MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER | | |

H1 BIOLOGY

8875/01

Paper 1 Multiple Choice

21 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

Write in soft pencils.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

There are thirty questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**. Choose the one you consider correct and record your choice in soft pencil on the Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

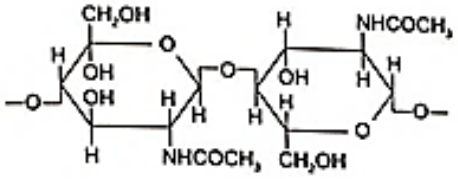
You may keep this booklet after the examination.

This paper consists of **16** printed pages.

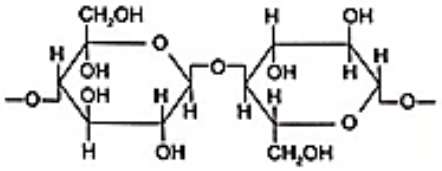
[Turn over]

QUESTION 1

The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



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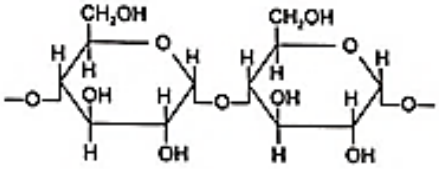

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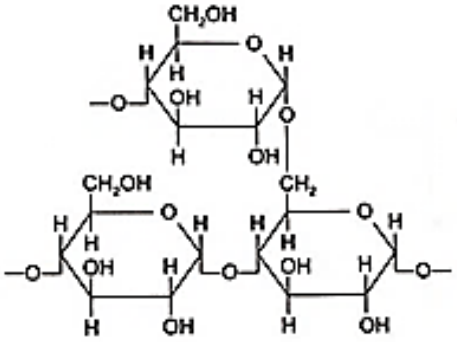

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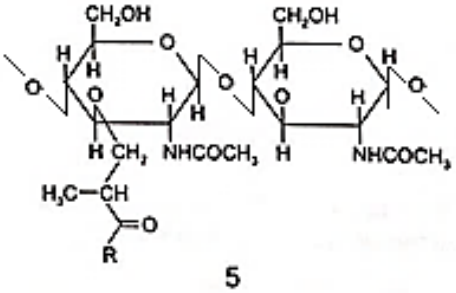

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The polysaccharides can be described as below.

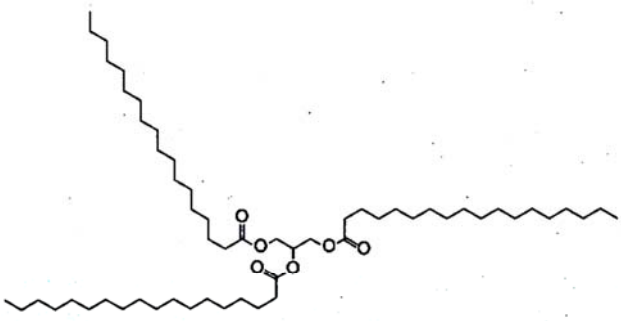
- Polysaccharide **F** is composed of β-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **G** is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds.
- Polysaccharide **J** is composed of α-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

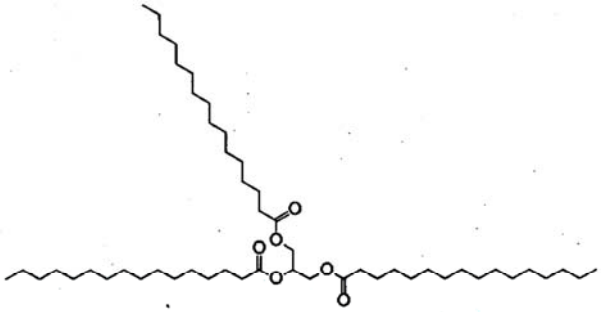
	Polysaccharide				
	F	**G**	**H**	**J**	**K**
A.	2	4	5	3	1
B.	2	5	4	1	3
C.	3	4	1	2	5
D.	3	5	4	1	2

QUESTION 2

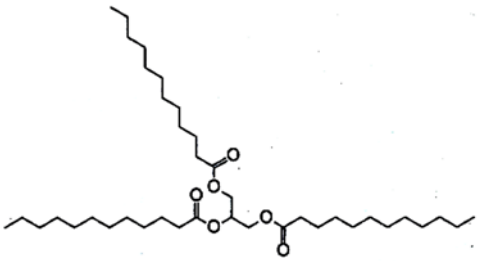
The formulae and melting points of five triglycerides are shown in the diagram. Each triglyceride contains three identical fatty acids.



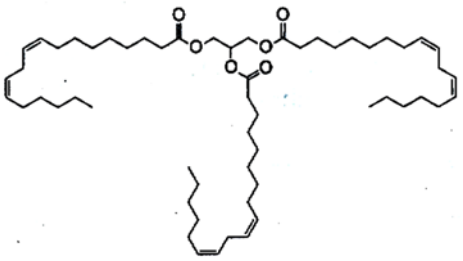
tristearin 72 °C



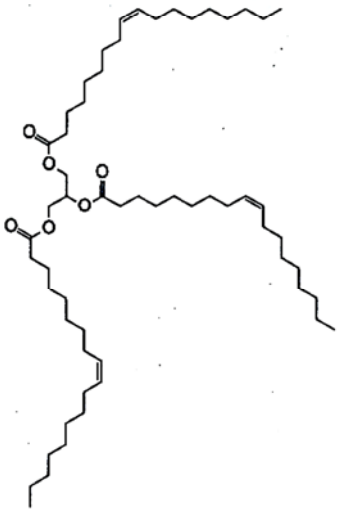
tripalmitin 65.5 °C



trilaurin 46 °C



trilinolein –13 °C



triolein –4 °C

Which two structural features of the molecules make the melting point higher?

	number of double bonds	length of fatty acid chains
A.	fewer	longer
B.	fewer	shorter
C.	more	longer
D.	more	shorter

QUESTION 3

Four students, **A, B, C** and **D**, were given the same sequence of amino acids removed from a collagen molecule. Each student was asked to analyse the sequence and to explain how their analysis could be linked to a feature of collagen

Which student's statement shows a correct feature of collagen linked to a correct analysis of the amino acid sequence?

A. Collagen has polypeptides arranged parallel to each other and the sequence contains a large variety of amino acids with different sized R-groups.

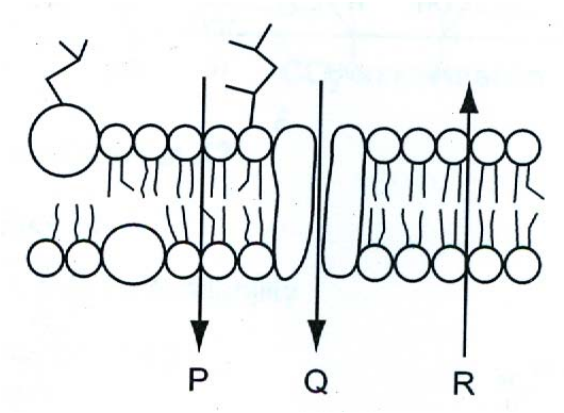
B. Collagen has polypeptides that are arranged very closely together and the sequence has every third amino acid as glycine.

C. Collagen has three polypeptides that can fold into a globular structure and the sequence contains cysteine and amino acids with hydrophobic R groups.

D. Collagen is an insoluble molecule and the sequence contains a large proportion of amino acids with hydrophilic R-groups.

QUESTION 4

The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.



What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

	P	Q	R
A.	diffusion of glucose	diffusion of oxygen	diffusion of water
B.	diffusion of oxygen	diffusion of water	diffusion of glucose
C.	diffusion of water	active transport of glucose	diffusion of oxygen
D.	diffusion of oxygen	Facilitated diffusion of glucose	diffusion of water

QUESTION 5
What could be a possible explanation for the ability of lysosomes to withstand self-digestion?

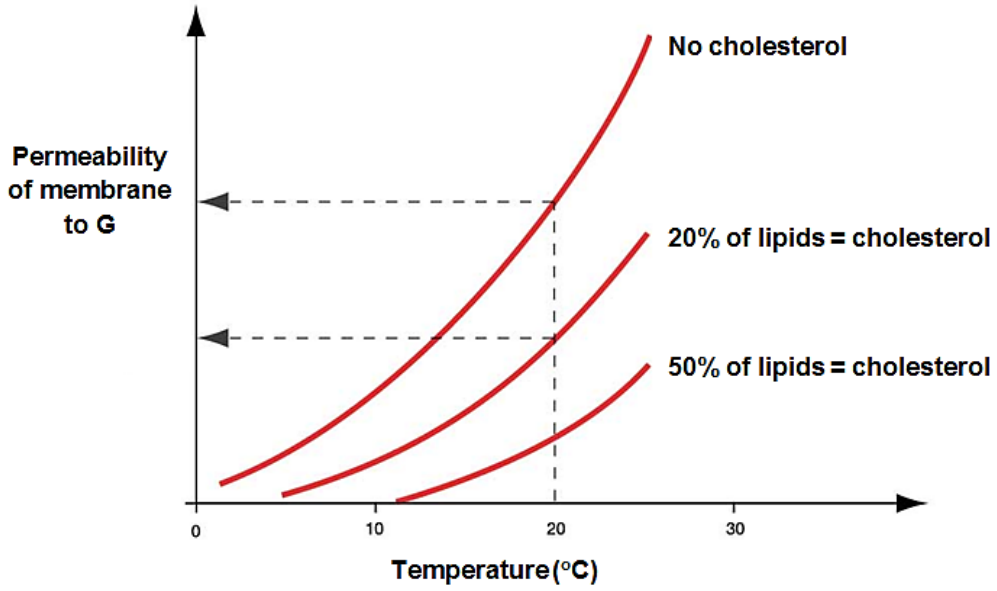
A. Lysosomes contain inactive hydrolytic enzymes.

B. Lysosome membrane has numerous modified proteins with carbohydrate side-chains.

C. Lysosomes do not contain lipases which are the enzymes capable of digesting the lipid membrane.

D. Hydrolases in the lysosomes are inhibited by the acidic internal environment of the lysosomes.

QUESTION 6
The graph below shows the permeability of three different membranes to chemical **G** at different temperatures. These three membranes differ in the amount of cholesterol present in the phospholipid bilayers.



Which of the following is a possible explanation for the observed data?

A. Increase in temperature increases the permeability of the membrane to **G** as cholesterol increases the fluidity of the phospholipids.

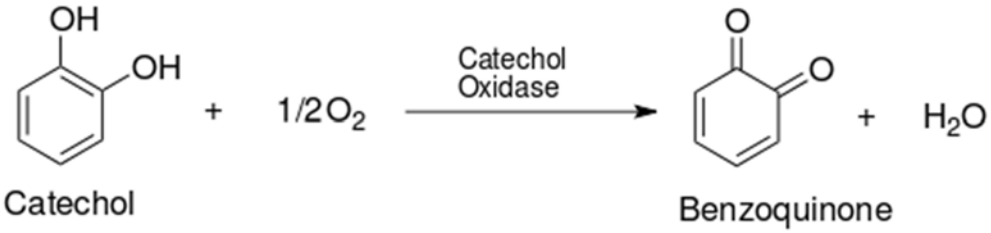
B. At 20°C, an increase in the proportion of cholesterol in the membrane increases the permeability of membrane to **G** as both cholesterol and **G** are non-polar.

C. Increase in the proportion of cholesterol decreases the permeability of the membrane to **G** as cholesterol decreases the fluidity of the phospholipids.

D. With an increase in the proportion of cholesterol in the membrane, a lower temperature is required to achieve the same level of permeability for **G** as **G** will gain a higher kinetic energy to penetrate the membrane.

QUESTION 7

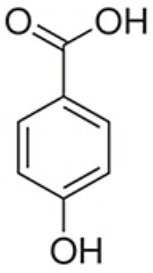
Catechol is oxidised to benzoquinone, as shown in the equation, resulting in darkening of peeled fruits.



Catechol

Benzoquinone

Catechol oxidase is an enzyme which is inhibited by parahydroxybenzoic acid (PHBA). When PHBA binds to catechol oxidase, it does not change the shape of the enzyme. The structure of PHBA is shown below.



PHBA

Which of the following statements are **not** correct?

1. PHBA acts as a competitive inhibitor because its structure is similar to the active site of catechol oxidase.
2. PHBA acts as a non-competitive inhibitor because it does not change the shape of the active site of catechol oxidase.
3. In the presence of PHBA, the same Vmax can be attained at higher catechol concentration.
4. PHBA prevents the formation of enzyme-substrate complex between catechol oxidase, catechol and O_2.

A. 1 and 2 only

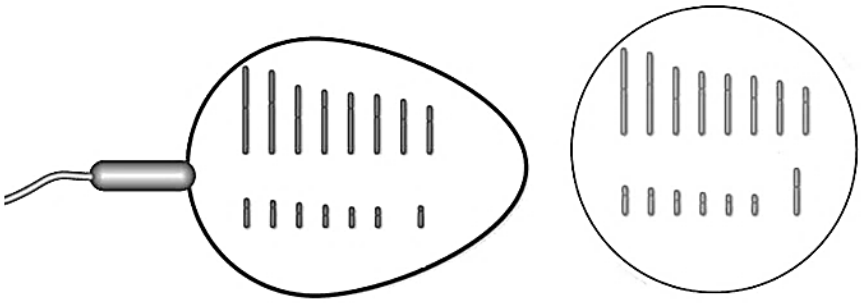
B. 3 and 4 only

C. 1, 2 and 3 only

D. All of the above

QUESTION 8

The diagram below shows the egg cell and sperm cell formed by one mammal species, as well as the number of chromosomes they contain.

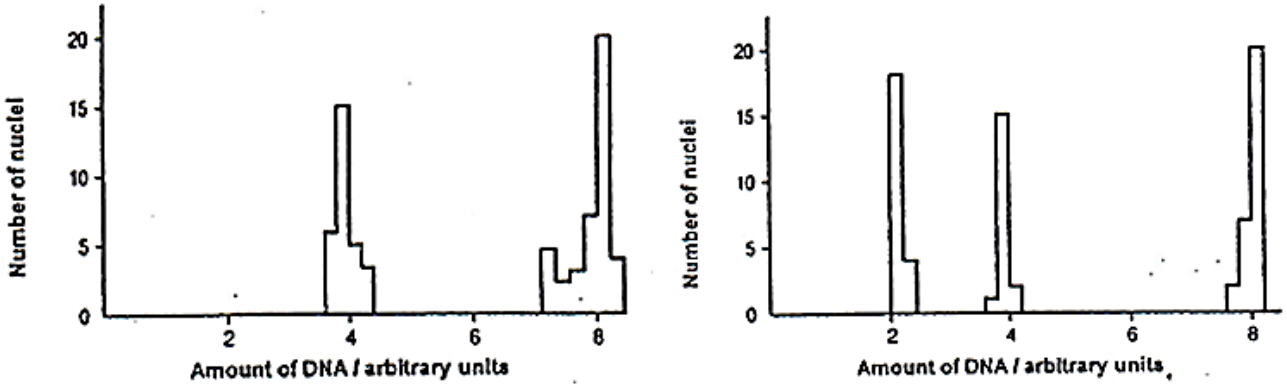


How many DNA molecules would be found in a germ cell (cell that gives rise to gametes) from this organism at prophase II of meiosis II?

A. 15 **B.** 30 **C.** 60 **D.** 120

QUESTION 9

The graphs below show the amount of DNA in the nuclei of cells taken from two different parts of a mammalian testis undergoing different nuclear division processes.



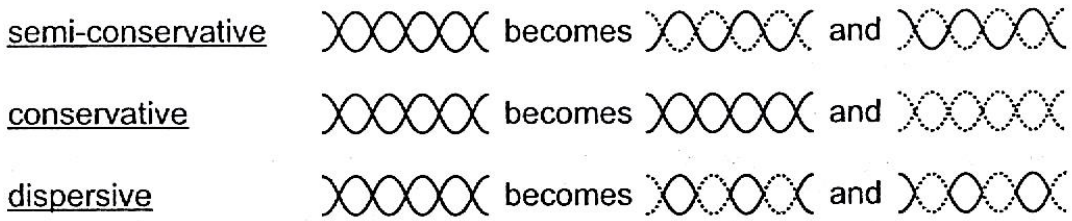
Which correctly describes one **unique** event taking place in the cells from graph **1** and graph **2** respectively?

	Graph 1	**Graph 2**
A.	Duplication of DNA	Separation of homologous chromosomes
B.	Separation of identical sister chromatids	Separation of non-identical sister chromatids
C.	Separation of non-identical sister chromatids	Formation of gametes
D.	Breaking and rejoining of homologous regions of chromosomes	Separation of homologous chromosomes

QUESTION 10

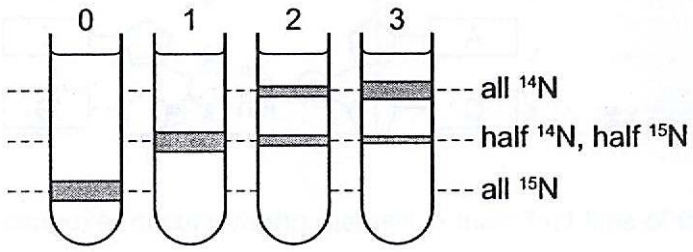
Meselson and Stahl found that in dividing cells, DNA is copied by semi-conservative replication. At the time of their discovery it was thought that DNA might be copied in one of three ways.

In the diagram, the original DNA strands are shown by solid lines and the copy strands by dotted lines.

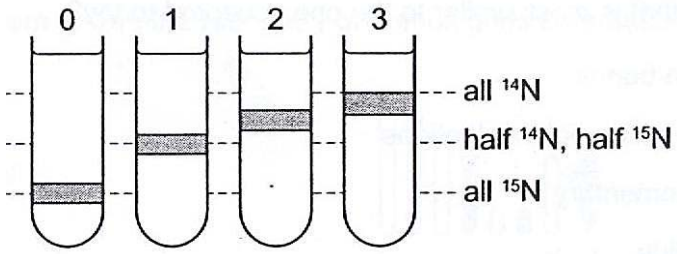


Which set of results would have proved that the DNA replication was **conservative**?

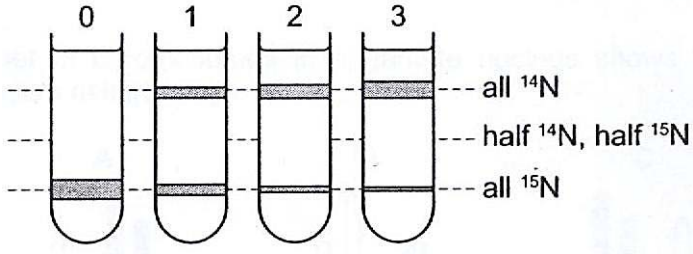
A.



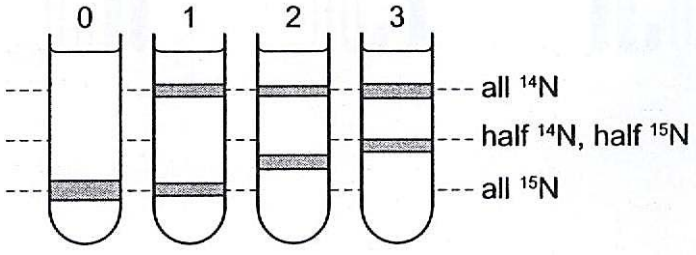
B.



C.



D.



key

0 = original culture in ^{15}N

1 = first generation in ^{14}N

2 = second generation in ^{14}N

3 = third generation in ^{14}N

QUESTION 11
Which statements about the genetic code are correct?

1. The genetic code has redundancy and is degenerate.
2. There is only one codon for the amino acid methionine.
3. Codons act as ‘stop’ and ‘start’ signals during transcription and translation.
4. Prokaryotes generally use the same genetic code as eukaryotes.
5. Stop codons are UAA, UGG and UGA.
6. mRNA codons have the same nucleotide sequence as DNA triplets on template strand.

A. 1, 2 and 4 **B.** 1, 3 and 5 **C.** 2, 4 and 6 **D.** 3, 5 and 6

QUESTION 12
In three different possible genetic dictionaries, the genetic code for the amino acid cysteine is given as:

I **ACA** or **ACG**
II **TGT** or **TGC**
III **UGU** or **UGC**

The explanation for this may be:

1. Some genetic dictionaries show mRNA codons, others show DNA triplets.
2. The genetic code can be read in either the 3’ or 5’ direction along the DNA.
3. Some genetic dictionaries show the triplet code on the DNA strand complementary to the mRNA code, others show the triplet code on the other DNA strand.
4. The genetic code is a degenerate triplet code.

A. 3 only **B.** 2 and 4 only **C.** 1, 2 and 3 only **D.** 1, 3 and 4 only

QUESTION 13
Fabry's Disease is a disease that results from a mutation that occurs in the *α-galactosidase A* gene.

The sequence of part of the normal and mutated alleles for *α-galactosidase A* gene is shown below.

Normal allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CAG	AGG	UUC	UAA	GGC	GGA

Mutated allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CCG	CAG	AGG	UUC	UAA	GGC

Using the information of the normal and mutated alleles above, it is reasonable to conclude that

A. A frame shift mutation has occurred.

B. A duplication has occurred.

C. An insertion of an amino acid has occurred in the mRNA.

D. The polypeptide that is translated from the mutated allele will be longer.

QUESTION 14
Which statement concerning polypeptide synthesis is correct?

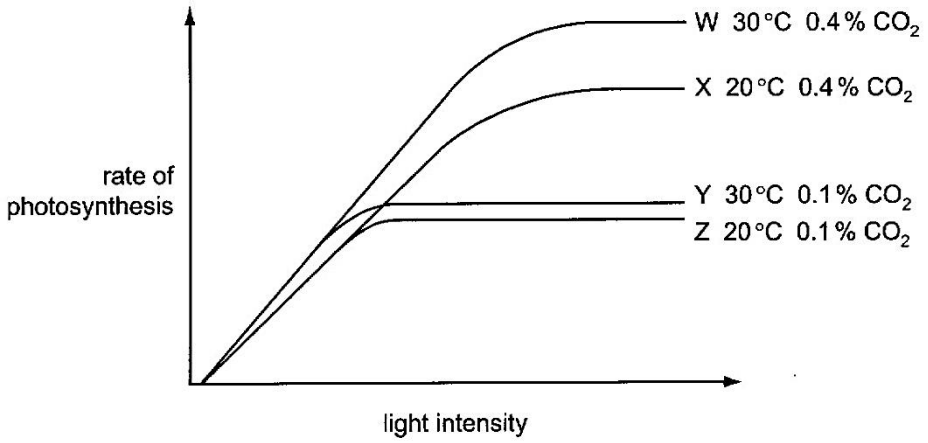
A. A particular cell type will transcribe all the genes present in one set of chromosomes but will only process particular pre-mRNA transcripts to enable polypeptide synthesis.

B. Different cell types will transcribe different sets of genes to produce different pre-mRNA transcripts and synthesise different polypeptides.

C. The same pre-mRNA transcripts are synthesised by all cell types but different introns are removed from the transcripts before translation to synthesise polypeptides.

D. The same set of genes will be transcribed by different cell types but different RNA transcripts in each cell type proceed to translation to synthesise different polypeptides.

QUESTION 15
The diagram shows the results of an investigation into the effect of changing light intensity on the rate of photosynthesis at two different carbon dioxide concentrations and two different temperatures.



Which factor is limiting the rate of photosynthesis shown in curve X at high light intensities and which curve supports this?

A. carbon dioxide, curve Y as a decrease in carbon dioxide concentration decreases rate

B. carbon dioxide, curve Z as rate becomes constant at lower light intensities

C. temperature, curve W as an increase in temperature increases rate

D. temperature, curve Z as rate becomes constant at lower light intensities

QUESTION 16
Which of the following is correct?

A. Cellular respiration uses ATP to produce energy for activities and reactions in the cell.

B. Cellular respiration oxidises ATP for activities and reactions in the cell.

C. Cellular respiration produces ATP for activities and reactions in the cell.

D. Cellular respiration hydrolyses ATP for activities and reactions in the cell.

QUESTION 17
Rotene, oligomycin and DNP are metabolic poisons which affect cellular respiration. The effects of rotene, oligomycin and DNP on aerobic respiration are summarised in the following table.

Metabolic Poisons	Effect of metabolic poison on cells		
	ability to use glucose	ability to use oxygen and amount used	ATP yield
rotene	yes	No	decreases
oligomycin	yes	Yes – same amount used	decreases
DNP	yes	Yes – increase amount used	decreases

Which of the following correctly identifies the specific functions of these metabolic poisons?

	rotene	oligomycin	DNP
A.	Increases inner membrane permeability	inhibits ATP synthase	Inhibits electron transport
B.	inhibits ATP synthase	Inhibits electron transport	Increases inner membrane permeability
C.	Inhibits electron transport	inhibits ATP synthase	Increases inner membrane permeability
D.	Inhibits electron transport	Increases inner membrane permeability	Inhibits ATP synthase

QUESTION 18
A child with Down syndrome has the genotype P^{1} P^{2} P^{3} for a polymorphism on chromosome 21 that has four different alleles — allele P^{1}, allele P^{2}, allele P^{3}, allele P^{4}. The child's mother has the genotype P^{1} P^{2} and the father has the genotype P^{3} P^{4}.

In which parent did chromosomes fail to separate, and did this event occur in the first or second meiotic division?

A. Mother; Meiosis I

B. Mother; Meiosis II

C. Father; Meiosis I

D. Father; Meiosis II

QUESTION 19
Achondroplastic dwarfism is an autosomal dominant disorder and red-green colour blindness is an X-linked recessive disorder.

An achondroplastic male dwarf with normal vision marries a colour-blind woman of normal height. The man's father is 1.7 meters tall while both the woman's parents are of average height.

What is the probability that their son will be colour-blind and of normal height?

A. 0.25 **B.** 0.5 **C.** 0.75 **D.** 1.0

QUESTION 20
A genetic cross performed on the fruit fly, *Drosophila melanogaster*, involved two independently-assorting (unlinked) genes.

gene	alleles
eye shape	bar (narrow) round
wing shape	Normal vestigial (reduced)

The F2 generation was observed to show the expected 9:3:3:1 phenotypic ratio, with the majority of the F2 offspring possessing bar eyes and normal wings.

Two different individuals with bar eyes and normal wings were removed from the F2 group each subjected to a test cross. The ratios of the resulting phenotypes are shown below.

test cross x individual P = 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

test cross x individual Q = 1 bar eye, normal wing **:** 1 round eye, normal wing

What is the expected phenotypic ratio for the offspring of a cross between individual P and individual Q?

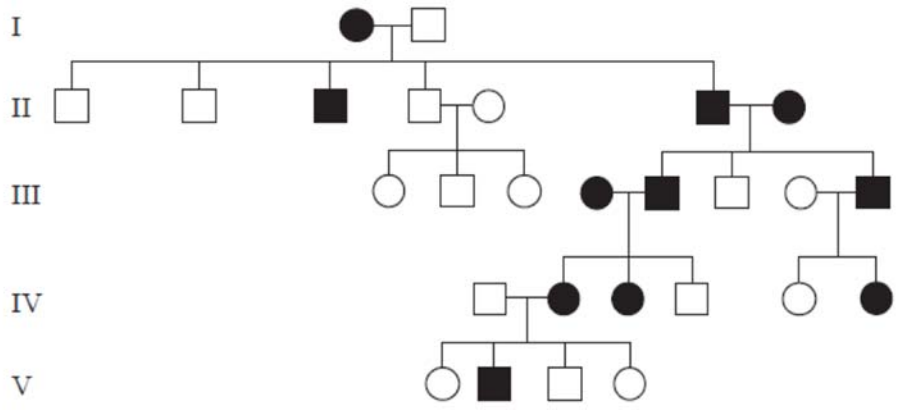
A. all bar eye, normal wing

B. 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

C. 3 bar eye, normal wing **:** 1 bar eye, vestigial wing

D. 3 bar eye, normal wing **:** 1 round eye, normal wing

QUESTION 21
The pedigree chart below shows the inheritance of a genetic disease in a family.



What is the nature of the allele that causes this disease?

A. autosomal dominant

B. sex-linked dominant

C. autosomal recessive

D. sex-linked recessive

QUESTION 22
Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

A. Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound oragnelles known as plasmids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colur in *Dendranthema.*

B. Identical genetic crosses performed between varieties of *Dandrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

C. The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an exhibit an extended flowering season compared with both parents.

D. The seeds of a cross between *Dendrathema weyrichii* (height varying between 12.5 – 15.0cm) and *Dendranthema grandiflora* (height varying between 8.0 – 25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0 – 71.0 cm.

QUESTION 23
The diagram shows part of the aligned DNA sequences for the same gene in six species of aquatic animals.

Fin whale	TAAACCCCAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Humpback whale	TAAACCCTAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Sperm whale	TAAACCCAGGTAGTCATAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Beaked whale	TAAACCTAAATAGTCTCAAAACAAGACTATTCGCCAGAGTACTACTAGCAAT
Dolphin	TAAACTTAAATAATCCCAAAACAAGATTATTCGCCAGAGTACTATCGGCAAC
Porpoise	TAAACCTAAATAGTCCTAAAACAAGACTATTCGCCAGAGTACTATCGGCAAC

Which is a correct assumption when using this information as evidence for evolutionary relationships?

A. Differences and similarities in DNA sequences reflect evolutionary relationships.

B. DNA sequences in different genes from the same six species will suggest different evolutionary relationships.

C. Point mutations in DNA sequences are not acted on by natural selection.

D. Mutations that do not change amino acid sequences in proteins are important for natural selection.

QUESTION 24
Which of the following is **not** an evidence for evolution?

A. A beetroot and a carrot are modified parts of plants

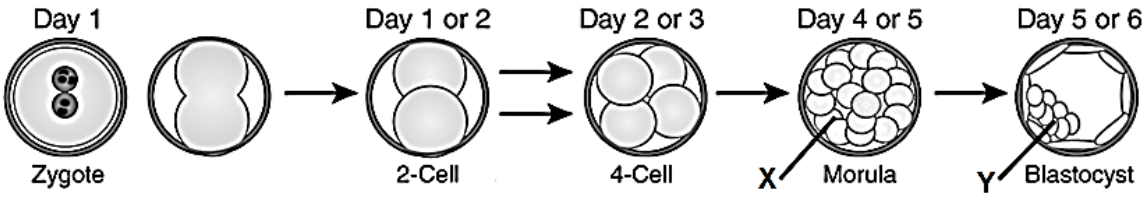
B. Presence of wing bones in the wingless bird, kiwi.

C. Presence of gills slits in human embryos.

D. Codon coding for a particular amino acid

QUESTION 25
The figure below shows several stages in the development of an embryo.

Which of the following statements are true about the cells labelled X and Y?



A. X is a pluripotent cell while Y is a multipotent cell.

B. X is a pluripotent cell while Y can give rise to multipotent cells.

C. Y will develop into the entire foetus including its placenta.

D. X can only give rise to totipotent cells but Y will give rise to pluripotent cells.

QUESTION 26
Induced pluripotent stem cells are stem cells that can be generated directly from differentiated somatic cells under the influence of molecular signals.

Which of the following statements are true?

1. An induced pluripotent stem cell can become any cell of the developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas a totipotent stem cell can produce a whole organism including extraembryonic tissue.
2. A totipotent stem cell and induced pluripotent stem cell can give rise to any cell type, including the extraembryonic membranes.
3. An induced pluripotent stem cell can give rise to a single cell lineage whereas a totipotent stem cell can give rise to multiple, but limited number of cell lineages.
4. A totipotent stem cell can become any cell of a developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas an induced pluripotent stem cell can produce a whole organism including extraembryonic tissue.
5. Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.

A. 1 only

B. 1 and 5 only

C. 2, 3 and 4 only

D. 3, 4 and 5 only

QUESTION 27
Which of the following is the restriction sequence for *Bam*HI?

A 5’ GGATCC 3’

B 5’ GACGAC 3’

C 5’ AATGCC 3’

D 5’ ACTACT 3’

QUESTION 28
What are the possible arguments against the use of genetically modified organisms (GMOs)?

1. Insufficient testing of genetically modified crop for their side effects
2. Unforeseen long-term effects of genetic manipulation
3. Accidental genetic recombination in humans as a result of consuming food derived from GMOs
4. Control of food supply by a small number of companies that have access to genetic engineering technology

A. 1 and 2 **B.** 2 and 3 **C.** 1, 2 and 3 **D.** 1, 2, 3 and 4

QUESTION 29
Which of the following technique does **not** involve any nucleic acid hybridization?

A. Gel electrophoresis

B. Gene probing

C. Polymerase Chain Reaction

D. DNA fingerprinting

QUESTION 30
A student performed the following steps in a Southern blot experiment to determine if a particular gene has been inserted in a genetically modified organism.

1. Transfer of DNA to nitrocellulose membrane.
2. Restriction digestion of genomic DNA.
3. Cleaved DNA separated using gel electrophoresis.
4. Synthesize radioactive probe.
5. Incubate probe and membrane.

Which is the correct sequence to the above steps?

A. $2 \rightarrow 3 \rightarrow 1 \rightarrow 4 \rightarrow 5$

B. $2 \rightarrow 3 \rightarrow 1 \rightarrow 5 \rightarrow 4$

C. $4 \rightarrow 5 \rightarrow 1 \rightarrow 2 \rightarrow 3$

D. $5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

☺ **End of Paper** ☺

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER | | |

H1 BIOLOGY

8875/01

Paper 1 Multiple Choice

21 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

Write in soft pencils.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

There are thirty questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in soft pencil on the Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

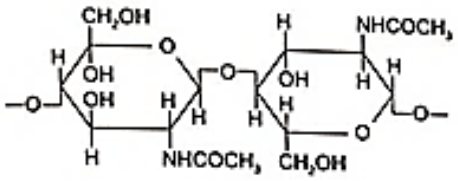
Any rough working should be done in this booklet.

You may keep this booklet after the examination.

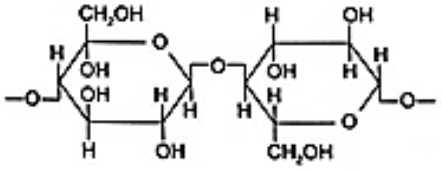
This paper consists of **19** printed pages.

QUESTION 1

The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



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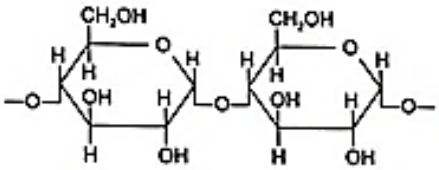

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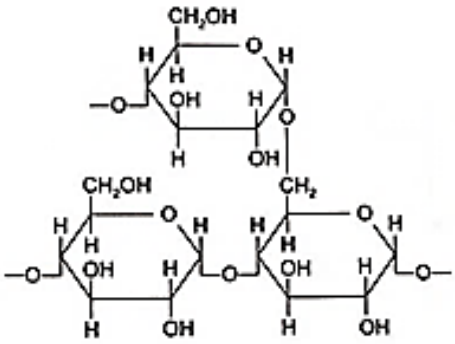

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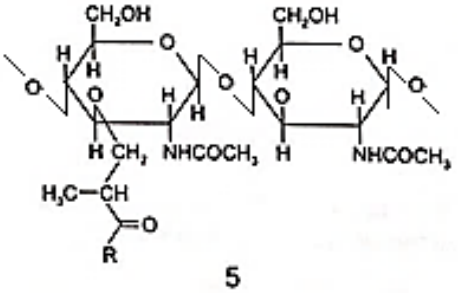


5

The polysaccharides can be described as below.

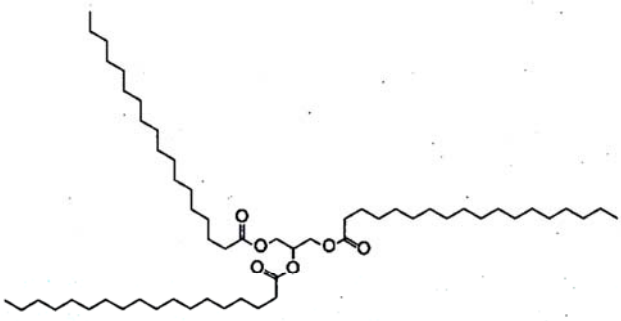
- Polysaccharide **F** is composed of β-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **G** is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds.
- Polysaccharide **J** is composed of α-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

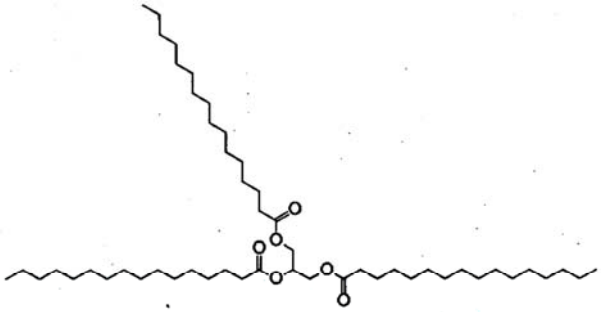
	Polysaccharide				
	F	**G**	**H**	**J**	**K**
A.	2	4	5	3	1
B.	2	5	4	1	3
C.	3	4	1	2	5
D.	3	5	4	1	2

QUESTION 2

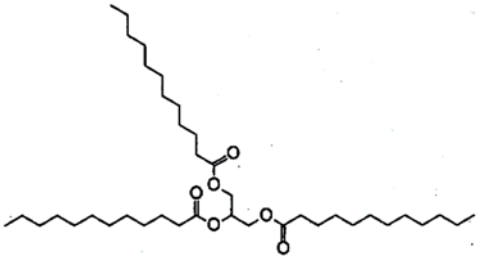
The formulae and melting points of five triglycerides are shown in the diagram. Each triglyceride contains three identical fatty acids.



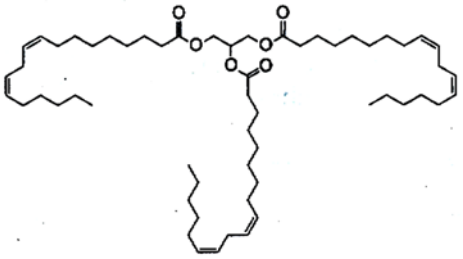
tristearin 72 °C



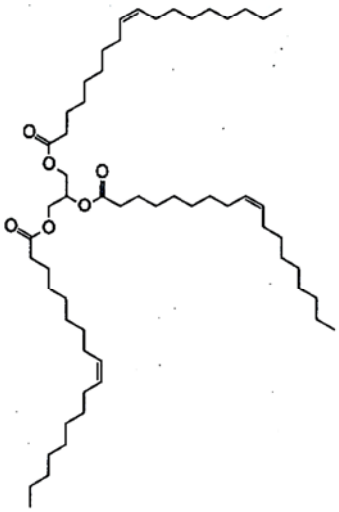
tripalmitin 65.5 °C



trilaurin 46 °C



trilinolein –13 °C



triolein –4 °C

Which two structural features of the molecules make the melting point higher?

	number of double bonds	length of fatty acid chains
A.	fewer	longer
B.	fewer	shorter
C.	more	longer
D.	more	shorter

QUESTION 3

Four students, **A, B ,C** and **D**, were given the same sequence of amino acids removed from a collagen molecule. Each student was asked to analyse the sequence and to explain how their analysis could be linked to a feature of collagen

Which student's statement shows a correct feature of collagen linked to a correct analysis of the amino acid sequence?

A. Collagen has polypeptides arranged parallel to each other and the sequence contains a large variety of amino acids with different sized R-groups.

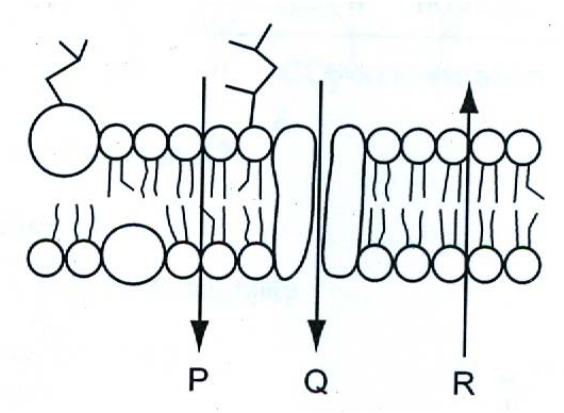
B. Collagen has polypeptides that are arranged very closely together and the sequence has every third amino acid as glycine.

C. Collagen has three polypeptides that can fold into a globular structure and the sequence contains cysteine and amino acids with hydrophobic R groups.

D. Collagen is an insoluble molecule and the sequence contains a large proportion of amino acids with hydrophilic R-groups.

QUESTION 4

The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.



What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

	P	Q	R
A.	diffusion of glucose	diffusion of oxygen	diffusion of water
B.	diffusion of oxygen	diffusion of water	diffusion of glucose
C.	diffusion of water	active transport of glucose	diffusion of oxygen
D.	diffusion of oxygen	Facilitated diffusion of glucose	diffusion of water

QUESTION 5
What could be a possible explanation for the ability of lysosomes to withstand self-digestion?

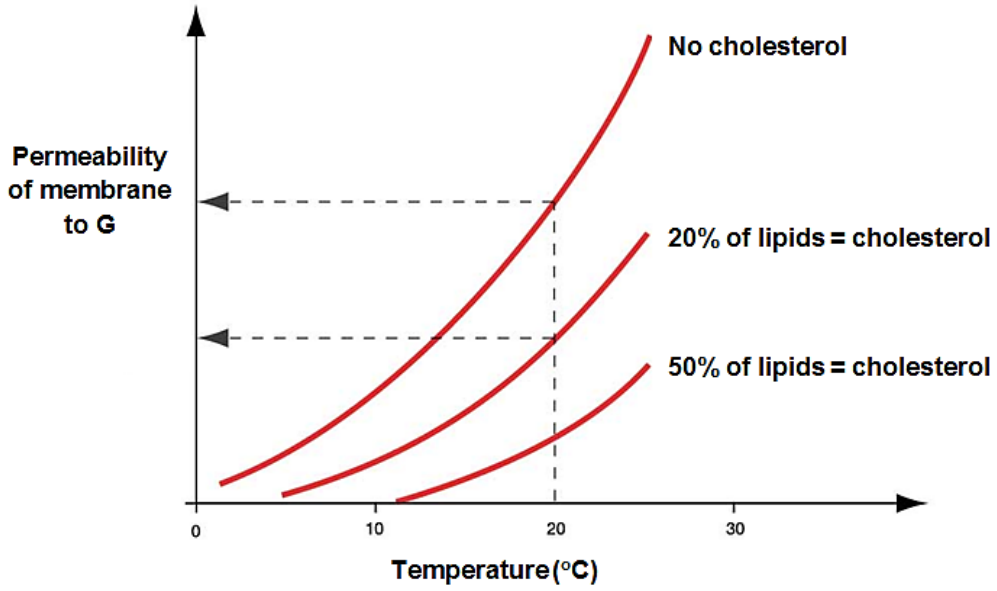
A. Lysosomes contain inactive hydrolytic enzymes.

B. Lysosome membrane has numerous modified proteins with carbohydrate side-chains.

C. Lysosomes do not contain lipases which are the enzymes capable of digesting the lipid membrane.

D. Hydrolases in the lysosomes are inhibited by the acidic internal environment of the lysosomes.

QUESTION 6
The graph below shows the permeability of three different membranes to chemical **G** at different temperatures. These three membranes differ in the amount of cholesterol present in the phospholipid bilayers.



Which of the following is a possible explanation for the observed data?

A. Increase in temperature increases the permeability of the membrane to **G** as cholesterol increases the fluidity of the phospholipids.

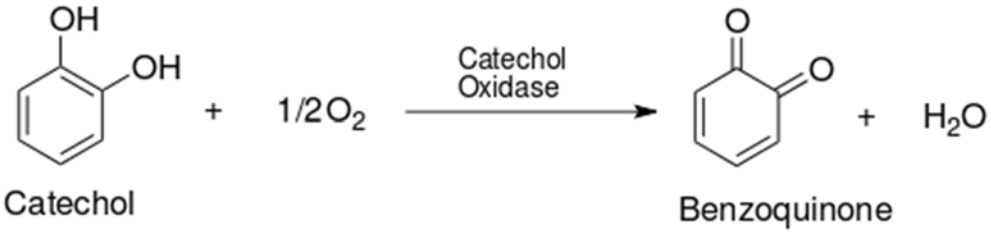
B. At 20°C, an increase in the proportion of cholesterol in the membrane increases the permeability of membrane to **G** as both cholesterol and **G** are non-polar.

C. Increase in the proportion of cholesterol decreases the permeability of the membrane to **G** as cholesterol decreases the fluidity of the phospholipids.

D. With an increase in the proportion of cholesterol in the membrane, a lower temperature is required to achieve the same level of permeability for **G** as **G** will gain a higher kinetic energy to penetrate the membrane.

QUESTION 7

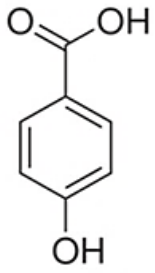
Catechol is oxidised to benzoquinone, as shown in the equation, resulting in darkening of peeled fruits.



Catechol

Benzoquinone

Catechol oxidase is an enzyme which is inhibited by parahydroxybenzoic acid (PHBA). When PHBA binds to catechol oxidase, it does not change the shape of the enzyme. The structure of PHBA is shown below.



PHBA

Which of the following statements are **not** correct?

1. PHBA acts as a competitive inhibitor because its structure is similar to the active site of catechol oxidase.
2. PHBA acts as a non-competitive inhibitor because it does not change the shape of the active site of catechol oxidase.
3. In the presence of PHBA, the same Vmax can be attained at higher catechol concentration.
4. PHBA prevents the formation of enzyme-substrate complex between catechol oxidase, catechol and O_2.

A. 1 and 2 only

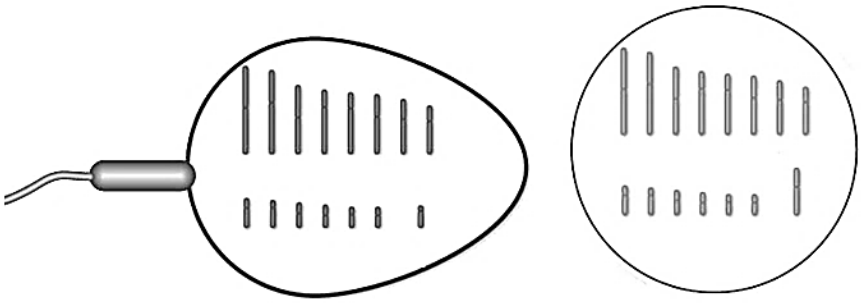
B. 3 and 4 only

C. 1, 2 and 3 only

D. All of the above

QUESTION 8

The diagram below shows the egg cell and sperm cell formed by one mammal species, as well as the number of chromosomes they contain.

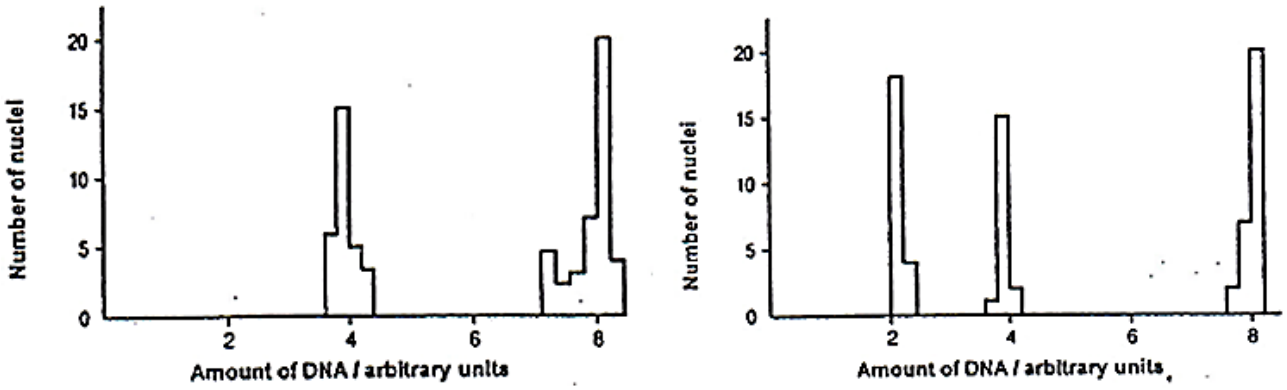


How many DNA molecules would be found in a germ cell (cell that gives rise to gametes) from this organism at prophase II of meiosis II?

A. 15 **B.** 30 **C.** 60 **D.** 120

QUESTION 9

The graphs below show the amount of DNA in the nuclei of cells taken from two different parts of a mammalian testis undergoing different nuclear division processes.



Graph 1 Graph 2

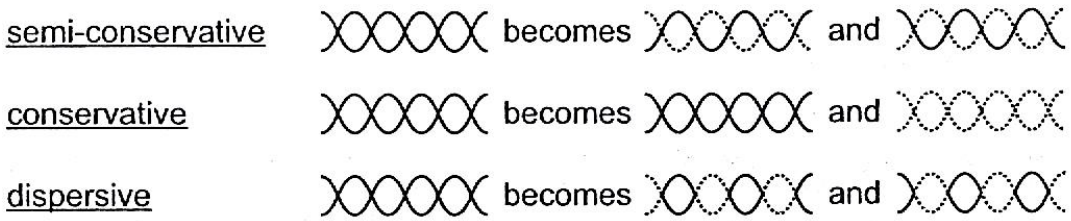
Which correctly describes one **unique** event taking place in the cells from graph **1** and graph **2** respectively?

	Graph 1	Graph 2
A.	Duplication of DNA	Separation of homologous chromosomes
B.	Separation of identical sister chromatids	Separation of non-identical sister chromatids
C.	Separation of non-identical sister chromatids	Formation of gametes
D.	Breaking and rejoining of homologous regions of chromosomes	Separation of homologous chromosomes

QUESTION 10

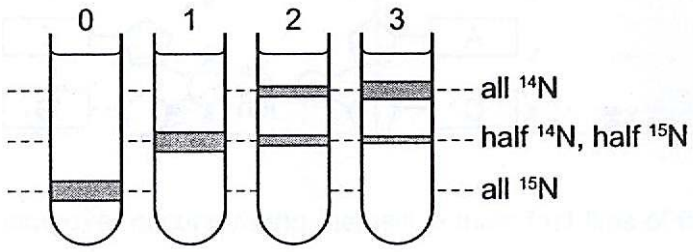
Meselson and Stahl found that in dividing cells, DNA is copied by semi-conservative replication. At the time of their discovery it was thought that DNA might be copied in one of three ways.

In the diagram, the original DNA strands are shown by solid lines and the copy strands by dotted lines.

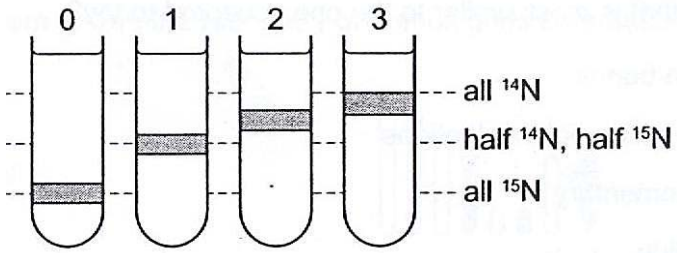


Which set of results would have proved that the DNA replication was **conservative**?

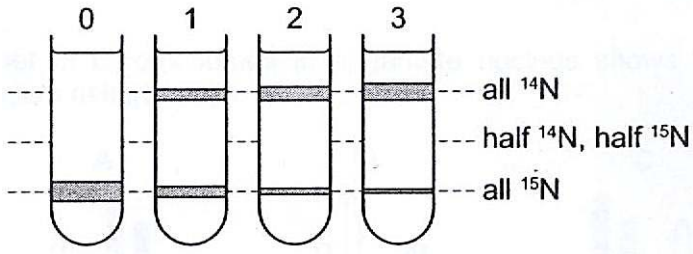
A.



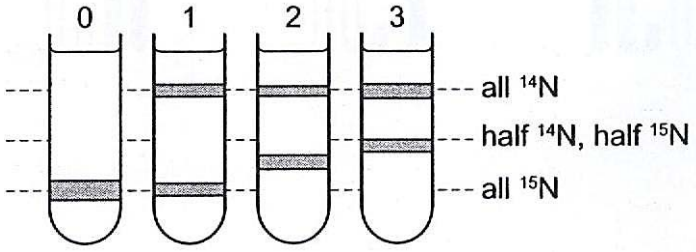
B.



C.



D.



key

0 = original culture in ^{15}N

1 = first generation in ^{14}N

2 = second generation in ^{14}N

3 = third generation in ^{14}N

QUESTION 11
Which statements about the genetic code are correct?

1. The genetic code has redundancy and is degenerate.
2. There is only one codon for the amino acid methionine.
3. Codons act as 'stop' and 'start' signals during transcription and translation.
4. Prokaryotes generally use the same genetic code as eukaryotes.
5. Stop codons are UAA, UGG and UGA.
6. mRNA codons have the same nucleotide sequence as DNA triplets on template strand.

A. 1, 2 and 4 **B.** 1, 3 and 5 **C.** 2, 4 and 6 **D.** 3, 5 and 6

QUESTION 12
In three different possible genetic dictionaries, the genetic code for the amino acid cysteine is given as:

I **ACA** or **ACG**
II **TGT** or **TGC**
III **UGU** or **UGC**

The explanation for this may be:

1. Some genetic dictionaries show mRNA codons, others show DNA triplets.
2. The genetic code can be read in either the 3' or 5' direction along the DNA.
3. Some genetic dictionaries show the triplet code on the DNA strand complementary to the mRNA code, others show the triplet code on the other DNA strand.
4. The genetic code is a degenerate triplet code.

A. 3 only **B.** 2 and 4 only **C.** 1, 2 and 3 only **D.** 1, 3 and 4 only

QUESTION 13
Fabry's Disease is a disease that results from a mutation that occurs in the *α-galactosidase A* gene.

The sequence of part of the normal and mutated alleles for *α-galactosidase A* gene is shown below.

Normal allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CAG	AGG	UUC	UAA	GGC	GGA

Mutated allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CCG	CAG	AGG	UUC	UAA	GGC

Using the information of the normal and mutated alleles above, it is reasonable to conclude that

A. A frame shift mutation has occurred.
B. A duplication has occurred.
C. An insertion of an amino acid has occurred in the mRNA.
D. The polypeptide that is translated from the mutated allele will be longer.

QUESTION 14
Which statement concerning polypeptide synthesis is correct?

A. A particular cell type will transcribe all the genes present in one set of chromosomes but will only process particular pre-mRNA transcripts to enable polypeptide synthesis.

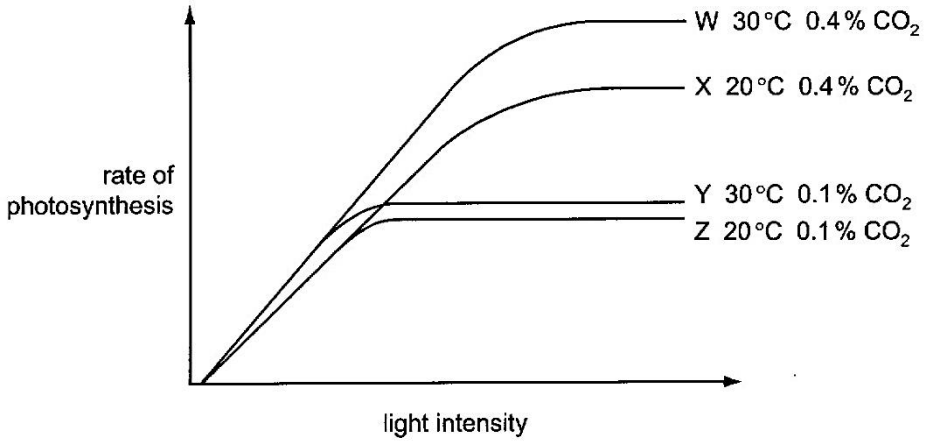
B. Different cell types will transcribe different sets of genes to produce different pre-mRNA transcripts and synthesise different polypeptides.

C. The same pre-mRNA transcripts are synthesised by all cell types but different introns are removed from the transcripts before translation to synthesise polypeptides.

D. The same set of genes will be transcribed by different cell types but different RNA transcripts in each cell type proceed to translation to synthesise different polypeptides.

QUESTION 15

The diagram shows the results of an investigation into the effect of changing light intensity on the rate of photosynthesis at two different carbon dioxide concentrations and two different temperatures.



Which factor is limiting the rate of photosynthesis shown in curve X at high light intensities and which curve supports this?

A. carbon dioxide, curve Y as a decrease in carbon dioxide concentration decreases rate

B. carbon dioxide, curve Z as rate becomes constant at lower light intensities

C. temperature, curve W as an increase in temperature increases rate

D. temperature, curve Z as rate becomes constant at lower light intensities

QUESTION 16

Which of the following is correct?

A. Cellular respiration uses ATP to produce energy for activities and reactions in the cell.

B. Cellular respiration oxidises ATP for activities and reactions in the cell.

C. Cellular respiration produces ATP for activities and reactions in the cell.

D. Cellular respiration hydrolyses ATP for activities and reactions in the cell.

QUESTION 17
Rotene, oligomycin and DNP are metabolic poisons which affect cellular respiration. The effects of rotene, oligomycin and DNP on aerobic respiration are summarised in the following table.

Metabolic Poisons	Effect of metabolic poison on cells		
	ability to use glucose	ability to use oxygen and amount used	ATP yield
rotene	yes	No	decreases
oligomycin	yes	Yes – same amount used	decreases
DNP	yes	Yes – increase amount used	decreases

Which of the following correctly identifies the specific functions of these metabolic poisons?

	rotene	oligomycin	DNP
A.	Increases inner membrane permeability	inhibits ATP synthase	Inhibits electron transport
B.	inhibits ATP synthase	Inhibits electron transport	Increases inner membrane permeability
C.	Inhibits electron transport	inhibits ATP synthase	Increases inner membrane permeability
D.	Inhibits electron transport	Increases inner membrane permeability	Inhibits ATP synthase

QUESTION 18
A child with Down syndrome has the genotype P^1 P^2 P^3 for a polymorphism on chromosome 21 that has four different alleles — allele P^1, allele P^2, allele P^3, allele P^4. The child's mother has the genotype P^1 P^2 and the father has the genotype P^3 P^4.

In which parent did chromosomes fail to separate, and did this event occur in the first or second meiotic division?

A. Mother; Meiosis I

B. Mother; Meiosis II

C. Father; Meiosis I

D. Father; Meiosis II

QUESTION 19
Achondroplastic dwarfism is an autosomal dominant disorder and red-green colour blindness is an X-linked recessive disorder.

An achondroplastic male dwarf with normal vision marries a colour-blind woman of normal height. The man's father is 1.7 meters tall while both the woman's parents are of average height.

What is the probability that their son will be colour-blind and of normal height?

A. 0.25 **B.** 0.5 **C.** 0.75 **D.** 1.0

QUESTION 20
A genetic cross performed on the fruit fly, *Drosophila melanogaster*, involved two independently-assorting (unlinked) genes.

gene	alleles
eye shape	bar (narrow) round
wing shape	Normal vestigial (reduced)

The F2 generation was observed to show the expected 9:3:3:1 phenotypic ratio, with the majority of the F2 offspring possessing bar eyes and normal wings.

Two different individuals with bar eyes and normal wings were removed from the F2 group each subjected to a test cross. The ratios of the resulting phenotypes are shown below.

test cross x individual P = 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

test cross x individual Q = 1 bar eye, normal wing **:** 1 round eye, normal wing

What is the expected phenotypic ratio for the offspring of a cross between individual P and individual Q?

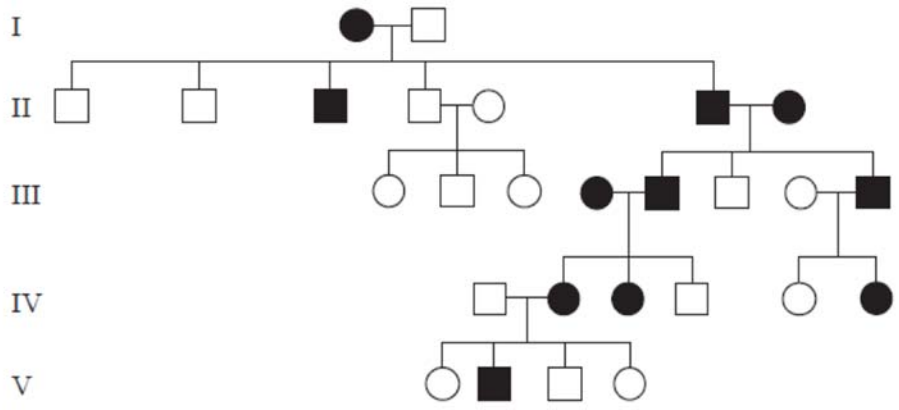
A. all bar eye, normal wing

B. 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

C. 3 bar eye, normal wing **:** 1 bar eye, vestigial wing

D. 3 bar eye, normal wing **:** 1 round eye, normal wing

QUESTION 21
The pedigree chart below shows the inheritance of a genetic disease in a family.



What is the nature of the allele that causes this disease?

A. autosomal dominant

B. sex-linked dominant

C. autosomal recessive

D. sex-linked recessive

QUESTION 22
Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

A. Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound oragnelles known as plasmids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colur in *Dendranthema.*

B. Identical genetic crosses performed between varieties of *Dandrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

C. The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an exhibit an extended flowering season compared with both parents.

D. The seeds of a cross between *Dendrathema weyrichii* (height varying between 12.5 – 15.0cm) and *Dendranthema grandiflora* (height varying between 8.0 – 25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0 – 71.0 cm.

QUESTION 23
The diagram shows part of the aligned DNA sequences for the same gene in six species of aquatic animals.

Fin whale	TAAACCCCAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Humpback whale	TAAACCCTAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Sperm whale	TAAACCCAGGTAGTCATAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Beaked whale	TAAACCTAAATAGTCTCAAAACAAGACTATTCGCCAGAGTACTACTAGCAAT
Dolphin	TAAACTTAAATAATCCCAAAACAAGATTATTCGCCAGAGTACTATCGGCAAC
Porpoise	TAAACCTAAATAGTCCTAAAACAAGACTATTCGCCAGAGTACTATCGGCAAC

Which is a correct assumption when using this information as evidence for evolutionary relationships?

A. Differences and similarities in DNA sequences reflect evolutionary relationships.

B. DNA sequences in different genes from the same six species will suggest different evolutionary relationships.

C. Point mutations in DNA sequences are not acted on by natural selection.

D. Mutations that do not change amino acid sequences in proteins are important for natural selection.

QUESTION 24
Which of the following is **not** an evidence for evolution?

A. A beetroot and a carrot are modified parts of plants

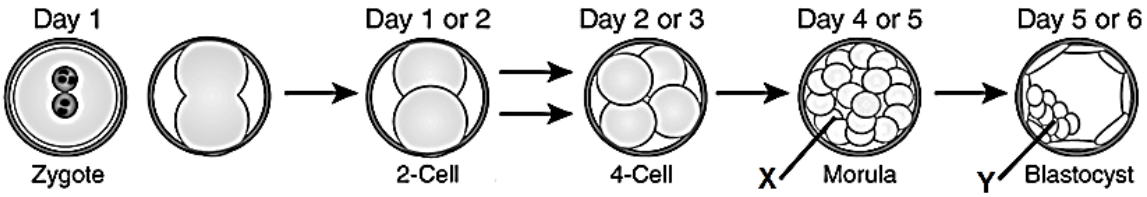
B. Presence of wing bones in the wingless bird, kiwi.

C. Presence of gills slits in human embryos.

D. Codon coding for a particular amino acid

QUESTION 25
The figure below shows several stages in the development of an embryo.

Which of the following statements are true about the cells labelled X and Y?



A. X is a pluripotent cell while Y is a multipotent cell.

B. X is a pluripotent cell while Y can give rise to multipotent cells.

C. Y will develop into the entire foetus including its placenta.

D. X can only give rise to totipotent cells but Y will give rise to pluripotent cells.

QUESTION 26
Induced pluripotent stem cells are stem cells that can be generated directly from differentiated somatic cells under the influence of molecular signals.

Which of the following statements are true?

1. An induced pluripotent stem cell can become any cell of the developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas a totipotent stem cell can produce a whole organism including extraembryonic tissue.
2. A totipotent stem cell and induced pluripotent stem cell can give rise to any cell type, including the extraembryonic membranes.
3. An induced pluripotent stem cell can give rise to a single cell lineage whereas a totipotent stem cell can give rise to multiple, but limited number of cell lineages.
4. A totipotent stem cell can become any cell of a developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas an induced pluripotent stem cell can produce a whole organism including extraembryonic tissue.
5. Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.

A. 1 only

B. 1 and 5 only

C. 2, 3 and 4 only

D. 3, 4 and 5 only

QUESTION 27
Which of the following is the restriction sequence for *Bam*HI?

A 5’ GGATCC 3’

B 5’ GACGAC 3’

C 5’ AATGCC 3’

D 5’ ACTACT 3’

QUESTION 28
What are the possible arguments against the use of genetically modified organisms (GMOs)?

1. Insufficient testing of genetically modified crop for their side effects
2. Unforeseen long-term effects of genetic manipulation
3. Accidental genetic recombination in humans as a result of consuming food derived from GMOs
4. Control of food supply by a small number of companies that have access to genetic engineering technology

A. 1 and 2 **B.** 2 and 3 **C.** 1, 2 and 3 **D.** 1, 2, 3 and 4

QUESTION 29
Which of the following technique does **not** involve any nucleic acid hybridization?

A. Gel electrophoresis
B. Gene probing
C. Polymerase Chain Reaction
D. DNA fingerprinting

QUESTION 30
A student performed the following steps in a Southern blot experiment to determine if a particular gene has been inserted in a genetically modified organism.

1. Transfer of DNA to nitrocellulose membrane.
2. Restriction digestion of genomic DNA.
3. Cleaved DNA separated using gel electrophoresis.
4. Synthesize radioactive probe.
5. Incubate probe and membrane.

Which is the correct sequence to the above steps?

A. $2 \rightarrow 3 \rightarrow 1 \rightarrow 4 \rightarrow 5$
B. $2 \rightarrow 3 \rightarrow 1 \rightarrow 5 \rightarrow 4$
C. $4 \rightarrow 5 \rightarrow 1 \rightarrow 2 \rightarrow 3$
D. $5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

• **THE END** •

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER | | |

H1 BIOLOGY

8875/02

Paper 2

15 September 2017
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number 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/tape.

Section A
Answer **all** questions.

Section B
Answer **one** question.

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

For examiner's Use	
Section A	
1	/ 14
2	/ 7
3	/ 9
4	/ 10
Section B	
5 or 6	/ 20
Total	/ 60

This paper consists of **16** printed pages.

[Turn over]

Section A

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

QUESTION 1

Pepsin is an enzyme that digests protein. It is synthesized in the cells of the stomach as a longer, inactive proenzyme called pepsinogen. Secretion of pepsinogen into the acidic environment of the stomach then activates it.

Fig. 1.1 shows the structures of pepsinogen and pepsin. The active site of pepsin is indicated.

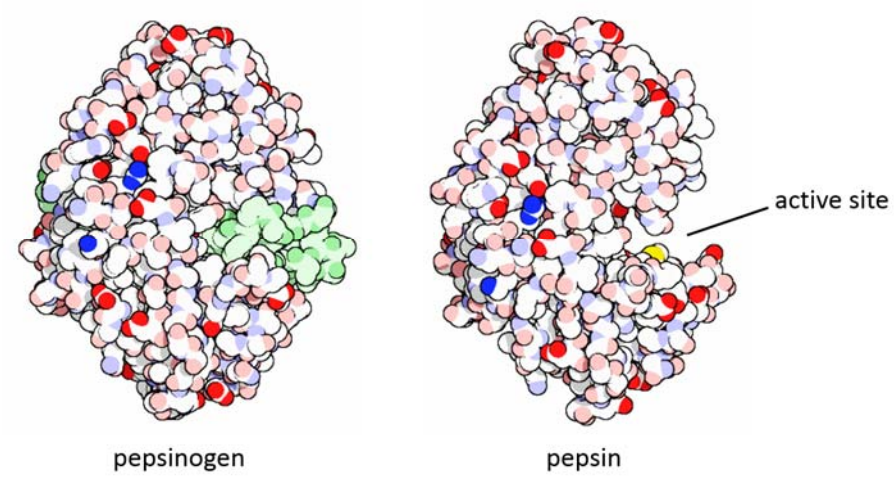


Fig. 1.1

a) With reference to Fig. 1.1, explain how the structure of pepsinogen allows it to be inactive. [2]

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b) Explain how a point mutation on DNA can change the primary structure of pepsin but not its globular structure. [4]

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c) Pepsinogen is secreted by the gastric chief cells of the stomach. These cells also synthesize and secrete gastric lipases that hydrolyze lipids.

Explain how gastric chief cells are structurally adapted for its role. [3]

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d) Another enzyme, DNA polymerase, carries out DNA replication with tight coordination of leading and lagging strand synthesis.

Describe **two** structural differences between DNA polymerase and its substrate. [2]

1. ……..

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2. ……..

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e) Fig. 1.2 shows the transport of substances in and out of the nucleus via the nuclear pore.

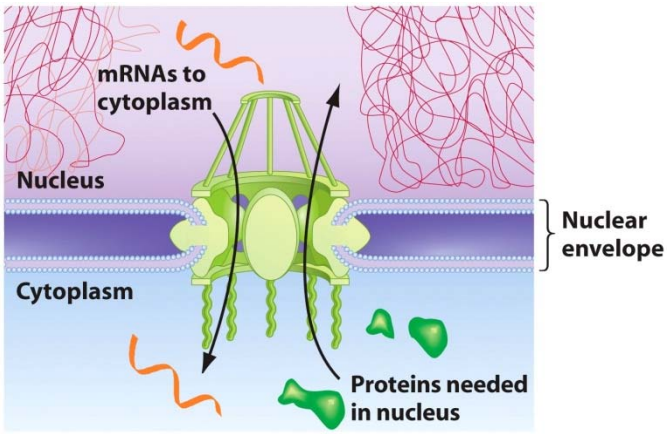

Fig. 1.2

i) Apart from enzymes and proteins that are directly involved in DNA replication and transcription, suggest **two** other substances that are transported from the cytosol into the nucleus. [2]

1. ……

2. ……

ii) Apart from messenger RNAs that exit the nucleus into the cytosol, suggest **one** other substances that are transported out of the nucleus. [1]

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[Total: 14]

QUESTION 2

In 1865, Gregor Mendel performed dihybrid crosses on pea plants for a variety of characteristics including flower colour, flower position and height (length of stem). From his observations he developed a fundamental law of genetics that some genetic characteristics are inherited independently.

For example, pure-breeding pea plants with red flowers on the sides of stems (axial) can be crossed with pure-breeding pea plants with white flowers on the ends of stems (terminal).

All the resultant plants (F_1 generation) have red flowers that are axial.

One set of results for the offspring from self-pollinating these F_1 plants is shown below.

261	red, axial flowers
86	red, terminal flowers
76	white, axial flowers
28	white, terminal flowers

a) Draw a genetic diagram to explain both crosses.

Use the following symbols to represent the different alleles involved:

R/r – Flower colour **A/a** – Flower position [5]

b) Explain how different characteristics are inherited independently in dihybrid inheritance. [2]

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[Total: 7]

QUESTION 3

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that evolution is taking place, leading to the formation of six different species.

Fig. 3.1 is a schematic representation of Madeira showing the distribution of the six populations.

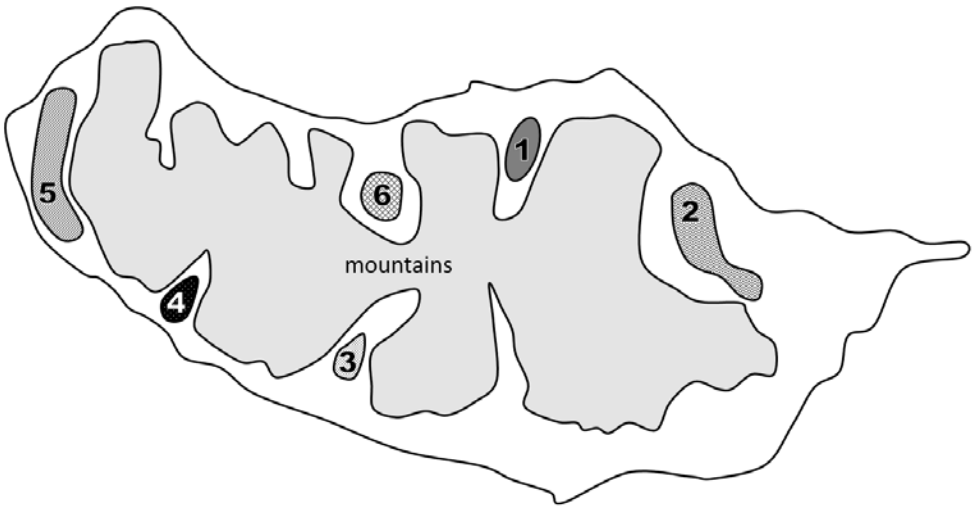

Fig. 3.1

a) '*It has been suggested that evolution is taking place, leading to the formation of six different species*.'

Explain how this process is occurring in the house mouse populations of Madeira. [4]

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b) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

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c) Cytochrome c is a protein that is found in all living organisms. Analysis of the amino acid sequences of proteins, such as cytochrome c, provides data that taxonomists use to produce more accurate classifications.

Explain why analyzing the amino acid sequences of proteins could provide useful data for taxonomists. [3]

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[Total: 9]

QUESTION 4

The artificial plasmid, pBR322, was constructed to act as a vector. It has often been used to insert human genes, such as the human insulin gene, into the bacterium, *Escherichia coli*.

The plasmid was constructed to include two genes, each giving resistance to a different antibiotic: an ampicillin-resistant gene and a tetracycline-resistant gene. The plasmid also has a target site for the restriction enzyme, *Bam*HI, in the middle of the tetracycline-resistance gene.

A pBR322 plasmid was cut using *Bam*HI and the cDNA gene for human insulin inserted into it.

Fig. 4.1 shows pBR322 and the recombinant plasmid.

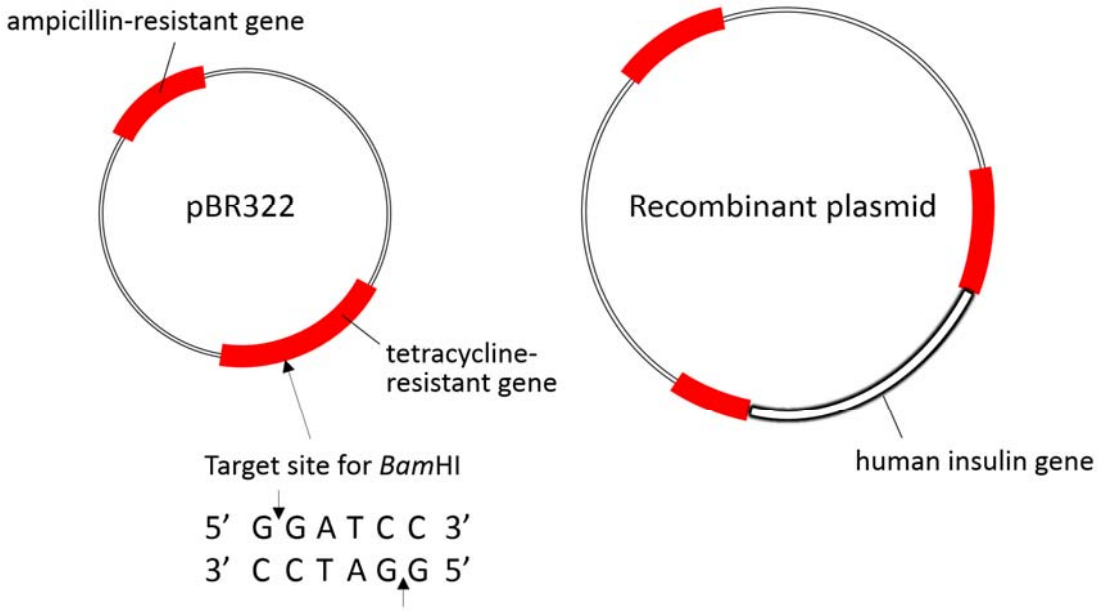

Fig. 4.1

a) The cDNA of human insulin gene obtained by reverse transcription does not contain sticky ends.

With reference to Fig. 4.1, describe how a cDNA of human insulin gene can be inserted into pBR322 that has been cut by *Bam*HI. [3]

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b) Bacteria were then mixed with the recombinant plasmids. Those bacteria which had successfully taken up recombinant plasmids were identified using the following steps:

Step 1 – the bacteria were spread onto culture plates containing nutrient agar and ampicillin and incubated to allow colonies to form

Step 2 – some bacteria from each of the colonies growing on these plates were transferred to plates (replica plating) containing nutrient agar and tetracycline, as shown in Fig. 4.2.

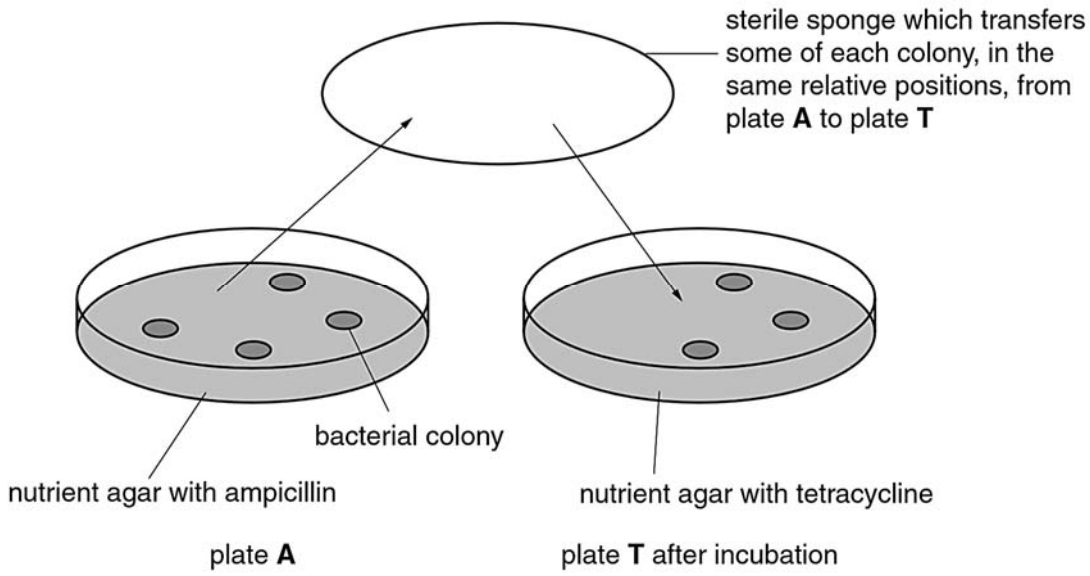

Fig. 4.2

i) Explain why the bacteria were first spread onto plates containing ampicillin. [2]

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ii) Explain why it is important that on the pBR322 plasmid, the target site for *Bam*HI is in the middle of the tetracycline resistance gene. [3]

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iii) Use a label line and the letter **C** to identify, on Fig. 4.2, a colony of bacteria that contains the recombinant plasmid. [1]

c) Plasmid vectors carrying antibiotic-resistant genes are now rarely used in gene technology because of the risk of transferring these genes to other bacteria that are previously susceptible to that antibiotic, hence conferring antibiotic-resistance to these bacteria.

State one type of gene that has replaced antibiotic-resistant genes in plasmid vectors **and** indicate how bacteria carrying this gene can be detected. [1]

Gene ……..

Detection ……..

……..

[Total: 10]

Section B

Answer **ONE** questions

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be in set out in questions **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 5

a) DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [10]

b) Explain the underlying principles of the polymerase chain reaction (PCR) **and** explain how the specificity of PCR is achieved. [5]

c) Describe the process of endocytosis.
[5]

[Total: 20]

QUESTION 6

a) Discuss the importance of hydrogen bonding in ensuring the continuity of life. [10]

b) Outline the functions of membranes **within** cells.
[5]

c) With reference to specific examples, discuss the roles of coenzymes in yeast.
[5]

[Total: 20]

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☺ **End of Paper** ☺

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER | | |

H1 BIOLOGY

8875/02

Paper 2

15 September 2017
2 hours

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Section A
Answer **all** questions.

Section B
Answer **all** questions.

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

ANSWER SCHEME

For examiner's Use	
Section A	
1	/ 14
2	/ 7
3	/ 9
4	/ 10
Section B	
5 or 6	/ 20
Total	/ 60

This paper consists of **12** printed pages.

[Turn over]

Section A

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

QUESTION 1

Pepsin is an enzyme that digests protein. It is synthesized in the cells of the stomach as a longer, inactive proenzyme called pepsinogen. Secretion of pepsinogen into the acidic environment of the stomach then activates it.

Fig. 1.1 shows the structures of pepsinogen and pepsin. The active site of pepsin is indicated.

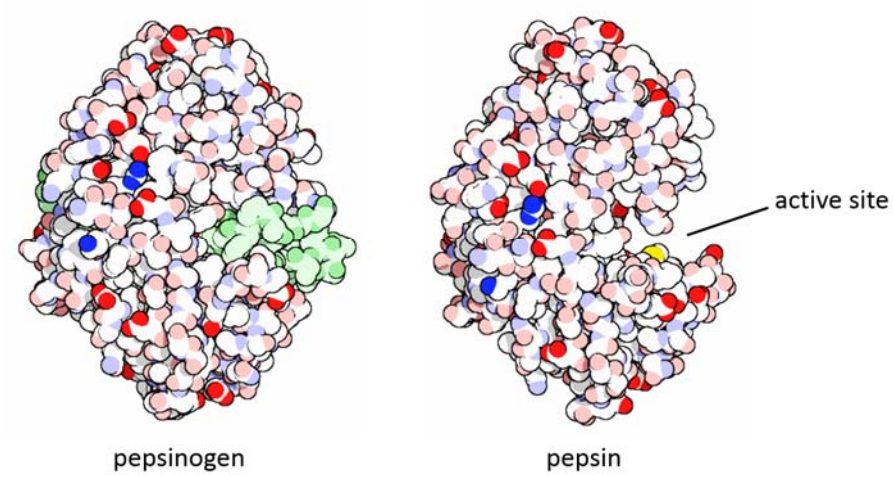

Fig. 1.1

a) With reference to Fig. 1.1, explain how the structure of pepsinogen allows it to be inactive. [2]

- Pepsinogen has **extra amino acids** in its primary structure, which **occupies the active site** of pepsin / active site is not exposed.
- **Prevents substrate from binding** to active site, because it is **not complementary in shape** to the substrate.

b) Explain how a point mutation on DNA can change the primary structure of pepsin but not its globular stcuture. [4]

[DNA level]
- **Single-base substitution** on a **triplet** on **DNA** on pepsin gene

[mRNA level]
- Changes the corresponding **mRNA codon**, and changes corresponding **amino acid**

[Polypeptide level]
- Amino acid has **similar property**, hence same R-group interactions occur
- **Folding** of the polypeptide chain **unchanged**, hence the **3D configuration** of pepsin **unchanged**

OR
- Amino acid is not involved in the formation of bonds important in maintaining three-dimensional configuration of pepsin
- **Folding** of the polypeptide chain **unchanged**, hence the **3D configuration** of pepsin **unchanged**

Reject: Silent mutation, since primary structure is changed.

c) Pepsinogen is secreted by the gastric chief cells of the stomach. These cells also synthesize and secrete gastric lipases that hydrolyze lipids.

Explain how gastric chief cells are structurally adapted for its role. [3]

- **Large number** of **rough endoplasmic reticulum** and **Golgi apparatus**.
- RER – for synthesis of **pepsinogen** and **lipases** [context], which are proteins.
- Golgi – for **biochemical modification** of pepsinogen and lipases and for formation for **secretory vesicles**

d) Another enzyme, DNA polymerase, carries out DNA replication with tight coordination of leading and lagging strand synthesis.

Describe **two** structural differences between DNA polymerase and its substrate. [2]

	Features	DNA polymerase	Substrate (DNA)
1	Overall structure	Compact spherical/ globular shape	Double helical shape
2	Monomers	Amino acids	Deoxyribonucleotides
3	Types of different monomers.	20	4
4	Bonds between monomers	Peptide bond	Phosphodiester bond
5	Other bonds supporting overall structure	hydrogen bonds, ionic bonds, disulfide bonds, hydrophobic and hydrophilic interactions	hydrogen bonding between nitrogenous bases, and hydrophobic interaction between stacked bases
6	Elements present	May contain sulphur (e.g. cysteine) **OR** Carbon, Hydrogen, Oxygen Nitrogen, Sulfur	Phosphorus **OR** Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous

e) Fig. 1.2 shows the transport of substances in and out of the nucleus via the nuclear pore.

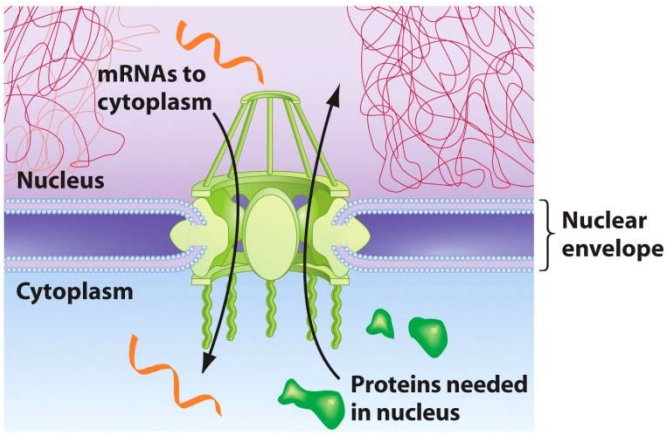

Fig. 1.2

i) Apart from enzymes and proteins that are directly involved in DNA replication and transcription, suggest **two** other substances that are transported from the cytosol into the nucleus. [2]

- Deoxyribonucleotides for DNA replication / ribonucleotides for transcription
- ATP as an energy molecule for energy-requiring processes in the nucleus
- Ribosomal proteins
- Histones (involved in DNA packing but not DNA replication)
- **AVP**

ii) Apart from messenger RNAs that exit the nucleus into the cytosol, suggest **one** other substances that are transported out of the nucleus. [1]

- Ribosomes / 80S ribosomes / large subunit of ribosome / small subunit of ribosome
- Transfer RNA / tRNA
- Nucleoside diphosphates / monophosphates
- **AVP**

[Total: 14]

QUESTION 2

In 1865, Gregor Mendel performed dihybrid crosses on pea plants for a variety of characteristics including flower colour, flower position and height (length of stem). From his observations he developed a fundamental law of genetics that some genetic characteristics are inherited independently.

For example, pure-breeding pea plants with red flowers on the sides of stems (axial) can be crossed with pure-breeding pea plants with white flowers on the ends of stems (terminal).

All the resultant plants (F_1 generation) have red flowers that are axial.

One set of results for the offspring from self-pollinating these F_1 plants is shown below.

261	red, axial flowers
86	red, terminal flowers
76	white, axial flowers
28	white, terminal flowers

a) Draw a genetic diagram to explain both crosses.

Use the following symbols to represent the different alleles involved:

R/r – Flower colour **A/a** – Flower position [5]

Parental phenotype: Red, axial flowers X White, terminal flowers
Parental genotype (2n): RRAA X rraa

Gametes (n): (RA) X (ra) **[1]**

F_1 genotype: RrAa
F_1 phenotype: Red, axial flowers **[1]**

Selfing F_1

F_1 phenotype: Red, axial flowers X Red, axial flowers
F_1 genotype (2n): RrAa X RrAa

Gametes (n): (RA) (rA) (Ra) (ra) X (RA) (rA) (Ra) (ra) **[1]**

F_2 genotype and phenotype (2n): **[1]**

	(RA)	(Ra)	(rA)	(ra)
(RA)	RRAA Red, axial	RRAa Red, axial	RrAA Red, axial	RrAa Red, axial
(Ra)	RRAa Red, axial	RRaa Red, terminal	RrAa Red, axial	Rraa Red, terminal
(rA)	RrAA Red, axial	RrAa Red, axial	rrAA White, axial	rrAa White, axial
(ra)	RrAa Red, axial	Rraa Red, terminal	rrAa White, axial	rraa White, terminal

F_2 phenotypic ratio: Red, axial : Red, terminal : White, axial : White, terminal
9 : 3 : 3 : 1

Which is close to observed number: 261 86 76 28 **[1]**

b) Explain how different characteristics are inherited independently in dihybrid inheritance. [2]

- Different **genes** coding for different proteins can be located on **different chromosomes**
- Based on the **law of independent assortment and segregation**, alleles of one gene on a chromosome independently assort and segregate from the alleles of another gene on another chromosome, during gamete formation/meiosis.

[Total: 7]

QUESTION 3

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that evolution is taking place, leading to the formation of six different species.

Fig. 3.1 is a schematic representation of Madeira showing the distribution of the six populations.

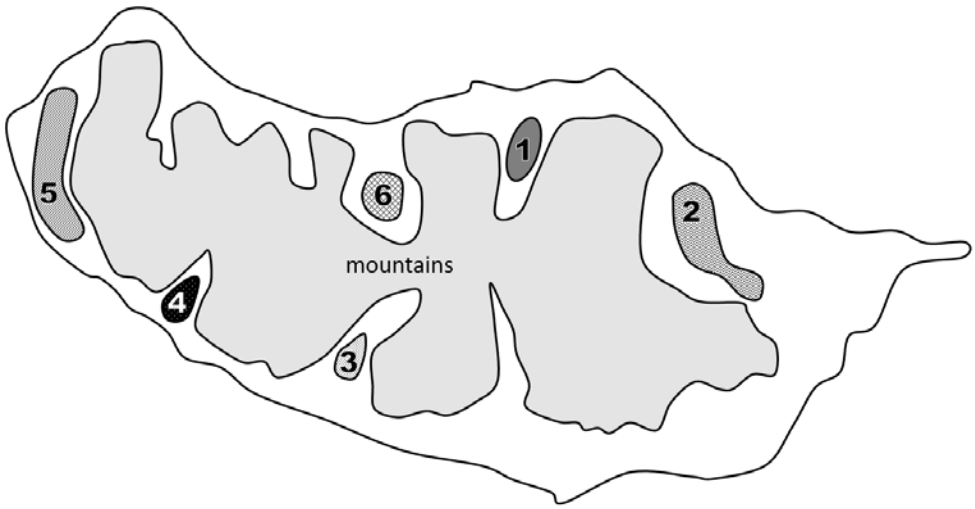

Fig. 3.1

a) '*It has been suggested that evolution is taking place, leading to the formation of six different species*.'

Explain how this process is occurring in the house mouse populations of Madeira. [4]

1. Due to **association with human settlements**, the mouse **population was scattered**.
2. **Steep mountains** serves as **geographical barriers** for the scattered populations, hence **no breeding / gene flow** between the separated populations.
3. **Different selection pressures** in each area where each population resides, hence **different alleles** are **selected for and against**.
4. **Random mutations** also occurred in each population.
5. Results in **change in allele frequency** / gene pool.
6. Develop **different chromosome numbers**, hence different species.

b) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

- Due to **different chromosome number** / diploid number
- As there is **no pairing of homologous chromosomes** in offspring, **meiosis cannot take place**, thus **no gametes** will be produced by offspring, hence **infertile**.

c) Cytochrome c is a protein that is found in all living organisms. Analysis of the amino acid sequences of proteins, such as cytochrome c, provides data that taxonomists use to produce more accurate classifications.

Explain why analyzing the amino acid sequences of proteins could provide useful data for taxonomists. [3]

- DNA codes for amino acid sequences
- Mutations result in altered DNA sequences, which results in differences in amino acid sequences
- Hence, large (small) difference in amino acid sequence between two species reflects distant (close) evolutionary relationship

[Total: 9]

QUESTION 4

The artificial plasmid, pBR322, was constructed to act as a vector. It has often been used to insert human genes, such as the human insulin gene, into the bacterium, *Escherichia coli*.

The plasmid was constructed to include two genes, each giving resistance to a different antibiotic: an ampicillin-resistant gene and a tetracycline-resistant gene. The plasmid also has a target site for the restriction enzyme, *Bam*HI, in the middle of the tetracycline-resistance gene.

A pBR322 plasmid was cut using *Bam*HI and the cDNA gene for human insulin inserted into it.

Fig. 4.1 shows pBR322 and the recombinant plasmid.

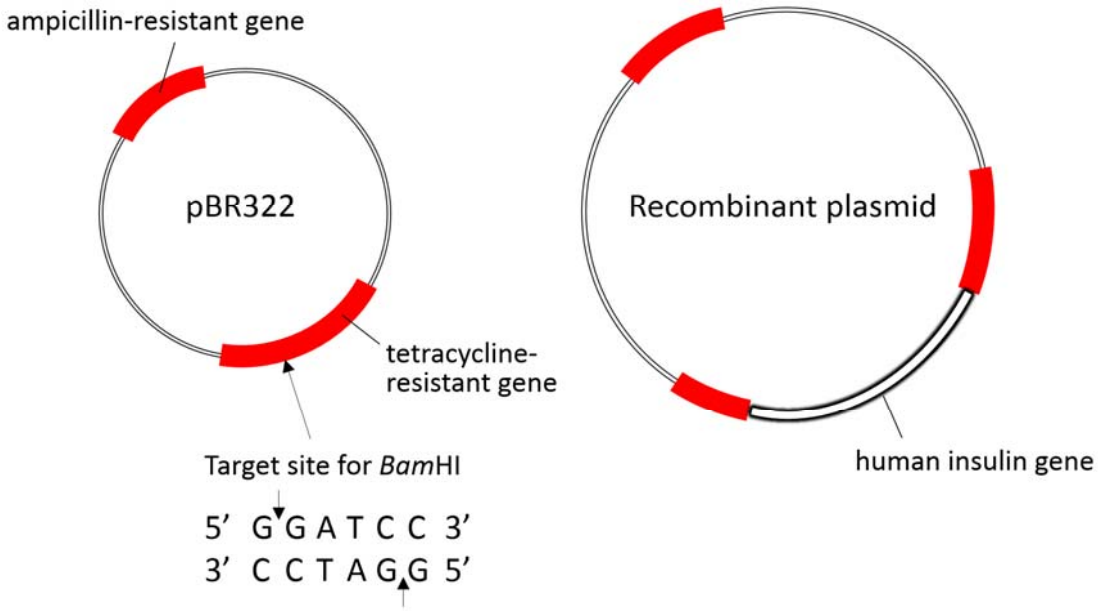

Fig. 4.1

a) The cDNA of human insulin gene obtained by reverse transcription does not contain sticky ends.

With reference to Fig. 4.1, describe how a cDNA of human insulin gene can be inserted into pBR322 that has been cut by *Bam*HI. [3]

- ***Bam*HI linkers** are added to the two ends of the cDNA gene and cut with *Bam*HI enzyme to produce *Bam*HI sticky ends GATC and CTAG
- Mix the cDNA with the *Bam*HI-cut plasmid
- Both have **same sticky ends**, hence can anneal by **complementary base pairing** through formation of **hydrogen bonds**
- **DNA ligase** seals the sugar-phosphate backbone by forming **phosphodiester bonds**

b) Bacteria were then mixed with the recombinant plasmids. Those bacteria which had successfully taken up recombinant plasmids were identified using the following steps:

Step 1 – the bacteria were spread onto culture plates containing nutrient agar and ampicillin and incubated to allow colonies to form

Step 2 – some bacteria from each of the colonies growing on these plates were transferred to plates (replica plating) containing nutrient agar and tetracycline, as shown in Fig. 4.2.

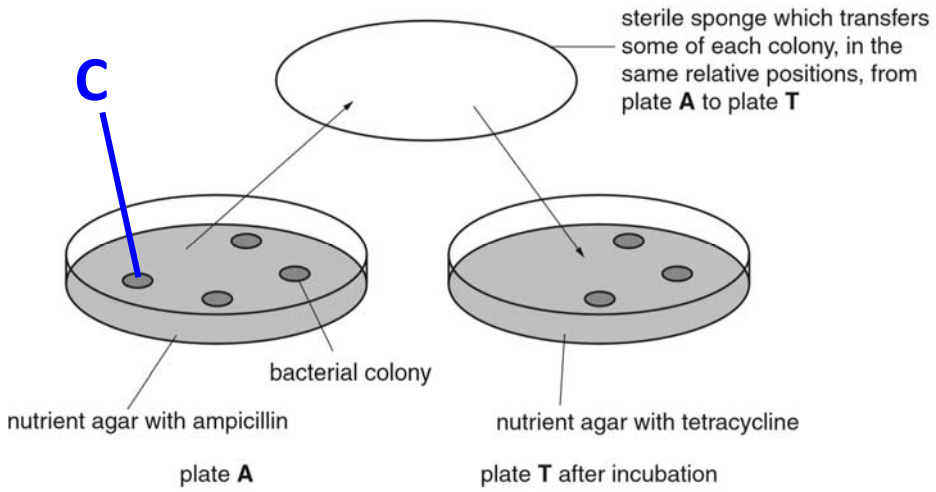

Fig. 4.2

i) Explain why the bacteria were first spread onto plates containing ampicillin. [2]

- To eliminate bacteria (>99%) which did not take up any plasmid / non-transformed bacteria
- Transformed bacteria took up (recombinant/re-annealed) **plasmid**, thus **acquiring ampicillin-resistant gene** on the plasmid
- Hence are **resistant to ampicillin** and able to **survive on ampicillin plate.**

ii) Explain why it is important that on the pBR322 plasmid, the target site for *Bam*HI is in the middle of the tetracycline resistance gene. [3]

- **Insertional inactivation / disruption of Tet^R gene** due to insertion of human insulin gene
- Colonies that are ampicillin-resistant but **not tetracycline-resistant** have taken up **recombinant plasmid**
- Colonies that survive on Tet plate have taken up the **re-annealed plasmid**
- **Compare** Amp plate and Tet plate. Colonies missing on Tet plate but present on Amp plate is the bacteria with recombinant plasmids.

iii) Use a label line and the letter **C** to identify, on Fig. 4.2, a colony of bacteria that contains the recombinant plasmid. [1]

c) Plasmid vectors carrying antibiotic-resistant genes are now rarely used in gene technology because of the risk of transferring these genes to other bacteria that are previously susceptible to that antibiotic, hence conferring antibiotic-resistance to these bacteria.

State one type of gene that has replaced antibiotic-resistant genes in plasmid vectors **and** indicate how bacteria carrying this gene can be detected. [1]

Gene	lacZ gene / β-galactosidase gene
Detection	bacterial colonies turn blue on X-GAL agar
	green fluorescent protein gene
	bacterial colonies fluoresce green under UV light
	luciferase gene
	bacterial colonies emit light on luciferin agar

[Total: 10]

Section B
Answer **all** questions

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be in set out in questions **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 5

a) DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [10]

[How DNA replication takes place accurately] – max 3
1. DNA is **double-stranded**, each strand is **complementary** to the other
2. Each strand acts as the **template** for synthesis of daughter strand by **complementary base pairing** (A=T, C≡G)
3. **DNA polymerase III** with **proofreading function** / 3'→5' exonuclease activity
4. Able to excise previous nucleotide that is wrongly paired and replace with the correct nucleotide
5. DNA polymerase I with proofreads newly-synthesized daughter strand / 5'→3' exonuclease activity

[Why DNA replication is not always perfect] – max 3
6. Exposure to radiation / chemical carcinogens / **AVP**
7. Causes structural damage to DNA + *cite an example below*
   - **a)** e.g. UV light causes thymine dimer formation
   - **b)** e.g. chemicals (such as nitrous acid) chemically reacts with base
   - **c)** e.g. ethidium bromide intercalates into DNA
8. Such structural damage causes wrong nucleotide(s) / extra nucleotide(s) / missing nucleotide(s) to be added during DNA replication.
9. Spontaneous mutation – DNA polymerase adds the wrong base, and is not being rectified.

[Why survival of offspring depends on DNA being stable] – max 2
10. ***Idea that*** Ensures sequence of DNA in genes is intact so that (normal amount of) functional proteins can be made
11. ***Idea that*** Mutation results in non-functional / hyperactive / overproduction / underproduction of proteins
12. ***Ref to*** Sickle-cell anemia – Single-base substitution to β-globin gene that causes Hb to crystallize, forming sickle-cell RBC which clogs blood vessels / inefficient O_2 transport
13. ***Ref to*** Cancer – a result of gain-of-function mutation to **proto-oncogenes** and loss-of-function mutation **tumor-suppressor genes**, leading to **uncontrolled cell division**.

[Why survival also depends on DNA being not *absolutely* stable] – max 2
14. **Ref. to** role of mutation in natural selection
    - **a.** Mutations allow for **formation for new alleles**
    - **b.** Provides **variation** between individuals in a population to allow the population to **respond to environmental change**
    - **c.** Survival of the fittest to allow population to evolve, hence **prevents extinction** of a species

b) Explain the underlying principles of the polymerase chain reaction (PCR) **and** explain how the specificity of PCR is achieved. [5]

[Underlying principles in PCR] – max 4

1. **Amplify** a segment of DNA from a very **minute amount**

[Denaturation step]

2. Use of **high heat (95°C)** to **denature template DNA** into single-stranded DNA by **breaking hydrogen bonds** between **complementary bases**.

[Annealing step]

3. Use of **DNA primers** to provide a **free 3'-OH end** for *Taq* polymerase in the elongation step.

[Elongation step]

4. Use of **thermostable *Taq* polymerase** which **does not denature at high temperatures**
5. At its optimal temperature at **72°C**, it catalyses the addition of **deoxyribonucleotides** to **3' end of primers** by forming **phosphodiester bond**

6. **Thermostable polymerase** and **excess primers and deoxyribonucleotides** allows PCR to be **automated** over many cycles.

[How the specificity of PCR is achieved] – max 1

7. Sequence of DNA primers is **complementary** to the **3' regions** of the sequence to be amplified

8. Length of primers must be **sufficiently long** (15-25 nucleotides) to ensure it binds only to target region

c) Describe the process of endocytosis.
[5]

[Phagocytosis]

1. The cell surface membrane extends **pseudopodia** / **cytoplasmic extensions** around it the particle.

2. The pseudopodia **fuse** to form a large vacuole around the particle, known as a **phagocytic vesicle**.

[Pinocytosis]

3. Process whereby a cell **invaginates** a region of the cell surface membrane, forming a **vesicle** around a small volume of **extracellular fluid.**

[Receptor-mediated endocytosis]

4. Process by which a cell can acquire **specific** molecules, even those that may be in low concentrations in the extracellular fluid.

5. The specific molecules bind to complementary **protein receptors** embedded on the cell surface membrane.

6. After binding, the receptor proteins cluster in regions of the membrane called **clathrin-coated pits**, which are lined on their cytoplasmic side by a layer of coat proteins

7. Each coated pit forms a **vesicle** containing the ligand molecules.

8. After the ligand molecules are released from the vesicle, the vesicle (and receptors) is then recycled to the cell surface membrane.

QUESTION 6

a) Discuss the importance of hydrogen bonding in ensuring the continuity of life. [10]

[Role of H-bonds between complementary base pairs]

1. Allows **complementary base pairing** to occur in **nucleic acid interactions**

[DNA]

2. Stabilizes two DNA strands to form **double helical** DNA molecule
3. ***Ref. to*** role of DNA (e.g. storing genetic information)

[tRNA]

4. Intra-molecular hydrogen bonding in tRNA allows tRNA to fold into a **clover-leaf structure**
5. ***Ref. to*** role of tRNA – carries amino acids to the ribosome for synthesis of polypeptide

[rRNA]

6. Intra-molecular hydrogen bonding in rRNA allows rRNA to fold into a **precise 3D structure** to **complex with ribosomal proteins** to form ribosome
7. ***Ref. to*** role of ribosome – translation machinery

[During DNA replication]

8. Important in DNA replication, where daughter DNA strand is synthesized via adding **complementary deoxyribonucleotides** to template DNA to ensure **accurate transmission** of genetic information.

[During transcription]

9. Important in transcription, where RNA is synthesized via adding **complementary ribonucleotides** to template DNA

[During translation]

10. Important in translation, where **codons** on mRNA complementary base pair with **anticodon** on tRNA to ensure **correct sequence of amino acids** forms the polypeptide

[Role in maintaining protein structure]

11. ***Ref. to*** maintaining **secondary** structures (**α-helices** and **β-pleated sheets**) in proteins, formed **between peptide regions**.
12. ***Ref. to*** maintaining **tertiary/quaternary** structure of proteins, formed **between R groups**.
13. ***Idea that*** **Shape** of proteins **dictates their specific functions** (e.g. in DNA replication and gene expression)

[Role in enzyme-substrate interaction]

14. ***Ref. to*** allow substrate to bind weakly to the active site of enzyme

[Role in solubility]

15. ***Ref. to*** allows hydrophilic substances to be soluble in aqueous environment to allow reaction to take place

16. ***AVP***

b) Outline the functions of membranes **within** cells. [5]

1. Form compartments (**compartmentalization)** within the cell (i.e. formation of organelles).

2. This allows the maintenance of optimal conditions for **specialized biochemical reactions** to occur.

    a) E.g. nuclear membrane: encloses DNA and allows DNA replication and transcription to occur
    b) E.g. Compartmentalization of lysosome keeps the **lysosomal lumen at pH 5** (optimal pH for lysosomal acid hydrolases).
    c) E.g. RER membrane being site of ribosome attachment for translation to take place and provide correct environment for protein folding
    d) **AVP**

3. **Attachment of specific proteins/enzymes** within organelle membrane allows enzyme-catalysed chemical reactions to take place in a **sequential manner** in a metabolic pathway

    a) E.g. photophosphorylation in the thylakoid membrane of chloroplast
    b) E.g. Oxidative phosphorylation in the inner mitochondrial membrane

4. Membranes are required for the **formation of transport vesicles** during intracellular transport.

    a) E.g. ER vesicles – transport proteins to Golgi for modification
    b) E.g. Golgi vesicles – transport proteins to their destination e.g. secretion, plasma membrane, other organelles.

5. **AVP**

c) With reference to specific examples, discuss the roles of coenzymes in yeast. [5]

[NAD]

1. NAD **oxidizes intermediates** of the **glycolysis**, **Link reaction**, and **Krebs cycle**, forming **NADH**.
2. *[A specific example of oxidation step in glycolysis / Krebs cycle that requires NAD]*

[FAD]

3. FAD **oxidizes intermediates** of the **Krebs cycle**, forming **$FADH_2$**.
4. *[A specific example of oxidation reaction in Krebs Cycle requires FAD]*

[NAD & FAD]

5. **Both NADH and $FADH_2$** acts as **electron donor** in **oxidative phosphorylation**…
6. …where they **donate electrons to the electron transport chain** and is **oxidized to NAD and FAD**.

[Coenzyme A]

7. In **link reaction** of respiration**, coenzyme A** combines with 2C compound/acetyl group to produce **acetyl CoA…**
8. **…** which then enters and is **oxidized** in the **Krebs cycle.**

[Total: 20]