

NANYANG JUNIOR COLLEGE
JC 2 PRELIMS
Higher 1

CANDIDATE
NAME

CLASS

BIOLOGY

Paper 2 Core Paper

8875/02

September 2015

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

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

Section A

Answer **all** questions,

Section B

Answer any **one** question.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

This document consists of **14** printed pages and **0** blank pages.

[Turn over

Section A

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

- 1 **Fig. 1.1** is a computer-generated image of the enzyme hexokinase binding with its substrate, glucose. The product of the enzyme-catalysed reaction is glucose-6-phosphate.

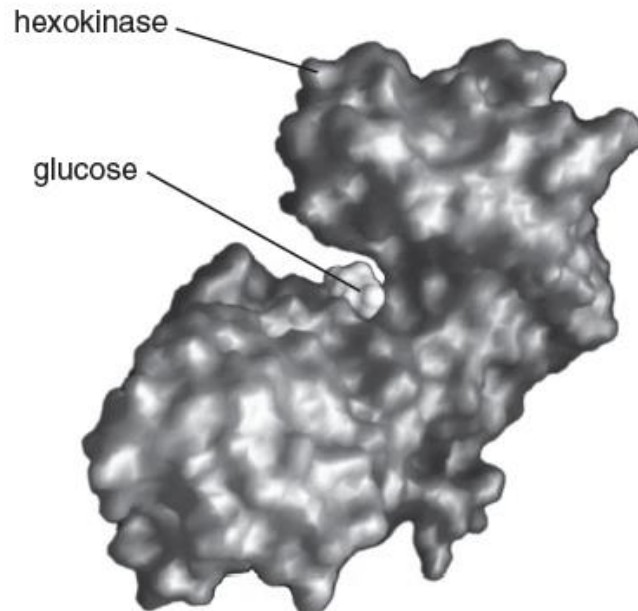


Fig. 1.1

- (a) Hexokinase binds with glucose using the induced fit mechanism.

Describe how an enzyme-substrate complex forms by this mechanism.

glucose/ substrate, is not complementary / is partially complementary, to active site ;

Enzyme's active site changes shape and fits around, when substrate, enters / binds ;
 ® if substrate/ glucose changes

stronger binding of substrate to active site ;

further detail ; e.g. becomes complementary to/ fits more tightly to, glucose/ substrate
 interaction of, functional groups /R-groups / side-chains formation of (named) bond
 but not disulfide or peptide bond

[3]

- (b) Suggest how enzymes which use the induced fit mechanism can be less affected by competitive inhibitors than those which use the lock and key mechanism.

(competitive) inhibitor has, same/ similar, shape to substrate ;

inhibitor does not induce the same change in, 3D shape/ tertiary structure/ active site
 (as the substrate) ;

so inhibitor) less likely to bind (successfully) in active site ;

idea that because it does not have same functional groups (in same positions)/AW ;

in lock and key the inhibitor, fits directly into/ is complementary to/ binds to, active
 site ;

[2]

- (c) Glucose can enter cells by active transport or facilitated diffusion.
Glucose-6-phosphate is a molecule that cannot move out of cells.

(i) Describe two **differences** between active transport and facilitated diffusion.

active transport requires, ATP/ energy (whereas facilitated diffusion does not) ;

active transport moves substances against the concentration gradient whereas facilitated diffusion moves substances down the concentration gradient ;

active transport uses only carrier proteins (whereas facilitated diffusion uses both carrier and channel proteins) ;

@ active transport can involve cotransport but facilitated diffusion does not

[2]

(ii) Suggest why glucose-6-phosphate cannot move out of cells.

too large/ too big to pass through temporary gaps in the phospholipid bilayer ; R 'it is a big molecule' unqualified

Polar / charged, so cannot pass through hydrophobic region of membrane / fatty acid tails ;

no, specific /AW, protein, in membrane/ carrier/ channel / no protein for G-6-P

AVP ; e.g. gated channels are closed

[2]

[Total: 9]

2 (a) Explain what is meant by the term heterozygous genotype.

heterozygous:

Two different alleles for a gene at a particular locus on a pair of homologous chromosomes

/ different allele pair for a gene / AW;

Produces gametes with different genotypes ;

genotype:

Alleles present in an organism / particular alleles of a gene / genetic constitution / AW;

[2]

- (b) Suggest how Tail length in cats is determined by the Japanese Bobtail gene. The normal wild-type allele T is dominant and codes for normal tail length in cats. The mutant allele t is recessive and codes for a short tail, as found in the Japanese Bobtail breed, hence the name.

Coat colour in cats is determined by the *tyr* gene, which codes for tyrosinase enzyme. This enzyme is involved in pigment production, and controls the intensity of body colour in cats. There are five different alleles for the *tyr* gene, namely full colour B, Burmese b^M , Siamese b^S , blue-eyed albino b^A , and albino b. Each allele gives rise to a different mutant tyrosinase enzyme, resulting in the different phenotypes observed.

Table 2.1 below shows the different breeds possible.

Table 2.1

	B	b^M	b^S	b^A	b
B	Normal	Normal	Normal	Normal	Normal
b^M		Burmese	Tonkinese	Burmese	Burmese
b^S			Siamese	Siamese	Siamese
b^A				Blue-Eyed Albino	Blue-Eyed Albino
b					Albino

- (i) With reference to **Table 2.1** above, determine the relative dominance of the alleles B, b^M , and b^S .

B is dominant over b^M and b^S ;

b^M and b^S are codominant / show incomplete dominance;

[2]

- (ii) A homozygous Burmese female cat with normal tail was crossed with a homozygous Siamese male cat with a short tail. The F₁ offspring were then sibling-mated to form the F₂ generation. Draw a genetic diagram to show the expected genotypes and phenotypes of the F₂ offspring.

Parental generation

Parental phenotypes Burmese, normal tail x Siamese, short tail
 Parental genotypes $b^M b^M TT$ $b^S b^S tt$

After meiosis,
gametes produced

$b^M T$

$b^S t$

Random fertilization

F₁ generation

F₁ Genotype $b^M b^S Tt$;

F₁ Phenotype All Tonkinese, normal tail

Mating of F₁ $b^M b^S Tt$ x $b^M b^S Tt$

After meiosis,
gametes produced

$b^M T$

$b^M t$

$b^S T$

$b^S t$

$b^M T$

$b^M t$

$b^S T$

$b^S t$

;

By random fertilization,

	$b^M T$	$b^M t$	$b^S T$	$b^S t$
$b^M T$	$b^M b^M TT$ Burmese, normal	$b^M b^M Tt$ Burmese, normal	$b^M b^S TT$ Tonkinese, normal	$b^M b^S Tt$ Tonkinese, normal
$b^M t$	$b^M b^M Tt$ Burmese, normal	$b^M b^M tt$ Burmese, short	$b^M b^S Tt$ Tonkinese, normal	$b^M b^S tt$ Tonkinese, short
$b^S T$	$b^M b^S TT$ Tonkinese, normal	$b^M b^S Tt$ Tonkinese, normal	$b^S b^S TT$ Siamese, normal	$b^S b^S Tt$ Siamese, normal
$b^S t$	$b^M b^S Tt$ Tonkinese, normal	$b^M b^S tt$ Tonkinese, short	$b^S b^S Tt$ Siamese, normal	$b^S b^S tt$ Siamese, short

F₂ generation

F ₂ genotypic ratio	2b ^M b ^S TT 4b ^M b ^S Tt:	1b ^M b ^M TT 2b ^M b ^M Tt	1b ^S b ^S TT, 2b ^S b ^S Tt	2b ^M b ^S tt	1b ^M b ^M tt	1b ^S b ^S tt	;
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F ₂ phenotypic ratio	6 Tonkinese, normal	3 Burmese, normal	3 Siamese, normal	2 Tonkinese, short	1 Burmese, short	1 Siamese, short	;
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- (c) Siamese cats have a unique coat pattern. They have a white body and black extremities. The extremities, which include ears, face, legs and tail, are cooler regions. These cats possess the tyr allele b^s , which codes for a temperature-sensitive mutant tyrosinase enzyme. **Fig. 2.2** below shows a diagram of a typical Siamese cat.



Fig. 2.2

Suggest how the environment results in the characteristic coat pattern in Siamese cats.

All cells of the Siamese cat possess the same genotype ($b^s b^s / b^s b^A / b^s b$) /contain the allele b^s ;

At lower temperatures, mutant tyrosinase enzyme has a unique three-dimensional conformation and is functional therefore fur is black at the extremities;

High temperature denatures mutant tyrosinase and therefore it is no longer functional;

No black pigment is formed and therefore cat has white body;

2 marks max

[2]

[Total: 10]

3 Fig. 3.1 outlines some steps in glucose metabolism in mammalian cells.

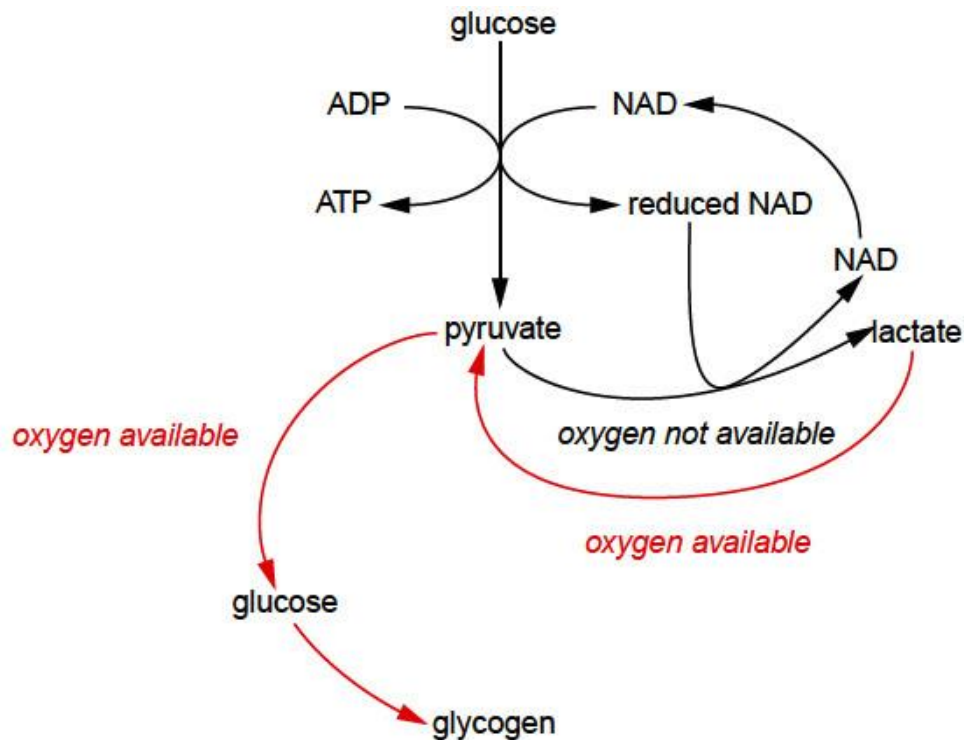


Fig. 3.1

(a) With reference to Fig. 3.1,

(i) explain why, in the absence of oxygen, pyruvate needs to be converted to lactate;
regenerate NAD^+ so that glycolysis can continue;

to produce (2) ATP via substrate level phosphorylation;

[2]

(i) name the type of reaction **and** the type of bonds formed when glucose molecules are used to make glycogen.

Type of reaction: condensation

Type of bonds: glycosidic bonds (α -1,4- and α -1,6-)

[1]

(b) ATP is often known as the universal 'energy currency'.

Outline how ATP is suitable for acting as an energy currency.

terminal phosphate removed easily ;

releasing, useful / AW, amount of energy when hydrolysed ;

allows efficient energy transfer ;

small / water soluble, easily moved around cell ;

is used by (many), enzymes / proteins ;

idea that adenine + ribose = recognition site;

idea that easily recycled ;

three phosphate groups are negatively charged and unstable ;

charged so does not pass through membranes (and lost to cell) ;
 AVP ;

[2]

- (c) Most ATP is made in cells by membrane systems that create proton gradients by pumping protons from one compartment to another.

Fig. 3.2 shows two such membrane systems.

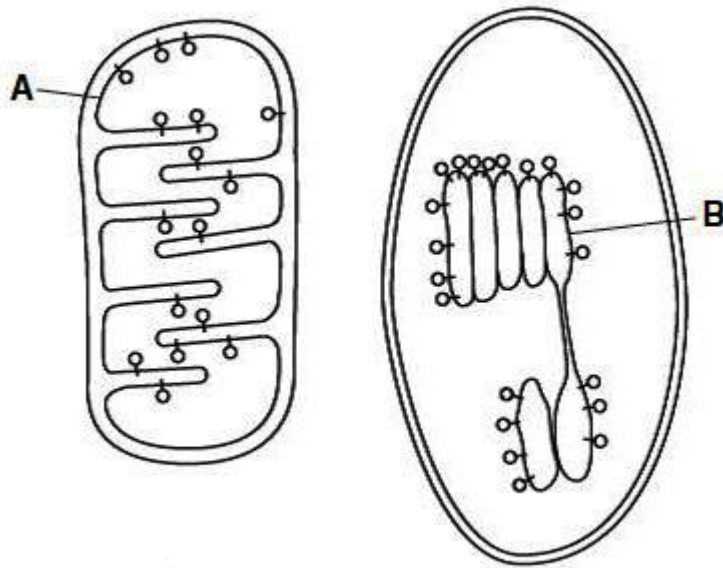


Fig. 3.2

- (i) Draw arrows onto each of the membrane systems in **Fig. 3.2** to show the direction in which protons are pumped.
 A – matrix to inter membrane space, (ignore leakage from organelle)
 B – into thylakoid,
 ® if goes through synthase

[1]

- (ii) Outline how energy is made available for pumping protons across such membranes.

Oxidation of glucose via glycolysis and Krebs cycle/ absorption of light energy by pigments results in formation of reduced coenzymes;

Electrons from reduced coenzymes/ NAD/ FAD/ NADP passed down electron carriers each with an energy level lower than the one preceding it;

Energy released by transfer of electrons used to pump H^+ from stroma/ matrix to thylakoid space/ intermembrane space;

energised electrons ;

(A) from oxidation of, food / named substrate(s) ;

from oxidation of reduced, hydrogen carriers / named ;

ref redox potential of reduced, NAD ; A ref FAD

(B) from absorption of light by pigments ;

electron transport chain ;

protein complexes with decreasing redox potential / AW ;

final acceptor for, electrons / hydrogen ;

[3]

- (iii) Explain how ATP synthase is involved in the production of ATP.

Diffusion of H^+ down the gradient through stalked particles containing ATP synthase;

Catalysing the formation of ATP from ADP + P_i

proton gradient / AW ;

facilitated diffusion ;

kinetic energy ;

phosphate added to ADP ;

detail of structure of ATP synthase ;

detail of function of ATP synthase ;

[2]

[Total: 11]

- 4 **Fig. 4.1** outlines how a gene coding for human insulin is produced by genetic engineering techniques.

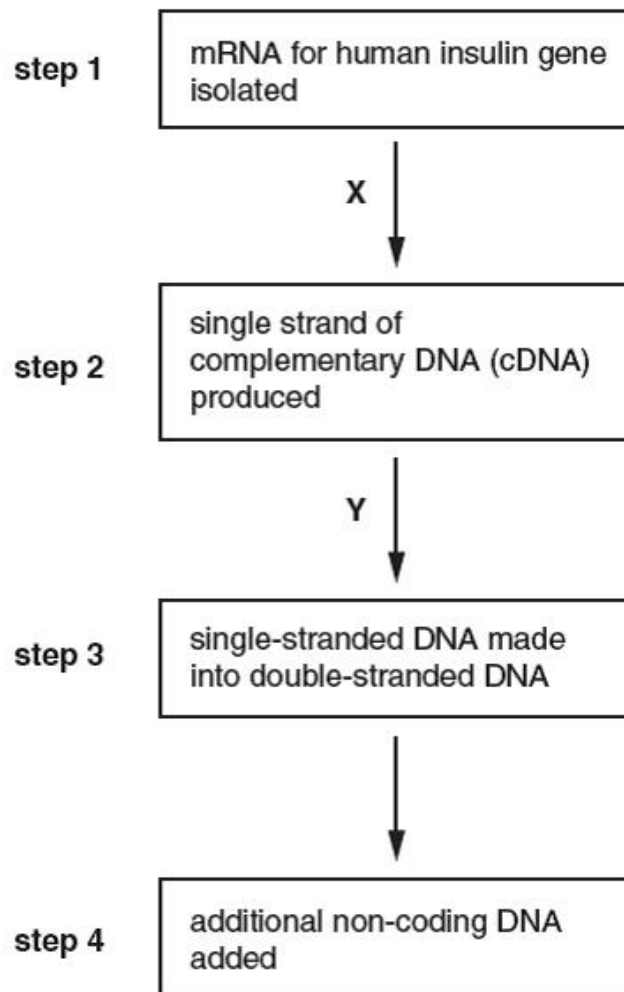


Fig. 4.1

(a) (i) Name the enzymes X and Y.

X reverse transcriptase

Y DNA polymerase

[2]

(ii) Explain why the starting point in this procedure is mRNA.

Large number of copies of mRNA readily available ;

idea of mRNA is only from gene coding for insulin (being expressed) ;

easier than, extracting/locating, gene from cell's DNA ;

AVP ; e.g. introns already removed/bacteria cannot remove introns ;

[2]

(b) 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 resistance gene and a tetracycline resistance 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. 4.2 shows pBR322 and the recombinant plasmid.

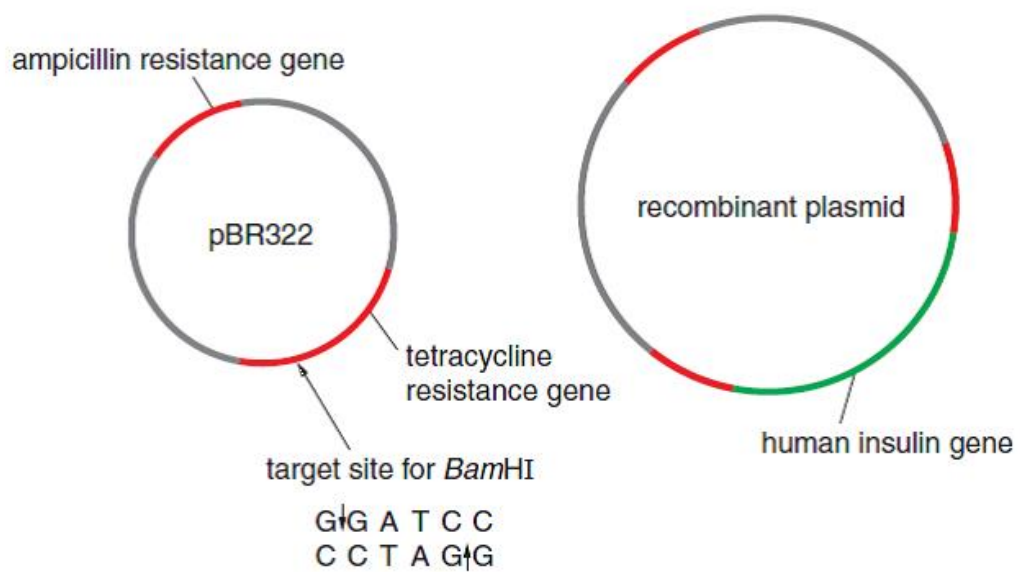


Fig. 4.2

- (c) Bacteria were then mixed with the recombinant plasmids shown in **Fig. 4.2**. 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 containing nutrient agar and tetracycline, as shown in **Fig. 4.3**.

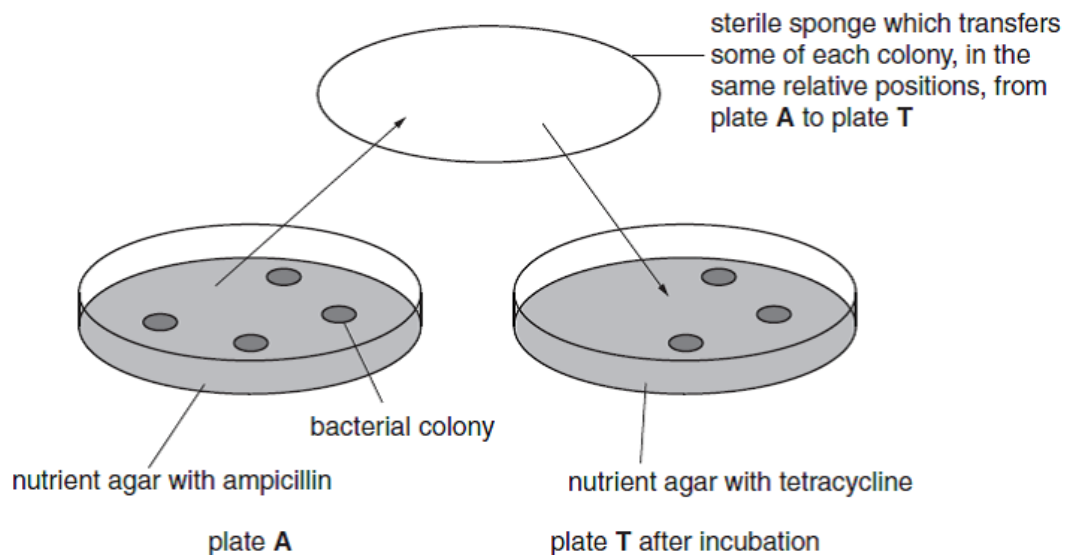


Fig. 4.3

- (i) Explain why the bacteria were first spread onto plates containing ampicillin.

idea of identifying bacteria that, are transformed / have taken up plasmid / have taken up ampicillin resistance gene;

these bacteria have survived;

these bacteria may contain pBR322 or recombinant plasmid / plasmids taken up may not contain human insulin gene;

other untransformed bacteria have been killed;

[2]

- (ii) Explain why it is important, for identifying bacteria that have successfully taken up the recombinant plasmid, that on pBR322 the target site for *Bam*HI is in the middle of the tetracycline resistance gene.

(BamHI) breaks the tetracycline resistance gene / insertional inactivation;

inserting human insulin gene makes tetracycline resistance gene inactive ;

colonies that are ampicillin-resistant but not tetracycline-resistant have taken up recombinant plasmid / insulin gene ;

colonies that survive on, tetracycline / both ampicillin and tetracycline / plate T, have not taken up the recombinant plasmid / insulin gene ;

[3]

- (iii) Use a label line and the letter **C** to identify, on **Fig. 4.3**, a colony of bacteria that contain the recombinant plasmid.

Answer on Fig. 1.2 left hand colony on plate A ;

[1]

[Total: 10]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

- 5** (a) Outline the arrangements and functions of named membranes within the cell. [7]
- (b) Explain how the fluid mosaic model of cell surface membrane facilitates the transport of substances. [7]
- (c) The enzyme catalase is found in potatoes. This enzyme catalyses the breakdown of hydrogen peroxide to water and oxygen.
Describe an investigation into the effect of substrate concentration on the activity of catalase in potatoes, by measuring the release of oxygen. [6]
- [Total: 20]**
- 6** (a) Compare the process of DNA replication with polymerase chain reaction (PCR). [7]
- (b) Explain how sexual reproduction can lead to variation. [8]
- (c) Following cytokinesis, one of the daughter cells may not have a nucleolus.
This cell is able to divide once more and then the new daughter cells die.

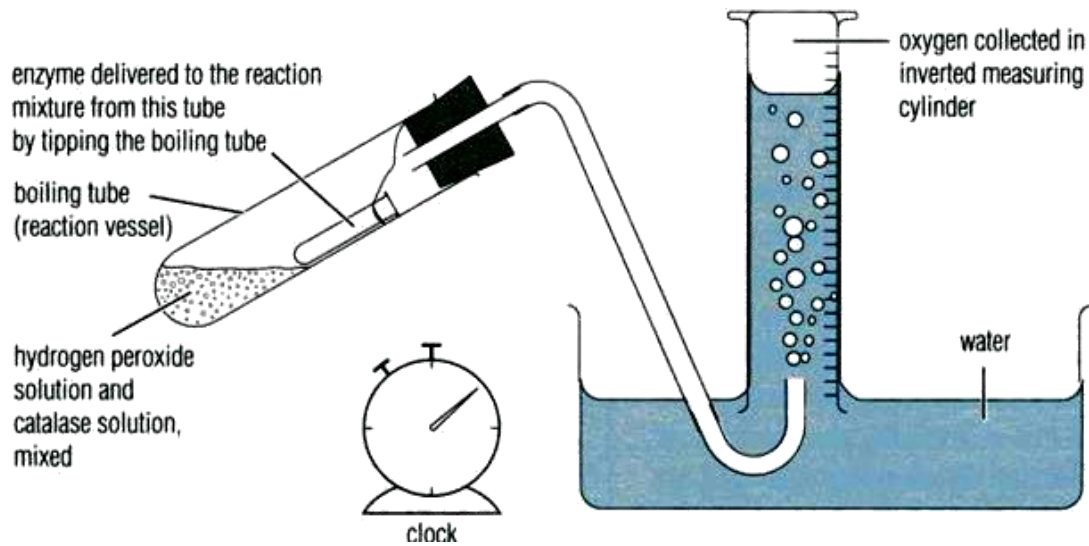
Explain how the cell is able to survive for one more cell division and suggest why the new daughter cells then die. [5]
- [Total: 20]**

5 (a) Outline the arrangements and functions of named membranes within the cell.

1. Nuclear envelope: double membrane structure with the presence of nuclear pores;
2. Encloses the DNA within the nucleus / nuclear pore allow for transport of mRNA from nucleus to cytoplasm;
3. Mitochondria: double membrane structure with the electron transport chain and stalked particles containing ATP synthase embedded in the cristae;
4. Allow for the synthesis of ATP when protons diffuse down the electrochemical proton gradient generated across the cristae.
5. Chloroplast: double membrane structure with the electron transport chain and stalked particles containing ATP synthase embedded in the thylakoids;
6. Allow for the synthesis of ATP through photophosphorylation for the reduction of glycerate phosphate to triose phosphate in Calvin cycle.
7. Endoplasmic reticulum: single membrane + transport vesicles bud off for intracellular transport / contain transport protein for polypeptide to enter lumen for folding into proteins;
8. Golgi apparatus: single membrane + transport vesicle from ER fuses with cis face;
9. And after chemical modification of proteins, secretory vesicles bud off trans face;
10. Vesicles contains proteins to be secreted out of cell by fusing with cell surface membrane through exocytosis;
11. Lysosomes: single membrane bound + contain hydrolytic enzymes;
12. Fuses with endosome for digestion of foreign particles;

5(b)

1. Cell surface membrane are made of phospholipids which are amphipathic;
2. Fluid refers to phospholipids and proteins can move freely;
3. Usually laterally within the same monolayer and seldom do a flip-flop;
4. Mosaic refers to proteins molecules are scattered and embedded within phospholipid bilayer;
5. Presence of transmembrane proteins spanning across both layers for transport of molecules;
6. Partially permeable membrane allows transport of certain molecules;
7. Hydrophobic tails repel polar substances like charged ions and close packing of hydrophobic tails prevents large molecules like glucose from passing through;
8. It allows the passage of hydrophobic molecule like oxygen and relatively small hydrophilic molecules such as water;
9. Membranes are impermeable to ions. Membrane allows transport of specific solutes through transport proteins. These proteins transport substances, like charged ions and large polar molecules like glucose, which do not readily pass through cell membrane;
10. Endocytosis is the process of intake of substances by formation of vesicles via invagination of cell surface membrane. A small area of plasma membrane sinks inwards and pinches off to form a vesicle containing the substance.
11. Exocytosis involves transport of materials out of cell. Materials to be transported out are enclosed in a secretory vesicle, usually from Golgi apparatus. Vesicles move along cytoskeleton to cell surface membrane and vesicle membrane fuses with it. Contents are then discharged from cell.



- 1 Fix the enzyme concentration at 1% catalase
- 2 Using a stock solution of 20% hydrogen peroxide, prepare 5 different concentration of hydrogen peroxide at 4%, 8%, 12%, 16% and 20% using distilled water to dilute.
- 3 Add 1 cm³ of 1% enzyme and 4 cm³ of hydrogen peroxide into a boiling tube.
- 4 The reaction mixture in a boiling tube is to be placed in a thermostatically water bath to ensure constant temperature.
- 5 Set up as shown in the diagram.
- 6 Measure the amount of oxygen in a fixed time / measure the time taken for 5 cm³ of oxygen to be released.

Similarities

- 1 Involve separation of two polynucleotides strands and each used as template;
- 2 Require DNA polymerase and primers;
- 3 Involve synthesis of new strands in 5" to 3" direction **or** primers added at the 3" ends **or** nucleotides are added to the 3" OH ends of the primers;
- 4 Both processes resulted in an increase in the amount of DNA

Features	DNA replication	PCR
Separation	Separation of double helix by helicase	Separation by heating to high temperature / denaturation ;
Replicated section	Entire DNA molecule replicated	A section of DNA replicated;
Primers used	RNA primers	DNA primers;
Presence of lagging strands	Presence of Okazaki fragments or supercoiling requiring the use of topoisomerase	No Okazaki fragments or lack of supercoiling not requiring the use of topoisomerase;
Polymerases involved	DNA polymerase	Taq DNA polymerase needed;
Accuracy of replication	Proofreading ability of DNA pol	Taq polymerase lacks proofreading ability;
Start of replication	Origins of replication	Where primers binds ;
Synthesis of Primers	Primers are made by primase or primers excised	Primers are added / made in the lab or primers not excised;
Temperature	Occurs at body temperature	Annealing 50-60°C Elongation 72°C and denaturation 90°C
Aim / Purpose	Occurs prior to cell division to replace dead cells lost due to wear and tear	To amplify DNA for forensics analysis

1. Meiosis is an important step for sexual reproduction as haploid gametes are produced
2. Gametes (haploid cells) fuse to form a diploid zygote, restoring the diploid state of somatic cells / maintaining the chromosome number;
1. Meiosis results in genetic variation as the reduction division allows the combining of genetic materials from two parents / individuals;
2. Due to crossing over of non-sister chromatids of homologous chromosomes, at the chiasmata, during prophase I;
3. Thus allowing corresponding sections to be exchanged, separating linked genes / creating new combination of alleles in each chromatid;
4. Due to independent assortment of chromosomes during metaphase I, whereby the orientation of homologous pair of chromosomes along the metaphase plate is independent of other bivalents;
5. This is followed by independent segregation during anaphase I, resulting in numerous possible chromosomal combinations in a gamete, i.e. 2^n , where n = number of homologous pairs of chromosomes;

6. In addition, during fertilization, random fusion of gametes occurs, resulting in numerous combinations of a zygote;
 - 1 The nucleolus contains the gene coding for ribosomal RNA;
 - 2 It is also the site of rRNA synthesis, assembly of rRNA and ribosomal proteins to form ribosomal subunits
 - 3 The absence of nucleolus results in the cell not able to synthesis rRNA.
 - 4 The cell is able to survive for one more cell division due to the pre existing ribosomes present allowing it to carry out protein synthesis.
 - 5 The new daughter cells because they are unable to form their own ribosomes and unable to carry out protein synthesis.