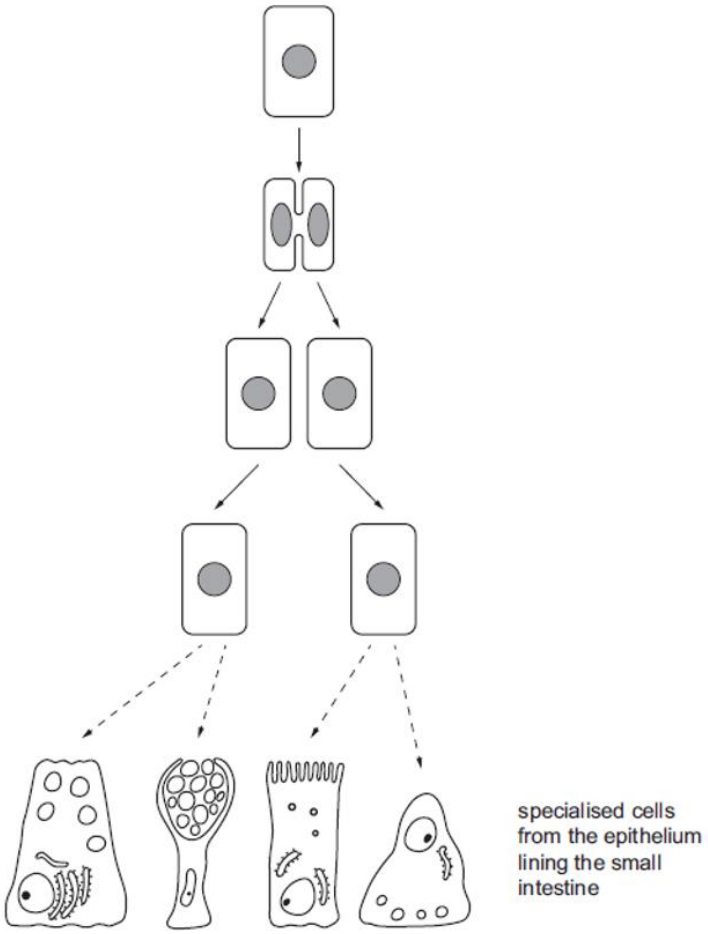


Fig. 1.1

(a) Explain why $Lgr5^+$ stem cells are required in the lining of the small intestine. [3]

any two from: I repair cells

1. to replace (old / worn-out / dead / short-lived) cells / repair (damaged) tissue **;**
2. (damaged by) movement of food through intestine / presence of pathogens,
3. stem cells divide and differentiate to become specialised **; A** form different types of cells
4. cells (produced by stem cells) are genetically identical so the function of the small intestine can continue
5. *idea of* self-renewal of stem cells/ stem cells divide via mitosis to maintain the, pool / number, of stem cells **;** *(I increase in number of stem cells)*
6. AVP *idea that* allows growth (of small intestine) during development (**R** growth of cells)

Fig. 1.2 shows one of the specialised cells, goblet cell that develops from $Lgr5^{+}$ stem cells in the small intestine.

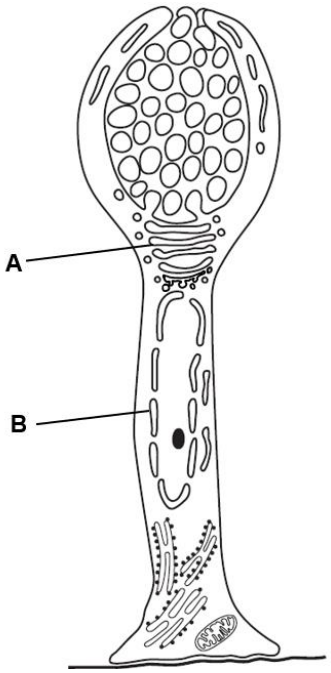


Fig. 1.2

(b) Identify the structures labelled **A** and **B**, as shown in Fig. 1.2.

For each structure, state its function **and one** identifying feature that can be seen in Fig. 1.2.

structure **A** *Golgi body/ Golgi apparatus*
function:
*-To chemically modify, sort proteins/polypeptides and lipids **A** any suitable type of modification or a description e.g. glycosylation / addition of sugars forming tertiary or quaternary structures*
-package proteins/polypeptides and lipids into vesicles (for transport)
-To maintain the plasma membrane (through fusion of vesicle membrane with plasma membrane)
-To form lysosomes

identifying feature:
- A stack of flattened, elongated, single membrane-bound sacs/ cisternae
*- (At the cis face) transport vesicles (from RER and SER) continuously **fuse** and release proteins and lipids into the lumen of the Golgi body./ **At the trans face**, **secretory vesicles, Golgi vesicles** and **lysosomes** continuously **bud/ pinch off**.*
- Presence of lumen

structure **B:** *nuclear envelope/ accept nucleus*
function for nuclear envelope:
To regulate entry and exit of specific molecules (state 2 examples e.g. DNA nucleotides, RNA nucleotides, DNA polymerase, RNA polymerase, helicase, ligase, mRNA, tRNA, rRNA etc)

function of nucleus
storage of DNA/ genetic information
site of transcription

Function must match that of structure identified

identifying feature (same for both):
double membrane surrounding the nucleolus (darkly stained region)
has numerous tiny openings called nuclear pores.
Accept presence of nucleolus (darkly stained region)

[Total: 9]

2 Neutrase® is an enzyme that is used to hydrolyse proteins in solution. When the enzyme is mixed with a 2% protein solution the reaction mixture changes from white to colourless.

A student carried out an experiment to find the effect of copper sulfate and potassium sulfate on the activity of Neutrase®.

The student made four reaction mixtures in test-tubes **A** to **D**. Test-tubes **A** to **C** contained equal volumes of protein solution and 0.1cm^3 of solutions of copper sulfate or potassium sulfate. Test-tube D contained the same volume of protein solution and 0.1 cm^3 of water.

0.5 cm^3 of a 1% Neutrase® solution was added to test-tube **A** and immediately placed into a colorimeter. The colorimeter was used to measure the intensity of light that is absorbed by the solution (absorbance) over 100 seconds. The procedure was repeated with the other reaction mixtures, **B**, **C** and **D**.

The results are shown in Fig. 2.1.

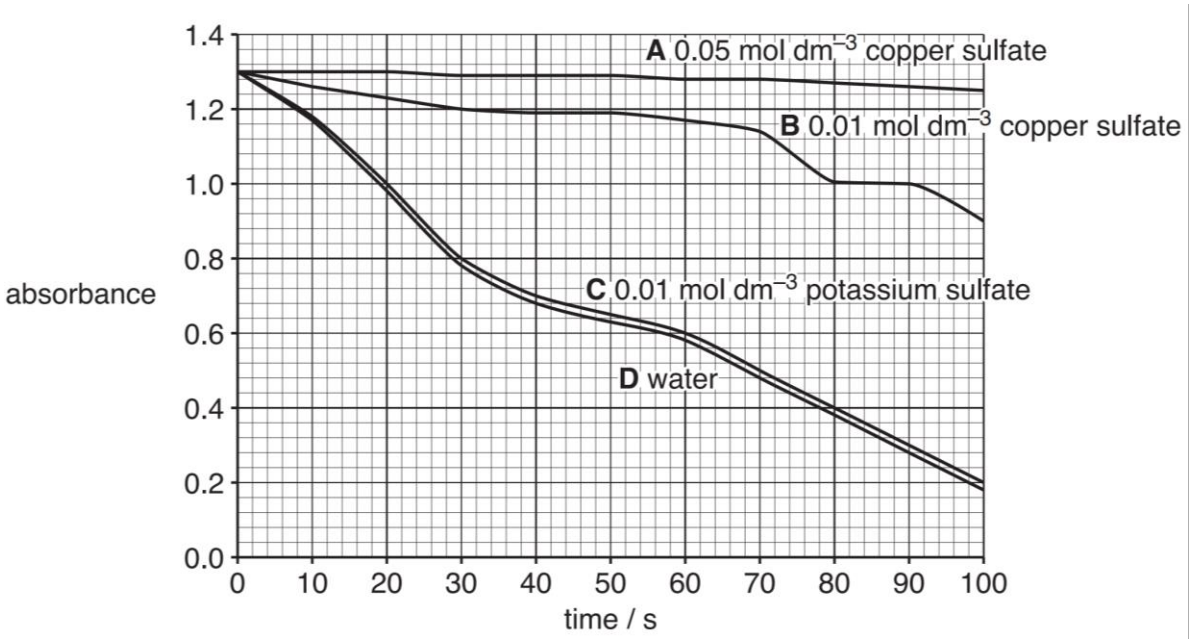


Fig. 2.1

(a) Suggest and explain why measuring the absorbance of the reaction mixture over 100 s is a suitable method for determining the activity of Neutrase®

Any two:

1. Neutrase® breaks down (hydrolyses) protein into peptides / amino acids (Accept: increase in solubility).

2. During the reaction, more light passes through the solution / more light is transmitted / less light is absorbed.

3. The idea that 100 seconds is a sufficient duration to observe the progress of the reaction / for complete reaction.

[2]

(b) With reference to Fig. 2.1,

(i) describe the effects of copper sulfate solution and potassium sulfate solution on the activity of Neutrase®.

Trend:

1. Copper sulfate **decreases** (or equivalent wording) the activity of Neutrase (reference to either A or B);

2. 0.01 mol dm^{-3} $CuSO_4$ has a greater decrease / smaller effect on the activity of Neutrase than 0.05 mol dm^{-3} (high concentration) (reference to A and B);

3. Potassium sulfate has **little / no effect** on Neutrase activity (reference to C) as the rate of decrease of absorbance is almost the same / similar to water added to the reaction (reference to D);

Quote data:

4. Data quote showing absorbance for two different lines at the same time, hence either compare
    - A/B and C to explain point 1 (lesser decrease in absorbance for 0.05 mol dm^{-3} $CuSO_4$)
    - A and B to show that absorbance of explain point 2

5. One time and two absorbance readings from different lines on the graph with the unit for time used once anywhere in the answer — allow 'at the end' to refer to 100 seconds

(Students may have difficulties linking the gradient of graph to rate of reaction.) [4]

(ii) suggest explanations for the effects described in **(b)(i)**.

1. Copper (sulfate) is a **non-competitive inhibitor** of Neutrase;

2. Copper sulfate binds to Neutrase at **allosteric site / site other than active site**;

3. **Shape** of **active site** changed/different/no longer complementary to substrate shape;

4. Substrate cannot enter / bind to the active site / enzyme-substrate complexes do not form (hence, lower rate / protein is not hydrolysed, absorbance does not decrease much).

5. Potassium sulfate is not an inhibitor;

(Reject: reference to increase in substrate concentration does not increase rate of reaction / cannot overcome effects of inhibition → because cannot see from graph. Note that x axis is time/s, and y axis is not rate of reaction.) [3]

[Total: 9]

3 Fig. 3.1 shows pie chart which represents the different stages of the cell cycle of an animal cell. One complete cycle takes 12 hours at 22˚C.

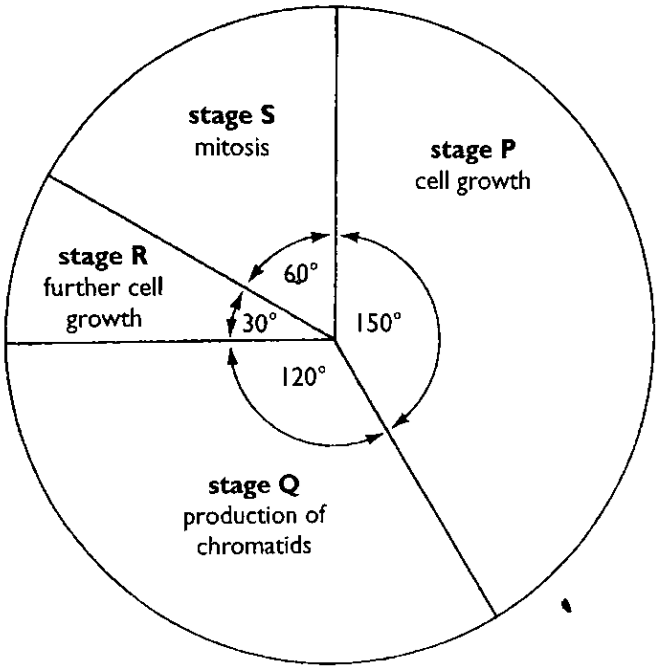


Fig. 3.1

(a) **(i)** Express as a whole number ratio the total time spent on cell growth to the time spent on production of chromatids at 22˚C.

P+R : Q
6hrs : 4hrs
3 : 2 [1]

(ii) Express the time spent on mitosis as a percentage of the total time required for one cycle at 22˚C. Express your answer to 3 significant figures.

2/12 x100%/ 60/360 x 100%= 16.7% (to 3sf) [1]

(iii) The cell cycle is controlled by check points.

Identify the checkpoint between stage P and stage Q **and** state its function.

(Any 2)
- *G1 checkpoint*

Checks that:
- Cell size is adequate (volume of cytoplasm/ quantity of organelles)
- There is sufficient nutrients are available to support daughter cells.
- Growth factors (Extracellular signal proteins that stimulate a cell to grow or divide) are present.
- No damage in DNA

Fig. 3.2 is a transmission electron micrograph of two human chromosomes at metaphase of mitosis, stage S of the cell cycle.

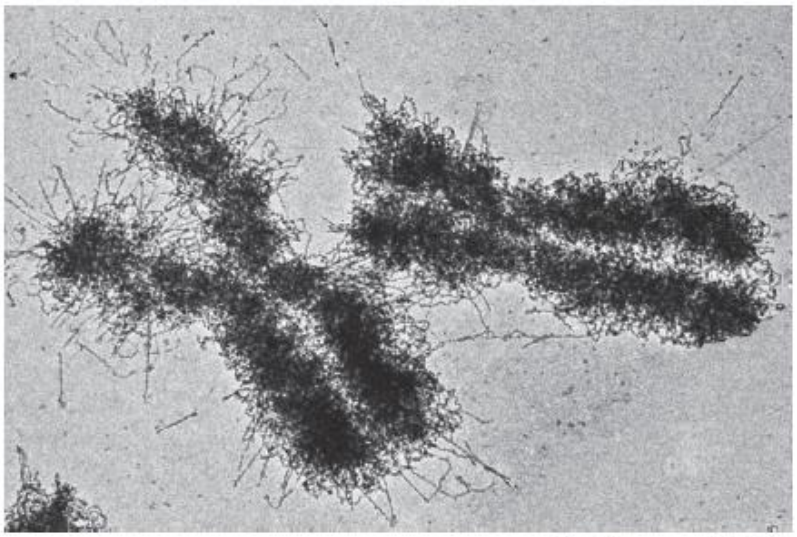


Fig. 3.2

(b) Outline how DNA molecules are packed to form the chromosomes shown in Fig. 3.2.

(any 3)

- *DNA wrapped around **histones** to form **nucleosome***
- *(string of nucleosome) coiled into **30nm chromatin fibre (solenoid)** enable by Interactions between histone tails, linker DNA and H1 histones*
- *(subsequently) **folds** to form **looped domains**, attached to a base of **scaffolding (non-histones) proteins***
- *the looped domains **coil** and **fold** further, compacting all the chromatin to highly form condensed metaphase chromosomes*
- *with (identical) two sister chromatids joined at the centromere*

(c) Describe what happens in the next stage of mitosis.

1. Anaphase
2. Centromere **divide** and sister chromatids **separate**, each becoming chromosomes;
3. Kinetochore microtubules shorten;
4. to pull chromosomes to opposite **poles** of the cell, **centromere leading**

[Total: 11]

4 **(a)** Outline the main steps in the polymerase chain reaction that allow many copies of a DNA fragment to be produced.

1. **Heating to 95°C separates** two strands of DNA double helix by **breaking hydrogen bond** between **complementary** bases / **denaturing DNA.** (Accept any temperature from 85°C to 95°C)
2. Cool to around **60°C**, in presence of **excess primers**. (Accept any temperature from 55°C to 65°C)
3. 2 primers **anneal** to 3' end (of target sequence) of **each template / single strand.**
4. At **72°C**, ***Taq* DNA polymerase synthesize / elongate** DNA strand via **complementary base pairing** from 3' OH end of primer;

(b) Fig 4.1 shows the alleles of two genes on chromosome 1 of two fruit flies. The female fruit fly is heterozygous for both Gene A and B, whereas the male fruit fly is homozygous for both Gene A and B.

The fruit flies were crossed and 200 progenies were produced. Using Southern Blotting, the banding patterns of the parents and progeny were visualized, as shown in Fig. 4.2.

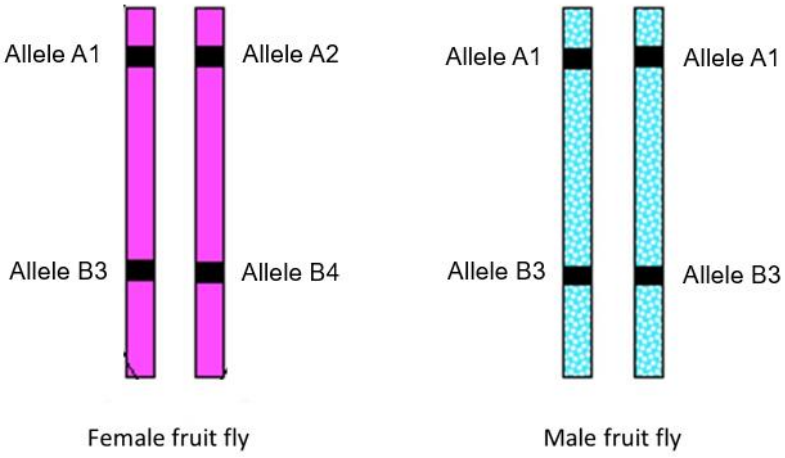


Fig. 4.1

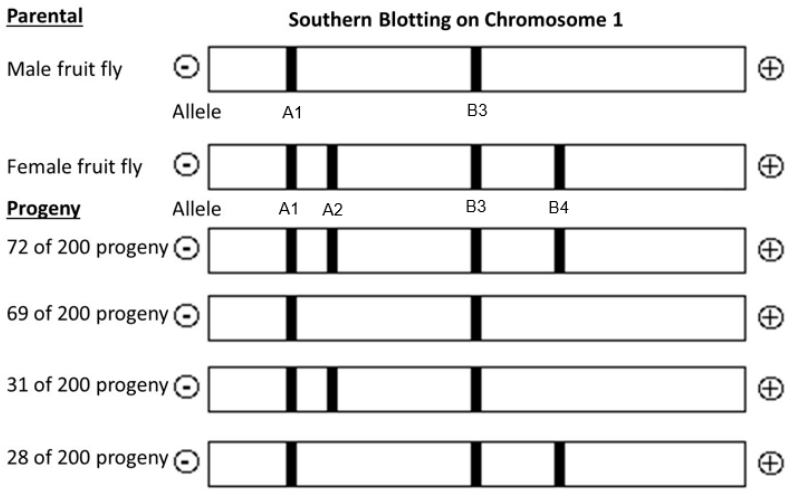


Fig. 4.2

With reference to Fig. 4.1 and Fig. 4.2,

(i) state precisely the type of genetic inheritance observed.

Autosomal Linked genes / autosomal linkage **R**: sex-linked [1]

(ii) explain your answer in **(b)(i)**.

1. **The genes A & B are found on the same chromosome 1. R:** alleles found on the same chromosome
2. **The parental type band patterns have a larger proportion** (72 with alleles A1, A2, B3 and B4, and 69 with alleles A1 and B3) with occur more frequently than recombinant types **than recombinant types**. Reject if only describing crossing over, exchange of non-sister chromatids.
3. **Therefore the expected ratio of 1:1:1:1** is not **observed in the progeny**. [2]

(c) Some of the germline cells in the parental female fruit fly have been discovered to have a mutation at the centromere of chromosome 5.

Suggest how this could affect the gametes formed from these cells.

1. Mutated centromere **different 3D conformation,** kinetochore cannot bind.
2. **Spindle fibres cannot attached**
3. **Nondisjunction** where **homologous chromosomes fail to separate properly during anaphase I** occurs / when **sister chromatids fail to separate properly during anaphase II** occurs.
4. **Aneuploidy**, where gametes are **n+1** and **n-1** **R**: Polyploidy

[Any 3]

[3]

[Total: 10]

5 Fig. 5.1 shows some molecules involved in protein synthesis.

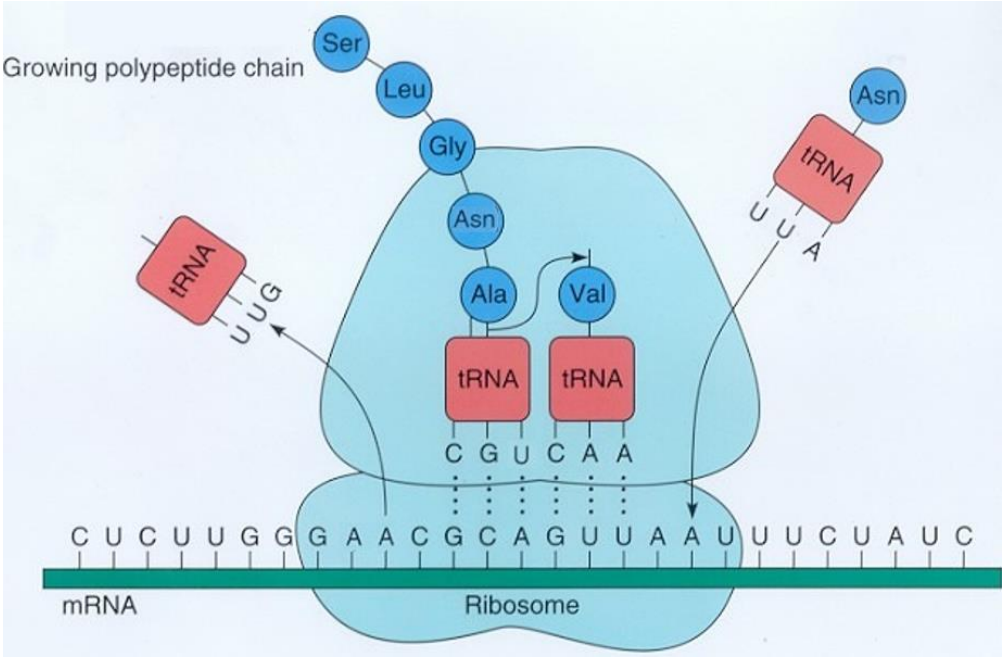


Fig. 5.1

(a) Outline how mRNA is formed. [3]

(Transcription (of portion of DNA carrying the) **gene** for **polypeptide chain)**
1. **RNA polymerase** binds to **promoter**
2. **unzips** (and unwinds) the DNA molecule
3. catalyzing formation of **phosphodiester bonds** between **RNA nucleotides**
4. which were added via **complementary base pairing**
6. with the **template DNA strand**
7. elongation occurs in the **5' to 3'** direction of the RNA strand / RNA nucleotides added to the **3' end** of elongating RNA strand

(b) The genetic code is a set of rules that determine how genetic information is used to synthesized during protein synthesis.

Explain the features of the genetic code that are evident in Fig. 5.1. [4]
1. **non-overla**pping - no base of a given codon contributes to part of the code of the next codon / codons are read as **successive read in groups of 3 bases** where after one codon has been read, the immediate 3 bases will be read as the next codon / A base from one codon cannot be used for adjacent codon
2. (quote any correct evidence in Fig. 5.1): Making reference to the idea that the anticodon of CGU and CAA base pairs with their respective adjacent codons/ No base in mRNA is being base-paired with another tRNA anticodon after it has base paired with one tRNA anticodon.
3. **Specific - each codon can only encode 1 amino acid**
4. e.g. GCA only codes for Alanine (if student was to mention codon then correct mRNA codon and respective amino acid to be read, cannot give anticodon)
5. One amino acid can be encoded by more than one codon
6. codons AAC and AAU code for same Asn

(c) Explain the function of the large ribosomal subunit in Fig. 5.1 [3]

1. Contain Peptidyl transferase (enzyme)
2. Form peptide bond between adjacent amino acids

3. Function of P: (has complementary shape to) holds/bind the tRNA carrying the growing polypeptide chain
4. Function of A: (has complementary shape to) holds/ binds the tRNA carrying the next / a amino acid (to be added to the chain)
5. Function of E: (has complementary shape to) holds/ binds the **empty tRNA** ready to leave the ribosome
6. Contains E, P, A site (no need to spell out)/ has **3 transfer RNA** (tRNA) **binding sites** (pity mark)

6 The foxglove, *Digitalis purpurea*, is a common plant in many parts of the world.

Fig. 6.1 shows a foxglove.

Fig. 6.1

Flower colour in foxgloves is controlled by two genes that interact with each other.

- Dominant allele **M** codes for an enzyme involved in the production of a purple pigment.
- Recessive allele **m** codes for a non-functioning enzyme so no purple pigment is produced, resulting in a white colour.
- Dominant allele **D** interacts with allele **M** to produce dark purple flowers.
- Recessive allele **d** does not interact with allele **M**.
- Neither allele **D** nor allele **d** interact with allele **m**.

A double homozygous foxglove with dark purple flowers was crossed with a double homozygous recessive foxglove with white flowers. All the offspring had dark purple flowers.

(a) Explain what is meant by the term *homozygous*.

having identical alleles (of a gene); [1]

(b) Using the symbols above, state the genotype of the offspring with dark purple flowers.

MmDd [1]

(c) Two of these offspring with dark purple flowers were crossed.

This cross produced a mixture of plants with three different flower colours:

- dark purple
- purple
- white

Draw a Punnett square to show the possible genotypes and phenotypes of the mixture of plants from this cross.

Write down the expected phenotypic ratio of plants with each flower colour.

gametes	**MD**	**Md**	**mD**	**md**
MD	**MMDD** dark purple	**MMDd** dark purple	**MmDD** dark purple	**MmDd** dark purple
Md	**MMDd** dark purple	**MMdd** purple	**MmDd** dark purple	**Mmdd** purple
mD	**MmDD** dark purple	**MmDd** dark purple	**mmDD** white	**mmDd** white
md	**MmDd** dark purple	**Mmdd** purple	**mmDd** white	**mmdd** white

one mark for gametes → must be circled ;
one mark for genotypes ; ;
one mark for phenotypes linked to genotypes → can be in another table (match phenotype to genotype) ; ;
one mark for correct ratio = 9 dark purple : 3 purple : 4 white ;

phenotypic ratio: ……..…… [4]

(d) The foxglove plants are naturally found at the bases of mountains (sea level), up to the sub-alpine regions (about 2000 m) in Europe.

Based on the information above, explain how climate change might alter the distribution of foxglove plants. [3]

Expected change:

1. **Range shift** to cooler altitudes up the mountains / may become locally extinct in warmer regions at sea level

   OR

   Species will experience **range contractions** as the species continually lose area at the low elevation part of their ranges but do not gain elevation at the high end;

Explain:

2. Increase in temperatures at lower altitudes may cause e.g. enzyme denaturation affecting metabolism (accept converse: higher altitudes, temperature within optimum of enzyme)
3. May affect reproductive success/flowering/germination;
4. **AVP (see lecture notes)**: e.g.
   a. water stress (increased temperatures tend to occur with incidences of low precipitation/rainfall. Stomata closure to prevent excessive loss of water through transpiration, lower photosynthesis rate, slower plant growth/plant death.)

[Total: 9]

7 Fig. 7.1 shows the arrangement of the bacterial chromosome and a plasmid in a bacterial cell.

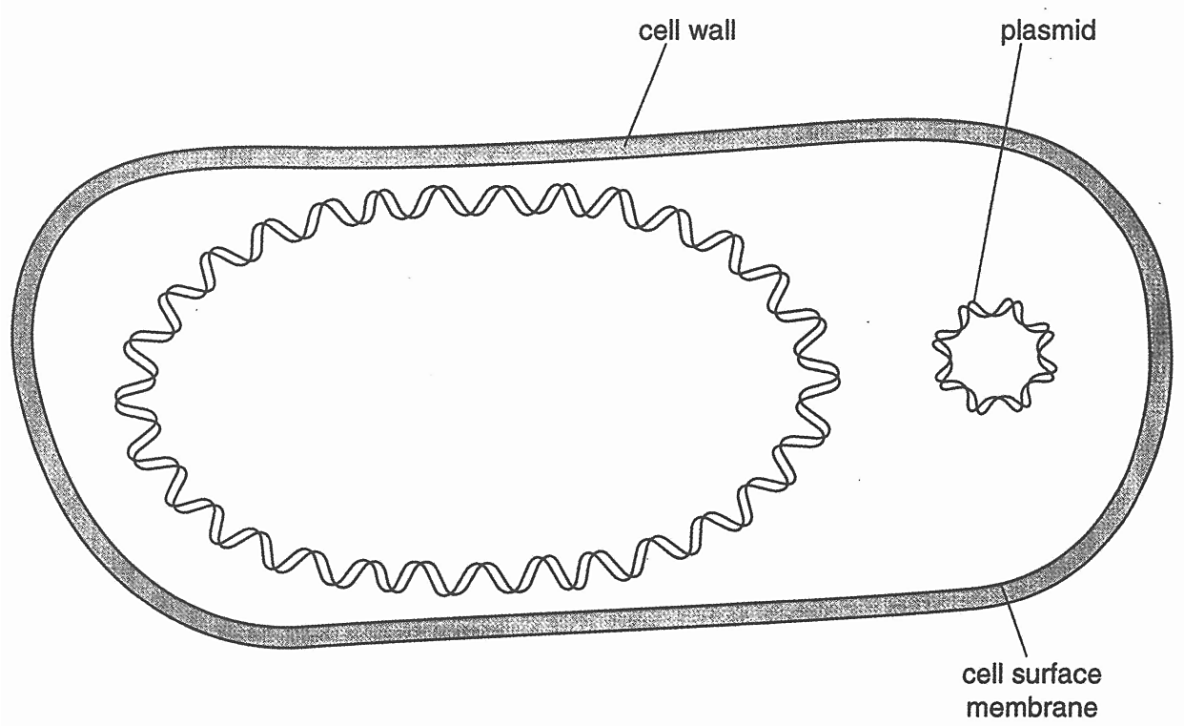


Fig. 7.1

(a) State two ways in which a plasmid such as F plasmid differs from the bacterial chromosome.

Any 2:

Relative number of genes & genome size	Bigger genome / more genes	Smaller genome / fewer genes
General function of genes	Essential for survival e.g enzymes for cell metabolism e.g. for syn of a.a such as trp	Not essential for survival but code for advantages traits e.g. antibiotic (such as ampicillin) resistance
No. per cell	Only 1	None, 1 copy, or many

[2]

(b) The F plasmid is involved in conjugation.

Discuss the potential benefit of conjugation in a population of bacteria.

1. The recipient bacteria can **acquire new genes** that

2. **code for advantageous traits** / give an example to illustrate → antibiotic resistance, resistance to heavy metals, resistance to drugs, ability to utilise new metabolites, etc.

3. Increase **genetic variation** in bacterial population (Binary fission only results in genetically identical cells. Mutations are random and spontaneous hence will not contribute significantly to genetic variation)

4. Ref to **evolutionary fitness/selective advantage** of bacteria such as (give any one example):
   - improve its ability to **survive**/colonise environments/exploit new nutrient sources
   - **reproduce** more successfully
   - compete more effectively with other bacteria

5. Ref to idea of: with genetic variation in a population, the **population as a whole may survive environmental changes** if at least some of its members in each generation can cope effectively with new conditions (long term survival of species). [3]

Genes on the bacterial chromosomes are organised into operons such as the *lac* and *trp* operons.

A fusion between the *trp* operon and the *lac* operon was created in a laboratory, resulting in the *trp-lac* fusion operon shown in Fig. 7.2.

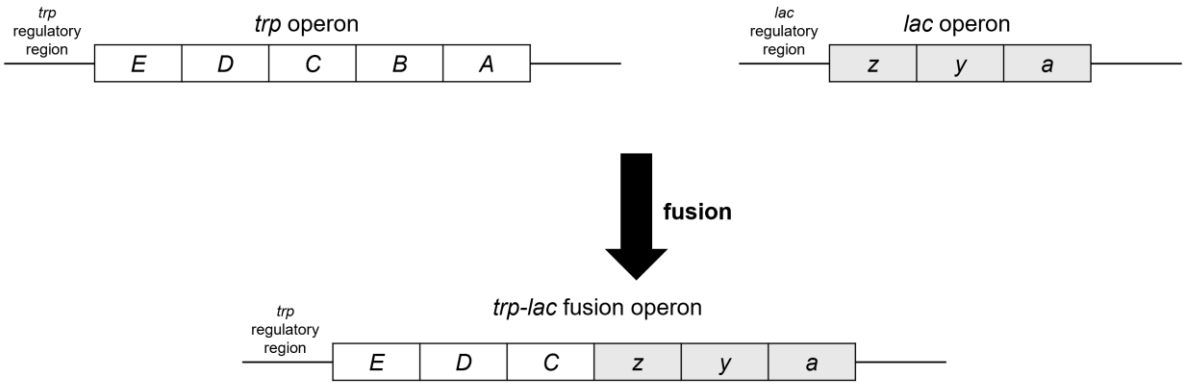


Fig. 7.2

(c) Predict and explain the effect of the presence of the following molecules on the expression of β-galactosidase in the *trp–lac* fusion operon.

(i) tryptophan

1. Compulsory mark about prediction: In the presence of tryptophan**,** β-galactosidase **is not expressed**.

And any two below:
2. Tryptophan acts as a **co-repressor**, binding to the Trp repressor → **trp repressor is activated**.
3. (Activated) Trp repressor **binds to trp operator / trp regulatory region**,
4. Transcription by RNA polymerase blocked / RNA polymerase cannot bind at (Trp) promoter → *Lac Z gene not transcribed*

[3]

(ii) lactose

1. Compulsory mark about prediction: In the **presence of lactose,** β-galactosidase **is not expressed / no effect**

2. because the **lac operator** / lac regulatory region / lacI gene coding for lac repressor **is absent**, (expression is now solely under control of trp repressor and operator) → **NOTE that the lacI gene is located very far away from the promoter and operator.**

[2]

[Total: 9]

8 Fig. 8.1 is a diagram of a mitochondrion.

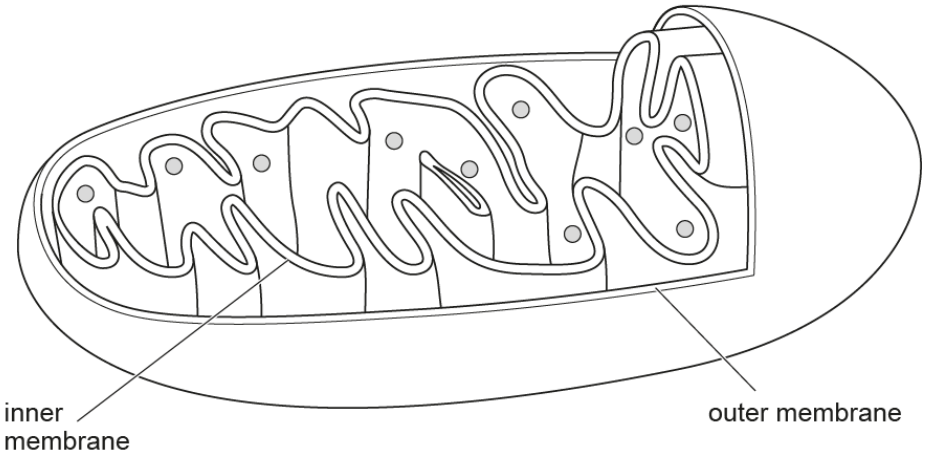


Fig. 8.1

(a) Compare the structure of the inner membrane and the outer membrane. [3]
(any 3)
1. Both are **phospholipid bilayers**.
2. Both contain **transport proteins/ carrier proteins** for **ATP/ ADP/ pyruvate**.
3. The inner membrane is highly **folded** to form **cristae** (but the outer membrane is unfolded).
4. The inner membrane contains **numerous electron transport chains/ ATP synthase/ stalked particles** (which are absent on the outer membrane).

(b) The shapes and numbers of mitochondria in a cell are continually changing due to fission. Fission occurs when one mitochondrion splits to form two mitochondria.

Suggest reasons why mitochondria carry out fission. [2]
1. to **replace damaged/ old/ worn-out mitochondria**
2. to ensure sufficient mitochondria to **meet the cell's energy needs**
3. in cells about to undergo **mitosis/ cell division**

(c) A respirometer is a piece of apparatus that can be used to measure the rate of respiration of living tissue such as germinating peas.

A simple respirometer is shown in Fig. 8.1.

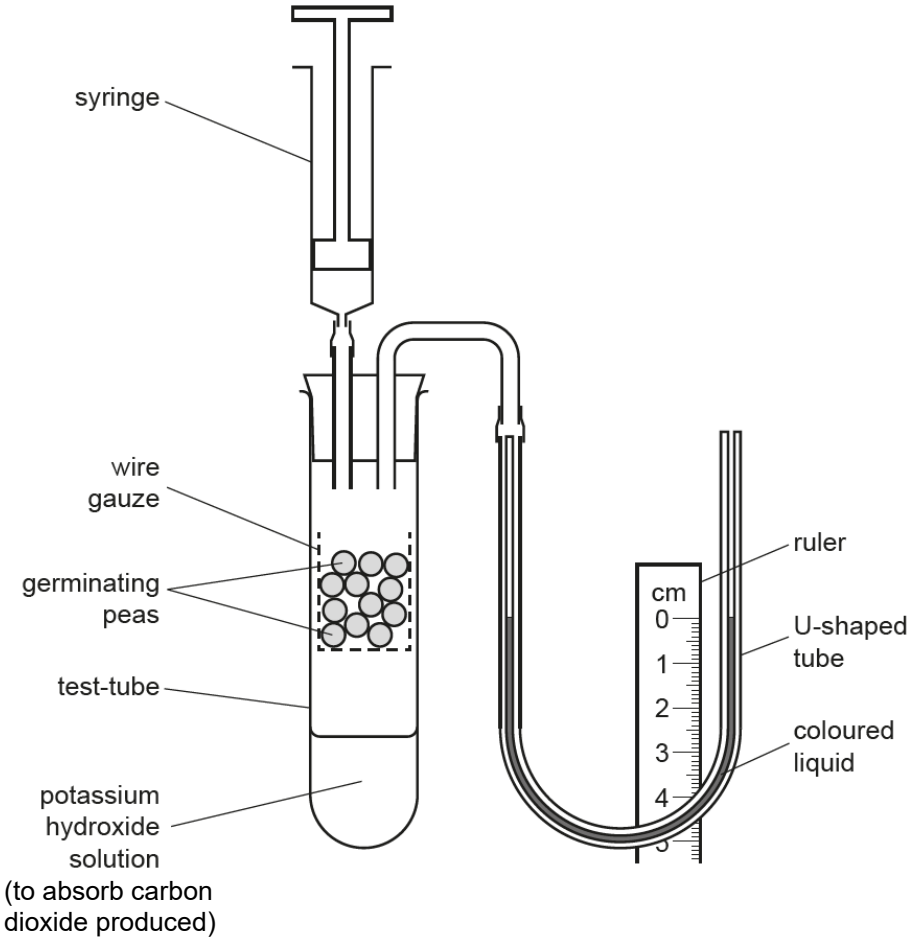


Fig. 8.1

A student carried out an investigation to determine the effect of temperature on the rate of respiration of germinating peas.

- The student set up the respirometer as shown in Fig. 8.1 and placed the respirometer in a water-bath at 10 °C.
- After five minutes, the student used the syringe to adjust the position of the coloured liquid in the right-hand side of the U-shaped tube so that it lined up with 0 cm on the ruler.
- The student immediately started a timer.
- The germinating peas used up oxygen, causing the coloured liquid in the U-shaped tube to move.
- The student measured the distance moved by the coloured liquid after 20 minutes.
- The student repeated the experiment at temperatures of 20 °C, 30 °C, 40 °C and 50 °C.

The rate of movement of the coloured liquid in the U-shaped tube, calculated from the results, is shown in Table 8.1.

Table 8.1

temperature / °C	rate of movement / mm min^{-1}
10	0.40
20	0.70
30	1.30
40	1.15
50	0.60

(i) Plot a graph of the results shown in Table 8.1 on the grid in Fig. 8.2.

Draw a curved line of best fit.

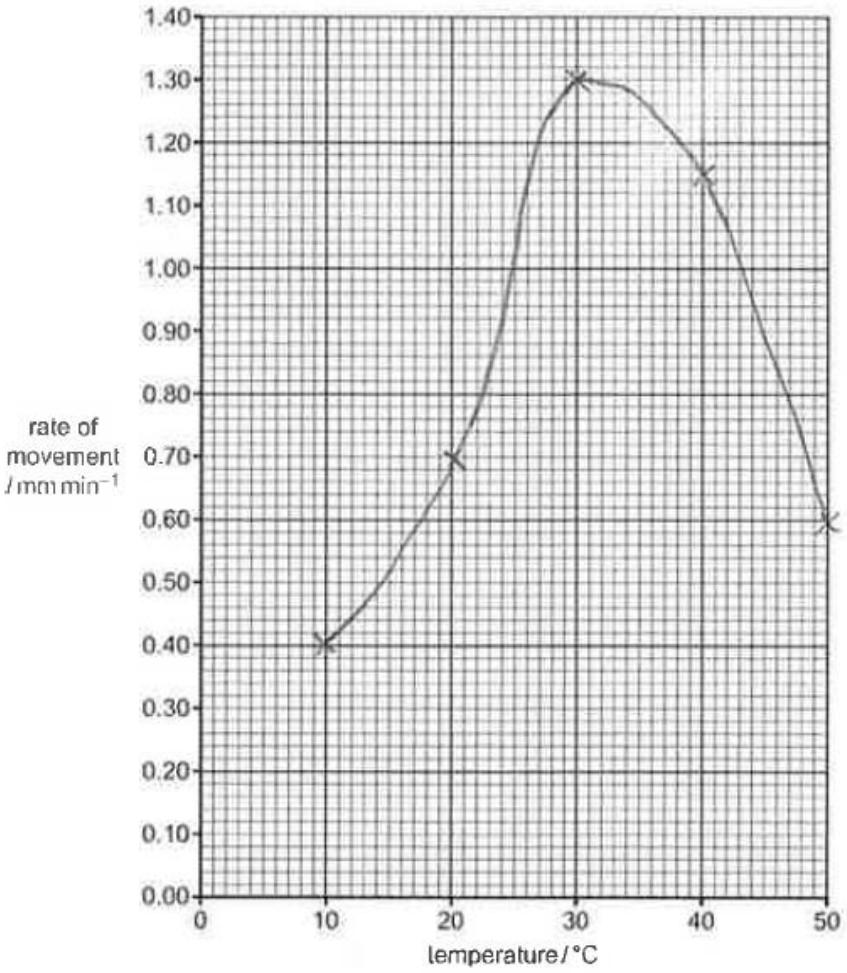


Fig. 8.2

[2]

1. 5 points plotted accurately
2. smooth curve drawn linking all plotted points / curve of best fit *(reject: extrapolation)*

(ii) The rate of movement of the coloured liquid is related to the rate of respiration.

Explain the effect of temperature on the rate of respiration shown in Table 8.1 and Fig. 8.2. [3]

1. *ref. to* respiration is controlled by **enzymes**
2. as temperature increases, the **kinetic energy** of enzymes and substrates **increase**
3. leading to an **increase** in the **frequency/rate of effective collision**s between enzymes and substrates/ **enzyme-substrate complex formation**
4. **30 ºC** is the **optimum temperature** where the **highest rate of respiration** is
5. rate decreases after 30 ºC due to **denaturation** of enzymes/ **loss of specific 3D conformation of active sites**

[Total: 9]

9 Living organisms display an incredible diversity in shape and function. To understand this diversity, biologists use classification systems and phylogeny.

(a) Explain the relationship between classification and phylogeny.

- Classification is organisation of species into groups based on shared **characteristics**(→ uses naming system)

- Classification may not take into consideration **evolutionary relationship** between the species
- Phylogeny is organisation of species according to particular characteristics (mainly molecular homology) which takes into **consideration evolutionary relationship** between the species. .(→ each organism is assigned a position on the phylogenetic tree)

Examiner's comments: Correct points required in the explanation are mirrored in the syllabus.

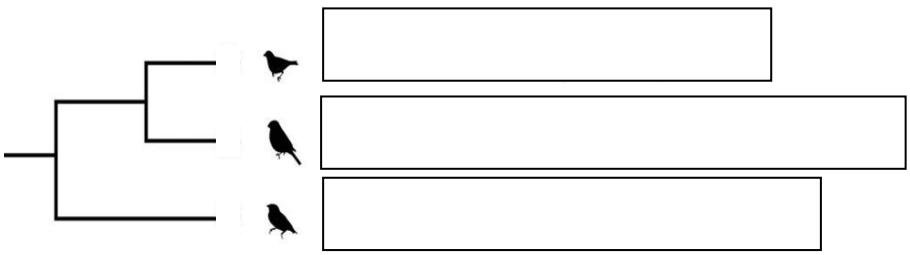
[2]

(b) Percentage similarity in DNA sequences of three different species of songbirds, *Spinus spinus*, *Carduelis carduelis* and *Serinus canaria* is determined by aligning homologous regions and calculating the proportion of identical bases. The results are shown in Table 9.1.

Table 9.1

Species of songbirds from which hybrid DNA was from	**Percentage of similarity in DNA sequences**
Spinus spinus and *Carduelis carduelis*	95.4
Carduelis carduelis and *Serinus canaria*	85.7
Spinus spinus and *Serinus canaria*	82.3

Using Table 9.1, complete the figure below.



[1]

Correct grouping of *Spinus spinus* and *Carduelis carduelis*, *Serinus canaria*; (Underline species names)

(c) The songbirds inhabit the coastlines of islands throughout the Galapagos archipelago.

Fig. 9.2 maps the biogeography of the three species on the Galapagos islands, where the circles represent the proportion of the different species of songbirds on each island.

It is known that the volcanic islands of Galapagos did not emerge at the same time, but progressively over a period of three million years. The map indicates the age of each island in mya (million years ago). The nearest mainland country, Ecuador, is 900 km east of these islands.

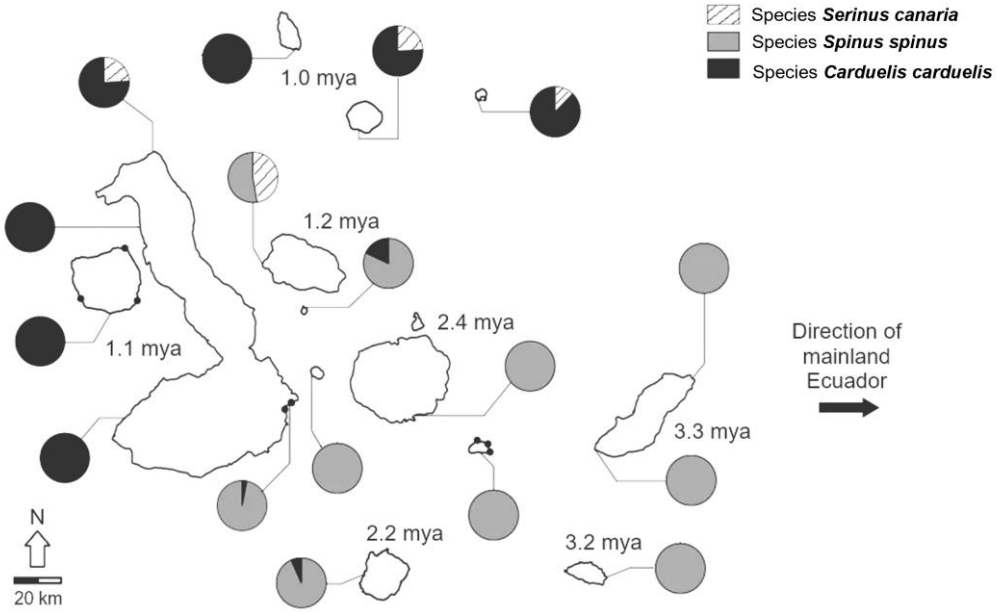


Fig. 9.2

Suggest an explanation for the difference in biogeography in Fig.9.2.

1. The Eastern islands formed earlier between 3.2 to 3.3 mya, followed by the West /Northern islands which are formed between 1.0 to 1.2 mya;
2. The ancestral population could have colonised the Eastern islands from mainland Ecuador;
3. New species may be formed due to geographical isolation by the water bodies, which limited gene flow between populations on different islands;
4. Genetically similar/related populations tend to be found on islands in geographical proximity;
5. Different islands may have varying environmental conditions which exert different selection pressures;
6. Hence different populations/species may experience different reproductive success on each island, resulting in the different proportions of iguanas from each species;

max 3 [3]

(d)
- Humans are drawn to songbirds for their melodic songs.
- Directed evolution is carried out in the laboratory in which different mutations are introduced into the FOXP2 gene (a key gene associated with the *Spinus spinus* songbird's ability to produce complex songs) to create a large number of variants of the FOXP2 gene.
- These gene variants are then injected into the *Spinus spinus* fertilized eggs which will then grow into *Spinus spinus* adult songbirds.
- The *Spinus spinus* adult songbird with the best ability to produce complex songs will then be selected.
- These *Spinus spinus* adult songbirds also thrive on the same dandelion plant seeds diet as the wild type *Spinus spinus*.

Using the information above and **two named** species concepts, explain why the *Spinus spinus* adult songbird that are grown from directed evolution is considered *Spinus spinus* sub-population and not a different species from the wild type *Spinus spinus*.

1. Using the genetic species concept;
2. the genetic distance between the populations is too little to consider them as a distinct species as only the FOXP2 genes is mutated while the entire genome remain largely similar;

3. Using the phylogenetic species concept;
4. there remains a high degree of homologies / similarities in the protein and DNA sequences among the strains and wild type even as FOXP2 genes is mutated, the genes are homologous, and so the sub-population and wild type shares a common ancestor;

5. Using the ecological species concept;
6. The sub-population and wild type are able to utilise the same dandelions plant seeds diet, hence they share the same ecological niche;

(Any 2 pairs) Pt 1 and 2 / pt 3 and 4 / pt 5 and 6 [4]

[Total: 10]

10 El Niño phenomenon is characterised by increased temperatures in the oceans.

(a) **(i)** Explain how El Niño affects coral habitats **and** food chains. [4]

1. El Niño events trigger coral bleaching;
2. Rise in temperature causes the coral to expel the zooxanthellae / cause death of zooxanthellae;
3. Without nutrients and oxygen provided by zooxanthellae;
4. causing death of corals;
5. loss of habitat / refuge / spawning & nursing ground, for other marine species;; or loss of food source, affecting food chain;;
6. predation/death (no place to camouflage/protection), leading to extinction of species;;

Besides loss of coral reef biodiversity, another impact of climate change is also the global spread of dengue. Fig. 10.1 shows the worldwide distribution of dengue.

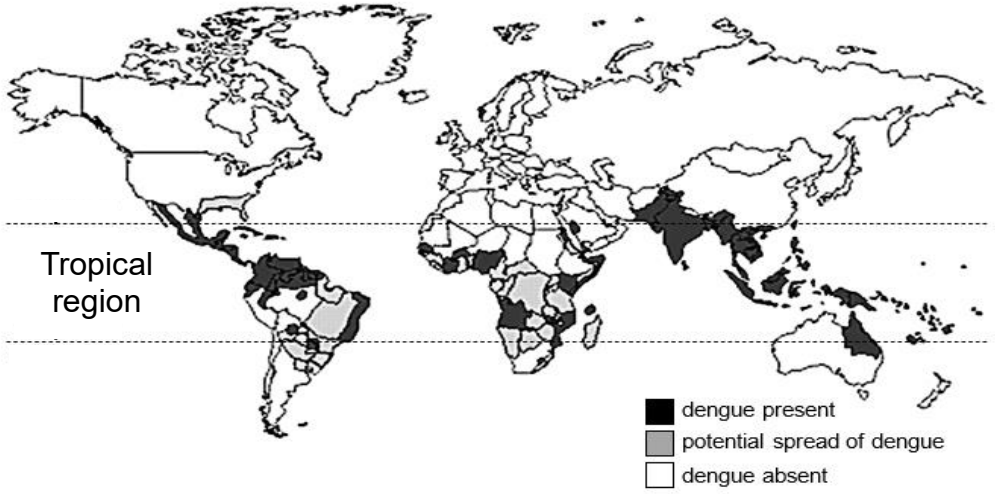


Fig. 10.1

(b) Explain why dengue shows the distribution pattern shown in Fig. 10.1.

1. Dengue is caused by dengue virus which reproduces within *Aedes* mosquito;
2. The *Aedes* mosquito lives in the Tropics (such as Southeast Asia, parts of India, Africa, and Central and South America) which are hot and humid;
3. higher temperatures will shorten the mosquito's life cycle;
4. more rainfall in certain areas creating more pools of stagnant water for mosquito breeding;
5. Potential spread into neighboring regions (including parts of southern United States, northern regions of South America, some regions in central Africa, areas in the Middle East and parts of southern Europe) due to; [3]
6. warming temperatures and human movement introducing dengue viruses into non-endemic zones.

[Total: 7]

11 Fig. 11.1 shows the main steps in an immune pathway involving an immune cell, which occurs during a viral infection.

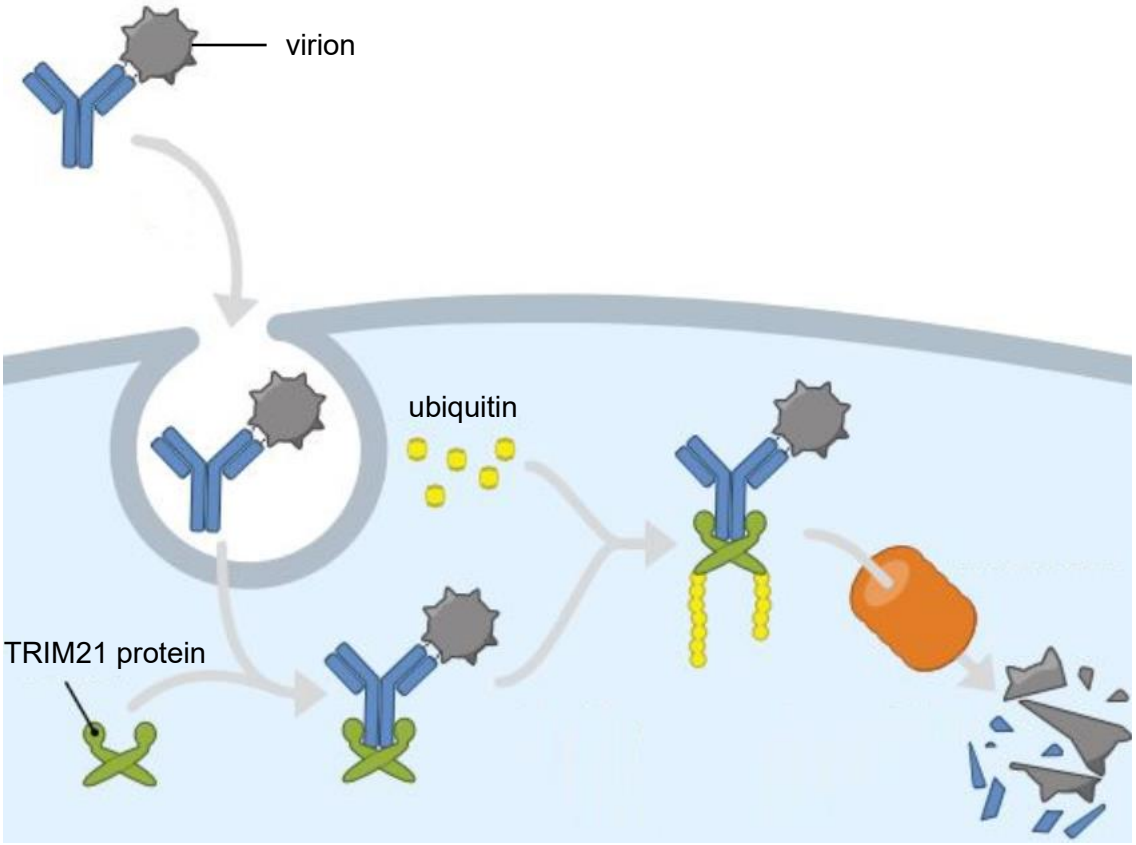


Fig. 11.1

Describe the main stages in this immune pathway, as shown in Fig. 11.1. [5]

1. Antibody **binds** via its **antigen-binding site** to **complementary epitope/ antigen** on the **virion**
2. Antibody-virion complex enters the immune cell by receptor-mediated **endocytosis/ phagocytosis**
3. **TRIM21** protein binds to the **constant region** of the antibody
4. **Ubiquitin** molecules **bind** to the TRIM-21-antibody-virion complex
5. which collectively enters the **proteasome** to be **degraded**

[Total: 5]