Candidate Name: _____

Class	Adm No

H

millennia institute

2023 End-of-Year Examination

Pre-University 3

H2 Biology **9744/02**

Paper 2 Structured Questions **12 September 2023**

2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the question booklet.

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. At the end of the examination, fasten all your work securely together.

For Examiner's Use	
Section A	
1	**/10**
2	**/9**
3	**/10**
4	**/12**
5	**/10**
6	**/13**
7	**/11**
8	**/12**
9	**/5**
10	**/8**
Total	**/100**

Answer **all** questions in this section.

1. Biomolecules function as building blocks for macromolecules to be assembled. Carbohydrate is made up of many monosaccharides and can be found in both animals and plants.

(a) Name the bond formed between monomers in cellulose.

B-(1,4) glycosidic bond; ..... [1]

(b) Illustrate with a **labelled** diagram how two monomers form the bond in **(a)** in cellulose. **Circle** the bond formed between the two monomers.

Fig. 1.1 shows the partial structure of the monomer.

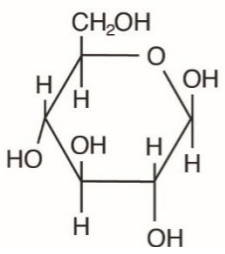
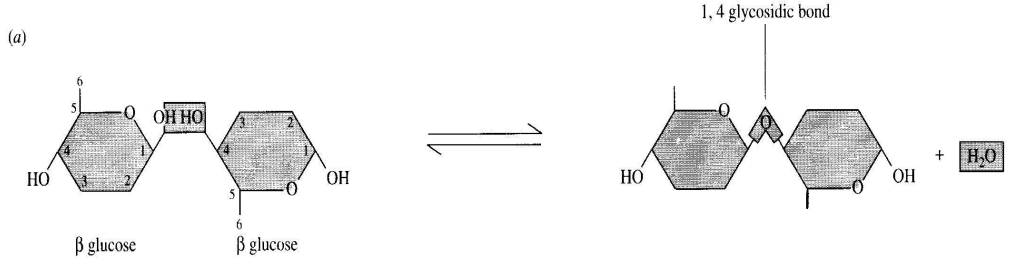


Fig. 1.1

1. Label: β -glucose, water, β(1,4) glycosidic bond
2. Circle glycosidic bond;
3. Water released as by-product;
4. Rotation of monomer;
5. Correct structure of cellobiose;



[4]

(c) One of the defining features of all cells is the cell surface membrane. This membrane is composed of phospholipid bilayer, with other biomolecules dispersed throughout the bilayer.

The carbohydrates portion of glycolipids and glycoproteins are involved in

1. cell-cell recognition, (idea of) which is the ability of a cell to determine if other cells it encounters are (idea of) alike or different from itself;
2. cell-cell adhesion, (idea of) where the two adjacent cells may (idea of) bind with each other, causing adhesion between the cells. This enables cells to orientate and form a tissue.
3. Glycoproteins can act as cell surface receptors that are embedded or attached to the cell surface membrane and have a binding site for specific ligands; [2]

(ii) During the synthesis of phospholipid, the phospholipid sometimes needs to be moved between the layers. The movement is facilitated by a transmembrane protein called floppase.

Fig.1.2 shows floppase moving a phospholipid from the inner layer to the outer layer of the cell surface membrane.

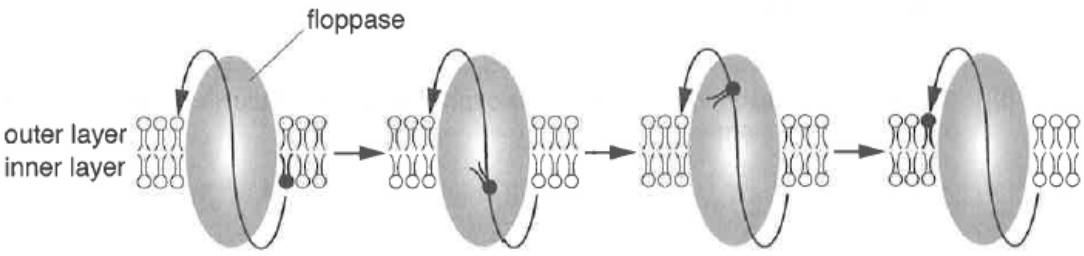


Fig. 1.2

Due to their hydrophilic heads, phospholipid molecules cannot cross the hydrophobic region of the membrane from the inner layer to the outer layer without floppase.

Using your knowledge of proteins, suggest how the structure of floppase allows phospholipids to cross the hydrophobic region of the membrane.

1. The interior channel of floppase is lined with amino acids with hydrophilic R-groups forming a hydrophilic channel;
2. Contains a binding site that is complementary to the 3D structure of phospholipids that allows it to transport only phospholipids;
3. The exterior of floppase is lined with amino acids with hydrophobic R-groups;
4. To allow floppase to be embedded in the membrane via hydrophobic interactions with the hydrophobic fatty acid tails; [3]

[Total :10]

2. Catalase is an enzyme that catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism.

A scientist investigated the activity of two forms of catalase, P and Q, extracted from *Anopheles gambiae*, an important vector of malaria. The scientists investigated the effect of increasing concentration of hydrogen peroxide on the activity of these two forms of catalase.

The results are shown in Fig. 2.1.

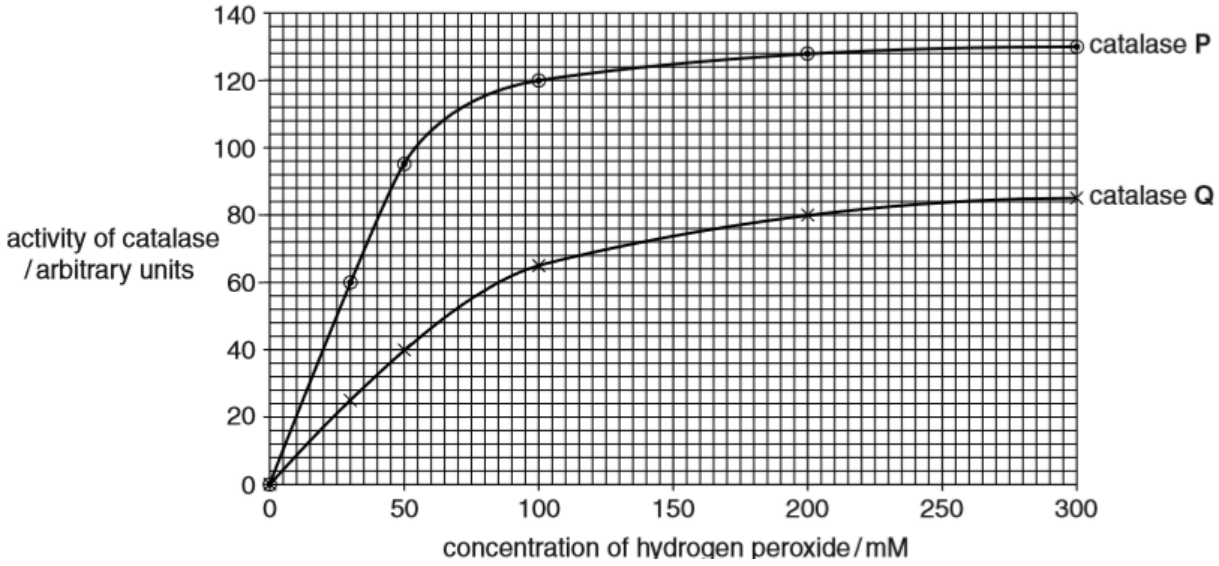


Fig. 2.1

(a) With reference to Fig. 2.1, describe and explain the effect of increasing concentration of hydrogen peroxide on the activity of catalase **P**.

Describe [2 marks]

1. As concentration of hydrogen peroxide increases from 0mM to 100mM, activity of catalase increases **steeply** from 0a.u. to 120 a.u;**OR**
2. As concentration of hydrogen peroxide increase from 0-50mM, activity of catalase increase steeply from 0-96a.u , 50-100mM of H2O2, increase in decreasing rate, 96-120a.u; **OR**
3. As concentration of hydrogen peroxide increases from 100mM to 250mM, activity of catalase increases **gently** from 120a.u. to 130 a.u;
4. As concentration of hydrogen peroxide increases from 250mM to 300mM, activity of catalase remains at **plateau** at around 130/132 a.u;

Explain [2 marks]

5. At low/increasing concentration of hydrogen peroxide, hydrogen peroxide/substrate is the limiting factor;**OR**
6. Active site of catalase/enzyme is available to bind to substrate/hydrogen peroxide;
7. At high concentration of hydrogen peroxide, enzyme/catalase is the limiting factor;**OR**
8. Active site of catalase/enzyme is saturated/mostly occupied by substrate;

..... [4]

(b) Each molecule of catalase consists of four identical polypeptides. The two forms of catalase in *Anopheles gambiae* differ by only one amino acid at position 2 in the amino acid sequence.

Explain how the difference in one amino acid sequence is responsible for the lower activity of catalase **Q** compared with catalase **P**.

1. Amino acid at position 2 is part of the active site of enzyme; [compulsory]
2. R group of the 2 amino acids are different with different properties;
3. Therefore, different folding of polypeptide/secondary structure/tertiary structure and give rise to different 3D conformation of active site;
4. Binding of substrates to catalase P is more (idea of) efficient/higher affinity than to catalase Q;

[3]

(c) Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

The scientist allowed female mosquitoes to feed on blood. They found that female mosquitoes with only catalase **P** produced more eggs than those with only catalase **Q**.

Suggest why there is a difference in egg production between the two types of *Anopheles gambiae.*

1. Increased metabolic rate means increased production of hydrogen peroxide;
2. Catalase P is more effective/has higher enzymatic activity, hydrolysing more hydrogen peroxide and thus lesser toxic hydrogen peroxide remains;
   OR
3. Catalase Q is less effective/has lower enzymatic activity, hydrolysing lesser hydrogen peroxide and thus more toxic hydrogen peroxide remains;
4. Hydrogen peroxide interferes/damaging to egg production;

[2]

[9]

3.

(a) State the function of DNA and describe its property that allow it to perform this function.

1. Function of DNA is to store genetic information;

Property

2. DNA must be chemically stable to encode information without being easily degraded;
3. DNA must be able to replicate accurately so that information can be passed down to the next generation;
4. DNA must be capable of variation to allow for evolutionary changes in a population;

… [2]

(b) In a somatic cell of a eukaryote, 20% of the nitrogenous base in the nuclear DNA is thymine.

Calculate the percentage of nitrogenous base in the nuclear DNA of this cell that is guanine and explain your answers.

Show your working clearly in the space below.

Percentage of thymine and adenine = 20% * 2 = 40 %
Percentage of guanine = (100-40)/2 = 30%

1. Students must show calculation of thymine & adenine, **and** final calculation of guanine;

2. In the double stranded DNA, nitrogenous base of each strand is complementary to the nitrogenous base of the adjacent strand;

3. Adenine base pair with thymine and cytosine base pair with guanine;

[3]

(c) Fig. 3.1 shows the process of DNA replication.

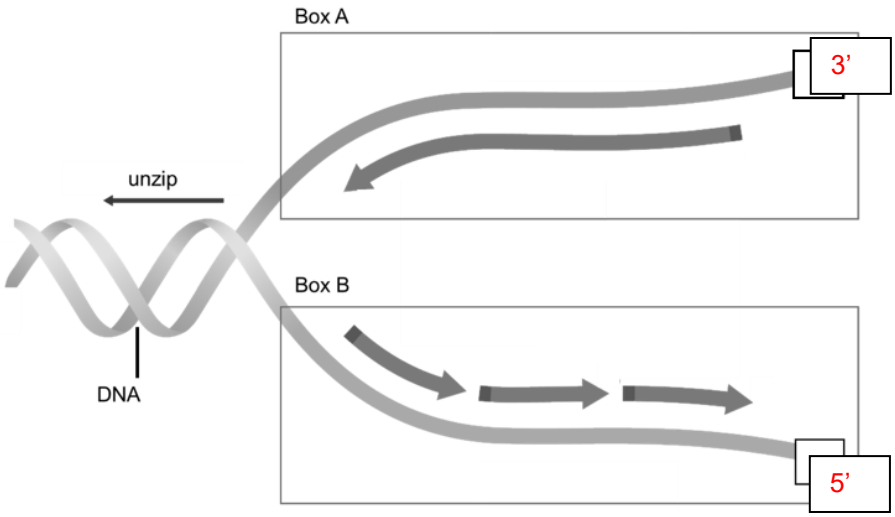


Fig. 3.1

(i) In the boxes provided in Fig. 3.1, label the end of DNA with either

- **3'** or
- **5'**.

[1]

(ii) Explain why DNA is replicated differently in Box **A** and Box **B**.

1. DNA polymerase III only add deoxyribonucleotide to 3'OH of existing strand;
2. DNA strands are antiparallel and DNA synthesis occurs bidirectional ;
3. DNA polymerase moves towards replication fork in Box A while DNA polymerase moves away from replication fork in Box B;OR
4. Daughter strand in Box A is synthesized continuously but daughter strand in Box B is synthesized discontinuously;
5. As DNA unwinds, new primer is needed in box B, forming Okazaki fragments;

..... [2]

(d) During protein synthesis, DNA is used as a template to form mRNA and the resulting mRNA is used as a template to form polypeptide chain.

Describe 2 other differences between the enzyme used to form mRNA and the enzyme used to form polypeptide chain.

1. RNA polymerase is protein in nature while peptidyl transferase is rRNA in nature;
2. Substrate for RNA polymerase is ribonucleotide while substrate for peptidyl transferase is amino acid/activated tRNA;
3. RNA polymerase catalyses the formation of phosphodiester bonds while peptidyl transferase catalyses the formation of peptide bond;
4. RNA polymerase works in the nucleus while peptidyl transferase works in the cytoplasm;

..... [2]
Total :10]

[Turn Over]

4. Sickle cell anaemia is most commonly caused by the haemoglobin variant HbS, a result of a point mutation.

(a) Describe the effect of the point mutation to haemoglobin.

1. Base-pair substitution of thymine to adenine;
2. In the β-globin gene coding for the β–globin polypeptide in haemoglobin;
3. resulting in the change in mRNA codon from GAG to GUG;
4. Instead of charged and hydrophilic glutamic acid, non-polar and hydrophobic valine is coded;
5. Resulting polypeptide folds differently, exposing hydrophobic patch on the outside of protein;
6. This hydrophobic patch may stick to/polymerizes with other hydrophobic patch of other polypeptide chains, forming rigid rod-like fibres;

……...

…… [4]

(b) Sickle cell anaemia can be treated with a drug called hydroxyurea which induces the formation of fetal haemoglobin (HbF). HbF is normally found in fetus and newborn. When present in individuals with sickle cell anaemia, HbF prevents sickling of red blood cells.

(i) Suggest how formation of HbF would be induced.

1. Description of mechanism leading to activation of transcription;
2. Gene coding for HbF is transcribed/activated;
3. Resulting mRNA coding for HbF is translated to form protein;

…… [2]

(ii) Suggest how elevated levels of HbF may reduce the symptoms of sickle cell anaemia.

1. There would be lesser HbS in red blood cells and so there would be less polymerization of haemoglobin;
2. Lesser sickling of red blood cells will result in longer lifespan of red blood cells;
3. HbF has greater affinity for oxygen than HbS, transporting oxygen more readily;

…… [2]

(c) Sickle cell anaemia is caused by a somatic mutation as it affects the somatic cell. On the other hand, germline mutation affects the gametes.

Explain why somatic mutation may have milder consequence than germline mutation.

1. (idea of) Somatic cells are not inherited but gametes are inherited;
2. When mutated gamete fuse with another gamete, the resulting zygote contains the mutation;
3. When the zygote undergoes mitosis, the mutation is transmitted to (idea of) all cells and may be significant for the future of the species;
4. Somatic mutation is lost on the death of the organism;

..... [2]

(d) Mitochondrial complex I deficiency is the most common mitochondrial disorder present in childhood. It can be caused by mutation in mitochondrial DNA (mtDNA) or mutation in nuclear DNA.

The characteristics of the deficiency caused by mutations in mtDNA are:

- a cell in an ovary produces gametes with different proportion of normal mitochondria and mitochondria that contains the mtDNA mutation
- a person has disease symptoms when the proportion of mutant mitochondria in their cells exceed a certain threshold
- the severity of disease symptoms, and the age at which they appear, can vary greatly in the children of one woman.

In a family with history of mitochondrial complex I deficiency that is caused by mutation in a nuclear DNA, the probability of a child inheriting the mutation can be predicted.

Suggest why, in families where mitochondrial complex I deficiency is caused by mtDNA mutation, it is not possible to predict the probability of a child inheriting the mutation.

1. Different children have different amount of mutant mtDNA/mitochondria;
2. Only mother/siblings, with proportion of mutant mitochondria in their cells exceed a certain threshold will show symptoms;
3. (idea of) Does not show typical patterns of inheritance;
4. mtDNA is inherited only from mother/maternally;

..... [2]

[Total :12]

5. Polymerase chain reaction (PCR) is a molecular technique commonly used in molecular biology.

(a) Describe the aim of PCR.

Produce/amplify a large number of identical copies of DNA from a very small starting sample;

..... [1]

(b) Describe what occurs in the

(i) first stage,

1. By heating / increasing temperature to ~95°C, the hydrogen bonds between the complementary base pairs are broken;
2. The target DNA double helix is denatured as the two strands of the target DNA molecules are separated into single-stranded DNA;

..... [2]

(ii) second stage,

1. decreasing temperature to ~55°C;
2. 2 complementary DNA primers anneal/ bind to the 3'ends of the single-stranded target DNA;

... [2]

(iii) third stage of PCR.

1. Heating to ~72 °C, the optimum temperature of Taq polymerase;
2. Catalyses the formation of phosphodiester bond between adjacent deoxyribonucleotides to synthesise new DNA strands via complementary base pairing in the 5' to 3' direction;

... [2]

(c) State the number of DNA molecules formed after 100 cycles of PCR.

2^{100} ..... [1]

In the set-up of PCR, all the required components are placed in a machine called thermocycler. The enzyme responsible for PCR has a half-life of around 40 minutes at 95^{o}C.

(d) With reference to your knowledge of PCR, explain why a half-life of 40 minutes at 95^{o}C allow many cycles of PCR before the enzyme needs to be replaced.

1. The denaturation step carried out at 95^{o}C only takes approximately 1 min/very short; …….
2. (idea of) Many cycles can occur within a single half-life of the enzyme before the enzyme loses its catalytic activity; …….

……. [2]

[Total :10]

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6. Prokaryote reproduces via asexual process, producing clones of daughter cells.

Despite this, prokaryotes exhibit a wide range of adaptations, suggesting the presence of genetic variation in prokaryotes. Genetic recombination and random mutation can lead to the variation in prokaryotic genome. However, the probability of random mutation occurring in the population is relatively low.

(a) State why random mutation may still lead to genetic variation in prokaryote despite its low rate.

1. Rapid reproduction rate/short generation time of binary fission;
2. Large population size of bacteria in a population;

[1]

Genetic recombination is the combination of DNA from two sources into the genome of an individual. In prokaryotes, transformation is one such processes.

(b) Describe how transformation leads to genetic variation in prokaryotic genome.

1. Uptake of foreign, naked DNA by prokaryotic cell from the surrounding environment;
2. The foreign DNA binds to the cell surface receptor on the surface of prokaryote;
3. Resulting DNA is incorporated into the prokaryote's genome via homologous recombination;

[2]

Transformation is exploited in the laboratory to make copies of eukaryotic genes in large amount. Fig. 6.1 shows how insulin gene is inserted into bacterial plasmid.

In Fig. 6.2, the resulting plasmid is added to bacteria cell that is treated with calcium chloride ($CaCl_2$). Usually, the bacterial cell is also subjected to heat shock to facilitate the uptake of plasmid DNA. Bacteria cells that have successfully taken up the plasmid DNA is known as transformed bacterial cells. The transformed bacterial cells are plated on agar plate with suitable growth medium, allowing scientists to identify cells that express the insulin gene.

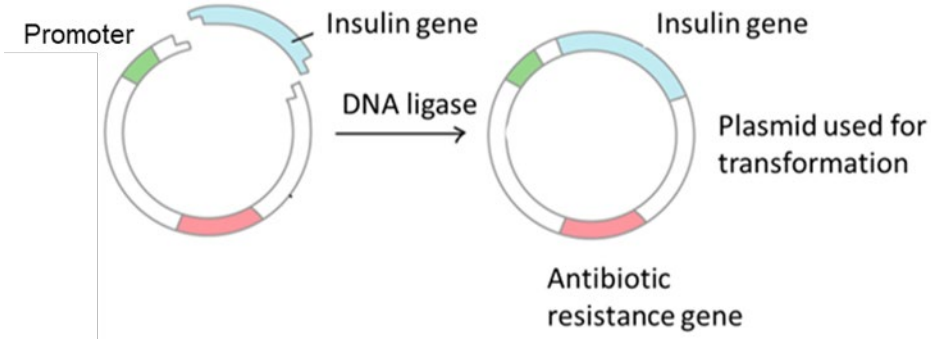


Fig. 6.1

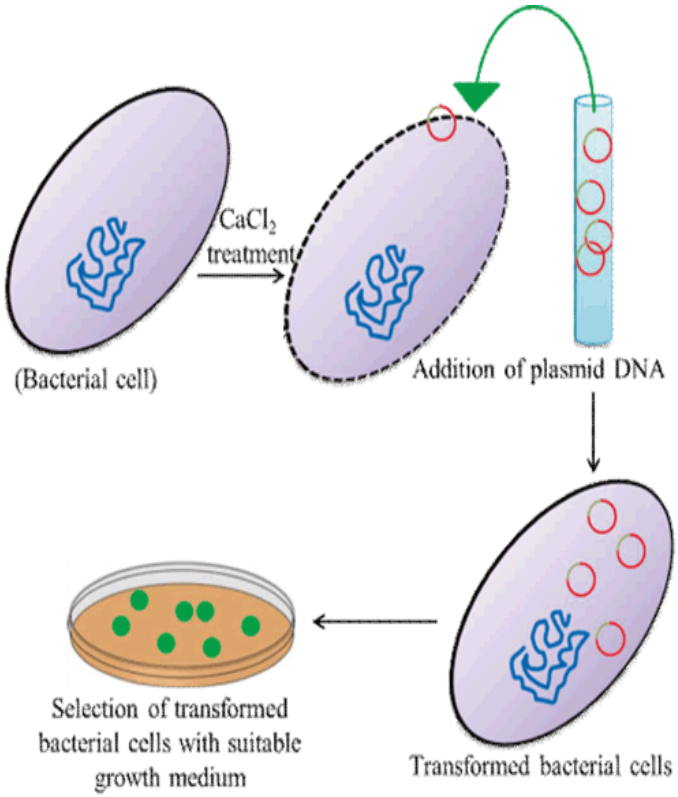


Fig. 6.2

(c) With reference to all the information provided and your knowledge of molecular biology,

(i) Explain why insulin gene obtained from eukaryote can be added into plasmid DNA.

1. Both insulin gene and plasmid are cut by the same restriction enzyme to produce sticky ends;**OR**
2. The ends of insulin gene have nucleotides that are complementary to the nucleotides on the end of plasmid DNA;
3. All organism has the same genetic code;
4. Both are dsDNA:

(ii) Explain the importance of growing bacterial cells on agar plate with suitable growth medium.

1. The growth medium contains antibiotics that allow selection of bacterial cells that express antibiotic resistance gene;
2. If the cells contain plasmid DNA, it will express antibiotic resistance gene that allows it to grow on agar containing the antibiotics;
3. To identify bacteria that may contain the plasmid DNA/recombinant plasmid;

..... [2]

(iii) Suggest how calcium chloride and heat shock can facilitate the uptake of plasmid DNA into the bacterial cell.

1. Calcium chloride will impart positive charge to the bacterial cell wall/cell surface membrane, attracting negative charged plasmid DNA to the bacterial cell;
2. Heat shock will disrupt the phospholipid bilayer/cell wall/open pores on bacterial surface;

..... [2]

After selection of transformed bacterial cell, DNA analysis is conducted to check if plasmid in bacteria contains the insulin gene.

(d) Outline how Southern Blot is used to detect the presence of insulin gene.

1. Plasmid DNA is digested with restriction enzyme to yield restriction fragments;
2. Restriction fragments are separated by gel electrophoresis;
3. DNA on the gel is transferred/blotted to nitrocellulose membrane;
4. DNA probe complementary to the insulin gene is used to identify insulin gene;
5. Labelled DNA probe is detected via either autoradiography/ or ultraviolet light;

..... [4]

[Total :13]

7. *Thermus thermophilus* is a bacterium found in hot springs. The bacterium respires aerobically, even though the high temperature of hot spring leads to low solubility of oxygen in water.

One strain of *Thermus thermophilus,* HB8, expresses the enzyme, nitrate reductase, which allows nitrate to be used as final electron acceptor in the electron transport chain.

(a) Name the cellular location(s) where ATP is formed during aerobic respiration.

Cytoplasm/cytosol and mitochondria; ..... [1]

(b) Explain the advantage that HB8 has in hot springs.

1. By having nitrate/another molecule as the final electron acceptor, oxidative phosphorylation can occur at higher rate despite the low amount of oxygen;
2. and (idea of more) increase rate of ATP formation;

..... [2]

A mutant strain of HB8, known as HB8 mutant, was artificially created by introducing mutation to the gene that codes for nitrate reductase.

An investigation was carried out to find out the population growth of HB8 and HB8 mutant in aerobic and anaerobic conditions. In each experiment, a flask containing bacterial culture medium was incubated. Table 7.1 shows how the flasks were set up.

Table 7.1

flask	bacteria	conditions
1	HB8	aerobic
2	HB8 mutant	
3	HB8 and HB8 mutant	
4	HB8	anaerobic
5	HB8 mutant	
6	HB8 and HB8 mutant	

The number of bacteria in each flask was calculated after 20 hours and the results are shown in Fig. 7.1.

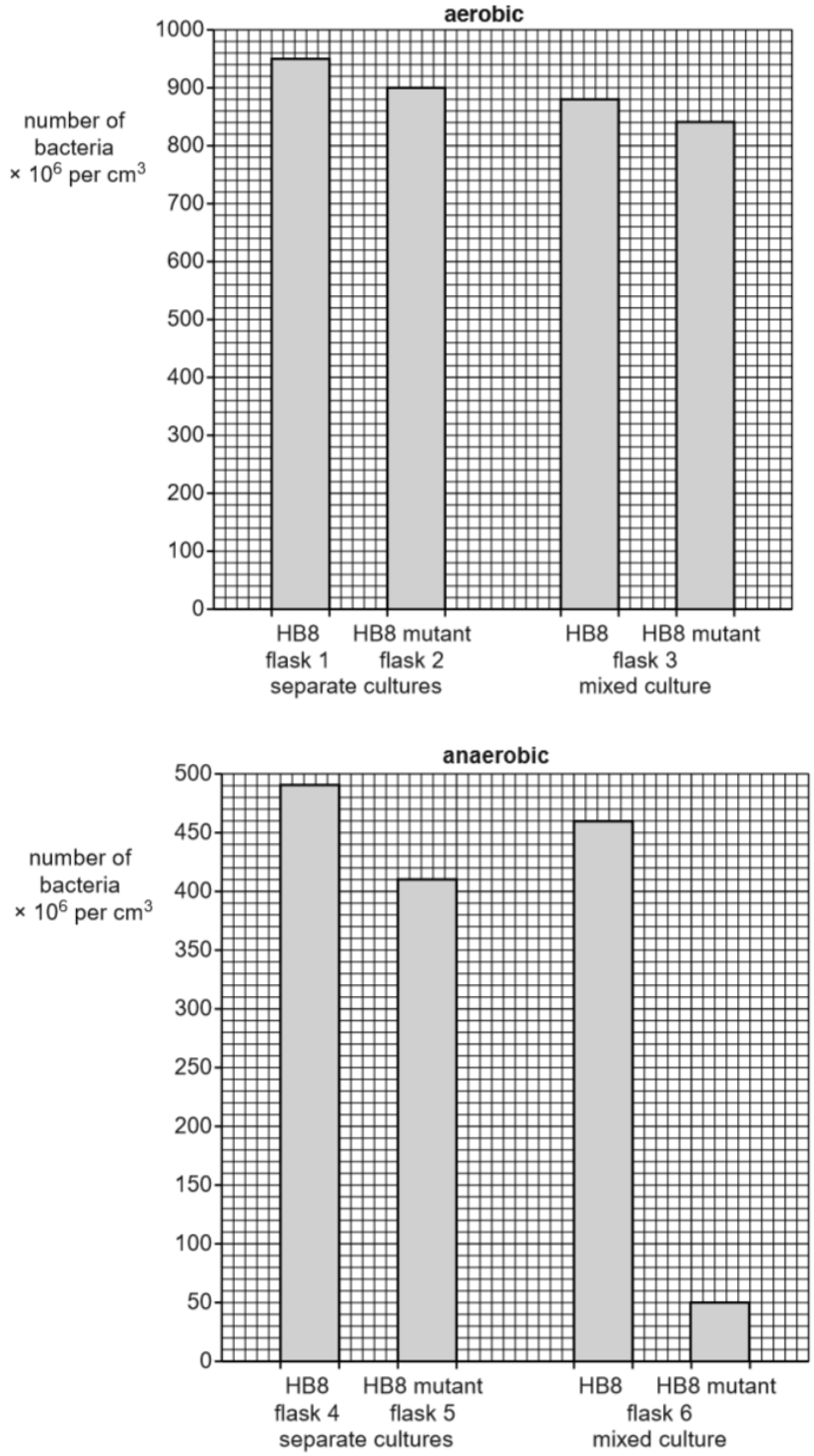


Fig. 7.1

(c) With reference to the information given, describe the growth of

(i) the two strains of bacteria in **aerobic and anaerobic** conditions in **separate** cultures,

1. There is always higher bacterial growth in HB8 than HB8 mutant in aerobic, as shown by 950 x 10^6 over 900 x 10^6 bacteria per cm^3 in aerobic respiration ;
2. There is always higher bacterial growth in HB8 than HB8 mutant in anaerobic respiration, as shown by 490 x 10^6 over 410 x 10^6 bacteria per cm^3 ;
3. The bacterial growth of both HB8 and HB8 mutant is higher in aerobic condition than anaerobic conditions, as shown by 950 x 10^6 over 490 x 10^6 bacteria per cm^3 of HB8 and 900 x 10^6 over 410 x 10^6 bacteria per cm^3 of HB8 mutant;

..... [2]

(ii) **all** the bacteria strains in **anaerobic** conditions.

1. There is higher bacterial growth in **HB8 than HB8 mutant** in separate culture, as shown by 490 x 10^6 over 410 x 10^6 bacteria per cm^3 in separate cultures;
2. There is higher bacterial growth in **HB8 than HB8 mutant** in mixed culture, as shown by 460 x 10^6 over 50 x 10^6 bacteria per cm^3 in mixed cultures;
3. The **difference between HB8 and HB8 mutant** is greater in mixed cultures than in separate culture;
4. The bacterial growth of both HB8 and HB8 mutant is higher in **separate cultures than mixed culture**, as shown by 490x 10^6 over 460 x 10^6 bacteria per cm^3 of HB8 and 410 x 10^6 over 50x 10^6 bacteria per cm^3 of HB8 mutant;

(d) Describe how anaerobic respiration in yeast cells differs from anaerobic respiration in bacterial cells.

1. Lactate fermentation occurs in bacterial cells while alcoholic fermentation occurs in yeast cell during anaerobic respiration;
2. During anaerobic respiration in bacterial cells, pyruvate is converted to lactate while in yeast cells, pyruvate is converted into ethanol;
3. Fermentation in bacterial cells is 1 step process but fermentation in yeast cells is two steps process/no intermediate vs with intermediate;
4. During anaerobic respiration in bacterial cells, no carbon dioxide/no decarboxylation while in yeast cells, carbon dioxides released/ decarboxylation occurs;
5. During fermentation in bacterial cells, lactate dehydrogenase is the enzyme while in yeast cells, pyruvate decarboxylase and ethanol/alcohol dehydrogenase are the enzymes;

[3]
11]

8. In the sweet pea plant, one gene codes for flower colour and one gene codes for pollen grain shape.

Flower colour is either purple or red, and the allele **F** coding for purple flowers is dominant over the allele **f** coding for red flowers.

Pollen grain shape is either long or round, and the allele **G** coding for long pollen grains is dominant over allele **g** coding for round pollen grains.

(a) A dihybrid cross was carried out between homozygous dominant and homozygous recessive sweet pea plant parents to produce the F1 generation.

The offspring from the F1 generation were crossed to produce the F2 generations. Table 8.1 shows the actual results of the cross.

Table 8.1

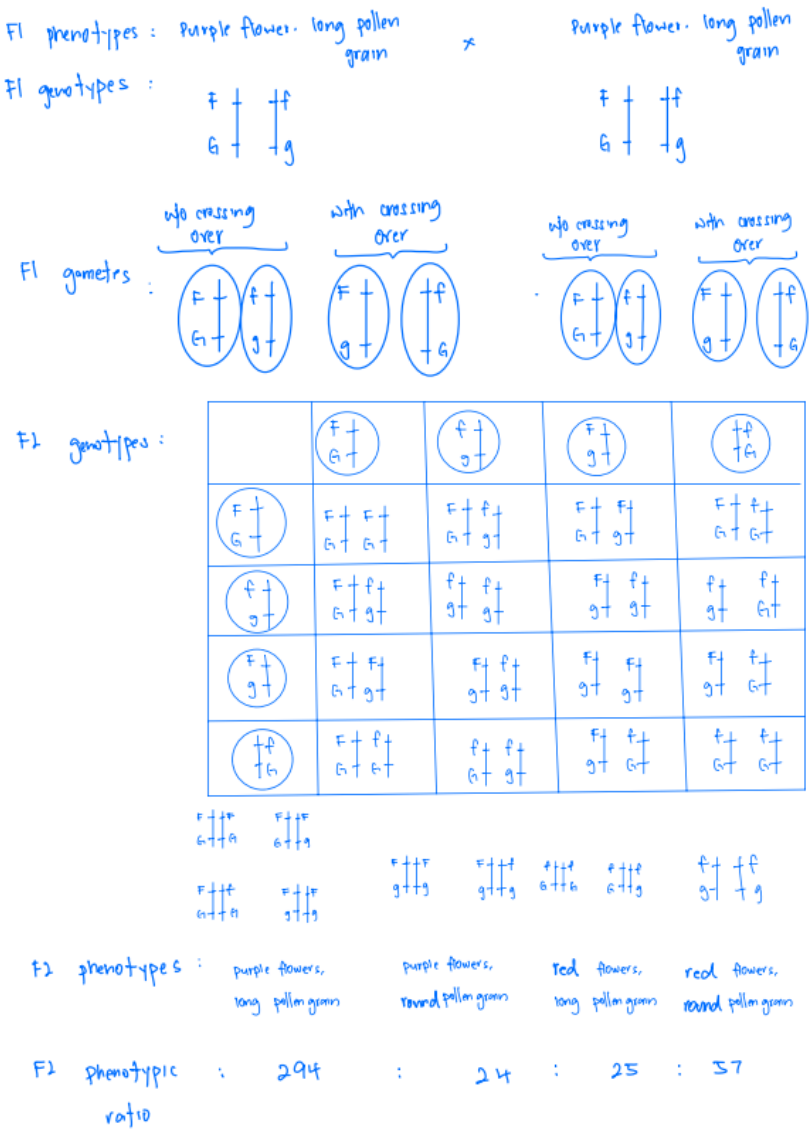
Phenotypes of F2 offspring	Number of individuals
purple flowers, long pollen grains	294
purple flowers, round pollen grains	24
red flowers, long pollen grains	25
red flowers, round pollen grains	57

(i) Explain how the results support the fact that this is a non-mendelian inheritance.

1. The F2 phenotypic ratio does not shown the mendelian F2 ratio of 9:3:3:1;
2. There are higher number of parental phenotypes than the number of recombinant phenotypes;

..... [2]

(ii) Draw a genetic diagram to show the actual cross between the two offspring from the F1 generation.



[4]

1. Correct F1 genotypes;
2. Correct F1 gametes; (e.c.f)
3. Punnett square; (e.c.f)
4. Correct F2 genotypes matched with phenotypes;
5. Correct F2 phenotypes and ratio;

(b) A test cross was carried out with sweet pea plants known to be heterozygous for both flower colour and pollen grain shape.

The results of the test cross are shown in Table 8.2.

Table 8.2

Phenotypes of F2 offspring	Observed number of individuals (O)	Expected number of individuals (E)	(O-E)	$(O-E)^2$	$\frac{(O-E)^2}{E}$
purple flowers, long pollen grains	105	50	55	3025	60.5
purple flowers, round pollen grains	15	50	-35	1225	24.5
red flowers, long pollen grains	16	50	-34	1156	23.12
red flowers, round pollen grains	64	50	14	196	3.92

(i) Chi-squared test was carried out to investigate if the results in Table 8.2 were significantly different from those expected.

The formula for chi-squared test is shown in Fig. 8.1.

$$X^2 = \Sigma \left\{ \frac{(O-E)^2}{E} \right\}$$

Fig. 8.1

Complete Table 8.2 and calculate the value of χ^2. Show your working clearly in the space below.

1. Correct E;
2. Correct $(O-E)^2$;
3. Correct $(O-E)^2/E$;
4. Correct chi-square of 112.04;

Value of χ^2 : ..... [4]

(ii) The results of a test cross can be used to determine a crossover value (COV). A crossover value is the percentage of the total number of offspring showing recombination.

The COV can be calculated using the formula below.

$$\text{COV} = \frac{\text{number of recombinants}}{\text{total number of individuals}} \; x \; 100$$

Calculate the COV from the **observed results** shown in Table 8.2. Show your working clearly in the space below.

COV = (15+16)/200 *100 ;
= 15.5 ;

COV : …… %[2]
[Total :12]

9. The greenish warbler, *Phylloscopus trochiloides*, is a species of small bird that originated in India. Thousands of years ago, populations of the greenish warbler spread around the world to establish themselves in north-eastern Europe and Siberia (Fig. 9.1).

The following describes the changes:

- A gradual change in characteristics occurred in these populations, leading to different forms of the greenish warbler.
- One example of gradual change is in the song of the male warbler, which is very distinctive and used in mating behaviour.
- When greenish warblers from north-eastern Europe meet those from Siberia, no mating takes place.

Fig. 9.1

Explain why the greenish warblers from north-eastern Europe and Siberia are considered different species.

1. Pre-existing variation occurs in ancestral population due to spontaneous mutations, with some individuals having different mating call;
2. Over many generations, the mating call became more distinct, and birds began to distinguish between the two mating calls, (idea of) mating preferentially with members with the same calls;
3. The two populations do no interbreed and gene flow between the subpopulations does not occur;
4. Change in allele frequency of each population take place through mutation, natural selection, and genetic drift independently;
5. Description of natural selection or genetic drift;
6. Over time, the two species became genetically distinct and are reproductively isolated, and sympatric speciation has occurred;
7. The greenish warblers from north-eastern Europe and Siberia are unable to interbreed to form fertile and viable offspring;

…… [5]
[Total:5]

10. The green sea turtle, *Chelonia mydas*, are found in coastal areas and can live for at least 70 years. The sex of green sea turtle is determined by the temperature at which their eggs develop in the nest. The sex of green sea turtles can therefore be affected by climate change.

Green sea turtles mate near the beach where they nest. The female lay about 100 eggs and the eggs hatch after about 55 days.

The Great Barrier Reef in the Coral Sea off the coast of Australia has two populations of green sea turtles.

- Population **N** breeds and nest at the northern end of the Great Barrier Reef
- Population **S** breeds and nest at the southern end of the Great Barrier Reef

In 2014, scientists studied the relative proportions of male and female green sea turtles in three age groups within population **N** and population **S**. The results of this study are shown in Table 10.1.

Table 10.1

Age/years	Percentage within each age group of population **N**		Percentage within each age group of population **S**	
	male	female	male	female
25 – 70	13	87	31	69
15 – 25	1	99	35	65
5 - 14	1	99	32	68

(a) For each population, describe the age-related trends in the percentage of males and females.

population **N** ……

For age group of 5 -14 and 15-25, percentage of females is significantly higher than percentage of male, except for age group 25-70 where percentage of male increases from 1% to 13%;

population **S** ……

For all age groups, percentage of female is (idea of) almost double of the percentage of males;

…… [2]

Fig. 10.1 shows how the temperature at which the eggs of green turtles develop determines the sex of offspring.

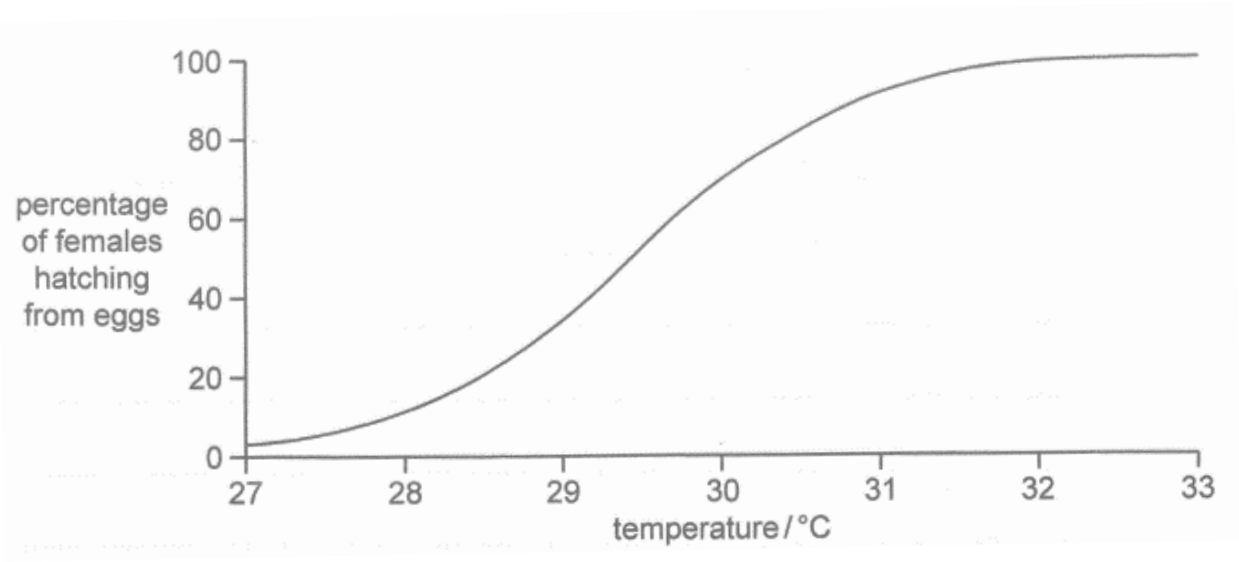


Fig. 10.1

(b) Use the information to suggest an explanation for the age-related trends in the percentage of males and females in each of the two populations, as shown in Table 10.1.

population **N** ……

1. Around 70 years ago, environmental temperature was around 30.5°C, resulting in around 87% of eggs to hatch as females;
2. Temperatures began to rose, around 25 years ago, environmental temperature rose to beyond 31°C, resulting in around 99% of eggs to hatch as females;

……..

……..

……..

population **S** ……

1. Temperature was relatively constant around 29.5°C for the past 70 years;
2. Resulting in around 65-69 percentage of eggs to hatch as females;

……..

……..

…… [4]

(c) Explain why population **N** could become extinct if the age-related trend in the percentage of males and females continues for another 50 years.

1. If temperatures continue to rise, 100% of eggs which hatch would be females;
2. As such, there would be no males to fertilise eggs and no offspring would be form, causing the population to go extinct;

…… [2]

[Total:8]

End of Paper