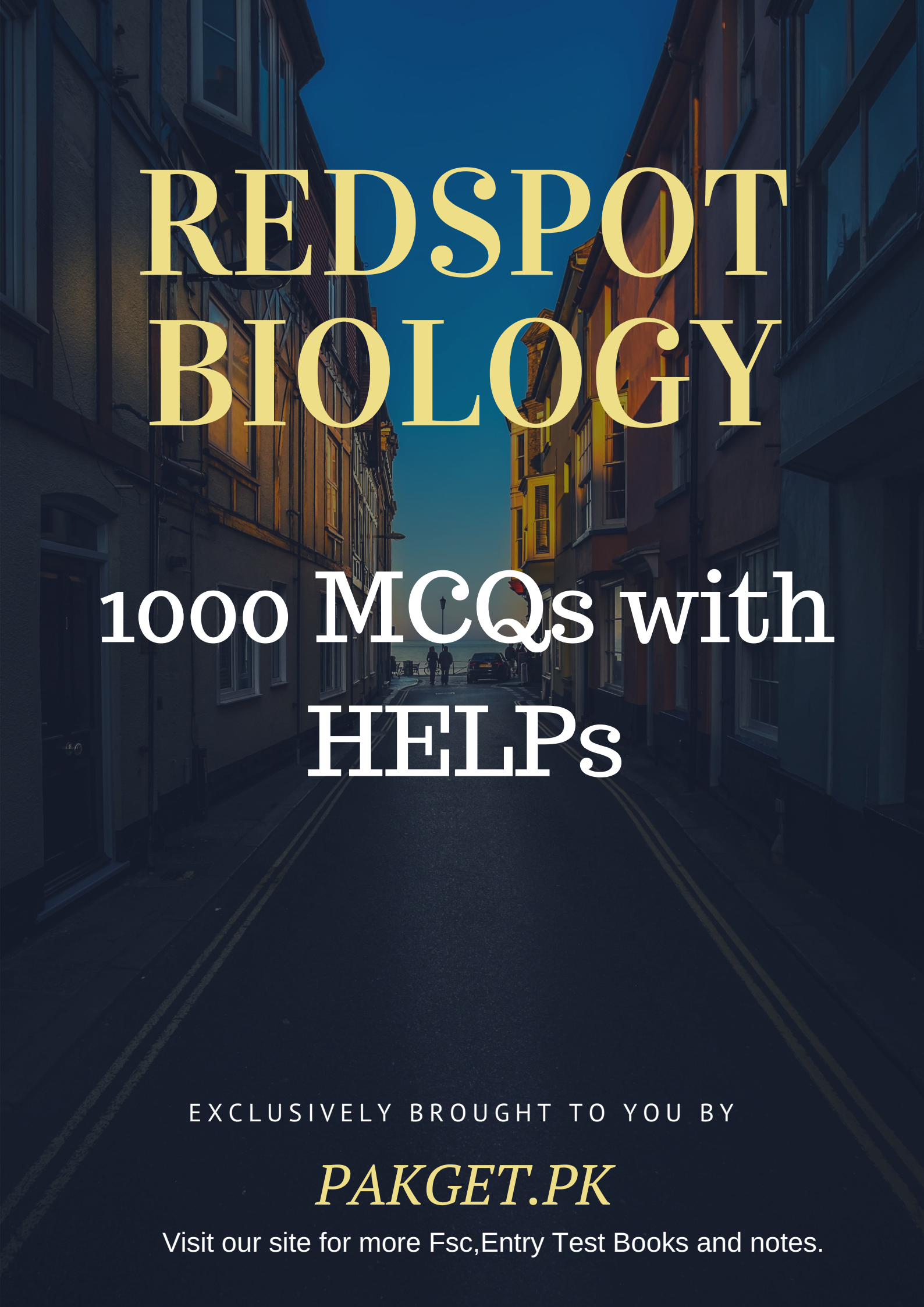

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TOPIC 1

CELLULAR FUNCTIONS

1(a) **Cell Organelles**

You should try to answer on your own before resorting to **HELP**.

Q1

Which one of the following organelles always contains DNA?

A centriole

B Golgi apparatus

C lysosome

D mitochondrion

HELP

Mitochondrial DNA is located in the matrix or sometimes attached to the inner mitochondrial membrane. The DNA encodes a similar set of rRNAs, tRNAs and essential mitochondrial proteins.

Q2

Which one of the following would exocrine cells be expected to contain as a result of their function?

A increased amounts of DNA

B increased amounts of rough endoplasmic reticulum

C increased numbers of lysosomes

D large mitochondria

HELP

Secretory cells always have abundant rER and Golgi apparatus. Newly made secretory proteins are localised to the lumen of the rough ER. The proteins then migrate to the Golgi complex in the membrane-bound vesicles.

Q3

The nuclei of both plant and animal cells contain one or more dense bodies known as nucleoli. Which one of the following correctly describes the function of nucleoli?

A the formation of new DNA molecules

B the organisation of the spindle during nuclear division

C the replication of mitochondria following nuclear division

D the formation of ribosomes

HELP

The nucleolus is a suborganelle of the nucleus. A region of one or more chromosomes in the nucleolus, called the nucleolar organiser, contains many copies of DNA which directs the synthesis of the rRNA. rRNAs are components of ribosomes which are essential in protein synthesis.

Q4

Which of the following cell structures contains the highest concentration of RNA?

A centriole B chromosome

C lysosome D nucleolus

HELP

The nucleolar organiser is a region of one or more chromosomes in the nucleolus which contains DNA copies that direct rRNA synthesis.

Q5

Some fresh rat liver was homogenised and the suspension subjected to differential centrifugation. The procedure is shown in the table below.

treatment		*sediment*
800 *g* for 10 minutes	→	fraction 1
↓ supernatant		
2000 *g* for 15 minutes	→	fraction 2
↓ supernatant		
25000 *g* for 15 minutes	→	fraction 3
↓ supernatant		
105000 *g* for 60 minutes	→	fraction 4

(*g* = gravitational force)

Which one of the following represents the order in which the organelles were removed from the suspension?

	fraction 1	fraction 2	fraction 3	fraction 4
A	mitochondria	lysosomes	nuclei	ribosomes
B	lysosomes	nuclei	ribosomes	mitochondria
C	mitochondria	nuclei	lysosomes	ribosomes
D	nuclei	mitochondria	lysosomes	ribosomes

HELP

The heaviest cell components will sediment first and the least dense component last. This result in the nuclei being removed first, followed by mitochondria, lysosomes and lastly, the ribosomes.

Q6

Which of the following, **A**, **B**, **C** or **D**, correctly shows structures which are found in a eukaryotic cell? (✓ = present; ✘ = absent)

	nuclear membranes	*mitochondria*	*ribosomes*
A	✘	✘	✘
B	✘	✓	✘
C	✓	✘	✘
D	✓	✓	✓

HELP

A eukaryotic cell has a nuclear membrane which envelopes the nucleus. Mitochondria are present for the respiratory process, and ribosomes are important in translation.

Q7

What distinguishes a prokaryotic cell from a eukaryotic cell?

A Prokaryotic cells have a cell wall and a nucleus.

B Prokaryotic cells have no membrane-bound organelles.

C Prokaryotic cells have a centriole.

D Prokaryotic cells have no ribosomes.

HELP

Prokaryotic cells include bacteria, and lack membrane-bound organelles, e.g. nuclear membrane. Instead, the nucleus is known as a nucleoid.

Q8

Which of the following is present in all eukaryotic cells?

A cell wall

B diploid nucleus

C flagellum

D membrane-bound organelles

HELP

All eukaryotic cells have organelles that are bound by membranes, whilst that of prokaryotes lack membranes.

Q9

Pancreas tissue from a freshly killed rat was removed, placed in warm isotonic saline solution and radioactively labelled amino acids were added. At intervals after adding the amino acids, samples of the tissue were removed, sections cut and the sites of radioactivity determined.

Which one of the following represents the order in which radioactivity appeared in organelles?

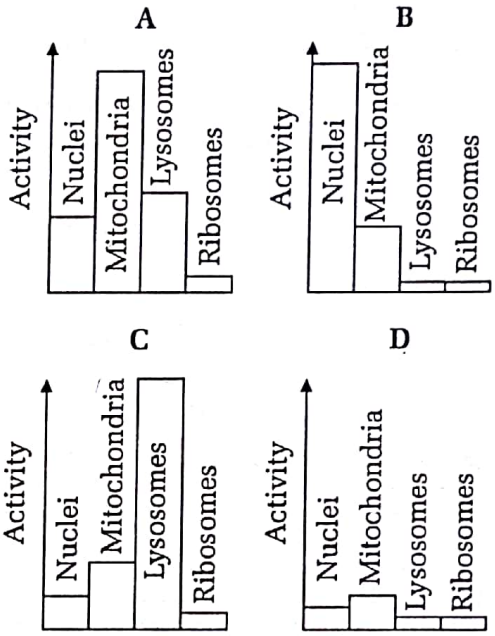
A	Golgi apparatus	smooth endoplasmic reticulum	rough endoplasmic reticulum	secretory vesicles
B	Golgi apparatus	rough endoplasmic reticulum	smooth endoplasmic reticulum	secretory vesicles
C	rough endoplasmic reticulum	smooth endoplasmic reticulum	Golgi apparatus	secretory vesicles
D	rough endoplasmic reticulum	smooth endoplasmic reticulum	secretory vesicles	Golgi apparatus

HELP

The labelled amino acids are first assembled into proteins in the rough ER, where the ribosomes are located. They then migrate to the Golgi apparatus for modification via the smooth ER. The proteins are then assembled in secretory vesicles ready for secretion.

Q10

A piece of mammalian tissue was homogenised and subjected to differential centrifugation. Five subcellular fractions were investigated to determine their relative biochemical activity. The diagrams below, **A**, **B**, **C** and **D**, indicate the relative activity of certain biochemical processes in these fractions.



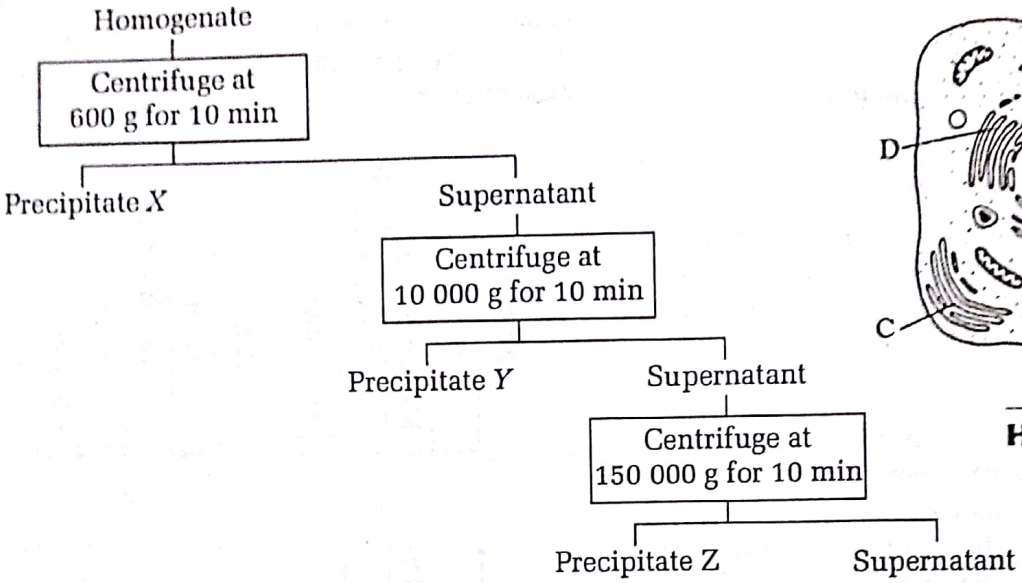
Which diagram indicates the fraction with maximum hydrolytic enzyme activity?

HELP

C is chosen because the highest biochemical activity is observed in the lysosomes, which are membrane-bound organelles which contain enzymes that degrade polymers into their monomeric subunits.

Q11

The diagram is an outline of the procedure for separation of cell components from a liver homogenate in 0.25 M sucrose at 0 °C.



What do *X*, *Y* and *Z* represent?

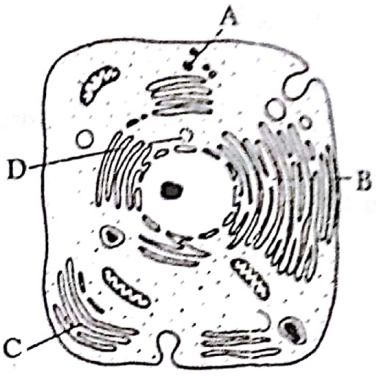
	X	*Y*	*Z*
A	cell walls	nuclei	mitochondria
B	endoplasmic reticulum and ribosomes	nuclei	mitochondria
C	endoplasmic reticulum and ribosomes	mitochondria	nuclei
D	nuclei	mitochondria	endoplasmic reticulum and ribosomes

HELP

During centrifugation, the cell components move up or down the medium to the level at which the density of the medium is equal to their own density. The nuclei, which have the highest density, precipitate first, followed by the next dense components, the mitochondria and the ER and lastly, the ribosomes.

Q12

The diagram shows a generalised animal cell. Which structure replicates during mitosis and generates the spindle?



HELP

The centriole, D, is a small cylindrical particle which radiates microtubules in all directions, forming asters. The centriole itself is made of microtubules and they duplicate during interphase to form daughter centrioles.

Q13

What is the site of enzyme synthesis in cells?

A Golgi apparatus
B lysosome
C ribosome
D smooth endoplasmic reticulum

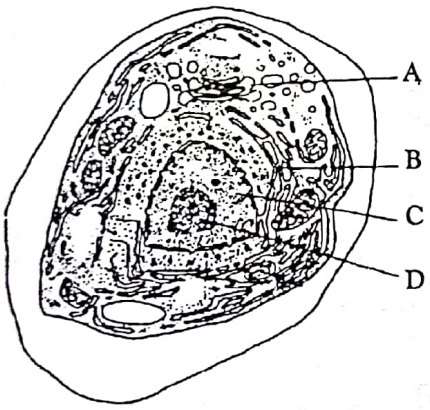
HELP

Enzymes are proteins and protein synthesis occurs in the ribosomes. The Golgi apparatus processes cell materials and transports them to other parts of the cell or to the cell surface membrane for secretion. The breakdown of structures and molecules

occurs in the lysosome. The smooth endoplasmic reticulum is the site of lipid and steroid synthesis.

Q14

The diagram shows the ultrastructure of a eukaryotic cell. Which organelle does **not** contain nucleic acid?



HELP

A represents the Golgi vesicles, which do not contain nucleic acids, It is the site where secretory proteins are first modified before they are directed to their destination.

Q15

Some cellular organelles are bound by a single membrane, while other organelles have two membranes (envelopes) around them. Which one of the following is correct?

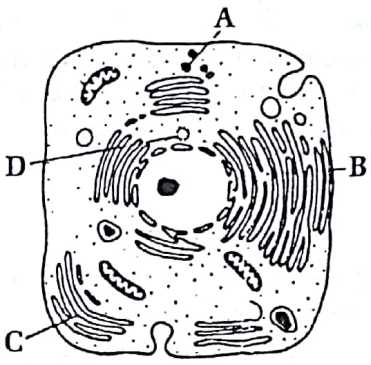
	single membrane		*two membranes*	
A	tonoplast	lysosome	nucleus	chloroplast
B	chloroplast	lysosome	nucleus	tonoplast
C	nucleus	chloroplast	lysosome	tonoplast
D	nucleus	lysosome	chloroplast	tonoplast

HELP

Both the tonoplast and lysosome are organelles which are bound by a single membrane each, whilst the nucleus and chloroplast have 2 enveloping membranes.

Q16

The diagram below shows some of the structures in an animal cell.



Which one of the structures **A**, **B**, **C** or **D**, would be involved in the final secretion of digestive enzymes from this cell?

HELP

A shows a secretory vesicle which buds off from the trans side of the Golgi complex after the secretory proteins are processed, it will fuse with the plasma membrane and release its contents into the extra-cellular space.

Q17

When a glycoprotein is being synthesised for secretion from a cell, which route is it most likely to take?

A Golgi apparatus → rough endoplasmic reticulum → smooth endoplasmic reticulum

B rough endoplasmic reticulum → Golgi apparatus → smooth endoplasmic reticulum

C rough endoplasmic reticulum → smooth endoplasmic reticulum → Golgi apparatus

D smooth endoplasmic reticulum → Golgi apparatus → rough endoplasmic reticulum

HELP

The protein part of the glycoprotein is first synthesised in the rough ER, where the ribosomes are situated. They then migrate through the smooth ER to the Golgi apparatus, where the carbohydrate chain is added on to the protein to form the glycoprotein. They are then directed to their destination.

Q18

The key below can be used to separate the following cell organelles:

nuclei, chloroplasts, mitochondria, ribosomes and lysosomes.

(i) membrane with definite pores V

(ii) inner membrane with stalked particles attached ..... W

(iii) inner membrane folded into thylakoids X

(iv) composed of one unit ..... Y

(v) composed of one large and one small sub-unit ..... Z

What are V, W, X, Y and Z?

	V	W	X	Y	Z
A	chloroplasts	lysosomes	nucleus	ribosomes	mitochondria
B	chloroplasts	nucleus	lysosomes	mitochondria	ribosomes
C	mitochondria	ribosomes	chloroplasts	nucleus	lysosomes
D	nucleus	mitochondria	chloroplasts	lysosomes	ribosomes

HELP

The nuclear membrane contains pores. The stalked particles in the mitochondria are responsible for electron transport during respiratory process whilst the chloroplast possess thylakoid membranes where the light dependent stage of photosynthesis occurs.

Q19

A tadpole's tail is gradually broken down during metamorphosis into an adult frog. Which organelle increases in number in the cells of the tail at this time?

A centriole

B endoplasmic reticulum

C Golgi apparatus

D lysosome

HELP

The components in the tail of the tadpole are taken up in pinocytotic vesicles, which then fuse with each other, forming larger vesicles, which in turn fuse with the lysosomes and are destroyed by the lysosomal enzymes.

Q20

Which of the following would be more prominent in a secretory cell than in a non-secretory cell?

A Golgi apparatus

B mitochondria

C pinocytotic vesicles

D ribosomes

HELP

Secretory cells always have abundant rER and Golgi apparatus. Newly made secretory proteins are localised to the lumen of the rough ER. The proteins then migrate to the Golgi complex via the smooth ER.

Q21

Which group of structures would be clearly seen in a suitably stained plant cell under the light microscope?

A chloroplasts, mitochondria, nuclei and ribosomes

B chloroplasts, nuclei, starch grains and vacuole

C endoplasmic reticulum, Golgi apparatus, mitochondria and nuclei

D endoplasmic reticulum, ribosomes, starch grains and vacuole

HELP

Only organelles which are larger than 0.2 mm may be viewed under the light microscope, which excludes organelles like the mitochondria, ribosomes, endoplasmic reticulum and Golgi apparatus. All the structures in option B may be viewed under the light microscope.

Q22

Which cell components, when appropriately stained, will be clearly visible under the high power of the light microscope?

	lysosomes	mitochondria	ribosomes	starch grains
A	✓	✓	✓	✓
B	✓	✓	✗	✗
C	✗	✓	✓	✓
D	✗	✗	✗	✓

HELP

Lysosomes and mitochondria will not be clearly seen. Ribosomes are non-membranous and may not be visible. As for starch granules, they are found within the chloroplasts and may be visible under a light microscope, when stained with iodine.

Q23

From which cell organelle are nucleic acids absent?

A chloroplast B Golgi apparatus

C mitochondrion D ribosome

HELP

Ribosomes contain ribosomal RNAs (ribonucleic acids). Chloroplasts and mitochondria contain circular DNA (deoxyribonucleic acid), similar to those found in prokaryotic cells; this supports the theory of endosymbiosis. The Golgi apparatus does not contain nucleic acids.

Q24

A structure, consisting of two parts and having a diameter of 20 nm, is found attached to membranes in cells.

What is the structure?

A Golgi apparatus B lysosome

C mitochondrion D ribosome

HELP

The ribosome has a diameter of about 20 nm and has two parts: a small sub-unit and large sub-unit. The nucleus is about 7 mm, the mitochondrion is about 2 mm and smaller organelles like the Golgi apparatus and lysosome are smaller than 0.2 mm since they cannot be seen under the light microscope.

Q25

Which organelles would be more prominent in a secretory cell than in a non-secretory cell?

A Golgi bodies

B lysosomes

C mitochondria

D pinocytic vesicles

HELP

A secretory cell would need secretory enzymes and glycoproteins required in secretions, which are produced by Golgi bodies.

Q26

What is the order of size of cell components?

	largest ⟶			smallest
A	mitochondria	ribosomes	starch grains	nuclei
B	nuclei	chloroplasts	mitochondria	ribosomes
C	ribosomes	mitochondria	chloroplasts	starch grains
D	starch grains	mitochondria	chloroplasts	ribosomes

HELP

Ribosomes tend to be one of the smallest organelles in the cell. The mitochondrion is quite large, but the nuclei and the chloroplasts are larger than it. From the table, it can be seen, that ribosomes is indicated as the smallest cell structure in B and D. The largest cell structure will have to be the nuclei.

Q27

Cells without nucleoli die because they do **not** possess

A centrioles and are unable to undergo cell division.

B lysosomes and are unable to destroy worn out organelles.

C mitochondria and are unable to obtain energy.

D ribosomes and are unable to manufacture proteins.

HELP

Nucleoli contain DNA that direct the synthesis of rRNA, components of ribosomes which are essential in protein synthesis.

Q28

Stained animal tissue is viewed under the light microscope at ×100 magnification. Which observation could be made?

A The cells had Golgi bodies and mitochondria.

B The cytoplasm contained endoplasmic reticulum and ribosomes.

C The cytoplasm contained many dense granular bodies.

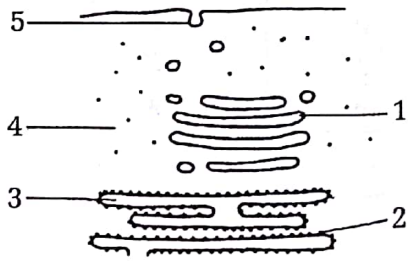
D The nuclear envelope was permeated by pores.

HELP

At 100× magnification, a light microscope is unable to allow the ultrastructure of cells to be seen, such as Golgi bodies, ER, ribosomes and nuclear pores. This is due to the lower resolution of the microscope.

Q29

Radioactive amino acids are supplied to a cell that uses them to make insulin.



Which route will the radioactive amino acids take?

	first ⟶				last
A	4	2	3	1	5
B	4	3	2	1	5
C	5	1	3	2	4
D	5	3	2	4	1

HELP

The amino acids are first carried to the ribosomes, for protein manufacture. All proteins that enter the endoplasmic reticulum are then passed through the Golgi apparatus in a strict sequence, followed by the secretory vesicles.

Q30

How do mitochondria differ from chloroplasts?

A ATP is synthesised only in mitochondria.

B DNA is found only in chloroplasts.

C Membrane-bound enzymes are found only in mitochondria.

D NADP is found only in chloroplasts.

HELP

Candidates must remember that NAD is found in mitochondria, whereas NADP is found in chloroplasts.

Q31

A strain of the African Clawed Toad, *Xenopus laevis*, exists in which there is only one nucleolus in the nucleus of each cell instead of the usual two.

When such animals are mated, approximately one quarter of the offspring have two nucleoli per nucleus, one half have one nucleolus per nucleus and one quarter have no nucleoli at all. Offspring without nucleoli die about four days after hatching.

These offspring die because they do **not** possess

A mitochondria and are unable to obtain energy.

B centrioles and are unable to undergo cell division.

C Golgi apparatus and are unable to secrete metabolites.

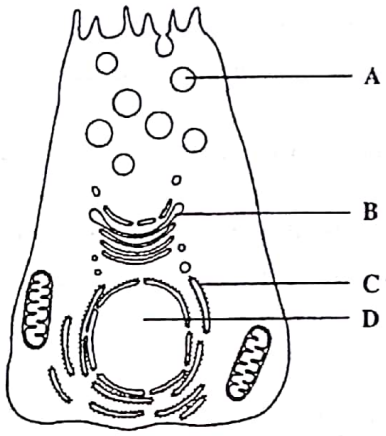
D ribosomes and are unable to manufacture proteins.

HELP

Ribosomes originate from the nucleolus and are important in the synthesis of proteins. The lack of nucleoli results in the absence of ribosomes, and so the offspring cannot exist.

Q32

Radioactively-labelled amino acids are introduced into a cell. In which cell structure will the radioactivity first appear?



HELP

A: secretory vesicles; B: Golgi body, C: rough ER, D: nucleus.

The outer membrane of the nucleus is continuous with the ER. The inner membrane with protein acts as an anchoring point for the chromosomes during interphase. All proteins produced by the ER are passed through the *cis*-Golgi network first. Note: If DNA is labeled with a radioactive isotope, the rate of disappearance from the DNA is the slowest as the DNA is very stable.

Q33

What is the function of nucleoli?

A the formation and breakdown of the nuclear membrane

B the formation of centromeres

C the formation of ribosomes

D the organisation of the spindle during nuclear division

HELP

When the nucleoli forms, spindle fibers disintegrate and the centrioles replicate. The next stage is for the nuclear membrane to form around the chromosomes.

Q34

When radioactively-labelled amino acids are taken up by pancreatic acinar (secretory) cells, what is the sequence of structures in which radioactivity will appear?

first ⟶ *last*

A cytoplasm, endoplasmic reticulum, Golgi apparatus

B cytoplasm, lysosomes, endoplasmic reticulum

C lysosomes, nucleus, Golgi apparatus

D membrane, cytoplasm, nucleus

HELP

The protein is synthesised in the cytoplasm by the ribosomes, and then translocated to the endoplasmic reticulum lumen, and later moved to the membrane stacks on the cis face of the Golgi complex, ready for processing before secretion.

Q35

In eukaryotic cells, transcription occurs in the nucleus.

In which other organelle does transcription occur?

A endoplasmic reticulum

B Golgi apparatus

C mitochondrion

D ribosome

HELP

Transcription involves the formation of the mRNA. It can occur in the nucleus, chloroplast and mitochondria.

Q36

Which cell components, when appropriately stained, will be clearly visible under the high power of the light microscope?

	lysosomes	endoplasmic reticulum	chloroplasts
A	✓	✓	×
B	✓	×	×
C	×	✓	✓
D	×	×	✓

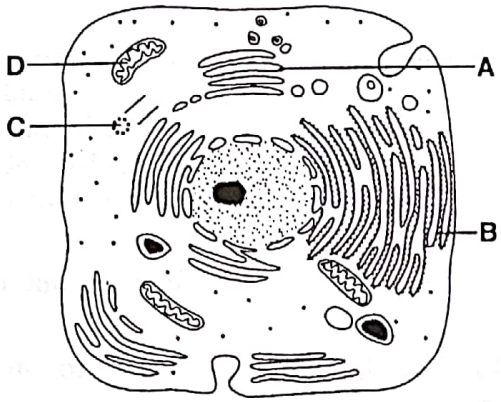
HELP

Among the three organelles, the lysosomes (the smallest at 0.1 – 1.0 μm) and the ER cannot be seen with a light microscope. The chloroplast, being larger at 5 – 10 μm, is visible high power up to 2000× magnification.

Q37

The diagram shows the ultrastructure of a cell.

In which cell component is a newly synthesised protein modified by adding carbohydrate?



HELP

A is the Golgi apparatus that helps produce glycoproteins by adding carbohydrate to the protein molecule.

Q38

Diagram 1 shows a stage micrometer, on which the graduations are 0.1 mm apart, and an eyepiece graticule, as seen through a light microscope.

Diagram 2 shows a section of plant tissue viewed at the same magnification.

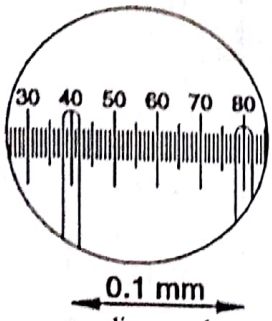


diagram 1

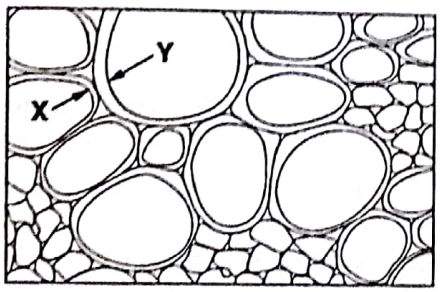


diagram 2

What is the approximate total thickness of the cell walls between X and Y?

A 10 μm B 20 μm

C 100 μm D 200 μm

HELP

In diagram 2, the distance between X and Y is measured at 3 mm. In diagram 1, that distance is equivalent to 5 fine graduations of the stage micrometer. Since 40 fine graduations is equal to 0.1 mm (100 μm), thus 5 fine graduations is approximately 10 μm.

Q39

What identifies a cell as a prokaryote?

A The DNA is associated with protein.

B The DNA is in a circular form.

C The DNA is in the form of a double spiral.

D The DNA is surrounded by a membrane system.

HELP

Prokaryote has no true nucleus. It has single circular DNA and there is a lack of histones.

Q40

The table gives the description of four membranous structures in a cell.

Which structure is correctly matched to its function?

	Function	Structure
A	packing of proteins	an organelle bounded by two membranes, the inner highly folded
B	aerobic respiration	a network of tubes and sacs, each tube and sac surrounded by a single membrane
C	autophagy	an organelle bounded by one membrane, containing hydrolytic enzymes
D	lipid synthesis	a stack of elongated, curved sacs, each sac surrounded by a single membrane

HELP

Option A: Packing of proteins is carried out by Golgi body (a stack of elongated, curved sacs, each sac surrounded by a single membrane).

Option B: Aerobic respiration is carried out by mitochondrion (an organelle bounded by two membranes, the inner highly folded).

Option C: Autophagy is carried out by lysosome (an organelle bounded by one membrane, containing hydrolytic enzymes).

Option D: Lipid synthesis is carried out by smooth endoplasmic reticulum (a network of tubes and sacs, each tube and sac surrounded by a single membrane).

Q41

A lysosome measures 0.4 μm in diameter.

What is the diameter in nm?

A 4 nm

B 40 nm

C 400 nm

D 4000 nm

HELP

1 μm = 1000 nm

0.4 μm = 0.4 × 1000 nm = 400 nm

Q42

What is the function of the smooth endoplasmic reticulum?

A aerobic respiration

B intracellular digestion

C synthesis of steroids

D transport of proteins

HELP

Functions of the smooth endoplasmic reticulum include:

1. Synthesis of lipids e.g. steroids.
2. Involved in carbohydrate metabolism in liver.
3. Detoxification of drugs and other poisons in liver.
4. Stores calcium ions necessary for muscle contraction.

Q43

In eukaryotic cells, nucleic acids are found in organelles other than the nucleus.

Which of the following is correct?

	chloroplast	ribosomes	mitochondrion
A	DNA and RNA	DNA	DNA and RNA
B	RNA	DNA and RNA	RNA
C	DNA and RNA	RNA	DNA and RNA
D	DNA and RNA	RNA	DNA

HELP

Ribosomes consist of ribosomal subunits that comprises of ribosomal RNA and protein.

Chloroplast and mitochondrion have ribosomes and a small amount of DNA that programs the synthesis of some of their own proteins.

Q44

When a potassium ion (K^+) passes from the soil into the vacuole of a root cell, it encounters some cellular barriers. Which of the following is the most direct path the K^+ would take through these barriers?

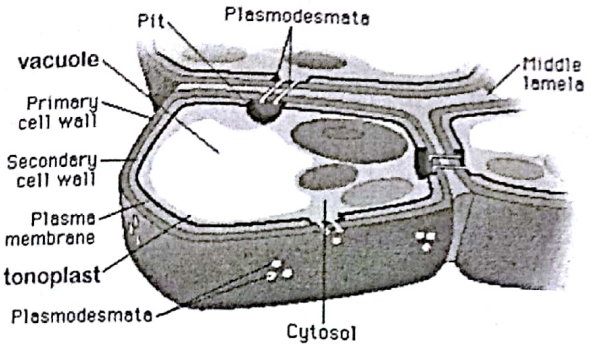
A Secondary cell wall → plasma membrane → thylakoid

B Primary cell wall → secondary cell wall → tonoplast

C Primary cell wall → plasma membrane → tonoplast

D Cell wall → plasma membrane → grana

HELP



Based on the above diagram, it can be seen that the path of K^+ from the soil into the vacuole of a root cell is as follows:

primary cell wall → secondary cell wall → plasma membrane → tonoplast → vacuole

Q45

What is the function of the Golgi Body?

A aerobic respiration

B intracellular digestion

C formation of lysosomes

D transport of proteins

HELP

Functions of the Golgi Body include:

1. Further modifying, sorting and packaging the secreted proteins into vesicles.
2. Synthesis of secretory polysaccharides.
3. Formation of lysosomes.

Q46

From which cell organelle are nucleic acids present?

A smooth endoplasmic reticulum

B Golgi apparatus

C ribosome

D secretory vesicles

HELP

Nucleic acids can be classified into DNA and RNA. Ribosomes consist of ribosomal subunits each comprises of ribosomal RNA and protein.

Q47

A sample of living cells from the pancreas in supplied with amino acids containing the heavy isotope of nitrogen, ^{15}N.

Which structures in the cells from the pancreas would show the highest concentration of ^{15}N?

A centrioles and nuclear envelope

B endoplasmic reticulum and mitochondria

C lysosome and nucleus

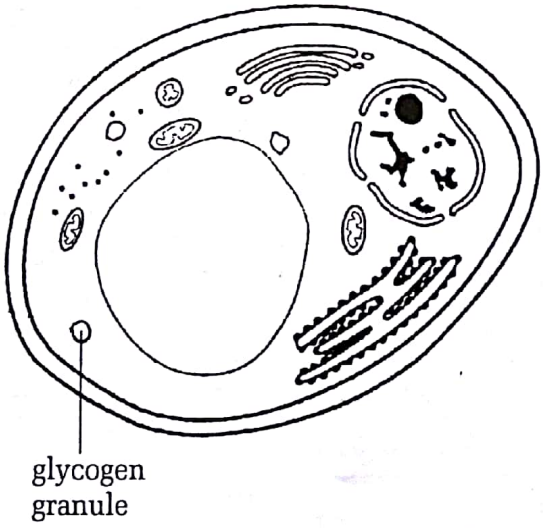
D ribosomes and Golgi body

HELP

Ribosomes is the site for protein synthesis. Ribosomes translate the genetic message, carried by mRNA into the specific amino acid sequence of a polypeptide chain. The protein modified in the rough endoplasmic reticulum is then transported to the Golgi body for further modifying, sorting and packaging.

Q48

The diagram shows the organelles that can be seen with an electron microscope in a yeast cell.



How do animal and plant cells differ from the yeast cell?

	Animal cell	Plant cell
A	do not have free ribosomes	have chloroplasts
B	have Golgi bodies	do not have free ribosomes
C	have centrioles	do not store glycogen
D	store glycogen	have Golgi bodies

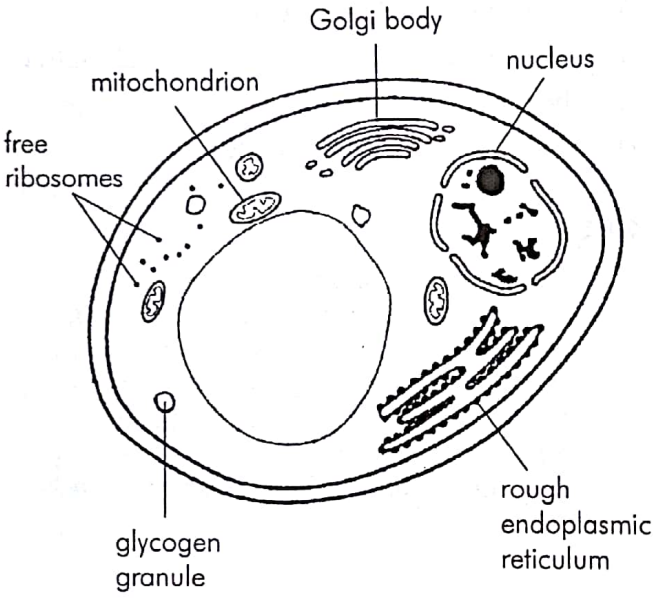
HELP

Ribosomes consist of ribosomal subunits each comprises of ribosomal RNA and protein.

Chloroplast and mitochondrion have ribosomes and a small amount of DNA that programs the synthesis of some of their own proteins.

There is an absence of DNA and RNA in endoplasmic reticulum.

HELP



Centrioles is only found in animal cells.

Plant cells store starch and not glycogen.

Q49

In eukaryotic cells, nucleic acids are found in organelles other than the nucleus.

Which of the following is correct?

	chloroplast	endoplasmic reticulum	ribosomes	mitochondrion
A	DNA and RNA	–	RNA	DNA and RNA
B	DNA	–	DNA	DNA and RNA
C	DNA and RNA	RNA	–	DNA
D	–	RNA	DNA and RNA	RNA

Q50

The table gives the description of four membranous structures in a cell. Which structure is correctly matched to its function?

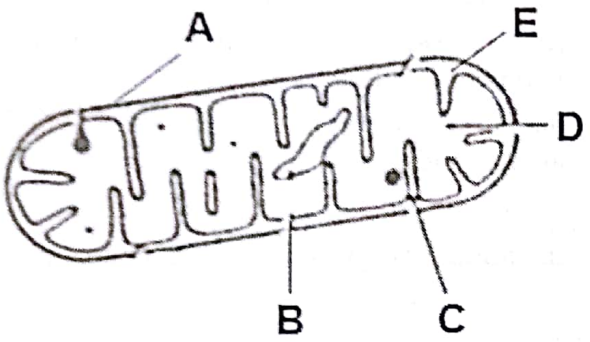
	Function	Structure
A	packing of proteins	a network of tubes and sacs, each tube and sac surrounded by a single membrane
B	aerobic respiration	an organelle bounded by two membranes, the inner highly folded
C	protein synthesis	an organelle bounded by one membrane, containing hydrolytic enzymes
D	lipid synthesis	a stack of elongated, curved sacs, each sac surrounded by a single membrane

HELP

Aerobic respiration is carried out by the mitochondrion. Mitochondrion is surrounded by an envelope of two membranes, the inner being folded to form cristae.

Q51

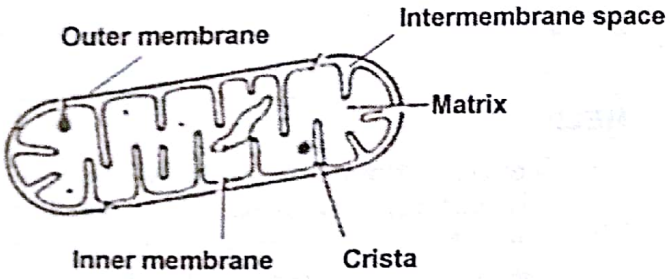
The diagram shows the components that can be seen with an electron microscope in a mitochondrion.



Identify the parts labelled A to E.

	A	B	C	D	E
A	outer membrane	inner membrane	crista	matrix	intermembrane space
B	outer membrane	inner membrane	crista	matrix	thylakoid space
C	outer membrane	inner membrane	cisternae	matrix	intermembrane space
D	outer membrane	inner membrane	crista	stroma	intermembrane space

HELP



Q52

The table gives the description of four membranous structures in a cell. Which structure is correctly matched to its function?

	Function	Structure
A	packing of proteins	an organelle bounded by two membranes, the inner highly folded
B	aerobic respiration	a stack of elongated, curved sacs, each sac surrounded by a single membrane
C	protein synthesis	an organelle bounded by one membrane, containing hydrolytic enzymes
D	lipid synthesis	a network of tubes and sacs, each tube and sac surrounded by a single membrane

HELP

Synthesis of lipids e.g. steroid is carried out by the smooth endoplasmic reticulum which consists of a network of tubes and sacs.

ANSWER KEYS

Topic 1(a) Cell Organelles

Q1 D	Q2 B	Q3 D	Q4 D	Q5 D	Q6 D	Q7 B	Q8 D
Q9 C	Q10 C	Q11 D	Q12 D	Q13 C	Q14 A	Q15 A	Q16 A
Q17 C	Q18 D	Q19 D	Q20 A	Q21 B	Q22 D	Q23 B	Q24 D
Q25 A	Q26 B	Q27 D	Q28 C	Q29 A	Q30 D	Q31 D	Q32 C
Q33 C	Q34 A	Q35 C	Q36 D	Q37 A	Q38 A	Q39 B	Q40 C
Q41 C	Q42 C	Q43 C	Q44 C	Q45 C	Q46 C	Q47 D	Q48 C
Q49 A	Q50 B	Q51 A	Q52 D				

TOPIC 1 — CELLULAR FUNCTIONS

1(b) Biological Molecules

You should try to answer on your own before resorting to **HELP**.

Q1

A peptide bond is formed between

A an aldehyde group and an amino group.

B an aldehyde group and a carboxyl group.

C an aldehyde group and an ester group.

D a carboxyl group and an amino group.

HELP

The peptide bond is the chemical bond that connects 2 amino acids in a polymer, and is formed between the amino group of one amino acid and the carboxyl group of another through the process of condensation.

Q2

A sequence of amino acids may end in either an amino group ($—NH_2$) or a carboxyl group (—COOH). What is the theoretical number of chemically different dipeptides that may be assembled from 20 different amino acids?

A 40

B 80

C 160

D 400

HELP

A dipeptide is made up of 2 amino acids which may be same or different. The total possible number of different dipeptides that may be assembled from 20 different amino acids will thus be $20^1 = 20^2 = 400$.

Q3

The *secondary order* of protein structure is

A the sequence of amino acids in the polypeptide chain.

B the formation of peptide bonds between amino acids.

C the coiling of the polypeptide chain.

D the folding of the coiled polypeptide chain.

HELP

The structures adopted by polypeptides can be divided into 4 levels of organisation: the primary, secondary, tertiary and quaternary structures. The secondary structure pertains to the folding of parts of the polypeptide chains into regular structure, such as α-helices and β-pleated sheets.

Q4

How many fatty acid molecules are normally present in a fat or oil molecule?

A 1

B 2

C 3

D 4

HELP

The typical storage forms of fatty acids in cells are triacylglycerols, which is formed from one molecule of glycerol by esterification of fatty acids to each of the 3 hydroxyl groups: $HOCH_2 — CH(OH) — CH_2OH$.

Q5

Which one of the following combinations of statements is true of polysaccharides in living organisms?

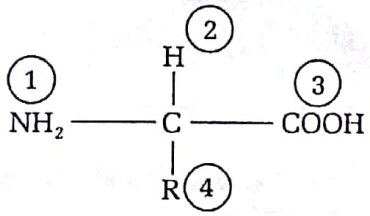
	They provide energy	*They form storage compounds*	*They form supporting structures*
A	No	No	Yes
B	No	No	No
C	Yes	No	No
D	Yes	Yes	Yes

HELP

Polysaccharides are made of monomeric saccharide (sugar) sub-units. They play important roles as energy storage molecules within the cell and as structural components on the outer cell surface of or between cells.

Q6

An amino acid molecule has the following structure:



Which **two** of the groups combine to form a peptide link?

A 1 and 2

B 1 and 3

C 2 and 3

D 2 and 4

HELP

The peptide bond is the chemical bond that connects 2 amino acids in a polymer, and is formed between the amino group of one amino acid and the carboxyl group of another through the process of condensation.

Q7

Polysaccharides are synthesised in plants by the process of

A condensation. B glycolysis.

C hydrolysis. D oxidation.

HELP

Polysaccharides are built of monomeric saccharide (sugar) sub-units. During the linkage of 2 monosaccharides, a carbon atom of one sugar molecule reacts with a hydroxyl group of another, resulting in the loss of H_2O. This process is condensation.

Q8

Which one of the following reactions results in the conversion of amino acids to proteins?

A condensation B deamination

C hydrolysis D phosphorylation

HELP

Amino acids are linked together by peptide bonds, which are formed between the amino group of one amino acid and the carboxyl group of another. This process is by condensation, releasing a molecule of water.

Q9

Most polysaccharides are composed of chains of condensed

A cellulose units.

B hexose units.

C pentose units.

D sucrose units.

HELP

Polysaccharides are built of monomeric saccharide (sugar) sub-units. Many polysaccharides, like starch and cellulose, are composed of hexose units.

Q10

Which one of the following types of bond is principally concerned in maintaining the alpha-helix shape of secondary protein structure?

A disulphide bonds
B ester bonds
C hydrogen bonds
D peptide bonds

HELP

The C=O and N–H groups in peptide bonds of different amino acids hydrogen bond at regular intervals to from the α-helical structure of proteins.

Q11

Benedict's test was performed on a 20 cm^3 sample of four fruit syrups. A second 20 cm^3 sample of each was then hydrolysed and tested with Benedict's solution. The table shows the masses of precipitate formed.

Which syrup contains the greatest mass of non-reducing sugar?

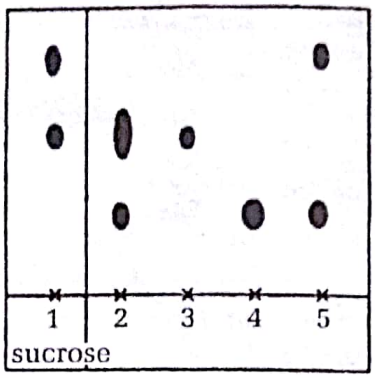
syrup	*mass of precipitate before hydrolysis* / mg	*total mass of precipitate after hydrolysis* / mg
A	25	55
B	50	70
C	55	55
D	75	85

HELP

The relative mass of non-reducing sugar is obtained from the difference between the mass of precipitate before hydrolysis and the total mass of precipitate after hydrolysis. It can be calculated that the difference is greatest in syrup A — 30 mg. For syrup B it is 20 mg, for syrup C it is 0 mg and for syrup D it is 10 mg.

Q12

Five disaccharides were each hydrolysed with dilute acid, and the purified products were separated by one-dimensional chromatography. The final chromatogram is shown in the diagram below.



If spot 1 represents the products obtained from the hydrolysis of sucrose, which one of the following indicates the results obtained from the hydrolysis of lactose and maltose?

	lactose	*maltose*
A	2	3
B	2	4
C	5	2
D	5	3

HELP

Sucrose is a disaccharide of glucose and fructose. Lactose is composed of glucose and galactose, whilst maltose comprises of 2 molecules of glucose. The common sugar is thus glucose.

Q13

Which one of the following molecules contains amino acids?

A ascorbic acid
B cellulose
C collagen
D galactose

HELP

Collagen is the major protein in the extracellular spaces of connective tissue. The type of collagen in the connective tissue forms insoluble fibres with very high tensile strength.

Q14

Which one of the following is a characteristic of saturated fats which distinguishes them from unsaturated fats?

A They do not contain glycerol.

B They contain a high proportion by mass of oxygen.

C They contain only unbranched fatty acids.

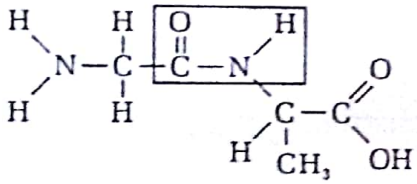
D They have no double bonds between their carbon atoms.

HELP

The maximum number of bonds a single carbon can form is 4. Saturated fats imply that all the carbon atoms in the compound are already bound to 4 other compounds or to another carbon atom. Unsaturated fats have double bonds between carbon atoms.

Q15

The diagram shows a molecular structure.



What is the structure enclosed by a box?

A an amino acid

B a glycosidic bond

C a nucleotide

D a peptide bond

HELP

The peptide bonds is the chemical bond which connects 2 amino acids in a polymer, and is formed between the amino group of one amino acid and the carboxyl group of another through condensation.

Q16

The helical form of a polypeptide chain is due to the presence within the molecule of

A covalent bonds.

B disulphide bonds.

C glycosidic bonds.

D hydrogen bonds.

HELP

Every C=O and N–H group in the peptide bonds can participate in a hydrogen bond, contributing to the α-helical structures of proteins.

Q17

Which of the following is a complex of globular protein with non-proteinaceous material?

A collagen B egg albumen

C haemoglobin D fibrinogen

HELP

Haemoglobin is a globular protein that binds to a non-proteinaceous substance, haem, which actually carries the oxygen. This material is known as a prosthetic group and influences the shape of the polypeptide.

Q18

What does a haemoglobin molecule contain?

A four iron (Fe^{2+}) ions attached to each haem group

B four oxygen molecules attached to each haem group

C four polypeptide chains each with four attached haem groups

D four polypeptide chains each with one attached haem group

HELP

One haemoglobin molecule contains four polypeptide chains, each containing one haem group. Each haem group has one Fe^{2+} ion attached to it.

Q19

Which of the following does **not** contain amino acids?

A carbonic anhydrase

B glycogen

C haemoglobin

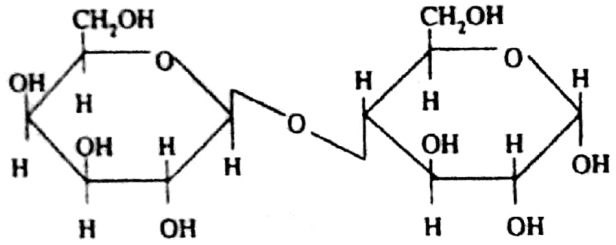
D insulin

HELP

Glycogen is the most common form of storage carbohydrate in animal cells, and is a very long, branched polymer of glucose. It is stored mainly in the liver and muscles.

Q20

The diagram shows a carbohydrate.



What is the name of the bond which links the two units?

A a glycosidic bond

B a hydrogen bond

C an oxygen bond

D a peptide bond

HELP

A glycosidic bond links monosaccharides together; and is formed when the carbon atom of a sugar molecule reacts with the hydroxyl group of another, resulting in the loss of water.

Q21

Which type of bond maintains the α-helix shape of secondary protein structure?

A disulphide **B** ester

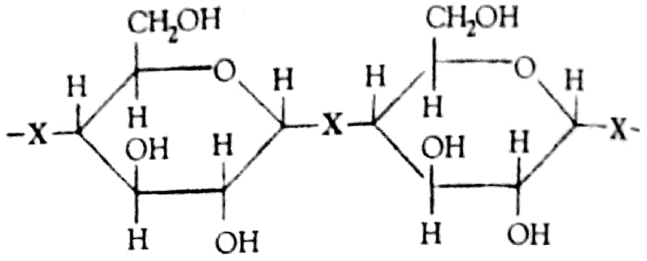
C hydrogen **D** peptide

HELP

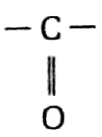
The C=O and N–H groups in peptide bonds participate in hydrogen bonding, which contributes to the α-helix structure of proteins.

Q22

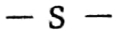
The diagram shows part of a polysaccharide chain.

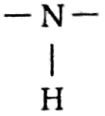


What type of bond is **X**?

A 

B 

C 

D 

HELP

The bond is a glycosidic bond, –C–O–C– which links monosaccharides together, forming the polysaccharides that constitute sugar molecules.

Q23

1 cm³ of solution **X** is mixed with an equal volume of 5% sodium hydroxide solution in a test-tube. When two drops of 1% copper sulphate solution are added, a purple colour is produced.

What does solution **X** contain?

A amino acids

B glycolipids

C lipids

D proteins

HELP

This is a test for proteins. A positive result of purple colour shows the presence of proteins in the solution.

Q24

In which column are the statements correctly applied to cellulose and sucrose? (✓=correct; ✗=incorrect; su=sucrose; ce=cellulose)

Property \ Column	A		B		C		D	
	su	ce	su	ce	su	ce	su	ce
It is a reducing sugar.	✓	✓	✓	✗	✗	✓	✗	✗
It is a polysaccharide.	✓	✓	✗	✓	✗	✓	✗	✓
It has a glycosidic link.	✓	✗	✓	✗	✗	✗	✓	✓
It produces monosaccharides on complete hydrolysis	✗	✗	✓	✓	✗	✓	✓	✓

HELP

Sucrose is a non-reducing disaccharide which is composed of the monosaccharides, glucose and fructose, linked together by a glycosidic bond. Cellulose is a long-chained polymer of glucose, linked by glycosidic bonds.

Q25

Which property of proteins enables them to act as pH buffers?

A They are soluble.

B They contain carboxyl and amino groups.

C They have a high molecular mass.

D They possess both secondary and tertiary structures.

HELP

Proteins can exist as buffers by resisting drastic changes in pH. This is because they possess the groups –NH and –COOH which act as buffer pairs which either accept H^+ or OH^- ions from the solution, and maintain its pH.

Q26

How many different polypeptides, each consisting of r amino acids, can be made if the number of different amino acids available is n?

A n^r B r^n

C nr D n

HELP

Since there are n different amino acids, the number of different polypeptides that can be formed, each with r amino acids, is n^r.

Q27

What is the theoretical number of chemically different dipeptides that may be assembled from 12 different amino acids?

A 24 B 72

C 144 D 400

HELP

Mathematically, the number of different combinations of two amino acids is $12^2 = 144$.

Q28

Which molecule contains amino acids?

A ATP B cellulose

C glycogen D haemoglobin

HELP

ATP (Adenosine triphosphate) contains an adenine nitrogenous base, a ribose monosaccharide and a triphosphate group. Glycogen and cellulose are carbohydrates. Haemoglobin is a protein which is made up of amino acids.

Q29

How many fatty acid residues are normally present in a phospholipid molecule?

A 1 B 2

C 3 D 4

HELP

One phospholipid molecule consists of one phosphate group and two fatty acids joined to one glycerol molecule.

Q30

The following statements describe three orders of structure of the insulin molecule.

1 The molecule consists of two polypeptide chains joined and folded around one another.

2 The sequence and number of amino acids in each polypeptide chain is known.

3 The amino acids in each chain are coiled into -helix and held in position by hydrogen bonds.

Which order is described by each statement?

	statement 1	*statement* 2	*statement* 3
A	primary	secondary	tertiary
B	primary	tertiary	secondary
C	tertiary	secondary	primary
D	tertiary	primary	secondary

HELP

The primary structure is a specific sequence of amino acids. The secondary structure is a result of hydrogen bonds at regular intervals along the polypeptide backbone. Two types of secondary structure are the α-helix and the β-pleated sheets. The tertiary structure includes the folding of regions within the same polypeptide and quaternary structure refers to 2 or more polypeptide chains joined and folded around one another. In this question, tertiary structure refers to what is known as the quaternary structure.

Q31

The helical form of a polypeptide chain is due to the presence within the molecule of

A disulphide bonds.

B glycosidic bonds.

C hydrogen bonds.

D peptide bonds.

HELP

The helical form is a secondary structure of protein, resulting from a hydrogen bond between every 4th peptide bond.

Q32

Which molecule contains peptide bonds?

A ATP B collagen

C DNA D maltose

HELP

Peptide bonds can be found in proteins and collagen is the only protein among all the options.

Q33

Which of the following is a polysaccharide present in human muscle?

A amylose

B collagen

C glycogen

D myoglobin

HELP

Glycogen	animal starch, stored in liver and muscle
Amylose	plant, component of starch
Collagen	fibrous protein, with structural functions
Myoglobin	found in blood

Q34

A student was asked to identify the two compounds in each of three test-tubes. The table shows the results of the student's tests.

	reagent added to test-tube		
test tube	sodium hydroxide + copper sulphate	Benedict's solution	iodine in potassium iodide
X	purple	brick red	brown
Y	blue	blue	blue-black
Z	blue	blue	blue-black

Which conclusion is consistent with the results?

A Egg white and sucrose had been placed in tube X.

B Maltose and starch had been placed in tube Z.

C Maltose and sucrose had been placed in tube X.

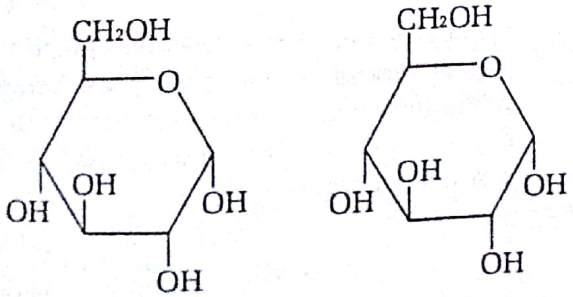
D Starch and sucrose had been placed in tube Y.

HELP

A purple colour for the Biuret test (sodium hydroxide + copper sulphate) indicates the presence of a protein like albumin found in egg white. A blue colour indicates that a protein is absent. A brick red precipitate with Benedict's solution indicates the presence of a reducing sugar like maltose. Sucrose, a non-reducing sugar, would give a negative result, which is blue colour. Iodine in potassium iodide turns blue-black when there is starch and remains brown in the absence of starch.

Q35

The diagram shows two molecules.



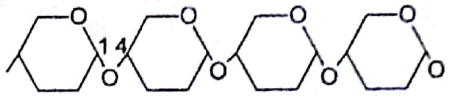
What is formed when a large number of these molecules are condensed?

A amylose B cellulose

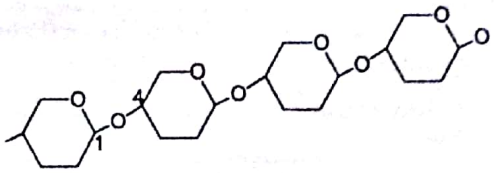
C phospholipid D protein

HELP

The molecule shown is α glucose. β glucose differs in that the OH group of carbon 1 (the rightmost carbon) is above the plane of the ring instead of below it. The monomer of amylose is α glucose while that of cellulose is β glucose. Phospholipid is not a polymer and proteins are formed from amino acids.



Starch: 1-4 linkage of α glucose



Cellulose: 1-4 linkage of β glucose

Q36

At which levels of protein structure do hydrophobic interactions occur?

A primary, secondary and tertiary

B primary, secondary, tertiary and quaternary

C tertiary and quaternary

D quaternary only

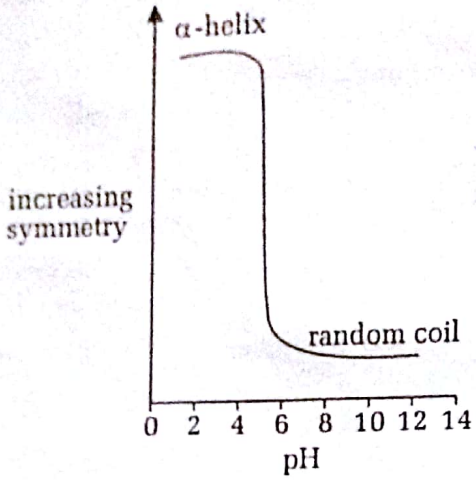
HELP

Tertiary structure: Polypeptide chain bends and folds. Maintained by the interactions of ionic, hydrogen and disulphide bonds, and hydrophobic interactions.

Quaternary structure: highly complex proteins consisting of an aggregation of polypeptide chains held together by hydrophobic interactions and hydrogen and ionic bonds.

Q37

The graph shows the effect of pH on the structure of a protein which consists entirely of repeating residues of one amino acid.



Which statement is true?

A At high acidity the protein loses its secondary structure.

B At high acidity the protein loses its tertiary structure.

C At low acidity the protein loses its primary structure.

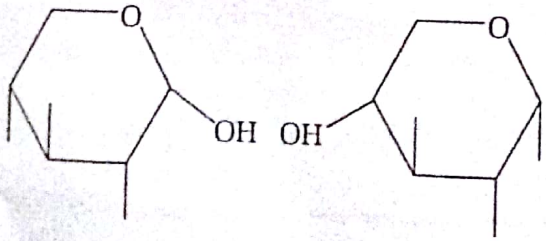
D At low acidity the protein loses its secondary structure.

HELP

In the α-helix protein, the secondary structure is most important, hence the answer could be A or D. A decrease in acidity (increase in pH), would drastically reduce the symmetry of the protein helix.

Q38

The diagram shows two molecules of a biological substance.



Which type of bond is formed when these molecules react to form a larger molecule?

A glycosidic B hydrophilic

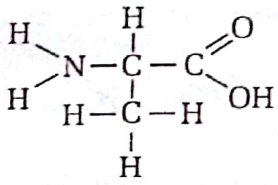
C hydrogen D peptide

HELP

The diagram is obviously a glucose structure with a 6-membered pyranose ring. The bond formed is between the 1st and 4th carbon elements, hence forming a glycosidic bond.

Q39

The diagram shows a molecule.



Which substance might include this molecule?

A cellulose B cholesterol

C glycerol D insulin

HELP

NH_2 forms and amino group and –COOH is a carboxyl group. Insulin is the only amino acid in the list. Cellulose is a polymer of glucose. Cholesterol and glycerol are both lipids.

Q40

Which protein has a fibrous structure?

A amylase B collagen

C haemoglobin D insulin

HELP

Fibrous protein has a primary structure of regular repetitive sequences. They are very stable molecules and have structural roles. E.g. collagen which is a constituent of animal connective tissue.

Q41

Food tests are carried out on four solutions.

Which solution contains only sucrose and protein?

solution	Benedict's test	acid hydrolysis then Benedict's test	iodine in potassium iodide solution	biuret test
A	✗	✓	✗	✓
B	✓	✓	✗	✓
C	✓	✓	✓	✗
D	✓	✗	✓	✗

key: ✓ = positive result
✗ = negative result

HELP

Sucrose is a disaccharide made from glucose and fructose. It is a non-reducing sugar, so, it should test negative for the Benedict's test.

Q42

Which combination describes a triglyceride?

	soluble in water	provides energy	produces water when respired
A	✗	✓	✓
B	✓	✗	✓
C	✓	✓	✗
D	✗	✓	✗

HELP

A triglyceride is formed by the condensation reaction of glycerol and fatty acids. When a triglyceride is oxidised, it involves the production of water molecules in the process. Triglycerides are also insoluble in water.

Q43

Which term most appropriately describes catalase, collagen and haemoglobin?

A enzymes
B fibrous proteins
C globular proteins
D polypeptides

HELP

Only collagen is a fibrous protein, whereas catalase and haemoglobin are both globular proteins. Therefore, the most appropriate answer that would include all these three proteins is a polypeptide.

Q44

Some germinating seeds are crushed with water and the extract is tested. The table shows the results of these tests.

test	*result*
Barford's test for disaccharides	positive
Benedict's test	yellow precipitate
biuret test	purple colour
Clinistix test for glucose	negative
emulsion test	clear solution
iodine test	blue-black colour

Which molecules are present in the extract?

A fat, maltose, starch only
B fat, protein, sucrose only
C glucose, protein, starch only
D maltose, protein, starch only

HELP

There is no fat since the emulsion test was negative (clear solution). There is no glucose since the Clinistix test was negative. Maltose is a reducing sugar, that is also a disaccharide. It is commonly found in germinating seeds.

Q45

Which description applies to cellulose?

	molecule	glycosidic bond linkage	structure
A	linear and branched	α 1.6 and β 1.4	fibrous
B	linear and branched	α 1.6 and β 1.4	non-fibrous
C	linear and unbranched	β 1.4	fibrous
D	linear and unbranched	α 1.6	non-fibrous

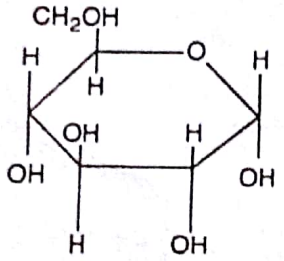
HELP

Cellulose molecules are unbranched. They have β-glucose 1-4 glycosidic links and cross bridges. It gives structural support and is hence, fibrous in nature.

Q46

The diagram shows a ring structure of glucose.

Which form of glucose is shown and in which molecule is it present?



	form of glucose	where present
A	α	cellulose
B	α	starch
C	β	cellulose
D	β	starch

HELP

The position of the hydroxyl (–OH) group on carbon atom 1 projecting downwards indicates that this glucose molecule is an α-isomer. Starch is made up of these isomers, whereas cellulose is made up of β-isomers.

Q47

Some microorganisms produce β-glucosidase enzymes, but mammals do not.

The presence of these microorganisms in a mammal's digestive system aids in the digestion of which substance?

A cellulose B glycogen

C protein D starch

HELP

Relationship between mammal and microorganism is mutualistic. Microorganisms secrete cellulase to digest cellulose, and another enzyme for protein. As the enzyme involved is β-glucosidase, it could be used in the digestion of cellulose that consists of β-glucose molecules.

Q48

Samples of a solution containing carbohydrates were treated as follows.

sample	treatment	result
1	tested with Benedict's reagent	no colour change
2	warmed with acid, neutralised and then tested with Benedict's reagent	brick-red precipitate
3	treated with amylase solution and then tested with Benedict's reagent	brick-red precipitate

Which carbohydrates were present in the solution?

A glucose, maltose and glycogen

B glucose, sucrose and glycogen

C maltose and starch

D sucrose and starch

HELP

From the results for sample 1 and 2, the carbohydrate present has to be a non-reducing sugar (e.g. sucrose) since it needs to be hydrolysed by an acid prior to the positive test. The result for sample 3 shows that the carbohydrate present has to be starch since it is digested by the enzyme amylase to produce reducing sugars that would test positive.

Q49

A marine mammal, such as a seal or porpoise, stores large amounts of subcutaneous fat as 'blubber'. Which one of the following is an **incorrect** statement about the adaptive value of this fat?

A It has a low energy content for its mass in comparison to other food reserves such as glycogen.

B It has an insulating function, fat having a low heat conductivity.

C It may act to streamline contours for swimming and be a protective shock absorber below the skin.

D It acts as an energy store, being utilised when the animal is short of food.

HELP

Fat has a very high energy content and serves to insulate marine animals from the cold environment.

Q50

A student was asked to identify the two food substances in each of three test-tubes. The table shows the results of the student's tests.

reagent added to test - tube

test-tube	*biuret solution*	*Benedict's solution*	*iodine in potassium iodide*
X	purple	brick-red	brown
Y	blue	blue	blue-black
Z	purple	blue	blue-black

Which conclusion is consistent with the results?

A Egg white and sucrose had been placed in tube X.

B Maltose and starch had been placed in tube Z.

C Maltose and sucrose had been placed in tube X.

D Starch and sucrose had been placed in tube Y.

HELP

Sucrose is a non-reducing sugar that would test negative with Benedict's solution and starch would test positive for the iodine test.

Q51

The table shows some differences between glucose and a triglyceride. Which difference explains the fact that glucose is soluble in water, while the triglyceride is insoluble in water?

	glucose	triglyceride
A	contains polar groups	does not contain polar groups
B	does not contain double bonds	contains double bonds
C	higher ratio of carbon : hydrogen	lower ratio of carbon : hydrogen
D	occurs in a ring form	does not occur in a ring form

HELP

Having polar groups enables glucose to be soluble in water as these groups help to bind to the hydrogen and hydroxyl ions in water.

Q52

Which feature is **not** characteristic of cellulose?

A β-glucose molecules

B fibrillar structure

C 1-6 glycosidic bonds

D hydrogen bonds

HELP

Cellulose has 1-4 glycosidic bonds, rather than the 1-6 bonds.

Q53

Compared to globular proteins, fibrous proteins are

A less regular in structure.

B less stable chemically.

C more readily soluble.

D more resistant to high temperatures.

HELP

Fibrous proteins have regular and more stable structures, thus are able to withstand high temperatures better than globular proteins. Fibrous proteins are also insoluble.

Q54

Which feature is true of cellulose and accounts for its strength?

A It contains both α-1, 4 and α-1, 6 links between glucose units.

B It has OH groups that form hydrogen bonds with adjacent cellulose molecules.

C It is a fibrous molecule which is insoluble in water.

D It is made up of long, branched and coiled chains of β-glucose units with 1, 4 links.

HELP

Cellulose consists of β-glucose units with adjacent molecules that are rotated 180° so that hydrogen bonds can form between hydroxyl groups of parallel chains. It is not branched or coiled, thus giving it structural stability.

Q55

A sample of solution **X** is mixed with an equal volume of 5% sodium hydroxide solution in a test-tube. When two drops of 1% copper sulphate solution are added, a purple colour is produced.

What does solution **X** contain?

A amino acids B lipids

C polysaccharides D proteins

HELP

Candidates are reminded that this is the procedure for the biuret test, which is used for determining proteins.

Q56

Which formula is a carbohydrate?

A CH_3CHO

B C_2H_5OH

C $C_3H_6O_3$

D $C_{15}H_{31}COOH$

HELP

Monosaccharides typically have the general formula of $C_nH_{2n}O_n$.

Q57

The following statements describe the structure of a certain protein molecule.

1 The molecule consists of two polypeptide chains which are folded around each other.

2 In each chain, the amino acids are held in a helix by hydrogen bonds.

Which orders of structure are described by these statements?

	statement 1	*statement 2*
A	primary	tertiary
B	secondary	tertiary
C	tertiary	secondary
D	quaternary	secondary

HELP

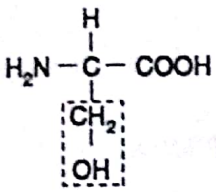
Candidates should remember that the folding of two or more polypeptide chains constitutes quaternary structure, not tertiary (which is a single polypeptide chain folded and twisted).

Q58

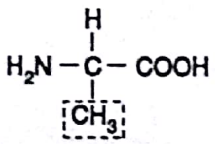
The diagram shows four different amino acids, each with a different R group (side group).

Which amino acid could form a hydrogen bond between its R group and that of another appropriate amino acid?

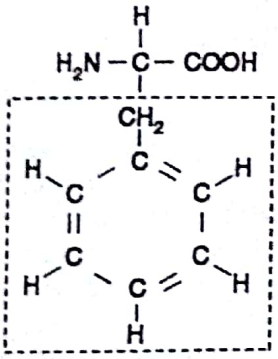
A



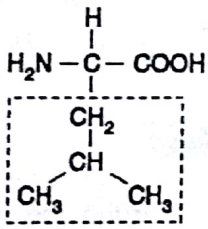
B



C



D

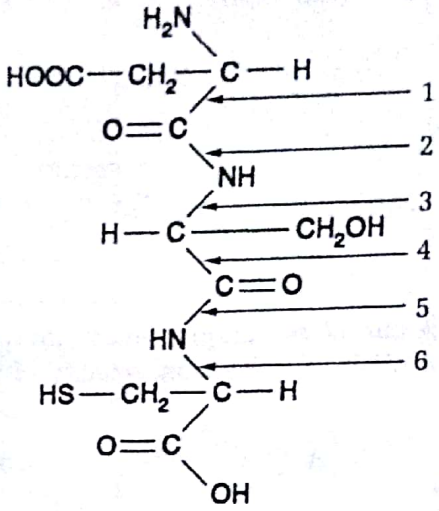


HELP

Only amino acid A has a hydroxyl ion with an electropositive hydrogen that can form a hydrogen bond with another amino acid that has an electronegative oxygen on the C=O group.

Q59

The diagram represents a tripeptide.



At which bonds does hydrolysis occur to release the amino acids from the tripeptide?

A 1 and 4 B 1 and 6

C 2 and 5 D 3 and 6

HELP

Hydrolysis should occur between the C=O and N–H bonds to separate the amino acids.

Topic 1(b) Biological Molecules

Q1 D	Q2 D	Q3 C	Q4 C	Q5 D	Q6 B	Q7 A	Q8 A
Q9 B	Q10 C	Q11 A	Q12 A	Q13 C	Q14 D	Q15 D	Q16 D
Q17 C	Q18 D	Q19 B	Q20 A	Q21 C	Q22 B	Q23 D	Q24 D
Q25 B	Q26 A	Q27 C	Q28 D	Q29 B	Q30 D	Q31 C	Q32 B
Q33 C	Q34 D	Q35 A	Q36 C	Q37 D	Q38 A	Q39 D	Q40 B
Q41 A	Q42 A	Q43 D	Q44 D	Q45 C	Q46 B	Q47 A	Q48 D
Q49 A	Q50 D	Q51 A	Q52 C	Q53 D	Q54 B	Q55 D	Q56 C
Q57 D	Q58 A	Q59 C					

TOPIC 1

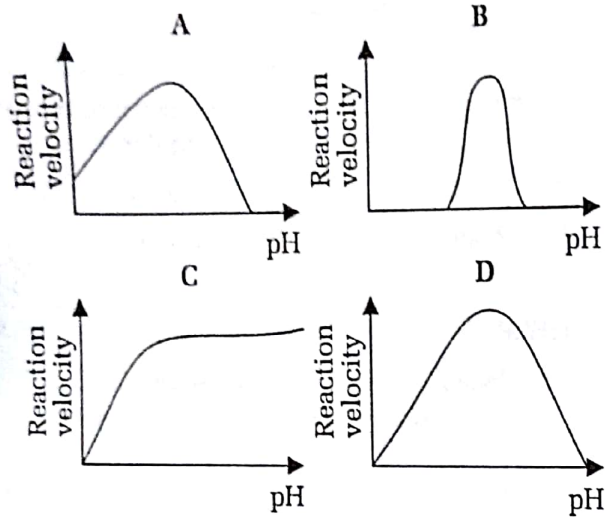
CELLULAR FUNCTIONS

1(c) **Enzymes**

You should try to answer on your own before resorting to **HELP**.

Q1

Which one of the graphs below shows the effect of pH on the reaction velocity of a typical enzyme?



HELP

The effective pH for a specific enzyme usually falls within a very narrow range of the optimum range. Further increase or decrease in the pH will result in inactivity of the enzyme, hence a decrease in reaction velocity.

Q2

Which molecule is a co-factor used by dehydrogenase enzymes?

A coenzyme A

B cytochrome

C lactate

D NAD

HELP

NAD is an obvious answer as it can exist in both a reduced and oxidized form. It tends to act as a H_2 acceptor.

Q3

The specificity of enzymes is due to

A their high molecular weight.

B their hydrogen bonding.

C their pH sensitivity.

D their surface configuration.

HELP

The surface configuration of enzymes, the active site, consists of certain amino acid side chains whose linear arrangement and the appropriate folding of the peptide chain give the enzyme its specificity. This site recognises and binds the substrate(s) and catalyses the reaction once the substrate(s) have been bound.

Q4

The diagram below represents reactions taking place in a bacterium in which amino acids are produced from one another by the action of specific enzymes. The numbers 1 to 3 refer to different amino acids and the letters V and X refer to different enzymes.

$$1 \xrightarrow{V} 2 \xrightarrow{X} 3$$

The artificial introduction into the cell of an excess of amino acid 3 reduces the rate of the reaction catalysed by enzyme X. What is the cause of this?

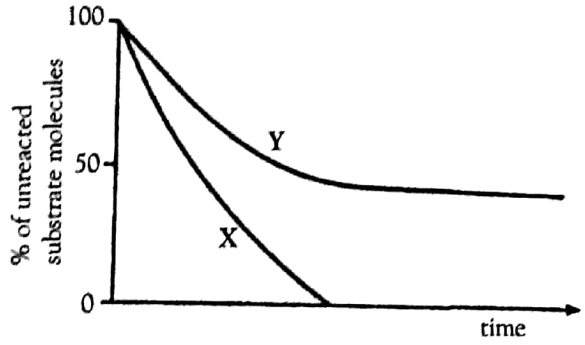
A competitive inhibition
B end product inhibition
C enzyme denaturation
D excess substrate inhibiting the enzyme

HELP

End-product inhibitor, or feedback inhibitor, is when an enzyme that catalyses one of a series of reactions is inhibited by the ultimate product of the pathway. This process regulates the level of the product.

Q5

Curve **X** shown below represents the course of an enzyme catalysed reaction under optimum conditions. Curve **Y** shows the action of the same enzyme on the same substrate but with one alteration to the reaction conditions.



Which one of the following factors, operating to a constant extent throughout the experiment, could give the results shown by curve **Y**?

A an end-product inhibitor
B a higher pH
C a lower temperature
D an increased substrate concentration

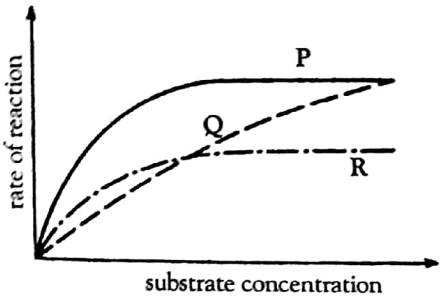
HELP

With increasing time, the percentage of unreacted substrate molecules decreases and eventually remains constant. This is because with the progress of the reaction, the end products start to inhibit the enzyme by interacting with its active site.

Q6

In the following graph, each of the curves **P**, **Q** and **R** represents an enzyme-controlled reaction in one of the following situations:

(i) with the enzyme uninhibited
(ii) with a non-competitive inhibitor added to the enzyme
(iii) with a competitive inhibitor added to the enzyme



Which curve represents each situation?

	uninhibited enzyme	*competitive inhibitor added*	*non-competitive inhibitor added*
A	P	Q	R
B	P	R	Q
C	Q	R	P
D	R	P	Q

HELP

Curve P is representative of a typical enzyme reaction where the rate of reaction remains unchanged after a certain point when all the active sites of the enzyme have been occupied by the substrates. When a competitive inhibitor is added, the reaction increases less rapidly since the probability of the substrate binding with the active site is less. For curve R, the number of active sites decrease, thus the maximum rate of reaction is lower.

Q7

Which one of the following enzymes shows the greatest substrate specificity?

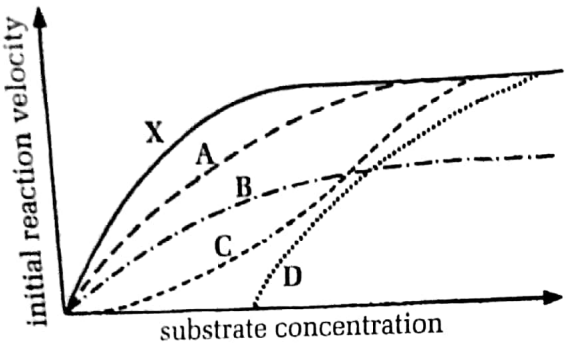
A lipase
B nuclease
C pepsin
D sucrase

HELP

Sucrase shows the most substrate specificity since it hydrolyses only the disaccharide, sucrose.

Q8

In the graph below, **X** represents the relationship between an enzyme and the concentration of its substrate under optimal conditions and without an inhibitor.

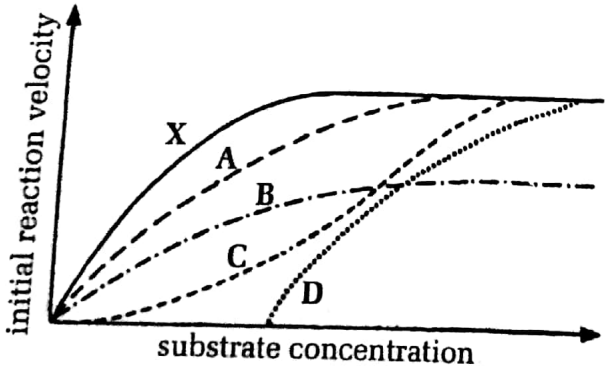


Which one of the curves, **A**, **B**, **C**, or **D**, represents the expected result when the same experiment is conducted in the presence of a fixed, low concentration of a **competitive** inhibitor?

HELP

In the presence of a competitive inhibitor, the probability of the substrate binding with an active site decreases since it has to compete with the inhibitor. Hence the rate of reaction increases at a slower rate and levels off later.

Q9



In the graph above, **X** represents the relationship between an enzyme and the concentration of its substrate under optimal conditions and without an inhibitor.

Which one of the curves, **A**, **B**, **C**, or **D**, represents the expected result when the same experiment is conducted in the presence of a fixed, low concentration of a **non-competitive** inhibitor?

HELP

The presence of a non-competitive inhibitor will cause the reaction to reach a lower optimum within a shorter time period, because it binds to sites on the enzyme other than the active site and inhibits the enzyme. Hence the number of active sites available will decrease.

Q10

The four acids shown below form part of an enzyme-catalysed sequence.

oxoglutaric acid (α-keto glutaric acid)

$$\xrightarrow{\text{enzyme 1}} \text{succinic acid} \xrightarrow[\downarrow 2H]{\text{enzyme 2}}$$

$$\text{fumaric acid} \xrightarrow{\text{enzyme 3}} \text{malic acid}$$

The addition of malonic acid results in no change in the concentration of oxoglutaric acid, an accumulation of succinic acid, and a near absence of both fumaric acid and malic acid.

Further addition of fumaric acid results in the formation of malic acid.

What does this information indicate about malonic acid?

A It is an inhibitor of enzyme 1.

B It catalyses the formation of succinic acid.

C It is an inhibitor of enzyme 2.

D It reacts with fumaric acid.

HELP

On addition of malonic acid, the formation of fumaric acid from succinic acid is inhibited, thus it can be concluded that if inhibits enzyme 2. Without fumaric acid as a substrate, enzyme 3 is also unable to act. However, the addition of fumaric acid results in the formation of malic acid, which means that enzyme 3 is not inhibited.

Q11

An enzyme increases the rate of a reaction by

A supplying the energy required to start the reaction.

B increasing the rate of random collisions of molecules.

C removing the product of the reaction so allowing it to continue.

D bringing the reacting molecules into precise orientation with each other.

HELP

An enzyme reduces the activation energy needed for the reaction to occur by binding with a substrate and straining its bonds so allowing for easier reaction, or binding multiple substrates in a way that brings them together in a precise orientation so they can react readily with one another.

Q12

Which one of the following bonds permanently to the active site of an enzyme?

A allosteric inhibitor

B coenzyme

C competitive inhibitor

D non-competitive inhibitor

HELP

A competitive inhibitor is structurally similar to the actual substrate, and can fit into the active site of the enzyme, forming an enzyme-inhibitor complex that prevents the substrate from binding to the enzyme.

Q13

A medical scientist investigates four species of insects. He knows that one feeds on human blood and that the others feed on plants. As the insects look similar, he investigates the digestive enzymes present in their guts.

Which insect feeds only on blood?

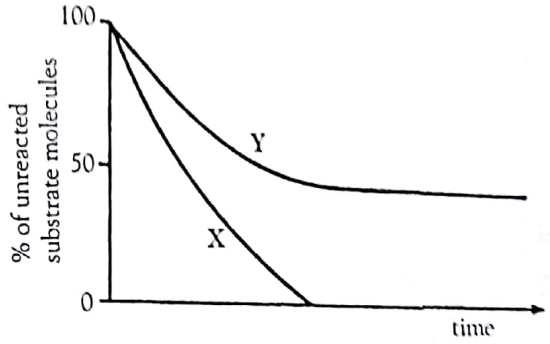
enzyme present in insect guts

insect	*amylase*	*lipase*	*protease*	*sucrase*
A	✓	×	✓	✓
B	✓	×	×	✓
C	×	✓	✓	×
D	×	✓	×	×

HELP

Complex carbohydrates are not found in blood so there would be no need for the enzymes amylase and sucrase to be present in the insect's guts.

Q14



Curve X represents the course of an enzyme-catalysed reaction under optimum conditions.

Curve Y shows the action of the same enzyme on the same substrate but with one alteration to the reaction conditions.

Which of the following factors, operating to a constant extent throughout the experiment, could give the results shown by curve Y?

A a higher pH

B a lower temperature

C an end-product inhibitor

D an increased substrate concentration

HELP

For Y, a certain amount of substrate molecules remains unreacted. This is because the end-product inhibits the reaction.

Q15

An essential feature of a competitive inhibitor is its ability to

A activate an operator gene.

B combine with a prosthetic group.

C modify a substrate.

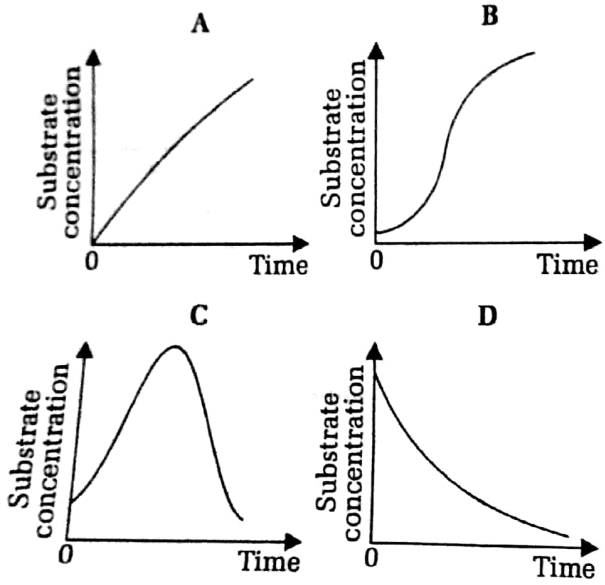
D occupy an active site.

HELP

A competitive inhibitor binds to the active site of the enzyme because it resembles the substrate. This results in a competition between the inhibitor and the substrate for the enzyme.

Q16

Which graph represents the changes in substrate concentration during the course of an enzyme-controlled reaction?

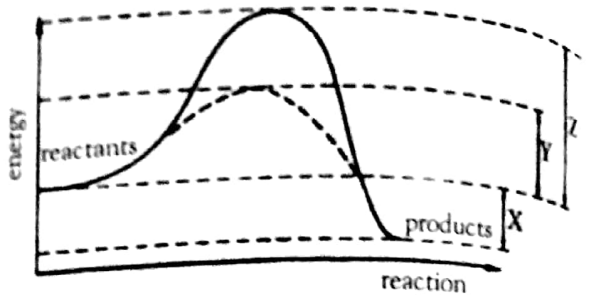


HELP

The substrate concentration decreases with time as more substrate molecules become substrate molecules become associated with the active site of the enzyme, and are converted into the products of the reaction.

Q17

The diagram illustrates energy changes in an enzyme controlled reaction.



Which of the following represents the lowering of the activation energy?

A X B Y

C Z D Z – Y

HELP

The energy required to initiate a reaction is known as the activation energy, E_a. The bold curve shows the uncatalysed reaction with E_a = Z, whilst Y represents the E_a of the catalysed reaction (dotted curve). The E_a is thus lowered by (Z – Y).

Q18

Which of the following is an example of feedback inhibition in a metabolic pathway?

A A non-competitive inhibitor binds irreversibly to the substrate.

B An enzyme-controlled reaction slows down as end product accumulates.

C There is competition between two enzymes for a common substrate.

D Variations in enzyme concentration affect the rate of the reaction it catalyses.

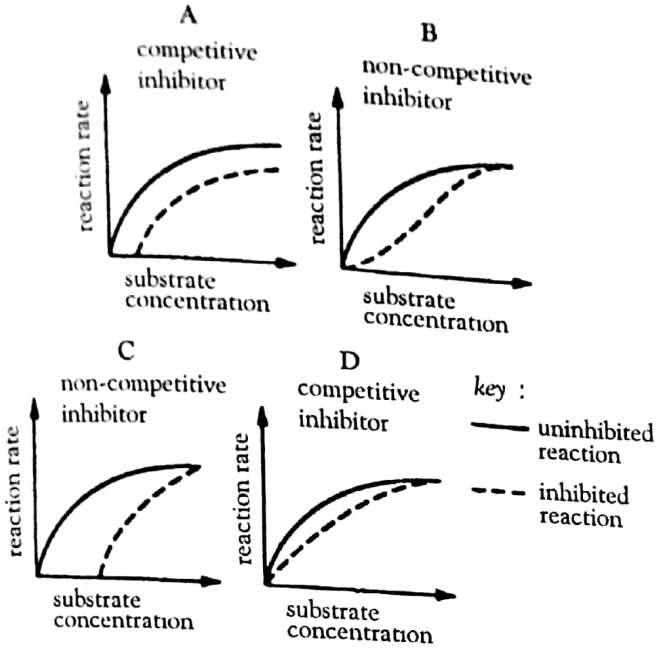
HELP

Some enzymes have, in addition to the active sites for binding to substrates sites that can recognise the end product. This results in the end product binding to the enzyme, suppressing its activity, thus regulating the enzyme action.

Q19

Each graph shows the rate of reaction of an uninhibited enzyme and that of the same enzyme in the presence of a constant amount of either a competitive or a noncompetitive inhibitor.

Which graph is correctly labelled?

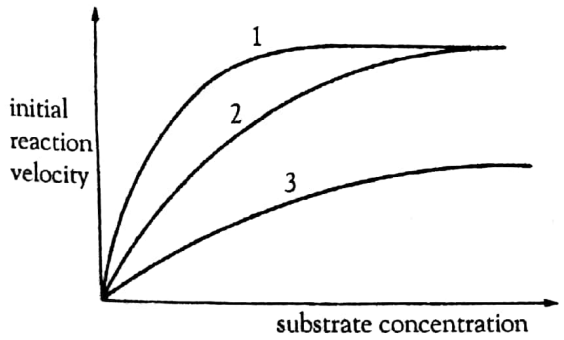


HELP

With increasing substrate concentration in the presence of a competitive inhibitor, the rate of reaction only remains constant at a later stage. This is because the additional substrates can compete with the inhibitor for the enzyme's active site.

Q20

The curves show the rates of reaction of an enzyme with and without inhibitors.



What do the curves show?

	curve 1	curve 2	curve 3
A	competitive inhibition	non-competitive inhibition	normal activity
B	competitive inhibition	normal activity	non-competitive inhibition
C	normal activity	competitive inhibition	non-competitive inhibition
D	normal activity	non-competitive inhibition	competitive inhibition

HELP

Curve 2 shows competitive inhibition, where with increasing substrate, the substrate can compete with the inhibitor for the enzyme's active site. The rate of the reaction thus remains constant at a later stage than if no inhibitor was present. Curve 3 shows non-competitive inhibition, where the increase in substrate concentration does not cause the reaction rate to level off slower because the inhibitor binds to a site other than the active site and causes a permanent configuration change in the enzyme.

Q21

The reaction rate of salivary amylase with starch **decreases** as the concentration of chloride ions is reduced.

Which of the following describes the role of the chloride ions?

A allosteric inhibitors

B coenzymes

C cofactors

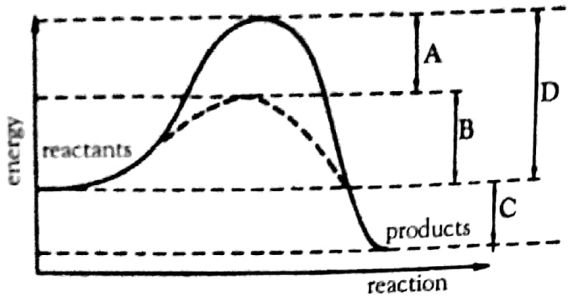
D competitive inhibitors

HELP

Some enzymes associate with a non-protein cofactor that is needed for enzymatic activity. Organic molecules that associate with enzymes in a similar way are called coenzymes. If chloride ions were inhibitors, whether allosteric or competitive, a decrease in concentration should result in an increase in the rate of reaction instead of a decrease.

Q22

The diagram represents a reaction with and without an enzyme. What is the activation energy of the enzyme-catalysed reaction?

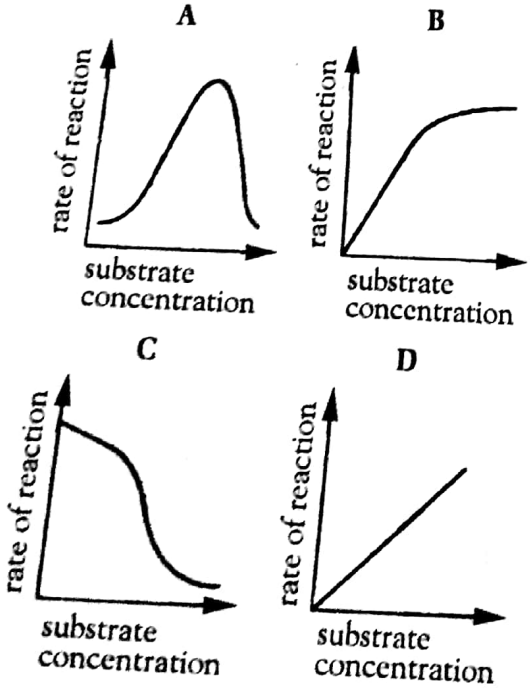


HELP

The reaction that is enzyme-catalysed has a lower activation energy and is represented by the dotted line. The energy input required to raise the energy of the reactants to a certain level before the reaction is triggered is called the activation energy. This is represented by the increase in energy of the reactants to the top of the 'hill', B.

Q23

Which graph shows the expected relationship between enzyme activity and substrate concentration?



HELP

As the substrate concentration increases, the rate of reaction increases until a maximum, when saturation of all the enzyme's active sites occurs. When this happens, the limiting factor is enzyme concentration.

Q24

Which statement is true for a non-competitive inhibitor of enzyme activity, but **not** for a competitive inhibitor?

A Inhibitor molecules are similar to normal substrate molecules in size and shape.

B Inhibition can be reduced by increasing the concentration of substrate molecules.

C Large numbers of inhibitor molecules are needed for effective enzyme inhibition.

D **The inhibitor binds to the enzyme molecule at a position away from the active centre.**

HELP

The competitive inhibitor binds reversibly to the active site and hence competes with the substrate for the site. The non-competitive inhibitor, on the other hand, binds to the enzyme at a site other than the active site, hence it does not compete with the substrate for the active site.

Q25

How does an enzyme increase the rate of a reaction?

A by bringing the reacting molecules into precise orientation

B by increasing the rate of random collisions of molecules

C by shifting the point of equilibrium of the reaction

D by supplying the energy required to start the reaction

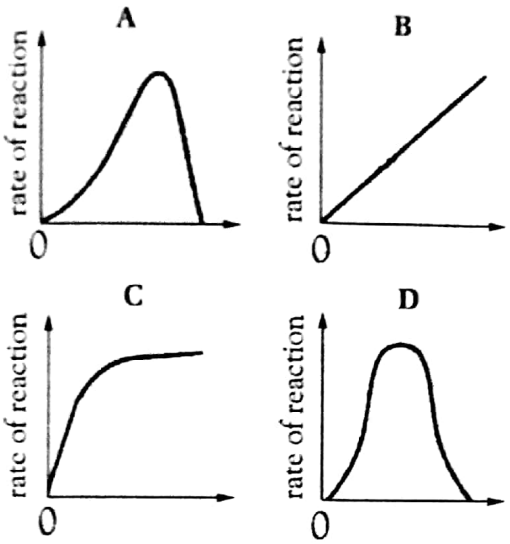
HELP

An enzyme increases the rate of reaction by either providing an alternate reaction path-

way with a lower free energy of activation or bringing the reacting molecules into a geometry resembling the transition state of the molecule, thus lowering the activation energy also.

Q26

Which graph represents the effect of temperature on enzyme activity?

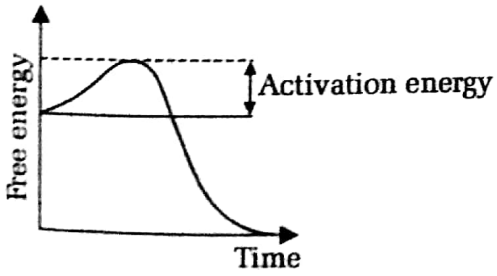


HELP

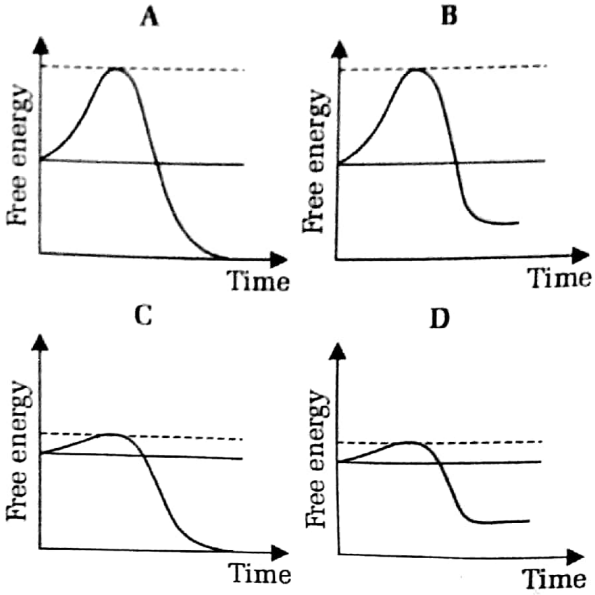
As the temperature increases, the rate increases at first until a maximum rate because an increased number of molecules have sufficient energy to pass over the energy barrier and react to form products. A further increase in temperature results in a more rapid decrease of reaction rate because of temperature-induced denaturation of the enzyme.

Q27

The graph shows energy changes during an uncatalysed chemical reaction.



Which graph shows the energy changes for the same reaction when it is catalysed by an enzyme?



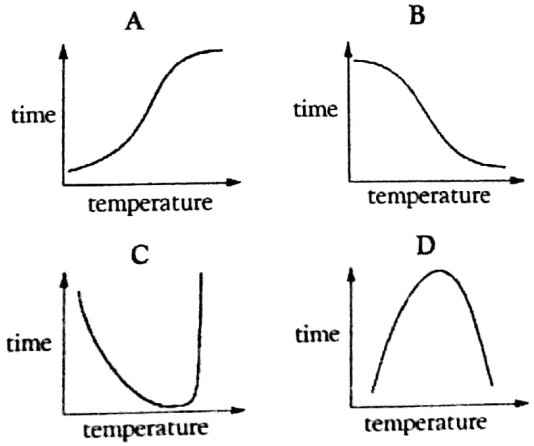
HELP

An enzyme decreases the activation energy of the reaction, illustrated by the lower 'hump'. However it does not change the free energies of the reactants and products, thus the start and end point must be at the same level.

Q28

In an investigation to determine the effect of temperature on the activity of an enzyme, the time for all the substrate to disappear from a standard solution was recorded.

Which graph shows the results of this investigation?

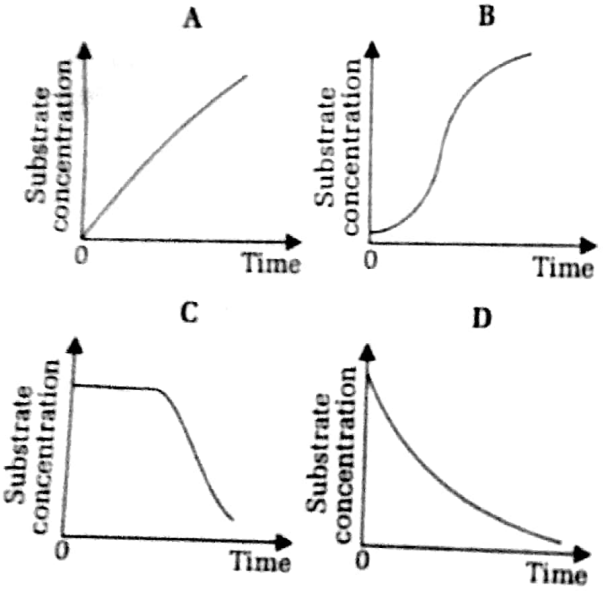


HELP

Since the y-axis is time, the graph obtained would be a vertically-inverted reaction rate vs temperature graph. As the temperature increases, the time needed decreases at first until a minimum because an increased number of molecules have sufficient energy to pass over the energy barrier and react to form products. A further increase in temperature results in a more rapid increase of time required because of temperature-induced denaturation of the enzyme.

Q29

Which graph represents the changes in substrate concentration during the course of an enzyme-catalysed reaction?



HELP

As the reaction progresses, substrate concentration should reduce as more products are formed. Therefore, the answer could be C or D. Initially the substrate and enzyme forms a complex, and so the graph plateaus for a while. A point is reached when all the substrate sites are being used, and the enzyme becomes a limiting factor. As products are formed, the enzyme is free and the reaction starts again. Hence, the answer should be C.

Q30

Which statement is true of all enzymes?

A They are denatured at temperatures above 60 °C.

B They catalyse the breakdown of large molecules into smaller ones.

C They have active sites which can bind to only one kind of substrate molecule.

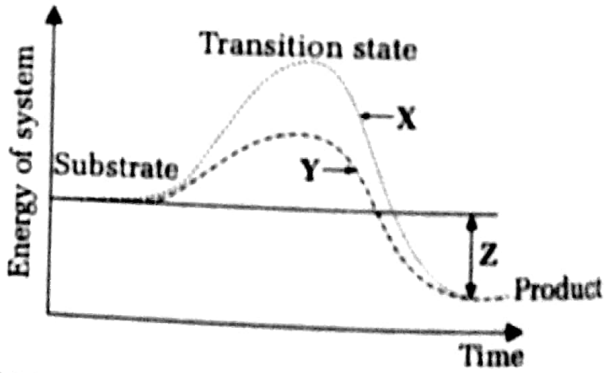
D They reduce the amount of energy required to start a reaction.

HELP

Enzymes reduce the amount of energy required to start a reaction by either providing an alternate reaction pathway with a lower activation energy or bringing the reacting molecules into a geometry resembling the transition state of the molecule, thus lowering the activation energy also.

Q31

The graph shows the effect of an enzyme on a reaction.



Which combination identifies X, Y and Z?

	X	Y	Z
A	catalysed reaction	uncatalysed reaction	activation energy
B	catalysed reaction	uncatalysed reaction	energy lost during reaction
C	uncatalysed reaction	catalysed reaction	energy gained by product
D	uncatalysed reaction	catalysed reaction	overall energy change

HELP

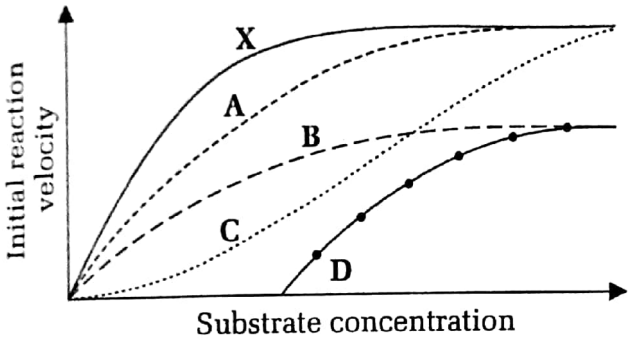
In the transition state, the reaction is uncatalysed. Therefore, X should read as an uncatalysed reaction. Y is part of the catalysed reaction. Portions of the graph above the initial energy level would indicate an energy increase.

Q32

In the graph, **X** represents the relationship between an enzyme and the concentration of its substrate under optimal conditions and without an inhibitor.

The same experiment is repeated in the presence of a fixed, low concentration of a competitive inhibitor.

Which curve represents the expected result?



HELP

Competitive inhibitors are reversible. The final result should be the same. Hence the answer could be A or C. As the inhibitors are in low concentration, graph A is more appropriate.

Q33

The diagram shows how the enzyme glutamine synthetase removes the ammonia produced during plant metabolism.

$$\text{ammonia} + \text{glutamate} \xrightarrow{\text{glutamine synthetase}} \text{glutamine}$$

Some herbicides contain an active agent which resembles glutamate.

What is the likely mode of action of this agent?

A It acts as an end-product inhibitor.

B It acts as a competitive inhibitor.

C It decreases levels of ammonia.

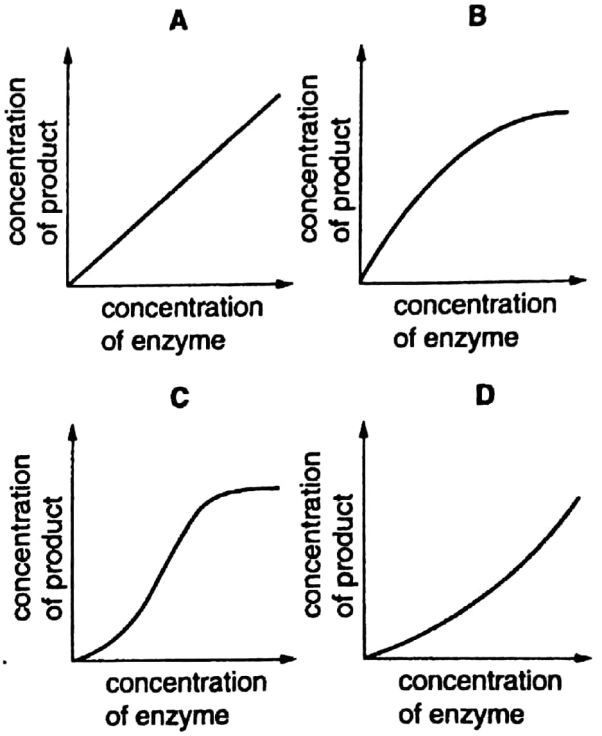
D It increases levels of glutamate.

HELP

The site of action is before the ammonia reacts with the enzyme. Since it resembles glutamate, it would be able to block the site of reaction, acting as a competitive inhibitor.

Q34

Which graph shows the effect of increasing enzyme concentration on product formation when there is an excess of substrate?



HELP

There would not be a slow down in the activity of the enzymes as there is excess substrate. Therefore, the graph does not plateau, but will increase proportionately.

Q35

What is the effect of increasing substrate concentration on the degree of inhibition of an enzyme controlled reaction?

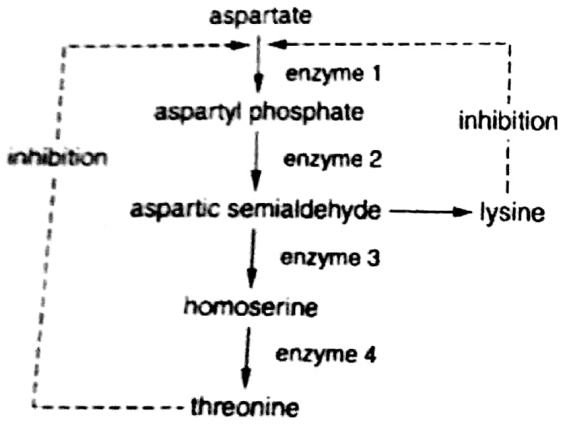
	competitive inhibition	non-competitive inhibition
A	decreased	increased
B	decreased	no change
C	increased	decreased
D	no change	increased

HELP

With an increase in substrate, there will be less competitive inhibition as more substrate can occupy the active sites. However, there will be no change in inhibition from non-competitive sources, e.g. the substrate itself, since the inhibitor does not compete with the substrate for the active sites.

Q36

A culture of bacteria produces the food supplement lysine by the metabolic pathway shown.



Which change in enzyme activity will result in the greatest increase in lysine yield?

	enzyme	change in activity
A	1	decrease
B	2	increase
C	3	increase
D	4	decrease

HELP

A decrease in (1), decrease in lysine.

An increase in (2), increase in lysine but also threonine.

An increase in (3), increase in threonine.

A decrease in (4), decrease in threonine.

Q37

A fungal amylase is incubated with starch at 22 °C at pH 8. When a sample is removed after five minutes and mixed with a solution of iodine in potassium iodide solution, the mixture is a light-brown colour.

What is the most likely explanation for this observation?

A All the starch has been hydrolysed to maltose.

B An inhibitor of the fungal amylase is present.

C Fungal amylase does not catalyse the hydrolysis of starch.

D The pH is too high to allow the reaction to proceed quickly.

HELP

The presence of starch turns the iodine into a dark blue solution. However, amylase is an enzyme that can digest starch by hydrolysis in alkaline conditions, thus there would no longer be any starch present for the iodine test.

Q38

Which statement is true of all enzymes?

A They are denatured at temperatures above 60 °C.

B They are inhibited at low pH values.

C They catalyse the breakdown of large molecules into smaller ones.

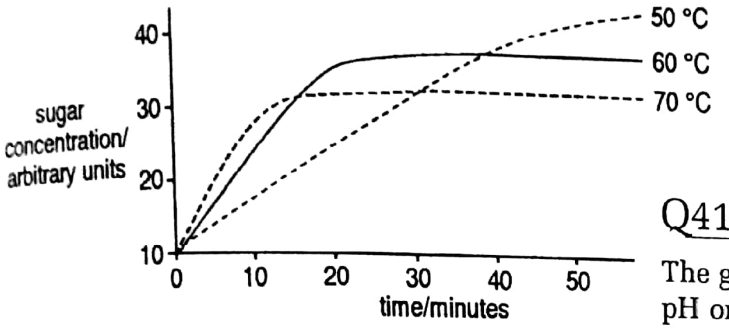
D They reduce the amount of energy required to start a reaction.

HELP

All enzymes lower the activation energy needed for a reaction to occur. Not all enzymes denature above 60 °C or catalyse the breakdown of only large molecules. Some enzymes work best at low pH values.

Q39

In beer-making, enzymes present in malting barley hydrolyse starch into sugar, ready for fermentation. The graph shows the production of sugar at three different temperatures over a period of 50 minutes. All other conditions were controlled.



What does the graph show?

A At 60 °C, all the starch is hydrolysed within 30 minutes.

B At 70 °C, the enzymes are denatured before hydrolysis is complete.

C Sugar is absent from the barley before malting.

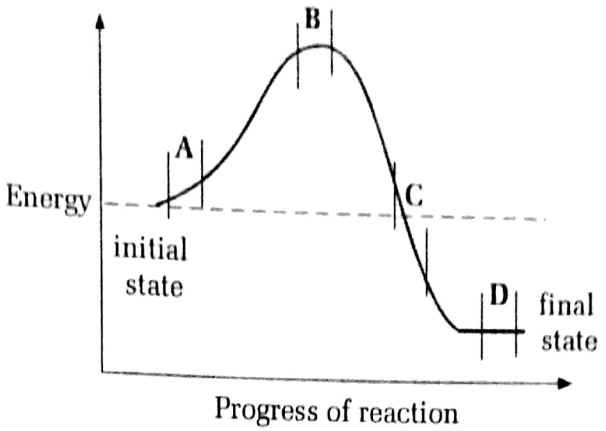
D The optimum temperature for the enzymes is 50 °C.

HELP

Optimum temperature is the temperature whereby the rate of enzyme reaction is at the maximum, as can be seen in the graph for 50 °C. It is not the temperature whereby the rate of reaction reaches a constant rate faster, as seen in the other two graphs.

Q40

The diagram shows the change in energy during an uncatalysed reaction. In which region will the introduction of an enzyme have most effect on the energy level of the reaction?

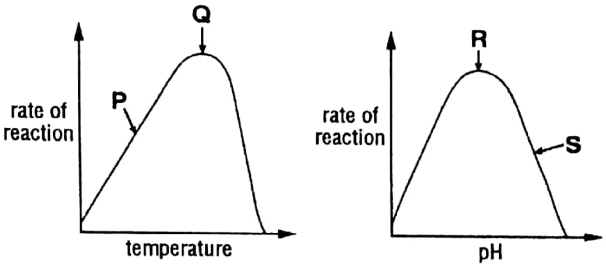


HELP

Enzymes help to lower the activation energy needed for a reaction to occur, thus region B would be lowered in the presence of an enzyme so that the reaction progresses faster.

Q41

The graphs show the effects of temperature and pH on enzyme activity.



Which statement is a correct explanation of the rate of reaction at the point shown?

A At **P**, hydrogen bonds in the enzyme are broken.

B At **Q**, the kinetic energy of enzyme and substrate is highest.

C At **R**, covalent bonds are formed between enzyme and substrate.

D At **S**, ionic bonds in the enzyme are broken.

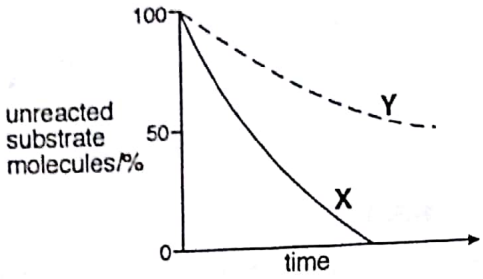
HELP

Q indicates the point where the rate of reaction is the highest, thus this is the optimum temperature for enzyme activity. The kinetic energy of the enzyme and substrate is at its peak so that more collisions can occur to speed up reaction.

Q42

Curve X represents the course of an enzyme-catalysed reaction under optimum conditions.

Curve Y shows the action of the same enzyme on the same substrate but with one alteration to the reaction conditions.



Which factor, operating to a constant extent throughout the experiment, could give the results shown by curve Y?

A increased substrate concentration

B inhibition by the end product

C less concentrated reaction mixture

D lower temperature

HELP

Curve Y shows that the percentage of unreacted substrate molecules is higher than X and tapers off at 50%, thus the factor is one that prevents the reaction from continuing on after a certain time. If it was low temperature or less concentrated mixture, the curve would still be able to reach 0%, but over a longer period of time.

Q43

In a reaction mixture, the concentrations of enzyme and inhibitor remain constant and the concentration of substrate is increased.

How is inhibition affected?

	competitive inhibition	*non-competitive inhibition*
A	decreases	increases
B	decreases	remains the same
C	increases	decreases
D	remains the same	increases

HELP

As competitive inhibitors compete for active sites on enzymes, increasing the concentration of substrate will enable more substrate molecules to occupy the active site than the inhibitors. In non-competitive inhibition, there will be no effect since the inhibitors do not compete for the same active sites as the substrate molecule.

Q44

Equal quantities of a 5% starch solution were added to equal quantities of different solutions.

After 5 minutes at room temperature, the solutions were tested with iodine in potassium iodide solution and the depth of colour was recorded using a colorimeter (with an arbitrary scale of 1 to 5, 5 being the darkest blue).

The results are given in the table.

solution	colorimeter reading
1. saliva and dilute HCl	4
2. saliva and dilute $NaHCO_3$	1
3. dilute HCl only	4
4. saliva at 100 °C	5
5. saliva at 20 °C	3

This experiment suggests that saliva contains a biologically active substance that

A hydrolyses starch in acid conditions.

B is denatured by hydrochloric acid.

C is promoted in its action by high temperatures.

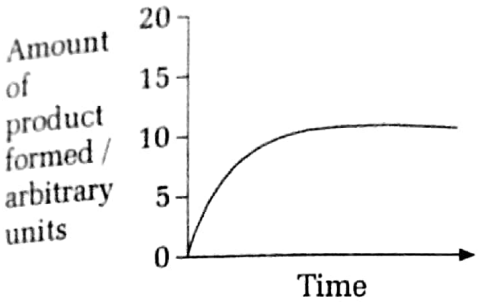
D may be activated by hydrogencarbonate ions.

HELP

Saliva contains amylase enzymes that function well at an optimum pH which is alkaline. Therefore, the presence of hydrogencarbonate ions provides the optimum pH for this enzyme.

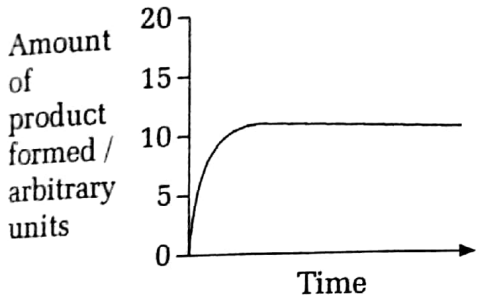
Q45

The graph shows the amount of product formed by a standard concentration of enzyme and a standard concentration of substrate at a temperature of 20 °C.

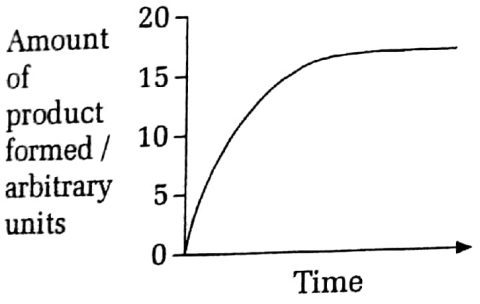


Which graph shows the effect on the activity of the enzyme of decreasing the temperature to 15 °C?

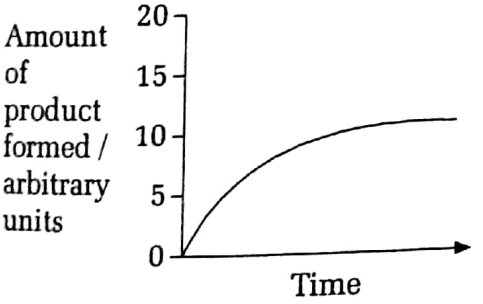
A



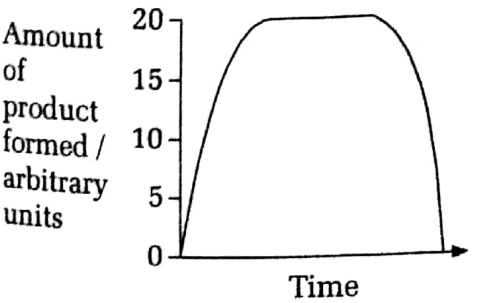
B



C



D



HELP

The rate of reaction can be determined from the gradient of the graph, the faster the rate of reaction, the steeper the gradient while the slower the rate of reaction, the more gentle the gradient.

Decreasing the temperature decreases the rate of enzyme-controlled reaction, resulting in a graph with a more gradual gradient with 10 arbitrary units of product formed.

Q46

Which statement does not correctly describe a possible action of a non-competitive enzyme inhibitor?

A It binds at a point where there are sulphur bridges and prevents the formation of an enzyme-substrate complex.

B It binds at the active site and does not prevent the formation of an enzyme-substrate complex.

C It binds near the active site and prevents the formation of an enzyme-substrate complex.

D It binds to an allosteric site and prevents the formation of an enzyme-substrate complex.

HELP

A non-competitive enzyme inhibitor has no structural similarity to the substrate and binds to the enzyme at allosteric site (site other than the active site), resulting in reduced reaction rate. Upon binding of the inhibitor to the enzyme, the enzyme configuration is changed such that its active site's conformation is altered, preventing the formation of enzyme-substrate complexes and reduces reaction rate.

Q47

What is the chemical nature of enzyme?

A Phospholipid **B** Polynucleotide

C Polypeptide **D** Polysaccharide

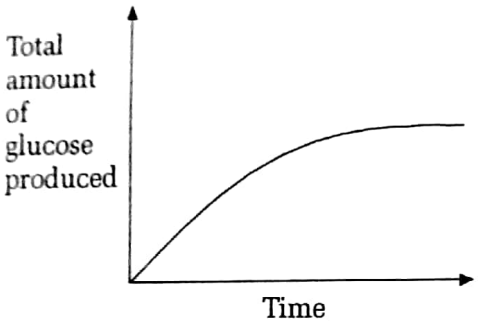
HELP

Enzymes are biological catalysts. Enzymes are normally globular protein made of polypeptide.

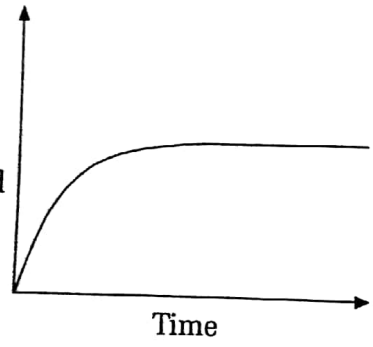
Q48

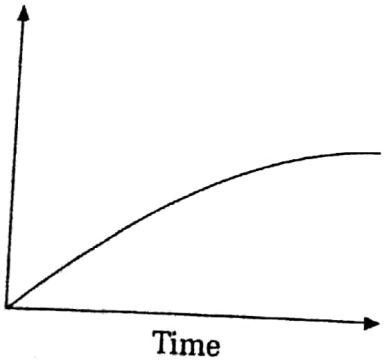
Lactose is a disaccharide present in milk. The enzyme β-galactosidase catalyses the conversion of lactose to glucose and galactose.

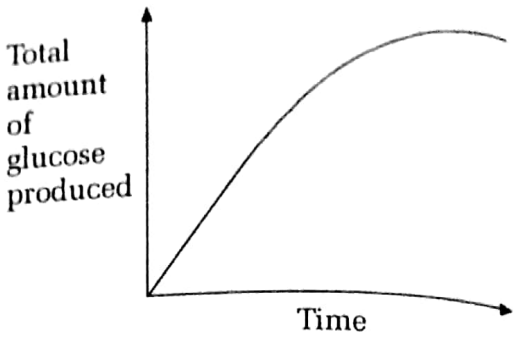
10 cm³ of a 1% β-galactosidase solution was added to 10 cm³ of milk. The graph shows the total amount of glucose produced over the next 10 minutes.

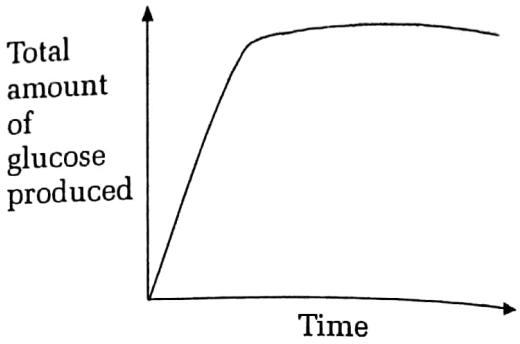


Then, 10 cm³ of a 2% β-galactosidase solution was added to 10 cm³ of milk. Which graph shows the results that would be obtained?

A


B


C


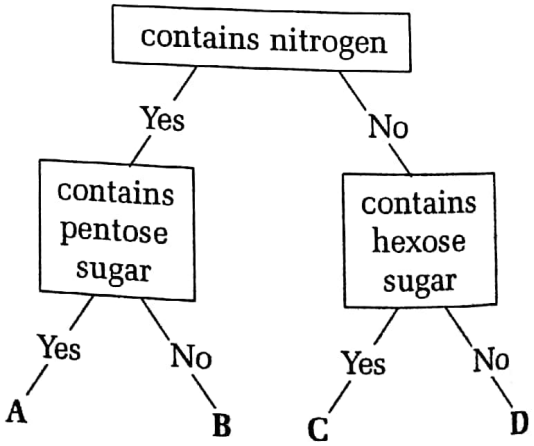
D


HELP

Increasing the β-galactosidase solution from 1% to 2% increases the enzyme concentration. As enzyme concentration increases, more active sites are now available for successful collisions between the enzyme and substrate to form more enzyme-substrate complexes, leading to an increase in the rate of reaction. As the substrate concentration remains the same at 10 cm³ of milk, thus the total amount of glucose produced will be the same.

Q49

Which molecule in the key is enzyme?



HELP

Enzyme is a protein and made up of amino acids. There is an absence of pentose sugar which is present only in nucleic acids and carbohydrates.

Each amino acid consists of a central a carbon atom bonded covalently to four groups: A basic amino group ($—NH_2$), an acidic carboxyl group (—COOH), a hydrogen atom and a variable group known as the R-group (also called the side chain).

In conclusion, there is presence of nitrogen and absence of pentose sugar.

Q50

Which statement correctly describes a possible action of a competitive enzyme inhibitor?

A It binds at the active site and prevents the formation of an enzyme-substrate complex.

B It binds near the active site and prevents the formation of an enzyme-substrate complex.

C It binds near an allosteric site and prevents the formation of an enzyme-substrate complex.

D It binds to an allosteric site and prevents the formation of an enzyme-substrate complex.

HELP

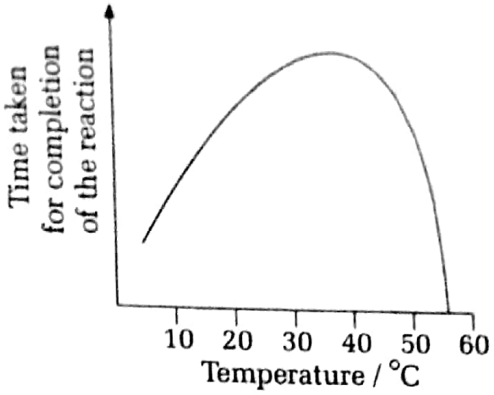
Competitive enzyme inhibitor is structurally similar to the actual substrate, and can fit into the active site of the enzyme. When it is bound at the active site, it prevents the actual substrate from entering the site, hence preventing the formation of enzyme-substrate complexes and generation of products.

Q51

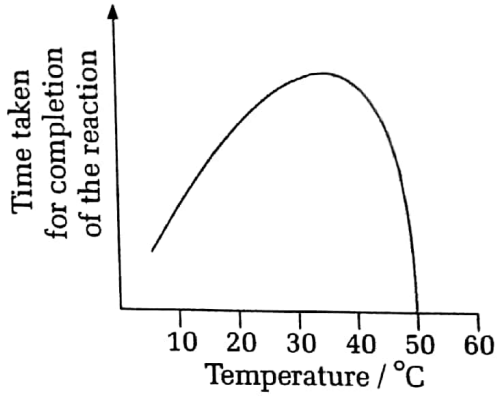
An enzyme is completely denatured at 50 °C. A fixed concentration of this enzyme is added to a fixed concentration of its substrate. The time taken for completion of the reaction is measured at different temperatures.

Which graph shows the results?

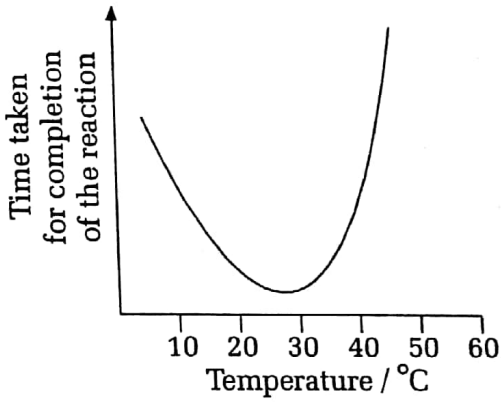
A



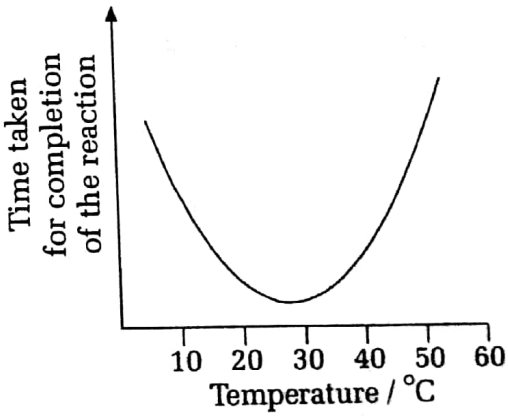
B



C



D



HELP

As the enzyme is completely denatured at 50 °C, the enzyme reaction will never reach completion at 50 °C regardless of the amount of time available.

Q52

Which type of bonds hold the tertiary structure of an enzyme?

	disulphide	glycosidic	hydrogen	ionic	peptide
A	✗	✓	✗	✗	✓
B	✗	✗	✓	✗	✓
C	✓	✓	✗	✓	✗
D	✓	✗	✓	✓	✗

HELP

Glycosidic bond is found in carbohydrates and absence in protein (enzyme).

To become a functional enzyme, a protein must assume it's primary, secondary and tertiary structure.

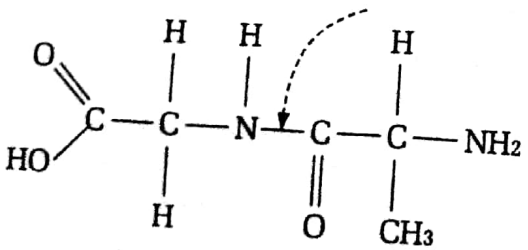
The primary structure of a protein molecule refers to its number, type and sequence of amino acids held together by peptide bonds in the linear strand of polypeptide chain.

Secondary structures are regular repeating structures stabilised by hydrogen bonds between groups in the main chain of the polypeptide.

Tertiary structure is the three-dimensional conformation of a polypeptide maintained by ionic bonds, hydrogen bonds, disulphide bonds and hydrophobic interactions.

Q53

The diagram shows a molecule. In which molecule would the linkage indicated by the arrow be found?

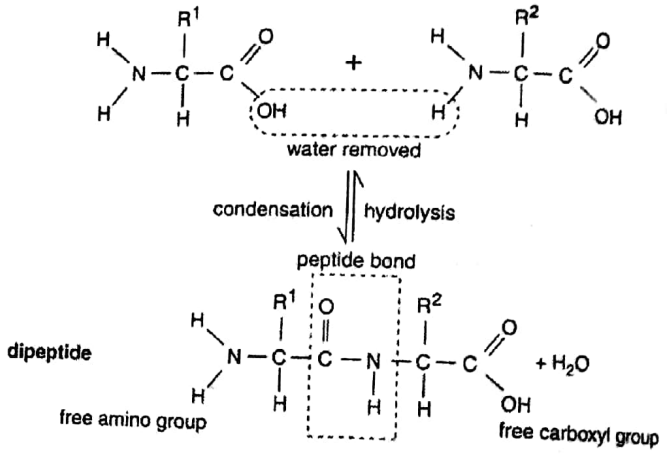


A Cellulose
B Amylose
C Amylase
D Cholesterol

HELP

Amylase is an enzyme that catalyzes the breakdown of starch into maltose. Amylase is formed by the condensation of amino acids.

Two amino acids react together in a condensation reaction with the loss of a water molecule to form a dipeptide. The linkage formed is a covalent bond known as a peptide bond.



Q54

At which levels of enzyme structure do hydrophobic interactions occur?

A primary, secondary and tertiary
B primary, secondary, tertiary and quaternary
C tertiary and quaternary
D quaternary only

HELP

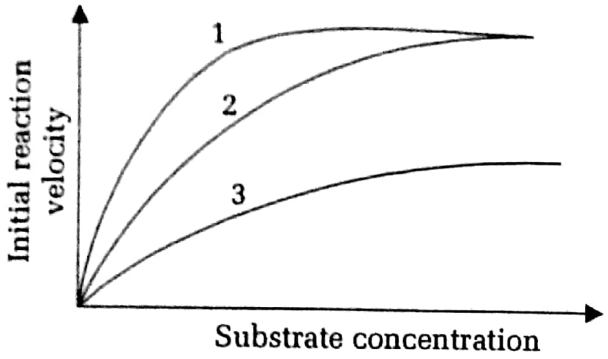
Tertiary structure is the three-dimensional conformation of a polypeptide maintained by ionic bonds, hydrogen bonds, disulphide bonds and hydrophobic interactions.

Many highly complex proteins consist of an aggregation of 2 or more polypeptide chains held together by hydrophobic interactions, disulphide linkages, hydrogen bonds and ionic bonds.

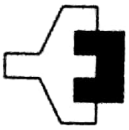
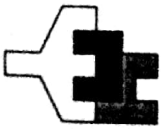
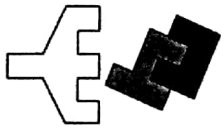
Q55

The diagram below shows the action of an enzyme on its substrate.

The rates of reaction of this enzyme were studied in the presence and absence of inhibitors, and the results shown in the curves below.



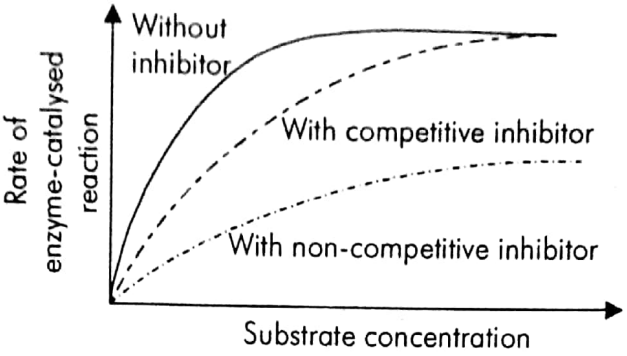
Which of the following reflects correctly the respective curves?

	Curve 1	Curve 2	Curve 3
A			
B			
C			
D			

HELP

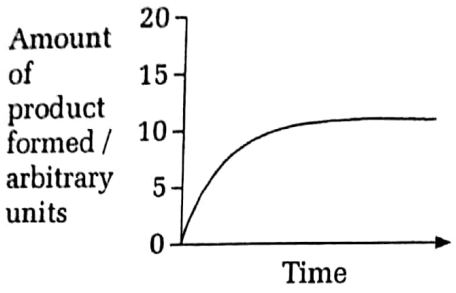
Definition of a competitive inhibitor – A compound that is structurally similar to the actual substrate, and can fit into the active site of the enzyme.

Definition of a non-competitive inhibitor – A compound that has no structural similarity to the substrate and binds to the enzyme at site other than the active site, resulting in reduced reaction rate.



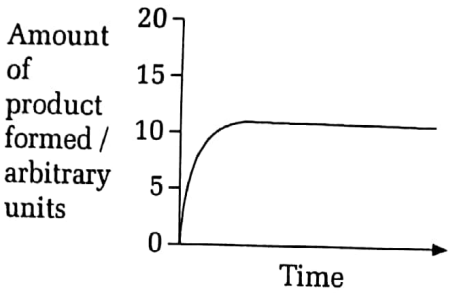
Q56

The graph shows the amount of product formed by a standard concentration of enzyme and a standard concentration of substrate at a temperature of 15 °C.

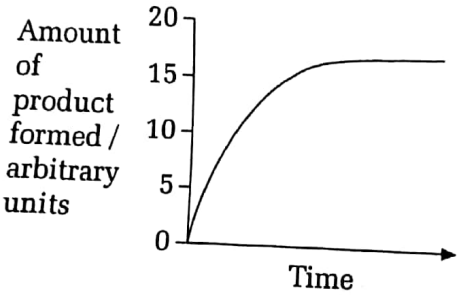


Which graph shows the effect on the activity of the enzyme of increasing the temperature to 20 °C?

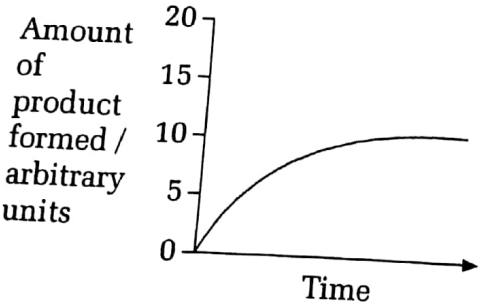
A



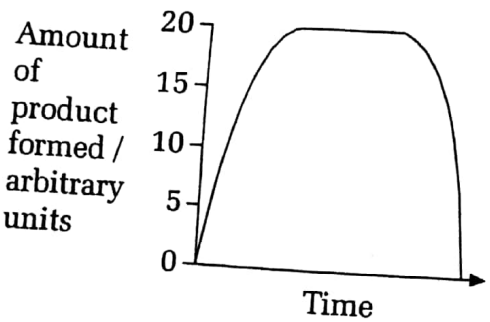
B



C



D



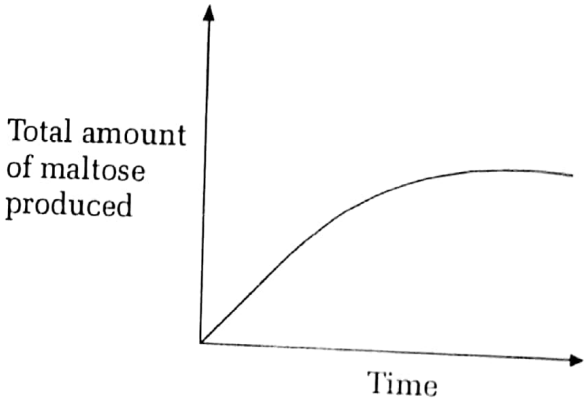
HELP

The rate of reaction can be determined from the gradient of the graph, the faster the rate of reaction, the steeper the gradient while the slower the rate of reaction, the more gentle the gradient.

The rate of an enzyme-controlled reaction is doubled for every rise of 10 °C. Thus, increasing the temperature increases the rate of enzyme-controlled reaction, resulting in a graph with a steeper gradient with 10 arbitrary units of product formed.

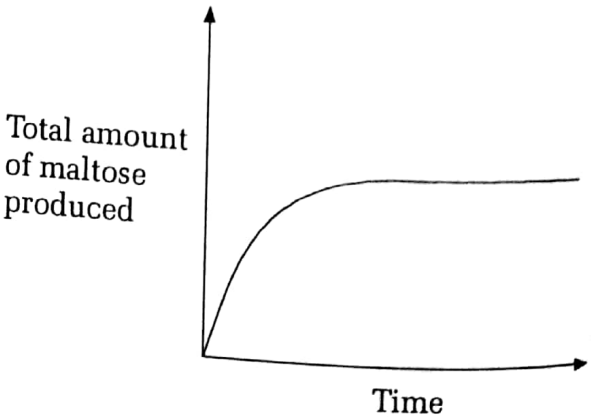
Q57

The enzyme amylase catalyses the conversion of starch to maltose. 10 cm^3 of a 1% amylase solution was added to 5 cm^3 of starch suspension. The graph shows the total amount of maltose produced over the next 15 minutes.

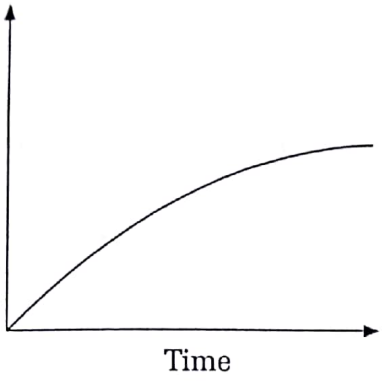


Then, 10 cm^3 of a 2% amylase solution was added to 10 cm^3 of starch suspension. Which graph shows the results that would be obtained?

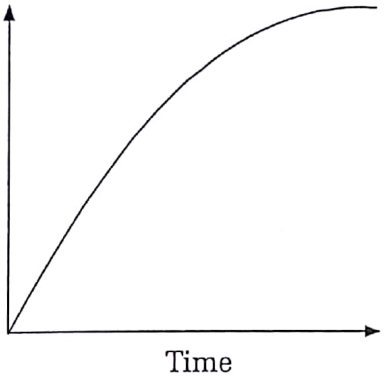
A



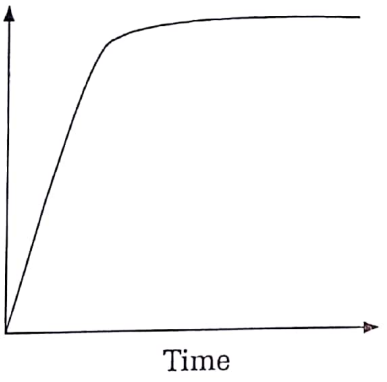
B



C



D



HELP

Increasing the amylase solution from 1% to 2% increases the enzyme concentration. As enzyme concentration increases, more active sites are now available for successful collisions between the enzyme and substrate to form more enzyme-substrate complexes, leading to an increase in the rate of reaction.

In addition, the substrate concentration increases from 5 cm^3 of starch suspension to 10 cm^3 of starch suspension, thus the total amount of maltose produced will be doubled.

Q58

A popular herbicide named glyphosate is reported to kill plants by affecting an enzyme in the pathway leading to the synthesis of several amino acids required in the assembly of plant proteins.

To determine the mechanism of glyphosate action, you conduct assays of that enzyme with increasing amounts of substrate and a constant amount of glyphosate.

The results are shown in the table below.

Assay of enzyme activity with increasing substrate, constant glyphosate levels:

Substrate concentration (mg/ml)	Relative enzyme activity (%)
10	20
15	40
20	60
25	80
30	100

The data show that glyphosate most likely

A acts directly on one of the amino acids.

B is a competitive inhibitor of the enzyme-catalysed reaction.

C does not affect activity at substrate concentrations below 10 mg/ml.

D acts as a noncompetitive inhibitor of the pathway.

HELP

From the data, it can be observed that at low substrate concentration (10 mg/ml), the relative enzyme activity is low (20%). That is, the frequency of enzyme-substrate collisions is similar to frequency of enzyme-inhibitor (E-I) collisions. Therefore, the number of enzyme-substrate (E-S) complex formed is about the same as E-I complex formed and this leads to a lower rate of reaction.

At high substrate concentrations (30 mg/ml), the relative enzyme activity is high (100%). That is, the substrate competes more successfully for active site, resulting in more successful collision between substrate and enzyme, hence more E-S complex are formed, and this leads to a higher rate of reaction.

The data above shows the characteristic of competitive inhibition. Competitive inhibition is reversible if substrate is present in high concentrations, as substrates can now outcompete the inhibitors for binding to the active site, and allow the rate of reaction to reach its maximum value.

At extremes of pH, the rate of reaction decreases. This is because the change in pH results in disruption of the ionic and hydrogen bonds that help to maintain the specific shape of the active site, causing enzyme to be denatured.

At low temperature, the rate of reaction is reduced. The enzyme is inactivated due to possession of minimal kinetic energy for collision with substrate.

Q59

The list shows three characteristic of enzyme activity.

1. Reaction rate decreases if the concentration of non-competitive inhibitor increases.
2. Reaction rate is reduced at extremes of pH.
3. Reaction rate is reduced at low temperature.

What explains each of these characteristics?

	Availability of active site is reduced	Reduced kinetic energy reduces the rate of molecular collisions	Hydrogen bonding is disrupted
A	1	2	3
B	2	1	3
C	1	3	2
D	2	3	1

HELP

Upon binding of the non-competitive inhibitor to the enzyme, the enzyme configuration is changed such that its active site's conformation is altered and can no longer bind the substrate. Formation of such enzyme-inhibitor complexes prevents the formation of Enzyme-Substrate complexes and reduces reaction rate.

Topic 1(c) Enzymes

Q1 B	Q2 D	Q3 D	Q4 B	Q5 A	Q6 A	Q7 D	Q8 A
Q9 B	Q10 C	Q11 D	Q12 C	Q13 C	Q14 C	Q15 D	Q16 B
Q17 D	Q18 B	Q19 D	Q20 C	Q21 C	Q22 B	Q23 B	Q24 D
Q25 A	Q26 A	Q27 C	Q28 C	Q29 C	Q30 D	Q31 C	Q32 A
Q33 B	Q34 A	Q35 B	Q36 D	Q37 A	Q38 D	Q39 D	Q40 B
Q41 B	Q42 B	Q43 B	Q44 D	Q45 C	Q46 D	Q47 C	Q48 A
Q49 B	Q50 A	Q51 C	Q52 B	Q53 C	Q54 C	Q55 D	Q56 A
Q57 D	Q58 B	Q59 C					

TOPIC 1

CELLULAR FUNCTIONS

1(d)

Cell and Nuclear Division

You should try to answer on your own before resorting to **HELP**.

Q1

The absence of centrioles from higher plant cells means that during somatic cell nuclear division there is

A no spindle formed.

B no equatorial arrangement of chromosomes at metaphase.

C no new cell wall laid down at telophase.

D no apparent organiser of mitotic spindles.

HELP

Centrioles in higher animal cells are the organising centres of spindle formation. These centrioles are absent in plant cells, despite the formation of spindle during cell division.

Q2

If one ignores the effect of crossing over, then the possible number of different haploid cells which could arise by the meiotic division of a diploid cell containing 10 chromosome (i.e. $n = 5$) is

A 2

B 4

C 8

D 32

HELP

The possible number of different haploid cells from meiosis can be calculated by the expression $2^5 = 32$.

Q3

The formation of chiasmata is an important feature of meiotic divisions because it

A ensures that the same genetic characteristics appear in daughter cells as in the parents.

B ensures that the number of genes in the new chromosomes remains constant.

C provides opportunities for new genotypes to arise.

D prevents homologous chromosomes from pairing.

HELP

In the formation of gametes during the first meiotic division, the homologous chromosomes pair up. This process is called synapsis. The paired (maternal and paternal) homologous chromosomes cross over at the chiasmata and homologous portions of the chromosomes are exchanged, resulting in recombination to form new genotypes.

Q4

'Suddenly, the chromatids belonging to each chromosome part company and move towards the opposite poles of the spindle.'

This is a description of mitotic

A anaphase.

B interphase.

C metaphase.

D prophase.

HELP

Mitosis is the complex process that apportions the new chromosomes equally to daughter cells. During anaphase, the 2 sister chromatids separate into independent chromosomes. Each contains a centromere that is linked by a spindle fibre to one pole towards which it moves. Thus one copy of each chromosome is donated to each daughter cell.

Q5

The events shown below occur during different phases of mitosis.

1 spiralization of DNA
2 hydration of DNA
3 centromeres split
4 centromeres attach to spindle fibres
5 DNA replicates

Which one of the following correctly identifies each of the phases described?

	interphase	prophase	metaphase	anaphase	telophase
A	1	2	3	4	5
B	1	5	4	2	3
C	2	4	1	3	5
D	5	1	4	3	2

HELP

During the S phase of interphase, there is replication of DNA, followed by prophase, where the chromatin condenses. At metaphase the centromeres are ready to split; this occurs at anaphase. Finally, division is complete at telophase.

Q6

During which phase of meiosis are chiasmata formed?

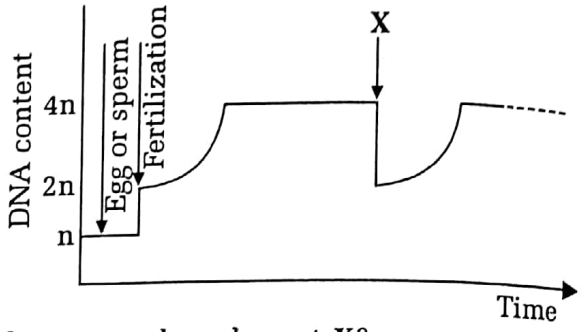
A prophase I **B** metaphase I
C anaphase II **D** metaphase II

HELP

Chiasmata are crossed chromosomes participating in recombination. These are formed during prophase I of meiosis.

Q7

The following graph represents the changes in the quantity of DNA present in the cell cycle at different stages.



What stage takes place at X?

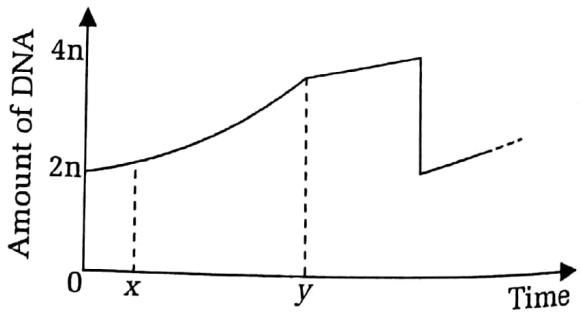
A anaphase **B** cytokinesis
C interphase **D** metaphase

HELP

After fertilisation, the DNA content in the cell increases because of the fusion of genetic material of the parents. Mitosis them occurs and is followed by cytokinesis at X, which is the division of the cytoplasm into 2 compartments, i.e. 2 cells.

Q8

The graph below shows the changes in DNA content in a single cell during the mitotic cycle.



Which stage occurs between time *x* and time *y*?

A interphase
B prophase
C metaphase
D anaphase

HELP

During interphase, chromosomal DNA is replicated and bound to protein. The pre-mitotic cell is 4n (i.e. there are 2 copies of each chromosome) and since there are 2 morphologic chromosome of each type, there are a total of 4 copies of each chromosome.

Q9

The absence of centrioles from higher plant cells means that during somatic cell nuclear division there is

A no apparent organiser of mitotic spindles.
B no equatorial arrangement of chromosomes at metaphase.
C no new cell wall laid down at telophase.
D no spindle formed.

HELP

Although no centrioles are visible, there is spindle formation and the chromosomes do exhibit equatorial arrangement. Spindle formation is probably by another organelle, unknown as yet.

Q10

A diploid cell contains three pairs of homologous chromosomes. Each pair is heterozygous for a pair of alleles, Aa, Bb and Cc, respectively. If this diploid cell undergoes meiosis, how many different combinations of these genes could be produced in the haploid daughter cells?

A 3
B 6
C 8
D 12

HELP

The eight ($2^n = 2^3$) different combinations of the alleles are: ABC, AbC, ABc, aBC, aBc, abC, Abc and abc.

Q11

In root tip cells, cell plate formation occurs during

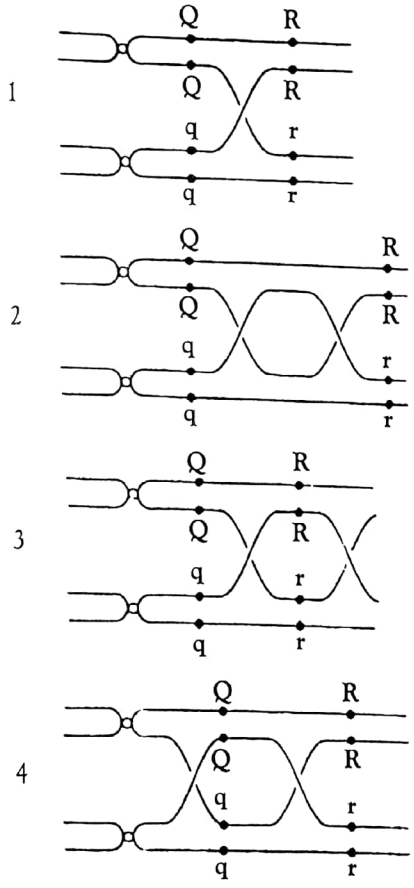
A anaphase.
B interphase.
C metaphase.
D telophase.

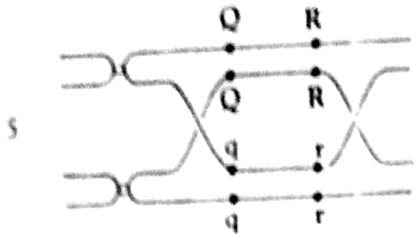
HELP

During telophase, new membranes form daughter nuclei. As the chromosomes uncoil and become less distinct, the nucleolus becomes visible again, and the nuclear membrane forms around each daughter nucleus. Cell plate formation then occurs for the formation of cell membranes during cytokinesis.

Q12

The diagrams below represent a pair of chromosomes during prophase I of meiosis. **Q** and **q** are alleles of one gene, and **R** and **r** are alleles of another gene.





Which diagrams represent situations which would result in the segregation of alleles **Q** and **q** at anaphase I?

A 1, 2 and 3

B 1, 2 and 4

C 2, 3 and 5

D 2, 4 and 5

HELP

The alleles Q and q should occur in the same loci but on different chromosomes after crossing over.

Q13

A diploid cell contains four chromosomes (2n = 4). If this cell divides by mitosis, and there is no mutation, how many genotypes exist among the daughter cells?

A 1 **B** 2

C 4 **D** 8

HELP

In somatic cells which undergo mitosis, the genotype always remains unchanged and the daughter cells are all identical, because there is no crossing over process or independent assortment.

Q14

Which one of the following structures would be found in an animal cell undergoing mitosis, but not in a plant cell undergoing mitosis?

A centriole

B centromere

C chromatid

D chromomere

HELP

Centrioles are organising centres for the spindle fibres which are composed of microtubules. These are present only in animal cells and not in plant cells.

Q15

Which is the longest phase in the cell cycle of human liver cells?

A anaphase

B cytoplasmic cleavage

C interphase

D prophase

HELP

The longest phase in the cell cycle is interphase, before the actual nuclear division process. DNA replication occurs during interphase.

Q16

In prophase of mitosis, which one of the following events occurs in animal cells but not in plant cells?

A Centrioles migrate to opposite sides of the nucleus.

B Chromosomes become invisible due to condensation.

C Homologous chromosomes do not associate.

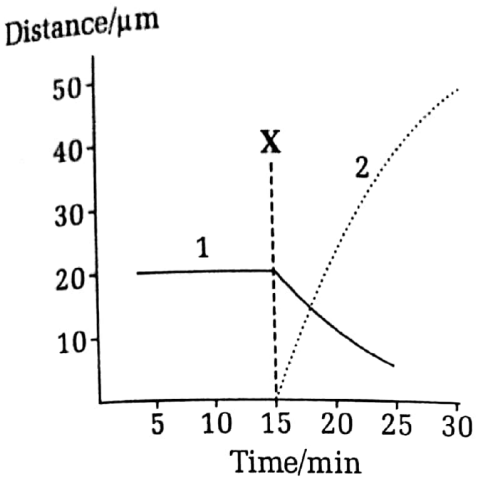
D The nuclear envelope (membrane) breaks down.

HELP

Centrioles move apart during nuclear division, and radiate microtubules, forming asters. These structures are not visible in higher plants, which instead have a microtubule-organising centre, from which spindle microtubules arise.

Q17

The graph below illustrates the behaviour of the chromosomes during one mitotic cell division.



Which one of the following correctly indicates the changes illustrated by curves 1 and 2, and the stage of mitosis which is commencing at X?

	stage of mitosis commencing at X	distance between centromeres of chromosomes and poles of spindle	distance between centromeres of sister chromatids
A	anaphase	1	2
B	anaphase	2	1
C	metaphase	1	2
D	metaphase	2	1

HELP

During anaphase, the sister chromatids of each chromosome separate at the centromere, each approaching opposite ends of the spindle pole. Hence the distance between the centromere and the poles decreases, whilst that between the centromeres of the sister chromatids increases.

Q18

The diagrams show stages of mitosis.

What is the order of these stages during mitosis?

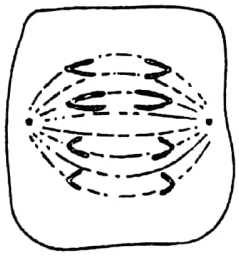
A	1	2	4	3	5
B	2	3	5	1	4
C	3	5	4	1	2
D	3	4	5	1	2

HELP

D shows the stages in mitosis from interphase (3), condensation of chromatin (4), alignment of chromosomes in metaphase (5), separation of sister chromatids in anaphase (1) and telophase (2).

Q19

The diagram below is of a cell from a gametophyte undergoing division.



What is the type of division and the stage?

A	meiosis;	prophase I;	2n = 8
B	meiosis;	metaphase II;	n = 8
C	mitosis;	prophase;	n = 8
D	mitosis;	early anaphase;	2n = 8

HELP

The diagram shows the separation of the sister chromatids at the early anaphase of mitosis. The resulting daughter cells are diploid with 8 chromosomes.

Q20

Throughout which phase of the mitotic cycle would DNA be present in the least amount in a nucleus?

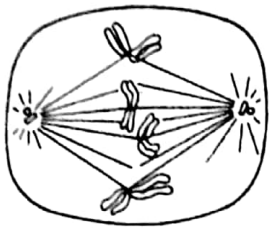
A	anaphase	B	interphase
C	metaphase	D	telophase

HELP

Nuclear division would have been completed by telophase, resulting in the amount of DNA in the nucleus being halved, compared to that at interphase, prophase and metaphase.

Q21

The diagram shows one stage of mitotic cell division.



From the position of the cell organelles and the chromosomes, what stage of mitosis has been reached?

A early anaphase **B** early telophase
C mid metaphase **D** late prophase

HELP

The diagram shows the alignment of chromosomes on the spindle, ready for division into the sister chromatids. This is the mid metaphase stage of mitosis.

Q22

If **x** units of DNA are present in the nucleus of a cell which has just divided, what is the relative amount present in this cell during prophase of the next mitosis?

A $\frac{x}{4}$ **B** $\frac{x}{2}$
C **x** **D** **2x**

HELP

During the S phase of interphase before mitosis, DNA replication occurs so that the amount of DNA is doubled (2x units). This process ensures that the chromosome number of each daughter cell is preserved (x units) after mitosis.

Q23

The chromosome drawings have been traced from photographs of cells dividing in a root tip.

X **Y** **Z**

In what order do these stages of cell division occur?

	first ⟶		*last stage*
A	**X**	**Y**	**Z**
B	**X**	**Z**	**Y**
C	**Y**	**X**	**Z**
D	**Y**	**Z**	**X**

HELP

Y shows the metaphase stage of mitosis, where the chromosomes have aligned on opposite poles. This is followed by X, anaphase, where the sister chromatids separate, and finally Z, where division is completed.

Q24

At which stages of the mitotic cell cycle do these events occur?

	DNA replication	breakdown of nuclear membrane	division of centromere
A	interphase	metaphase	metaphase
B	interphase	prophase	anaphase
C	interphase	interphase	anaphase
D	prophase	prophase	anaphase

HELP

Before nuclear division, there is DNA replication during S phase of interphase. At prophase, the nuclear membrane breaks down to allow the division process. The centromere finally divides at anaphase to separate the sister chromatids of each chromosome.

Q25

The amount of DNA in a mammalian cell in early prophase I is **x**.

What is the amount of DNA in the same cell in anaphase I of meiosis?

A $\frac{x}{4}$ B $\frac{x}{2}$

C x D 2x

HELP

At prophase I, DNA replication has already occurred, and the original amount of DNA has been doubled to x. At anaphase I, the amount of DNA in the cell remains the same because no cytokinesis has occurred yet to separate the cytoplasm.

Q26

When is the DNA content of a cell doubled?

A anaphase B interphase

C metaphase D prophase

HELP

The DNA content of a cell is doubled during the S phase of interphase, when DNA replication occurs prior to nuclear division.

Q27

A diploid cell contains two pairs of homologous chromosomes. Each pair is heterozygous for a pair of alleles, **Aa** and **Bb**.

After meiosis, how many different combinations of these alleles could be produced in the haploid daughter cells?

A 2 B 4

C 8 D 16

HELP

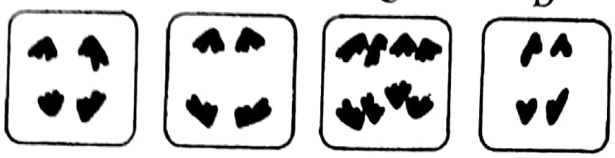
The alleles are A, a, B and b. After meiosis, the 4 possible combinations in the haploid daughter cells are AB, Ab, aB, ab.

Q28

The diagram shows anaphase of mitosis.

Which of the following diagrams shows anaphase I during meiosis in the same organism?

A B C D

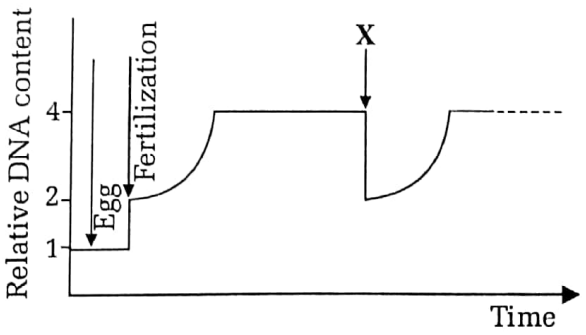


HELP

Anaphase of mitosis is the separation of sister chromatids of each chromosome, whilst anaphase I of meiosis is the separation of homologous chromosomes, This is represented by A. In B, one pair of homologous chromosomes end up on one side and the second pair end up on the other side (the different homologous pairs can be differentiated by their differing lengths).

Q29

The graph represents the changes in the quantity of DNA present in one nucleus at different stages in the life cycle.



Which stage takes place at **X**?

A interphase B metaphase

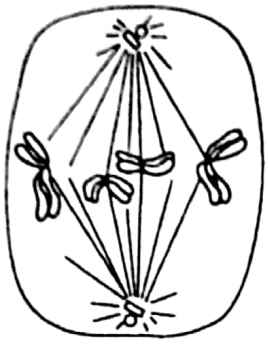
C prophase D telophase

HELP

The relative DNA content decreases from 4 to 2. X marks the end of the nuclear division process (mitosis), where at telophase, two daughter cells are formed.

Q30

The diagram shows two pairs of homologous chromosomes.



Which stage of nuclear division is shown?

A anaphase of mitosis

B anaphase I of meiosis

C metaphase of mitosis

D metaphase I of meiosis

HELP

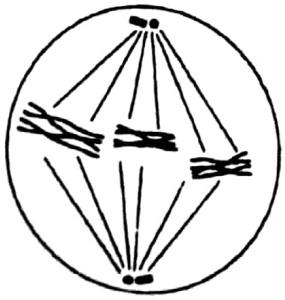
The diagram shows the metaphase stage of mitosis, where the chromosomes have aligned along the equatorial axis of the spindle, ready to be split into the sister chromatids.

Q31

The diagrams below show chromosomes in a cell undergoing mitosis and in a cell undergoing meiosis.

mitosis

meiosis



Which of the following names the stages of division correctly?

	mitosis	*meiosis*
A	prophase	prophase I
B	prophase	metaphase I
C	metaphase	anaphase I
D	metaphase	metaphase II

HELP

The centrioles in the first diagram have not separated to opposite poles yet, and the sister chromatids have not yet separated. The stage is this prophase. In the second diagram, the homologous chromosomes have undergone pairing, but have not separated into the opposite poles. The centrioles are already on opposite poles. The stage is thus metaphase I.

Q32

During which phase in somatic cell division does replication of the chromosomes take place?

A interphase

B early prophase

C middle prophase

D late prophase

HELP

The replication of chromosomes takes place during interphase, before the rest of the mitotic cycle.

Q33

During which stage of meiosis do homologous chromosomes separate?

A prophase I

B anaphase I

C prophase II

D anaphase II

HELP

The homologous chromosomes, one maternal and one paternal, separate during anaphase I. The sister chromatids then separate at anaphase II, resulting in the formation of 4 daughter cells, each with half the number of chromosomes that was present in the parent cell.

Q34

When identical twins marry identical twins, the children of both couples are genetically

A different because of random segregation during parental meiosis.

B different because of the high probability of random mutation.

C identical because of a low probability of mutation.

D identical unless crossing-over takes place.

HELP

During meiosis, the homologous pairs of chromosomes separate independently of each other. Through this process of random segregation, the genotypes of different gametes in one parent are different. Hence, even different children borne by the same parents are genetically different, unless they are identical twins. It then goes without saying that the children of both couples would be genetically different.

Q35

During which stage of the mitotic cell cycle is DNA replicated?

A prophase B metaphase

C telophase D interphase

HELP

Prophase, metaphase and telophase are the some of the processes during mitosis. Interphase is the stage before mitosis during which the DNA is replicated in the cell.

Q36

The second division of meiosis differs from mitosis because in meiosis

A chiasmata form between the chromatids.

B each chromosome replicates at metaphase.

C individual chromosomes line up at random on the equator.

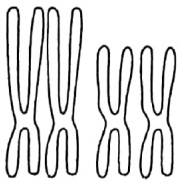
D the separating chromatids differ genetically.

HELP

In meiosis, the sister chromatids differ genetically due to crossing over during prophase I. In mitosis, crossing over does not occur and the chromatids and thus genetically identical.

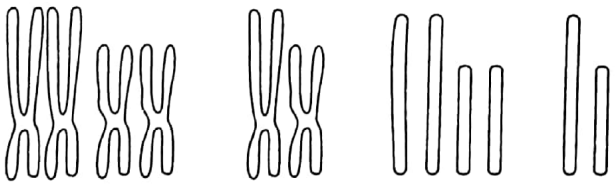
Q37

The diagram shows the chromosome complement of a cell just before the metaphase stage of mitosis.



What will be the chromosome complement at telophase?

A B C D



HELP

At the metaphase stage of mitosis, each chromosome exists as a pair of sister chromatids, joined together at the centromere. At telophase, the sister chromatids have been separated and each sister chromatid exists as a separate chromosome. The number of chromosomes is not halved in mitosis as it is in meiosis, hence excluding option D.

Q38

Albinism in humans is controlled by a recessive allele.

How many copies of this allele will be found at one of the poles of a cell at telophase I of meiosis in an albino person?

A 23 B 4

C 2 D 1

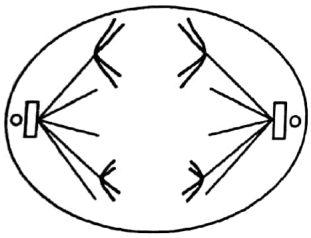
HELP

Since the allele is recessive, both homologous chromosomes in a somatic cell of an albino person would have the allele. After meiosis I, each end would have a homologous chromosome with the allele. As the chromosome is existing as a pair of sister chromatids at this stage, each chromosome and hence each end would have two copies of the allele.

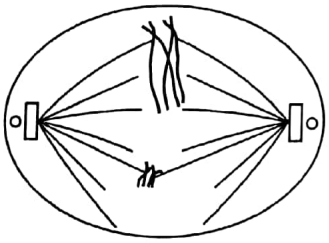
Q39

Which diagram represents a cell undergoing metaphase I of meiosis?

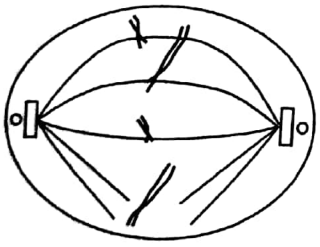
A



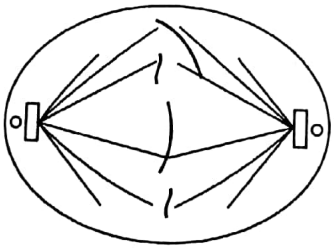
B



C



D



HELP

In metaphase I of meiosis, homologous chromosomes, each existing as a pair of sister chromatids, separate to different ends of the cell.

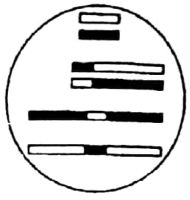
Q40

The diagram shows the maternal and paternal chromosomes from a diploid cell.

If the cell divides by meiosis, which diagram shows a possible viable gamete?

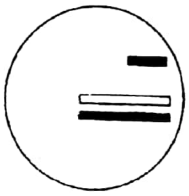
A

B



C

D



HELP

A viable gamete would have one of each of the three homologous pairs of chromosomes, represented by the different lengths. The combination of maternal and paternal parts in one chromosomes occurs during crossing over and is a natural process that leaves the gamete viable.

Q41

The diagram shows some chromosomes at late prophase of mitosis.

How many chromosomes would be present in one nucleus at telophase II of meiosis?

A 6 B 12

C 18 D 24

HELP

There are 12 chromosomes present. In a mitotic division, the number of chromosomes remain the same, i.e. 2n → 2n. In a meiotic division the number is halved, i.e. 2n → n. So there should only be 6 chromosomes in the nucleus.

Q42

The following events occur in mitosis and/or meiosis. Which event occurs **only** in meiosis?

A chromatid formation

B chromosome condensation

C chromosome movement to poles

D chromosome pairing

HELP

In meiosis, chromosome pairing occurs during metaphase I, and the homologous chromosomes separate into different cells after meiosis I. This does not occur in mitosis.

Q43

How does the second meiotic division differ from mitosis?

A Chiasmata form between the chromatids of a bivalent.

B Each chromosome forms two chromatids during metaphase.

C Exchange of genetic material occurs between chromatids.

D The separating chromatids of a pair differ genetically.

HELP

One of the most important factors about meiosis is that it gives rise to individuals who are genetically different. The chromatids undergo crossing-over before they are separated to the different poles in the nucleus.

Q44

The presence of starch in maize pollen grains is controlled by one allele of a particular gene. The other allele results in the absence of starch.

Why do half the pollen grains of a heterozygous maize plant contain starch?

Because alleles separate at meiosis during

A anaphase I and anaphase II.

B metaphase I and anaphase I.

C metaphase II and anaphase II.

D prophase I and prophase II.

HELP

It is only during anaphase that the chromosomes are pulled to the poles by the spindle fibers.

Q45

At prophase of mitosis, a eukaryote chromosome consists of two chromatids.

What is the structure of a single chromatid?

A one molecule of single-stranded DNA coiled around protein molecules

B two molecules of single-stranded DNA each coiled around protein molecules

C one double helix of DNA coiled around protein molecules

D two double helices of DNA each coiled around protein molecules

HELP

A chromatid consists of a DNA double helix attached with histones (protein molecules) to form nucleosomes.

Q46

At which stage of the cell cycle does the quantity of DNA per cell decrease by half?

A anaphase

B cytokinesis

C metaphase

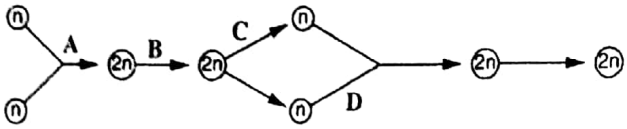
D telophase

HELP

At telophase I, the nucleus envelope forms and the spindle disappears.

Q47

The diagram represents the life cycle of an animal. At which stage in the life cycle does mitosis occur?



HELP

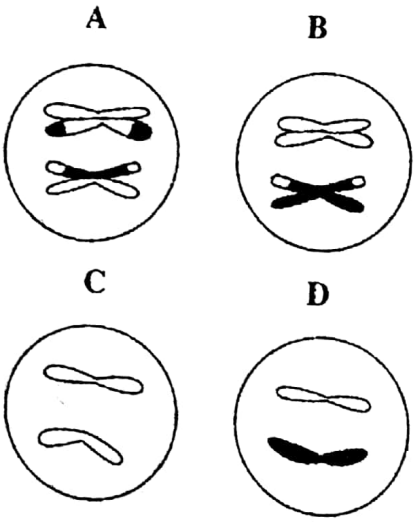
Mitosis: 2n → 2n

A is fertilization, C is meiosis and D is also fertilization.

Q48

The diagram shows a cell at anaphase I of meiosis.

Which diagram shows a normal gamete that could be produced from this cell?

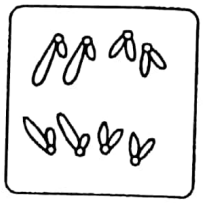


HELP

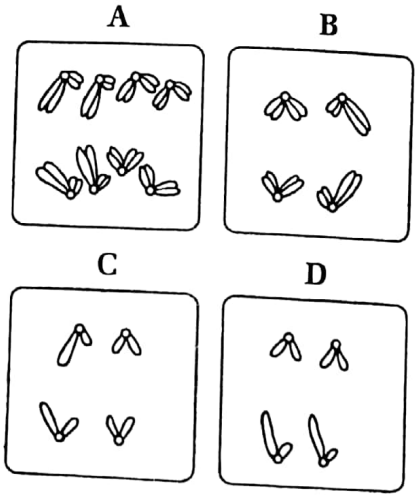
Meiosis is the process of halving the number of chromosomes to form sex cells. Thus the final answer should be either C or D. C is formed from identical chromatids, whereas D is the outcome after separation of sister chromatids (after anaphase II).

Q49

The diagram shows anaphase of mitosis.



Which diagram shows anaphase I during meiosis in the same organism?



HELP

The original cell has 4 sets of chromosomes. In meiosis, each chromosome is seen to comprise 2 chromatids. So there should be 4 separate chromosomes, but with 2 chromatids each.

Q50

Which statement correctly describes homologous chromosomes?

A They are formed during meiosis.

B **They are held together by centromeres.**

C They are identical.

D They carry the same gene loci.

HELP

Homologous chromosomes are made up of two chromosomes, which need not be identical, but is important in determining the same characteristics for that individual. E.g. blood group, eye colour etc.

Q51

At which stage of mitosis do these events occur?

	spiralisation and condensation of DNA	nuclear envelope breaks down	centromeres separate
A	interphase	interphase	metaphase
B	interphase	prophase	metaphase
C	prophase	metaphase	anaphase
D	prophase	prophase	anaphase

HELP

During prophase, the chromosomes become visible as long, thin tangled threads. Gradually they shorten and thicken. The nucleolus disappears and the nuclear envelope disintegrates.

Q52

In the fruit fly, *Drosophila melanogaster*, the diploid number of chromosomes is eight.

In the absence of crossing over or mutation, how many genetically unique kinds of gamete might be formed by one individual?

A 4 **B** 8

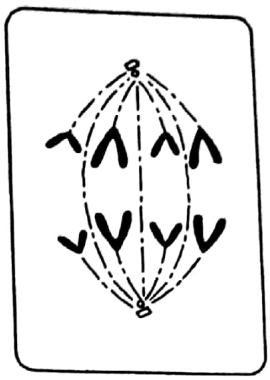
C 16 **D** 32

HELP

As the diploid number is 8, there would be 4 pairs of homologous chromosome pairing. This gives rise to a combination of $4^2 = 16$ kinds of gametes.

Q53

The diagram shows a dividing nucleus containing two pairs of homologous chromosomes.



Which phase of nuclear division is represented?

A anaphase of mitosis

B anaphase II of meiosis

C metaphase I of meiosis

D metaphase of mitosis

HELP

As the chromatids are seen to be separating, this phase is anaphase and not metaphase where the chromatids would be seen lining up at the equator of the spindle. However, this anaphase stage is occurring during mitosis since the homologous chromosomes are still in the same nucleus.

Q54

During which stage of meiosis do centromeres divide?

A prophase I

B metaphase I

C prophase II

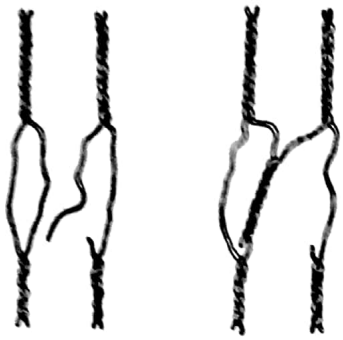
D metaphase II

HELP

In prophase, the centromeres do not divide. In metaphase I, only the homologous chromosomes are about to separate and not yet the chromatids.

Q55

The diagram shows the uncoiling and coiling that might take place between homologous regions of two double helical nucleic acid molecules.



What do the diagrams represent?

A chromosome mutation

B DNA replication

C mRNA synthesis

D the early stages of crossing over

HELP

The diagram shows the meiotic process, where there is crossing over between homologous chromosomes, resulting in new combinations of genes.

Q56

If the nucleus of a human motor neurone contains 6.8 picograms (pg) of DNA, what mass of DNA is the nucleus of an actively dividing human skin cell likely to contain at the end of interphase?

A 3.4 pg **B** 6.8 pg

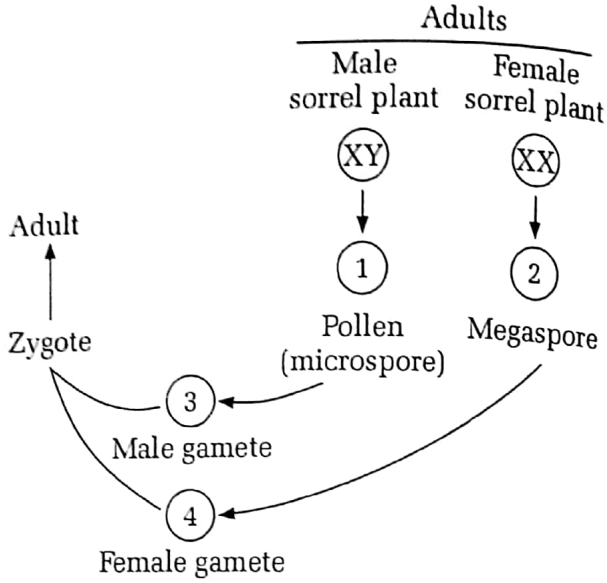
C 13.6 pg **D** 20.4 pg

HELP

The amount of DNA in the 2 somatic cells, the motor neurone and the skin cell should be the same. After interphase where DNA has already replicated, the amount of DNA is doubled, i.e. 6.8 × 2 pg = 13.6 pg.

Q57

The sorrel plant, *Rumex acetosa*, is a flowering plant with separate sexes. The diagram below is an outline of its life cycle, including the sex chromosomes of the adults.



Which sex chromosomes would be found in cells 1 to 4 if a male zygote were produced?

	cell 1	*cell* 2	*cell* 3	*cell* 4
A	Y	X	Y	X
B	Y	X	YY	XX
C	XY	XX	Y	X
D	XY	XX	XY	XX

HELP

The male zygote must have the genotype XY. Since the Y chromosome can only come from the male plant, the female plant contributes the X chromosome.

Q58

What is the role of centrioles during meiosis in animal cells?

A breaking down the nuclear membrane during prophase

B helping homologous chromosomes to pair and form bivalents

C holding the two chromatids of a chromosome together

D organising microtubules to form spindle fibres

HELP

Centrioles migrate to the poles at mid prophase I and start to form the spindle fibres at late prophase I.

Q59

In the table, a tick (✓) indicates that structures are genetically identical; a cross (×) that they are not.

Which sequence of ticks and crosses is correct?

	tubers on a potato plant	seeds in the same fruit	pollen grains in the same anther	brother and sister twins	sperm produced by the same male
A	✓	✓	✓	✓	✓
B	✓	×	×	×	✓
C	✓	×	×	×	×
D	×	✓	✓	×	✓

HELP

Only cells produced from mitotic division are identical. These are somatic cells, e.g. tubers on a potato plant. The rest of the choices arise from meiosis, thus are genetically different.

Q60

The genotype of a human zygote will differ from that of both parents.

Which of the following does **not** contribute to this variation?

A chiasmata occurring during meiosis

B mutation of genes

C presence of dominant genes

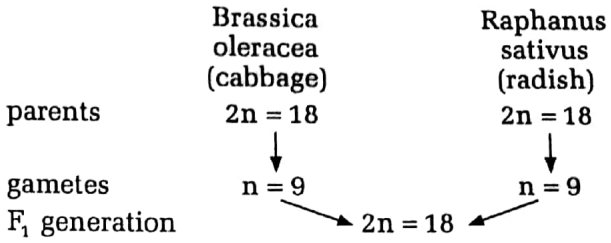
D random combination of gametes

HELP

The presence or absence of dominant genes affects the genotype of the offspring, but it would not contribute to the variation in the resulting zygote.

Q61

The diagram shows an intergeneric cross performed in a breeding experiment.



Which of the following statements explains why the F_1 hybrid plants were sterile?

A Non-disjunction occurred in parental gamete formation.

B There was an odd number of chromosomes in the gametes.

C The chromosomes of the F_1 hybrid could not form homologous pairs during meiosis.

D The F_1 hybrid was polyploid and could not undergo gametogenesis.

HELP

Although the chromosome number of the F_1 generation was normal, they did not form homologous pairs during meiosis, resulting in sterile hybrids.

Q62

What happens to chromosomes in prophase I of meiosis?

A They are formed by replication of DNA.

B **They attach to the spindle fibres.**

C They divide to form chromatids.

D They shorten and become visible.

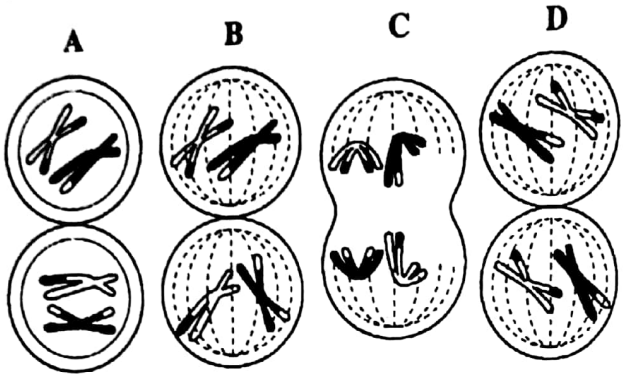
HELP

Chromatids are formed after DNA replicates during interphase and not due to division of chromosomes. Attachment to spindle fibre occurs as the chromosomes arrange at the equator during metaphase I.

Q63

The diagram shows anaphase I of meiosis.

Which diagram shows metaphase II as meiosis continues in this cell?



HELP

Cell A shows early prophase II as the nuclear envelope has not yet disintegrated. Cell C shows anaphase I as the homologous chromosomes are moving to opposite poles of the cell. Cell D shows incorrect exchange of genes between homologous chromosomes after crossing over.

Q64

What is a definition of homologous chromosomes?

A They are divided into two identical chromatids.

B They have the same sequence of bases.

C They have the same sequence of genes.

D They move to the same pole during nuclear division.

HELP

Homologous chromosomes are similar due to the genes being in the same position, thus the chromosomes are the same in length. Identical chromatids occur after the DNA has replicated during interphase.

Q65

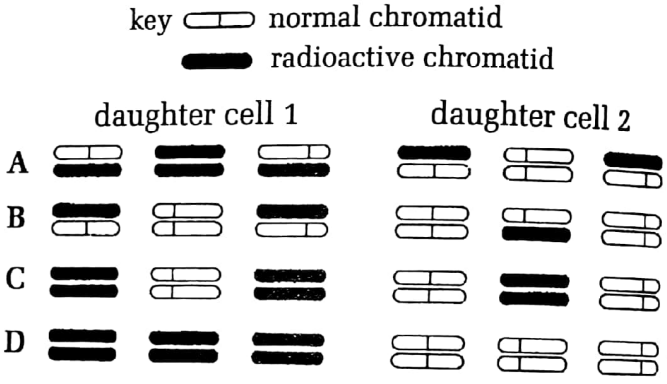
The following experiment was carried out.

1 Haploid cells, containing three chromosomes each, were grown in a medium containing radioactive thymine, so that all the DNA was labelled.

2 Cells in early interphase were then transferred to a medium where the available thymine was not radioactive.

3 A single cell was immediately isolated and allowed to divide once. When the two daughter cells reached the next metaphase, they were fixed and their three chromosomes were inspected for radioactivity.

Which diagram represents the distribution of radioactivity at metaphase in the two daughter cells?

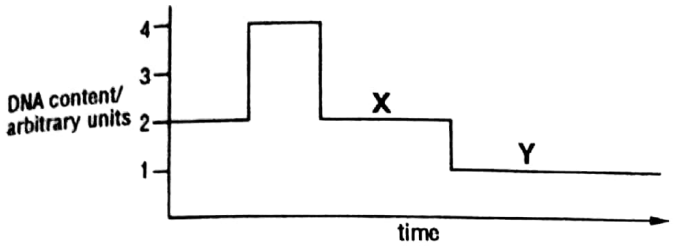


HELP

Candidates should take note that there would be only 3 radioactive chromatids altogether for the 2 daughter cells. This is due to the isolated haploid cell replicating its DNA with non-radioactive thymine during the earlier division. After the next metaphase, there should still be only 3 radioactive chromatids, since no more radioactive thymine was used for subsequent replications.

Q66

The graph shows the amount of DNA present in the nuclei of cells undergoing division in a multicellular organism.



Which combination is correct?

	type of nuclear division	X	Y
A	meiosis	metaphase I	telophase II
B	meiosis	telophase I	telophase II
C	mitosis	anaphase	telophase
D	mitosis	metaphase	telophase

HELP

As the final DNA content is half of the original, this division is meiosis. Stage X has to be telophase I because the DNA content has returned to the original amount after the doubling during replication. This is due to the separation of the homologous chromosomes at telophase I.

Q67

Albinism in humans is controlled by a recessive allele. How many copies of this allele will be found at one of the poles of a cell at telophase I of meiosis in an albino person?

A 23 B 4

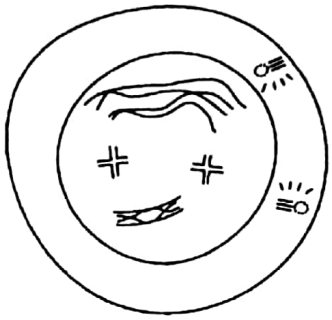
C 2 D 1

HELP

An albino person would have 4 copies of the recessive allele at prophase I. At telophase I, the 4 copies would have been halved to 2 when the homologous chromosomes carrying the allele separate to opposite poles of the cell.

Q68

An organism has a genome with four pairs of chromosomes. A cell from this organism during division is shown.



What does the drawing represent?

A metaphase of meiosis I

B metaphase of meiosis II

C prophase of meiosis I

D prophase of meiosis II

HELP

As the 4 pairs are homologous chromosomes still enclosed by a nuclear envelope, this stage is prophase I. In meiosis II, the homologous chromosomes would have separated.

Q69

Between which two phases in meiosis do identical centromeres start to separate?

A metaphase I and anaphase I

B metaphase II and anaphase II

C prophase I and metaphase I

D prophase II and metaphase II

HELP

Between metaphase I and anaphase I, the homologous chromosomes separate (but not their centromeres) to opposite poles of the cell. However, between metaphase II and anaphase II, the centromeres divide so that the sister chromatids can separate.

Q70

The second division of meiosis differs from mitosis because in meiosis

A chiasmata form between the chromatids.

B each chromosome replicates at metaphase.

C individual chromosomes line up at random on the equator.

D the separating chromatids differ genetically.

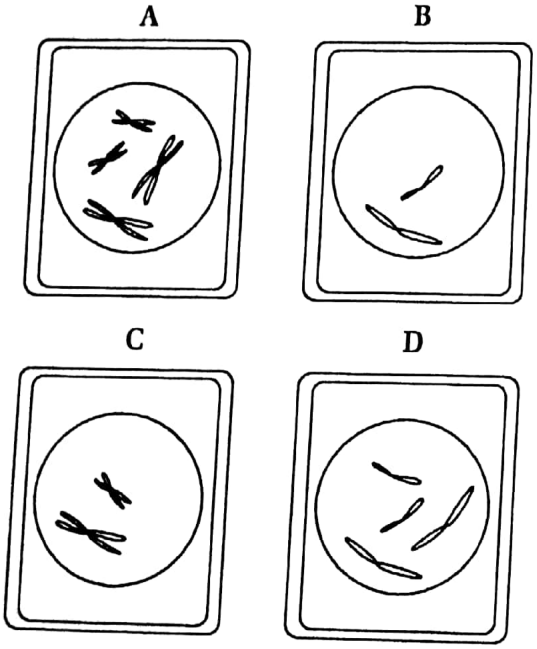
HELP

Candidates should take note that chiasmata form between the chromatids during the first division of meiosis (prophase I) and not during the second division of meiosis.

Q71

A diploid cell contains four chromosomes.

Which diagram shows the nucleus at prophase II of meiosis?



HELP

At prophase II, the chromosomes should no longer be seen as homologous pairs (as in diagram A), but only as one chromosome consisting of two sister chromatids.

Topic 1(d) Cell and Nuclear Division

Q1 D	Q2 D	Q3 C	Q4 A	Q5 D	Q6 A	Q7 B	Q8 A
Q9 A	Q10 C	Q11 D	Q12 A	Q13 A	Q14 A	Q15 C	Q16 A
Q17 A	Q18 D	Q19 D	Q20 D	Q21 C	Q22 D	Q23 C	Q24 B
Q25 C	Q26 B	Q27 B	Q28 A	Q29 D	Q30 C	Q31 B	Q32 A
Q33 B	Q34 A	Q35 D	Q36 D	Q37 C	Q38 C	Q39 B	Q40 C
Q41 A	Q42 D	Q43 D	Q44 A	Q45 C	Q46 D	Q47 B	Q48 D
Q49 B	Q50 D	Q51 D	Q52 C	Q53 A	Q54 D	Q55 D	Q56 C
Q57 A	Q58 D	Q59 C	Q60 C	Q61 C	Q62 D	Q63 B	Q64 C
Q65 B	Q66 B	Q67 C	Q68 C	Q69 B	Q70 D	Q71 C	

TOPIC 2

DNA AND GENOMICS

2(a) DNA — Structure and Function

You should try to answer on your own before resorting to **HELP**.

Q1

A molecule of transfer RNA has the anticodon sequence UAC.

What will be the corresponding nucleotide sequence in the DNA?

A ATG B AUG

C TAC D TUG

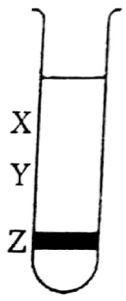
HELP

Corresponding pairs for uracil is adenine, and adenine is uracil, and cytosine is guanine. Also, the thymine pairs with adenine. The corresponding codon on the mRNA is AUG.

Q2

A culture of bacteria had all its DNA labelled with the heavy isotope of nitrogen, ^{15}N. The culture was then allowed to reproduce using nucleotides containing normal ^{14}N. The DNA was examined using a centrifuge after one generation and again after two generations.

The diagram shows the position of the DNA band at Z in the centrifuge tube when the DNA was first labelled.



In which pattern would the DNA be found after the first and after the second cell generations?

	after first generation	*after second generation*
A	half at X and half at Y	quarter at X and at Z and half at Y
B	half at X and half at Z	quarter at X and at Z and half at Y
C	all at Y	half at X and half at Y
D	all at Z	half at Y and half at Z

HELP

Due to the theory of semi-conservation replication, the 1st generation DNA is made up of one original strand of heavy DNA and one new strand of light DNA. Therefore its weight would be intermediate between the heavy and the light types.

Q3

The two pyrimidine bases most commonly found in DNA are

A uracil and thymine.

B cytosine and uracil.

C cytosine and thiamine.

D cytosine and thymine.

HELP

In the DNA double helix, purines base pair with pyrimidines via hydrogen bonding. The 2 pyrimidine bases are made up of only 1 ring and are heterocyclic, i.e. built of more than one kind of atom, N and C.

Q4

Deoxyribonucleic acid, adenosine triphosphate and ribonucleic acid do **not** contain

A bases.

B nucleotides.

C pentose sugars.

D peptides.

HELP

	DNA	RNA	ATP
Nucleotide	Double poly-nucleotide chain	Single poly-nucleotide chain	Nucleotide AMP + 2 phosphate groups
Pentose sugar	Deoxyribose	Ribose	Ribose
Base	ACGT	ACGU	present

Q5

The potentiality for replication of deoxyribose nucleic acid depends on

A covalent bonds between bases.

B electrovalent bonds between base and phosphate groups.

C high energy bonds between phosphate groups.

D hydrogen bonds between bases.

HELP

The DNA double helix consists of 2 sugar-phosphate anti-parallel strands that wind around each other, and are held together by hydrogen bonds between specific bases. In DNA replication, the strands of the helix separate, and each strand then seeks to replace the specific hydrogen-bonded complementary nucleotides it has lost.

Q6

Cells from a bacterial clone were grown for many generations on a medium in which all the nitrogen compounds contained only the isotope nitrogen 15 (^{15}N). Adenine comprised 36% of the nitrogen bases present.

A sample of these bacteria was transferred to a medium in which the only nitrogen source was ^{14}N and was provided with conditions suitable for asexual reproduction.

What was the percentage of guanine in the DNA?

A 14%

B 18%

C 28%

D 36%

HELP

Adenine will base pair with thymine in the bacterial DNA. Thus, the percentage of T will also be 36%. The bases guanine and cytosine will constitute 28% of the total number of bases, of which guanine represents half of it, i.e. 14%.

Q7

Which statement describes the base pairing in nucleic acids?

A Purine bases always pair with other purine bases.

B Purine bases can only pair with pyrimidine bases.

C Adenine cannot pair with either uracil or thymine.

D Hydrogen bonding can only occur between the pyrimidine bases.

HELP

The purine bases, A and G, will base pair with the pyrimidine bases, T and C, respectively in a DNA molecule. A pairs with the pyrimidine of U in a RNA molecule.

Q8

What is the advantage of DNA having two complementary strands?

A Pairing can occur between chromatids.

B Transcription and replication can occur simultaneously.

C Semi-conservative replication is possible.

D Diploid cells can inherit DNA from both parents.

HELP

A DNA molecule is made up of 2 complementary strands so that semi-conservative replication may be possible, where each old chain becomes paired with a new chain which is copied from it.

Q9

Which of the following statements about the strands of a newly replicated DNA molecule is correct?

A Both strands are made up of newly assembled nucleotides.

B One strand is new and the other is part of the original molecule.

C Both strands contain some nucleotides from the original molecule.

D The sugar-phosphate chains are conserved and new bases are inserted between them.

HELP

DNA replication is a semi-conservative process whereby the newly replicated DNA molecule consists of an old chain coiled around the new one.

Q10

Adenine comprised 36% of the nitrogenous bases in the DNA of cells from a bacterial clone. What was the percentage of guanine in the DNA?

A 14% **B** 18%

C 28% **D** 36%

HELP

36% of adenine base pairs with 36% of thymine in a DNA molecule, leaving 28% of guanine and cytosine bases, each constituting 14% of the total bases in the DNA.

Q11

Which of the following is involved in the inter-chain linkage between complementary strands of DNA?

A covalent bonding between the sugar and nitrogenous bases

B covalent bonding between the sugar and the phosphate groups

C covalent bonding between adjacent sugar groups

D hydrogen bonding between the nitrogenous bases

HELP

The complementary strands of DNA are held together by hydrogen bonds between the bases. A base pairs with T via two hydrogen bonds, whilst C and G are bonded by three hydrogen bonds.

Q12

In 1951, Chargaff analysed bovine thymus DNA and calculated the relative amounts of four nitrogenous bases. His results are shown in the table.

purines		*pyrimidines*	
adenine	*base 1*	*base 2*	*base 3*
28.2%	21.5%	27.8%	22.5%

What are the bases *1*, *2* and *3*?

	base 1	*base 2*	*base 3*
A	cytosine	thymine	guanine
B	guanine	cytosine	thymine
C	guanine	thymine	cytosine
D	thymine	cytosine	guanine

HELP

The purines present in DNA are adenine and guanine (base 1), whilst the pyrimidine present are thymine (which will be about the same amount as adenine with which they form base pairs with), and cytosine (which base pairs with guanine).

Q13

Which statement describes base pairing in nucleic acids?

A Adenine cannot pair with either uracil or thymine.

B Guanine is paired with adenine.

C Hydrogen bonding can only occur between pyrimidine bases.

D Purine bases can only pair with pyrimidine bases.

HELP

In nucleic acids, the purine bases, e.g. A and G, will base pair via hydrogen bonding, with the pyrimidines, T and C, respectively.

Q14

The following events occur in the replication of DNA:

1 bonds between complementary bases break
2 bonds between complementary bases form
3 DNA molecule uncoils
4 opposite strands separate
5 sugar-phosphate bonds form
6 free nucleotides align with complementary nucleotides on each strand

In which order do these events take place?

A	1	3	6	4	2	5
B	3	1	4	6	2	5
C	3	6	1	4	5	2
D	4	3	1	6	5	2

HELP

The tightly coiled DNA strands must first uncoil, causing the hydrogen bonds in the duplex to break. As the opposite strands break, the free nucleotides can complement with that on the nascent strand, forming bonds again. Finally, the sugar-phosphate bonds are formed.

Q15

What is the function of the enzyme DNA polymerase?

A To build a strand of DNA using DNA as a template.

B To build a strand of DNA using a polypeptide as a template.

C To build a strand of mRNA using DNA as a template.

D To build a polypeptide using mRNA as a template.

HELP

DNA polymerase is the enzyme involved in DNA replication, where a strand of DNA is synthesised using an old DNA strand as the template.

Q16

Which of the following describes the structure of DNA?

	Polynucleotide chains	*number of base pairs per complete turn of helix*
A	parallel	5
B	anti-parallel	10
C	parallel	15
D	anti-parallel	20

HELP

The DNA double helical chains are bound to each other via hydrogen bonds in an anti-parallel fashion, i.e. 3' OH is bound to the 5' P end. There are 10 base pairs per complete helical turn.

Q17

The table shows the percentages of bases in DNA from various types of cell.

source of DNA	*adenine*	*guanine*	*thymine*	*cytosine*
ox thymus	28.2	21.5	27.8	22.5
ox spleen	27.9	22.7	27.3	22.1
ox sperm	28.7	22.2	27.2	22.0
rat bone marrow	28.6	21.4	28.4	21.5
yeast	31.3	18.7	32.9	17.1

Which of the following is a valid deduction from these data?

A DNA is composed of two strands twisted around each other.

B DNA occurs in about the same amounts in all cells from the same species.

C The four bases show complementary base pairing.

D The structure of DNA is the same in both yeast and animal cells.

HELP

The amount of adenine and thymine are similar, as are the amounts of guanine and cytosine. This shows that there is complementary base pairing between the purines and pyrimidines.

Q18

Which of the following is found in both DNA and messenger RNA?

A double helix structure

B ribose

C sugar-phosphate chain

D thymine

HELP

The double helix structure is only found in DNA. Ribose is only found in mRNA, DNA has deoxyribose instead. Thymine is found only in DNA, uracil replaces thymine in mRNA. Only the sugar-phosphate backbone is found in both.

Q19

The diagram represents part of a DNA molecule.

A—T
C—G
C—G
T—A
G—C
C—G
T—A

What would be the appearance after semi-conservative replication had occurred?

A		B	C	D
A—T	T—A	A—T—U	U—	A—
C—G	G—C	C—G—C	G—	C—
C—G	G—C	C—G—C	G—	C—
T—A	A—T	T—A—T	A—	T—
G—C	C—G	G—C—G	C—	G—
C—G	G—C	C—G—C	G—	C—
T—A	A—T	T—A—T	A—	T—

HELP

In semi-conservative replication, each DNA strand becomes the template for the formation of a nascent chain. Therefore, the complementary nascent chains are shown base-paired to the old chain.

Q20

The table shows percentage concentration of three bases in DNA from four different sources. Which source is a species of mammal with a concentration of adenine of 31.0%?

source	*cytosine*	*guanine*	*thymine*
A	19.1	30.9	19.0
B	19.5	19.7	29.8
C	22.8	22.8	23.4
D	30.9	19.1	19.0

HELP

Cytosine pairs with guanine and hence they should be present in approximately equal amounts. Adenine pairs with thymine and so they should also be present in approximately equal amounts.

Q21

Which type of sugar and bonds are found in a DNA molecule?

	type of sugar	*bonds linking complementary bases*
A	hexose	hydrogen
B	hexose	peptide
C	pentose	hydrogen
D	pentose	peptide

HELP

Each nucleotide has a pentose sugar, which is ribose in RNA and deoxyribose in DNA. Hydrogen bonds are formed between the nitrogenous bases of complementary nucleotides. Adenine is joined to its complementary base thymine/uracil by 2 hydrogen bonds while cytosine is joined to its complementary base guanine by 3 hydrogen bonds.

Q22

Biochemical analysis of a sample of DNA shows that cytosine forms 40% of the nitrogenous bases.

Which percentage of the bases is adenine?

A 10%

B 20%

C 40%

D 60%

HELP

Guanine + Cytosine
40% 40%

Adenine + thymine
10% 10%

Q23

Analysis of DNA produced the following ratios of nitrogenous bases.

source of DNA	*ratio of purines to pyrimidines*
bean seeds	0.99
cow heart	1.01
human liver	1.02
rat bone marrow	1.00

Which statement explains the difference in the ratios?

A Animal DNA contains more purines than pyrimidines.

B Different parts of organisms contain different proportions of purines and pyrimidines.

C DNA contains thymine instead of uracil.

D There are variations in the accuracy of analytical techniques.

HELP

The small differences in ratios obtained for the different sources of DNA are insignificant. They are probably due to experimental inaccuracies. Besides, A and B are false statements while C should not affect the ratio since both thymine and uracil are pyrimidines.

Q24

What is the effect of the enzyme DNA ligase?

A DNA is broken up at specific sites.

B DNA fragments are joined together.

C DNA replication occurs.

D DNA transcription occurs.

HELP

DNA polymerase can produce 1 new DNA molecule at a time. DNA ligase joins these newly synthesized polynucleotides.

Q25

Pyrimidine bases contain 4 carbon atoms and purine bases contain 5.

How many carbon atoms are there in a nucleotide containing cytosine?

A 8 B 9

C 10 D 11

HELP

Phosphate group, ribose or deoxyribose group and the cytosine group form the nucleotide.

- Phosphate (H_3PO_4)
- Ribose ($C_5H_{10}O_5$)
- Deoxyribose ($C_5H_{10}O_4$)
- Cytosine has 4 carbon atoms, as it is a pyrimidine

Therefore the nucleotide should have 5C + 4C = 9C

Q26

The table shows the percentages of nitrogenous bases in four samples of nucleic acids.

Which base is adenine?

sample	bases				
	A	B	C	D	uracil
1	19	31	30	19	nil
2	27	23	24	26	nil
3	25	25	nil	25	25
4	17	32	33	18	nil

HELP

DNA has no uracil base (Sample 1,2 and 4). It has bases A, G, C and T.

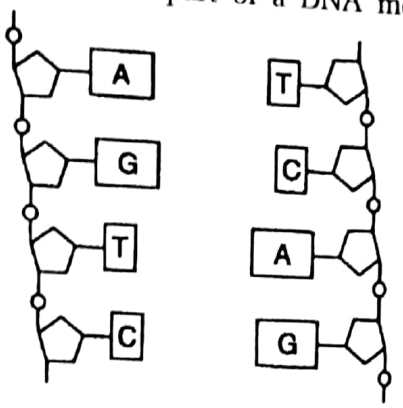
G pairs with C and A pairs with T.

Sample 3 could be RNA with bases A, G, C and U. Therefore, C should be thymine, which is missing in RNA.

In the DNA samples, A binds with T. From the figures, it can be deduced that B represents adenine.

Q27

The diagram shows part of a DNA molecule.



How many hydrogen bonds are involved in holding these strands of DNA together?

A 10 B 8

C 6 D 4

HELP

Candidates need to remember that each A-T pairing involves 2 hydrogen bonds and each C-G pairing involves 3 hydrogen bonds.

Q28

How does DNA synthesis along the lagging strand differ from that on the leading strand?

A An RNA primer is needed on the lagging strand, but not on the leading strand.

B Deoxyribonucleotides are added to the 5' end instead of the 3' end.

C Helicase synthesizes Okazaki fragments, which are then linked together.

D Okazaki fragments, synthesized 5' → 3', are linked by DNA ligase.

HELP

Option A: RNA primer is needed on both the lagging and leading strand.

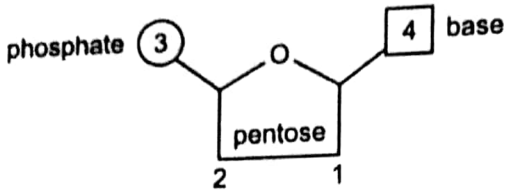
Option B: Deoxyribonucleotides are added to the 3' end.

Option C: DNA polymerase synthesizes Okazaki fragments.

Option D: The lagging strand is synthesized discontinuously, the newly synthesized DNAs exist as small fragments (called Okazaki fragments), which are linked together by DNA ligase.

Q29

The diagram shows the structure of a nucleotide.

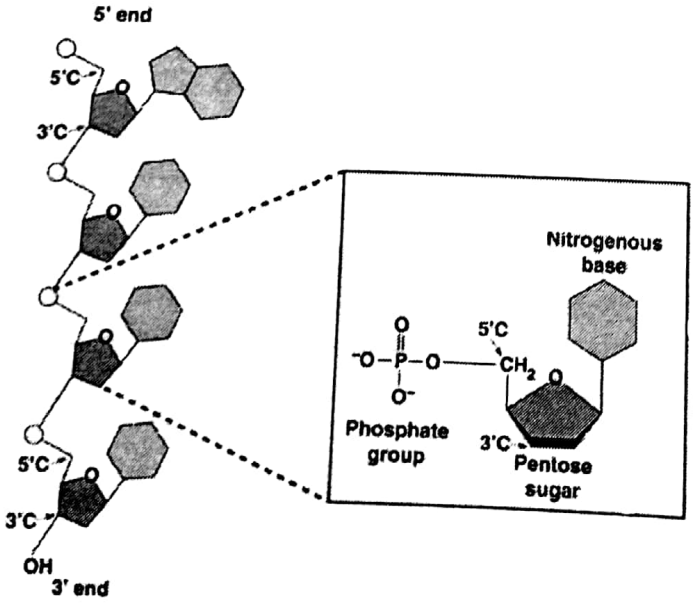


One type of polynucleotide consists of a single strand, twisted into a clover leaf shape. Which is the type of pentose of this molecule and the bonding between the nucleotides?

	Pentose	Bonding between nucleotides
A	deoxyribose	between positions 1 and 3
B	deoxyribose	between positions 2 and 3
C	ribose	between positions 1 and 3
D	ribose	between positions 2 and 3

HELP

tRNA comprises a single polynucleotide strand. It forms a clover-leaf shape with three loops and a stem. Ribonucleotides contains ribose are known as ribonucleotides.



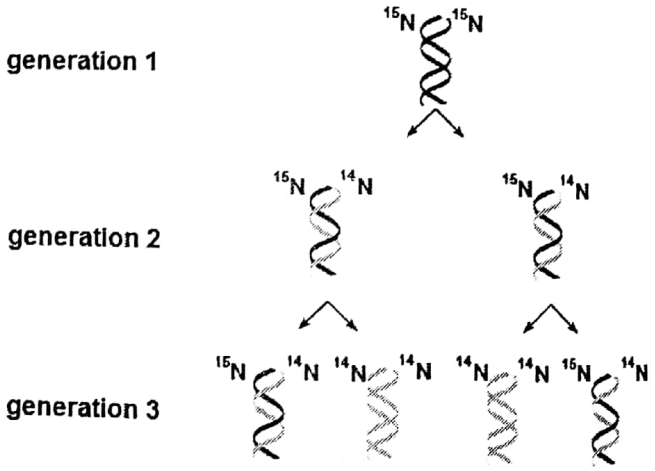
Q30

Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all the DNA was labeled. These bacteria (generation 1) were then grown in a medium containing only normal nitrogen (^{14}N) for two more generations (generations 2 and 3). The percentage of cells containing ^{15}N in each generation was estimated.

What will be the percentage of cells containing ^{15}N in generations 2 and 3?

	Percentage of cells containing ^{15}N	
	Generation 2	Generation 3
A	100	100
B	100	50
C	50	50
D	50	25

HELP



Q31

Which of the following enzymes or proteins is **NOT** used in the process of DNA replication?

A Primase

B DNA polymerase

C Translocase

D Single-strand binding protein

HELP

In DNA replication, primase catalyse the formation of a short RNA primer, DNA polymerase catalyse the formation of a phosphodiester bond between the free nucleotide and the preceding nucleotide, thus extending the new strand of DNA while single-stranded binding protein binds to the 2 separated strands of parental DNA to stabilise the single-stranded DNA formed.

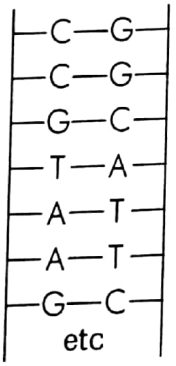
Q32

The table shows the results of an analysis of percentage concentration of three bases in nucleic acids from four sources. Three of the sources are DNA and one is RNA. Which source is RNA?

source	adenine	cytosine	guanine
A	19.7	30.4	30.2
B	25.5	24.6	23.8
C	26.7	28.8	22.3
D	31.1	18.3	18.7

HELP

In DNA molecule, the width between the 2 backbones is equals to the width of 1 base pair i.e. 1 purine and 1 pyrimidine.



In DNA, the bases pair with complementary bases of the opposite chain via hydrogen bonds, adenine to thymine and cytosine to guanine. Thus, the number of G = C, number of A = T.

Hence, when the percentage concentration of cytosine is similar to guanine, this suggests that the source is DNA.

Q33

In studying a virus, you find the following proportions of nitrogenous bases present: adenine 23%, guanine 37%, cytosine 23%, uracil 17%. Which of the following statement(s) regarding this virus is/are correct?

I It probably uses RNA as its genetic material.

II The genetic material of this virus is probably single stranded.

III Base pairing rules in this virus include adenine : cytosine.

A I only.

B I and II only.

C II and III only.

D All of the above.

HELP

Statement I: Uracil is a nitrogenous base present in RNA.

Statement II: If the genetic material is double stranded, the percentage of G = C, percentage of A = U. This is not observed in the virus (adenine 23%, uracil 17%, guanine 37%, cytosine 23%).

Statement III: If adenine base pair to cytosine, uracil will base pair with guanine. The ratio of uracil : guanine should be 27% : 27%.

Q34

Which of the functions of RNA is incorrectly matched?

A Messenger RNAs encode information for synthesis of polypeptides.

B Ribosomal RNAs bind with tRNA to catalyse the formation of phosphodiester bonds.

C Small nuclear RNAs bind with ribonucleoproteins to form spliceosomes.

D Transfer RNAs bind with mRNA to facilitate translation.

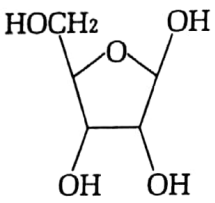
HELP

Ribosomal RNA is made in the nucleus. Ribosomal RNA binds with proteins to form large and small ribosomal subunits which combine to form ribosomes in the cytoplasm.

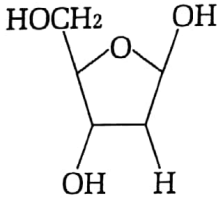
Q35

Which of these molecules are linked to form a nucleotide containing uracil?

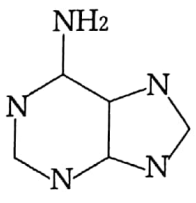
1 Ribose



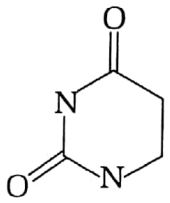
2 Deoxyribose



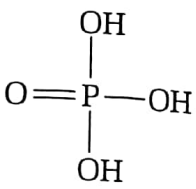
3 Purine



4 Pyrimidine



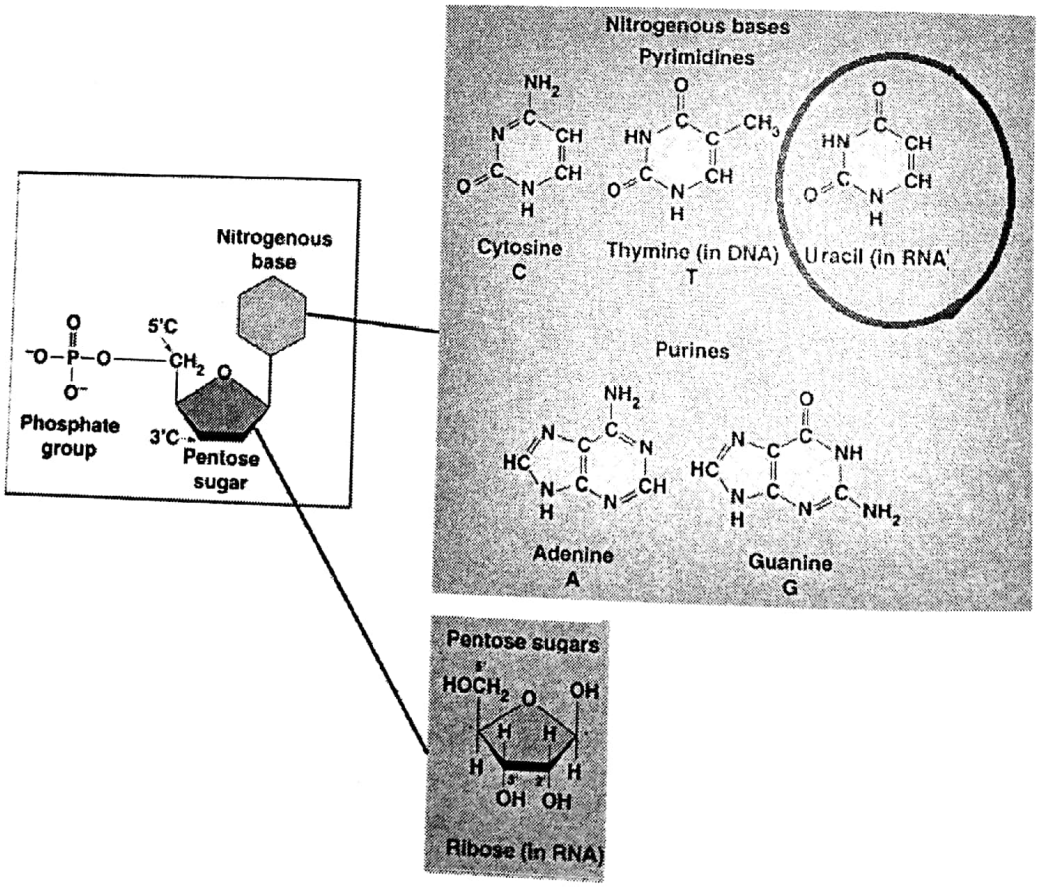
5 Phosphate



A 2, 3 and 5 **B** 2, 4 and 5

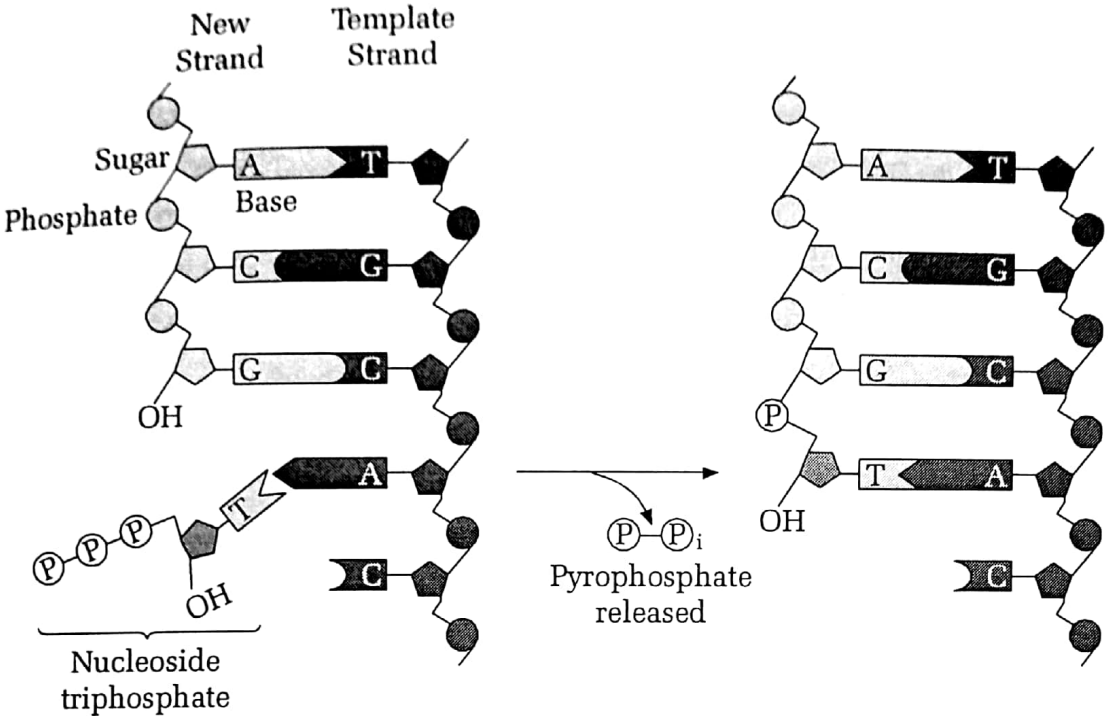
C 1, 2 and 5 **D** 1, 4 and 5

HELP



Q36

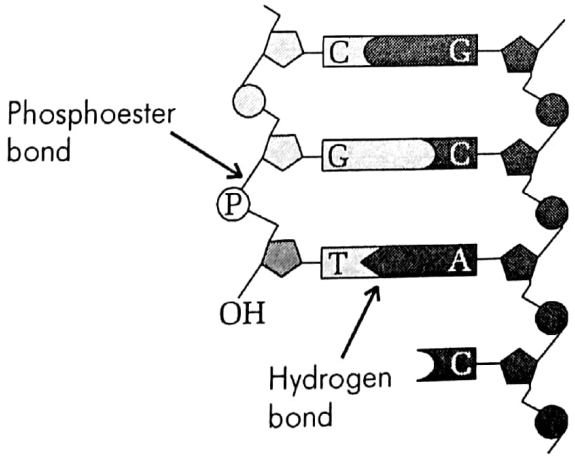
The diagram below shows the synthesis of a new strand of DNA during interphase.



Which of the following shows the correct combination of bond(s) that need to be formed and the kind of reaction that is involved in order for the nucleotide to be added to the DNA chain?

	Bond(s) to be formed	*Reaction(s) involved*
A	Phosphodiester	Condensation
B	Phosphodiester	Hydrolysis
C	Phosphoester and Hydrogen	Condensation
D	Phosphoester	Dephosphorylation

HELP



Two nucleotides are joined by condensation reaction, between the sugar of one nucleotide (hydroxyl group on C3) with the phosphate group of another nucleotide.

Q37

Which of the following statements about the structure of DNA is incorrect?

A One complete turn requires 3.4 nm and 10 base pairs.

B The backbones of each strand run in opposite directions relative to each other.

C Each pair of nucleotides is held together by three hydrogen bonds.

D The width of the molecule is a constant 2 nm.

HELP

Each pair of nucleotides consists of 1 purine and 1 pyrimidine. The bases pair with complementary bases of the opposite chain via hydrogen bonds. 2 hydrogen bonds between adenine and thymine and 3 hydrogen bonds between cytosine and guanine.

Q38

In studying a virus, you find the following proportions of nitrogenous bases present: adenine 23%, guanine 27%, cytosine 27%, thymine 23%.

What statement(s) can you make about this virus?

I It probably uses RNA as its genetic material.

II It probably uses DNA as its genetic material.

III The genetic material of this virus is probably double-stranded.

IV Base pairing rules in this virus include thymine : guanine.

A I only

B I and III only

C II and III only

D II and IV only

HELP

Statement I and Statement II: Absence of uracil (a nitrogenous base present in RNA) suggests that this virus's genetic material is DNA.

Statement III: If the genetic material is double stranded, the percentage of G = C, percentage of A = T. This is observed in the virus (adenine 23%, thymine 23%, guanine 27%, cytosine 27%).

Statement IV: If thymine will base pair with guanine, the ratio of thymine : guanine should be the same.

Q39

A mutation in one of the replication enzymes causes DNA polymerase to be unable to add nucleotides at the origin of replication, hence no daughter strands of DNA can be synthesized. Which of the following is the defective enzyme?

A Helicase

B Primase

C DNA Ligase

D Topoisomerase

HELP

DNA polymerase binds to the single stranded RNA primer and catalyse the formation of a phosphodiester bond between the free nucleotide and the preceding nucleotide, thus extending the new strand of DNA. In the event that the primase is defective, RNA primer will be absent and DNA polymerase is unable to add nucleotides at the origin of replication.

Q40

Which one of the following is associated with accuracy of DNA replication?

A High energy bonds between phosphate groups.

B Covalent bonds between bases and phosphate groups.

C Hydrogen bonds between bases.

D Covalent bonds between bases.

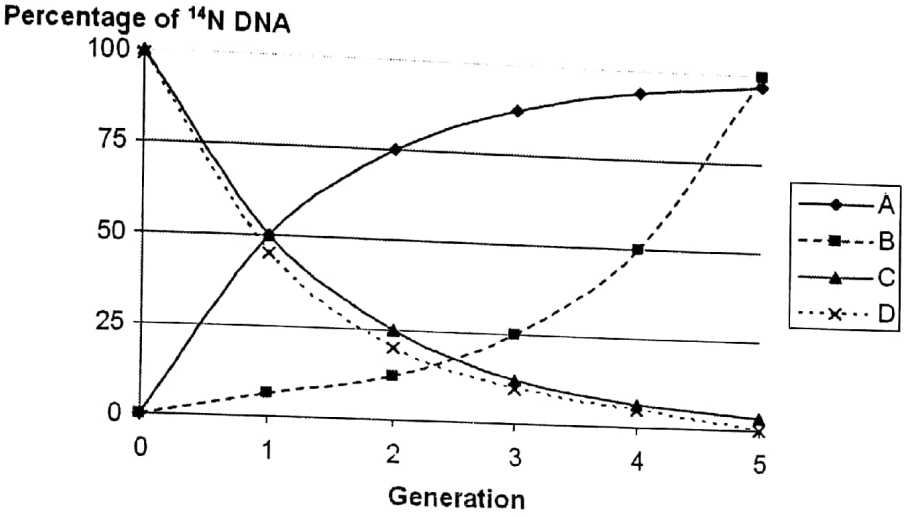
HELP

In DNA replication, the DNA strands separate and serve as a template for synthesis of a new daughter strand. Free deoxyribonucleotides with the correct complementary nitrogenous base, forms hydrogen bonds to the base in the template DNA, ensuring accuracy of DNA replication.

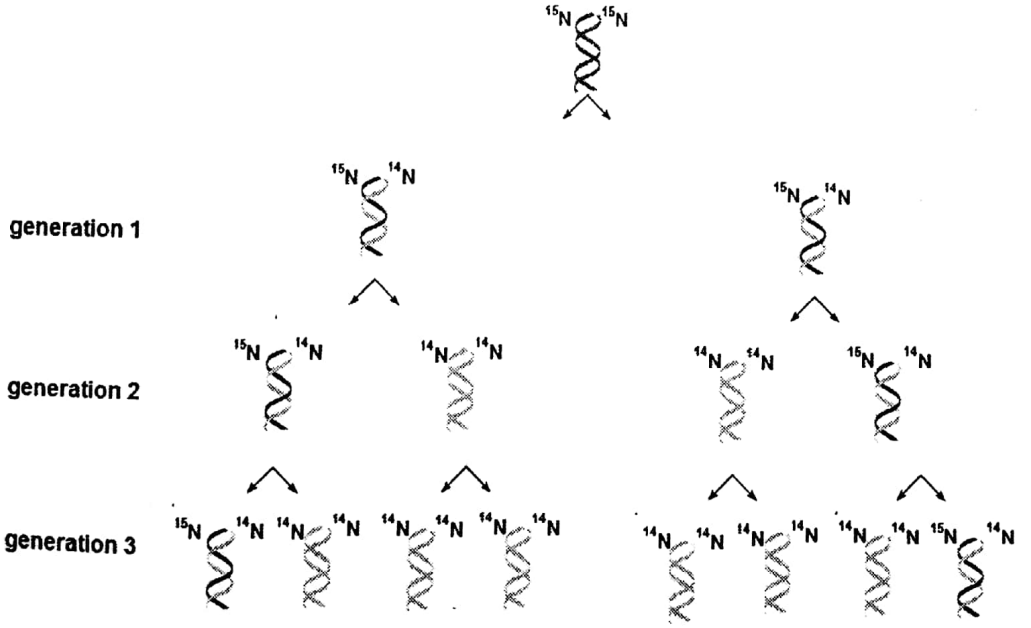
Q41

Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all DNA was labelled. These bacteria were then grown in a medium containing only normal nitrogen (^{14}N) for 5 generations. The percentage of ^{14}N DNA strands in each generation was estimated.

Which curve provides evidence that DNA replication is semi-conservative?



HELP



From the diagram above, it can be seen that as the generation increases, the percentage of ^{14}N DNA increases from 2/4 = 50% (generation 1) to 6/8 = 75% (generation 2) to 14/16 = 87.5% (generation 3).

Q42

What is the basis for the difference in the synthesis of the leading and lagging strands of DNA molecules?

A DNA ligase works only in the 3' to 5' direction.

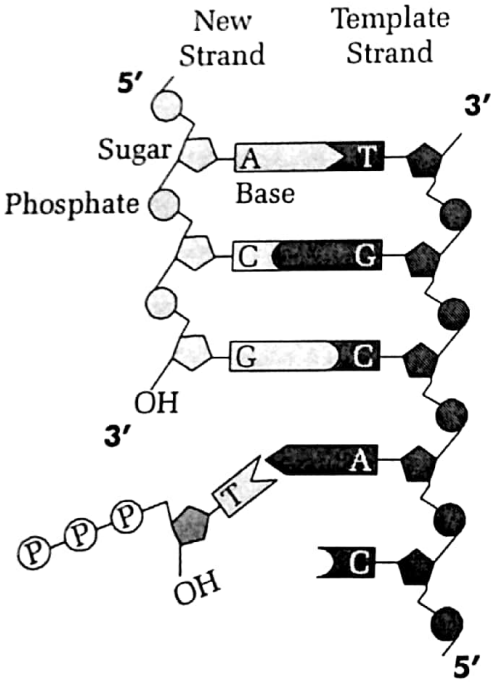
B The origins of replication occur only at the 5' end.

C Helicases and single-stranded binding proteins work at the 5' end.

D DNA polymerase can join new nucleotides only to the 3' end of a growing strand.

HELP

Synthesis of new daughter strand by DNA polymerase is only in the 5′ to 3′ direction as DNA polymerase can only add nucleotides to the 3′ end of a growing strand.



Q43

A biochemist isolates and purifies various molecules needed for DNA replication. When she adds some DNA, replication occurs but the DNA molecules formed are defective. Each consists of a normal DNA strand paired with numerous segments of DNA a few hundred nucleotides long.

What has she probably left out of the mixture?

A DNA polymerase

B Nucleotides

C Primers

D Ligase

HELP

DNA ligase is needed to join the numerous segments of DNA together. DNA ligase closes the gaps between these segments of DNA by forming a phosphodiester bond between the nucleotides to form a continuous strand.

Q44

Identify the correct statements regarding the replication of DNA.

1 Only 1 strand of DNA is replicated.

2 It occurs in interphase in both mitosis and meiosis.

3 It occurs after the completion of telophase in meiosis.

A 1 only **B** 1 and 3 only

C 2 only **D** 2 and 3 only

HELP

Statement 1: Both strands of DNA is replicated. Each strand of a parental DNA molecule separates and acts as template for the synthesis of its new complementary strand.

Statement 2: DNA replication occurs during S phase of interphase in both mitosis and meiosis.

Statement 3: DNA replication (if it takes place) occurs after the completion of telophase in mitosis and telophase II of meiosis II.

Q45

What is the basis for the difference in the synthesis of the leading and lagging strands of DNA molecules?

I The anti-parallel arrangement of the DNA strands.

II The RNA primers are required to initiate DNA elongation.

III DNA polymerase joins new nucleotides to the 3' end of the growing strand.

IV Helicase and single-stranded binding proteins work at the 5' end of the DNA strand.

A II and IV

B I and III

C I and IV

D II and III

HELP

The DNA strands are antiparallel i.e. run in opposite directions. Synthesis of new daughter strand by DNA polymerase is only in the 5′ to 3′ direction, thus the DNA template is read in the 3′ → 5′ direction. This means only the leading strand can be synthesized continuously because the DNA polymerase is moving in the same direction as the unwinding DNA. The lagging strand is synthesized discontinuously, because the DNA polymerase has to move away from the unwinding enzyme in the 5′ to 3′ direction.

Topic 2(a) DNA — Structure and Function

Q1 C	Q2 C	Q3 D	Q4 D	Q5 D	Q6 A	Q7 B	Q8 C
Q9 B	Q10 A	Q11 D	Q12 C	Q13 D	Q14 B	Q15 A	Q16 B
Q17 C	Q18 C	Q19 A	Q20 B	Q21 C	Q22 A	Q23 D	Q24 B
Q25 B	Q26 B	Q27 A	Q28 D	Q29 D	Q30 B	Q31 C	Q32 C
Q33 B	Q34 B	Q35 D	Q36 C	Q37 C	Q38 C	Q39 B	Q40 C
Q41 A	Q42 D	Q43 D	Q44 C	Q45 B			

TOPIC 2

DNA AND GENOMICS

2(b)

Protein Synthesis

You should try to answer on your own before resorting to **HELP**.

Q1

Five different amino acids (numbered 1—5 below) form the following sequence in part of a polypeptide chain:

1 — 2 — 3 — 4 — 2 — 5 — 3

Messenger RNA (mRNA) codons which correspond to these amino acids are:

amino acid 1	UGU
amino acid 2	GAU
amino acid 3	CAC
amino acid 4	UAG
amino acid 5	AAG

Which one of the following DNA base sequences could provide the code for the given section of polypeptide?

A ACACTTGTGATGCTATTCGTG

B ACACUAGUGAUGCUAUUCGUG

C ACACTAGTGATGCTAAACGTG

D ACACTAGTGATCCTATTCGTG

HELP

For the mRNA codons:

UGU-GAU-CAC-UAG-GAU-AAG-CAC

The corresponding DNA is:

ACA-CTA-GTG-ATC-CTA-TTC-GTG

Q2

The complementary messenger RNA triplet for the DNA triplet GAT would read

A CTA **B** CUA

C CTG **D** CTC

HELP

Purines will only base pair with pyrimidines, and vice versa. The purines in RNA are adenine and guanine, whilst the pyrimidines are cytosine and uracil. Thus guanine will base pair with cytosine, adenine with uracil, and thymine with adenine.

Q3

The nitrogenous bases present in RNA are the same as those present in DNA except that

A adenine replaces cytosine.

B adenine replaces thymine.

C uracil replaces adenine.

D uracil replaces thymine.

HELP

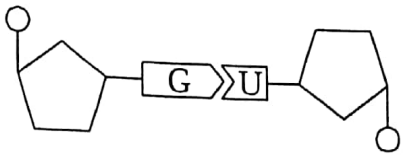
Uracil is a pyrimidine found in RNA and replaces thymine which usually base pairs with the purine and adenine in DNA.

Q4

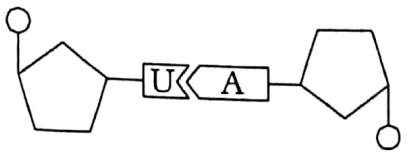
Which one of the following correctly represents how a RNA nucleotide aligns itself opposite a DNA nucleotide during transcription?

RNA DNA

A



B



C 

D 

HELP

There is a complementary base-pairing between the RNA and DNA molecule. The A nucleotide usually pairs with the residue U, which is the RNA nucleotide equivalent to the T residue in DNA molecule.

Q5

Three polypeptides were made using synthetic mRNA molecules as shown.

synthetic mRNA used	*polypeptide produced*
UUUUUUUUUUUU	phenylalanine-phenylalanine -phenylalanine-phenylalanine
AAAAAAAAAAAA	lysine-lysine-lysine-lysine
UUUAAAUUUAAA	phenylalanine-lysine -phenylalanine-lysine

What are the DNA codes for the amino acids phenylalanine and lysine?

	phenylalanine	*lysine*
A	AAA	TTT
B	AAA	UUU
C	GGG	CCC
D	TTT	GGG

HELP

The triplet codon of phenylalanine (UUU) will base pair with AA in the DNA molecule, and that of lysine (AAA) will base pair with TTT.

Q6

An anti-codon is the sequence of the nitrogenous bases on the

A complementary strand of DNA which codes for one amino acid.

B complementary strand of mRNA which codes for one amino acid.

C tRNA molecule where the amino acid is attached.

D tRNA molecule which recognises the appropriate sequence of bases on the mRNA.

HELP

The anticodon of 3 bases is located at the centre of the middle loop of a tRNA molecule and can base pair with the complementary three nucleotides of the mRNA codon during translation.

Q7

Which of the following basis is **never** found in RNA?

A adenine

B cytosine

C guanine

D thymine

HELP

Thymine is the pyrimidine base that cannot be found in RNA. Instead, uracil is the base that base pairs with the purine, adenine.

Q8

What is a codon?

A a length of DNA which codes for a particular protein

B a part of the transfer RNA molecule to which a specific amino acid is attached

C a part of the transfer RNA molecule which recognises the triplet code on the messenger RNA

D a part of the messenger RNA molecule that has a sequence of bases coding for an amino acid

HELP

The triplet codon is made up of 3 nucleotide bases and is located at the centre of the middle loop of tRNA molecule, and base pairs with the complementary bases on an mRNA molecule during protein synthesis.

Q9

A mutation involving the substitution of one nitrogenous base for another has altered the base sequence of a DNA molecule, coding for four amino acids, as shown below.

normal A–G–C–A–T–G–G–A–T–C–C–T

mutant A–G–C–A–T–G–C–A–T–C–C–T

The table shows six codons and the corresponding amino acids into which each is translated.

mRNA codon	*amino acid*
AAG	lysine
CUA	leucine
GGA	glycine
GUA	valine
UAC	tyrosine
UCG	serine

The mutation has changed the amino acid

A leucine to valine.

B lysine to glycine.

C serine to leucine.

D tyrosine to lysine.

HELP

The segment coding for GAT on the normal DNA molecule will be transcribed into CUA in the mRNA molecule, whilst the mutant DNA strand CAT will be transcribed into GUA on the mRNA molecule. This implies a change from the amino acid leucine to valine.

Q10

Listed below are the stages in the cellular synthesis of a protein.

1 movement of mRNA from nucleus to cytoplasm

2 linking of adjacent amino acid molecules

3 transcription of mRNA from a DNA template

4 formation of the polypeptide chain

5 attachment of the mRNA strand to a ribosome

In which order do these stages take place?

A 1 3 2 5 4

B 1 5 3 4 2

C 3 1 5 2 4

D 3 4 1 2 5

HELP

Transcription of DNA into mRNA must first occur, and then this mRNA attaches itself onto a ribosome in the cytoplasm, and the translation machinery begins the protein synthesis process.

Q11

Below is part of the DNA genetic code for six amino acids.

CGG codes for alanine

TTT codes for lysine

GCG codes for arginine

AAA codes for phenylalanine

CCA codes for glycine

CAA codes for valine

The diagram shows part of a mRNA molecule, but the corresponding part of the protein formed was found to be:

arginine–glycine–lysine–valine–alanine

Which triplet contains a single transcription error?

A the first

B the second

C the third

D the fourth

HELP

The corresponding DNA for the mRNA is shown below:

MRNA: CGCGUUAAAGUUGCC

DNA: GCGCAATTTCAACGG

Q12

Three consecutive bases in the DNA molecule (a triplet) provide the code for each amino acid in a protein molecule.

What is the maximum number of different triplets that could occur?

A 16 **B** 20

C 24 **D** 64

HELP

The triplet code consists of three of the four nucleotide bases — A, C, G or T. Thus the maximum number of possible amino acids that can be coded for is $4^3 = 64$.

Q13

The DNA code for glutamic acid is CTC or CTT. The code for valine is CAA or CAT. In sickle cell haemoglobin, valine is present instead of glutamic acid.

Assuming a single base pair substitution has occurred, what is the mRNA code in the affected mutant?

A CUU

B GAA

C GAG

D GUA

HELP

Since a single base pair substitution has caused this mutation, the original codon for glutamic acid must have been CTT, and the mutant codon is CAT. The mRNA code for this mutant is hence GUA, i.e. complementary to CAT.

Q14

Listed below are some amino acids and their corresponding mRNA triplets.

amino acid	*mRNA triplet*
phenylalanine	UUU
lysine	AAG
arginine	CGA
alanine	GCA

Which DNA sequence would be needed to produce the following polypeptide sequence?

alanine-arginine-lysine-phenylalanine

A CGT GCT TTC AAA

B CGT GCT TTC TTT

C CGU GCU UUC AAA

D CGU GCU UUC TTT

HELP

The complementary bases of GCA-CGA-AAG-UUU are CGT-GCT-TTC-AAA on the DNA strand. Note that U in the mRNA base pairs with A on the DNA molecule.

Q15

Insulin is a protein containing 51 amino acids. These include 17 of the 20 different amino acids commonly occurring in proteins.

What is the minimum number of different kinds of tRNA molecules involved in the synthesis of insulin?

A 3

B 17

C 20

D 51

HELP

Since there are 17 different amino acids that constitute insulin, and each amino acid is coded for by a triplet codon attached to a tRNA molecule, the minimum number of different tRNA molecules is $17 \times 3 = 51$.

Q16

Which statement correctly describes the transcription of DNA?

A It produces amino acids.

B It produces messenger RNA.

C It results in increased DNA synthesis.

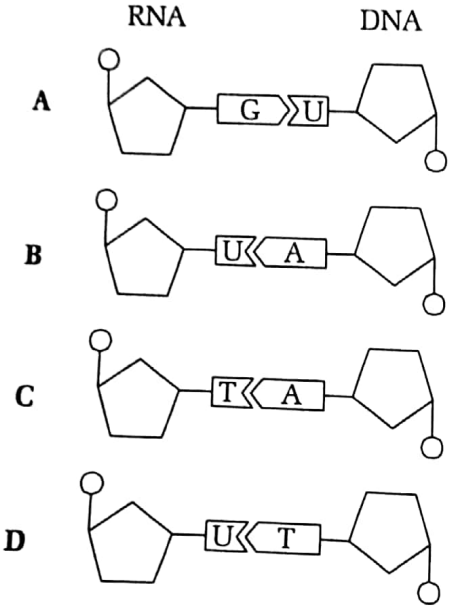
D It is a semi-conservative process.

HELP

DNA transcription is a process whereby the DNA message is copied into mRNA, a process carried out by RNA polymerase.

Q17

Which diagram shows the pairing of an RNA nucleotide with a DNA nucleotide during transcription?



HELP

C (cytosine) pairs with G (guanine) and A (adenine) pairs with T (thymine) / U (uracil). This excludes options A and D. DNA has the T nucleotide, while in RNA T is replaced by U.

Q18

The insulin molecule is composed of two polypeptide chains, one consisting of 20 amino acids and the other consisting of 31.

What is the minimum number of base pairs of DNA required to code for this molecule?

A 20

B 51

C 102

D 153

HELP

Each amino acid is coded by a codon of 3 nucleotides bases. Hence, the least number of base pairs = $20 \times 3 + 31 \times 3 = 153$.

Q19

Three consecutive bases in the DNA molecule (a triplet) provide the code for each amino acid in a protein molecule. What is the maximum number of different triplets that could occur?

A 20 **B** 24

C 48 **D** 64

HELP

There are 4 different bases — A, G, C and T in DNA. Mathematically, the maximum number of different triplets is $4^3 = 64$.

Q20

Which statement correctly describes messenger RNA (mRNA)?

A mRNA binds amino acids for incorporation into proteins

B mRNA contains the five-carbon sugar deoxyribose

C mRNA is a double stranded helix

D mRNA recognises the anticodon of tRNA

HELP

The mRNA has a series of three nucleotides, called the codon, coding for each amino acid. This is complementary to the anticodon found on the tRNA which holds the corresponding amino acid.

Q21

What is an anticodon?

A three bases on a DNA molecule coding for an amino acid in translation

B three bases on a mRNA molecule after transcription from DNA

C three bases on a tRNA molecule involved in transcription from DNA

D three bases on a tRNA molecule involved in translation into protein

HELP

Each tRNA carries a specific amino acid and has a particular sequence of three nucleotides called the anticodon. When these three bases are complementary to the codon on the mRNA, the amino acid is added to the growing polypeptide chain.

Q22

One complete turn of the double helix of DNA contains 10 pairs of bases and is 3.4 nm long.

What is the approximate length of the DNA coding sequence of lysozyme, a protein of 129 amino acids?

A 132 nm

B 113 nm

C 66 nm

D 44 nm

HELP

The DNA coding sequence is 129 × 3 = 387 bases long because each amino acid is coded for by three bases. Hence the length of DNA is 387/10 × 3.4 = 132 nm.

Q23

In many cells, ribosomes occur in groups along messenger RNA molecules.

What is the advantage of this when compared with single ribosomes?

A A greater variety of polypeptides can be produced.

B Fewer transfer RNA molecules are used in protein synthesis.

C Larger polypeptide chains can be produced.

D Polypeptides can be produced more rapidly.

HELP

Polypeptides are produced more rapidly as several ribosomes can work on different stretches on one mRNA strand at the same time. The polypeptide produced depends on the mRNA sequence and not the ribosomes.

Q24

Compared with single ribosomes, polyribosomes increase the efficiency of protein synthesis.

How is this achieved?

A Different protein molecules can be made simultaneously.

B Each copy of a protein can be made more rapidly.

C More than one copy of the mRNA molecule can be read at the same time.

D Many copies of the same protein can be made simultaneously from one mRNA molecule.

HELP

During protein synthesis, the ribosomes move along the mRNA molecule. Rather than 1 ribosome at a time passing along the RNA, the process is carried out more efficiently by a number of ribosomes moving simultaneously along the mRNA, like beads on a string. This resulting chain of ribosomes is called a polyribosome or polysome.

Q25

In a genetic engineering experiment a piece of DNA containing 6000 nucleotides is transcribed and translated into protein.

How many amino acids are required?

A 500

B 1000

C 3000

D 4500

HELP

There is usually a triplet code for most amino acids, e.g. GUA, CGG, CGU. As DNA is a double stranded molecule, there are 6000/2 = 3000 nucleotides on each strand. One strand is used for protein synthesis. Therefore 3000/3 = 1000 amino acids are required.

Q26

A synthetic mRNA molecule is made by using only two types of nucleotide, containing adenine and cytosine.

How many different codons could it contain?

A 2 **B** 4

C 8 **D** 16

HELP

With only 2 different bases present in the mRNA, only 8 different codons could be formed. This is derived from $2^3 = 8$, as each codon consists of a triplet code.

Q27

An mRNA codon for the amino acid alanine is GCC.

How many alanine molecules are present in the polypeptide, containing eight amino acids, coded for by the following DNA template?

TCGGCCTACCGGGCCCATGCCAAT

A 0 **B** 1

C 2 **D** 3

HELP

TCG GCC TAC CGG GCC CAT GCC

There is only one alanine code present, as CGG would be the corresponding triplet of bases on the DNA template. Note that GCC is the codon on the mRNA, not the DNA, that codes for alanine.

Q28

Which sugar and base, in addition to inorganic phosphate, will be released from the hydrolysis of a certain nucleotide?

	sugar	base
A	deoxyribose	uracil
B	fructose	thymine
C	glucose	thymine
D	ribose	uracil

HELP

The sugars involved are either ribose or deoxyribose. DNA is a double-stranded polynucleotide that contains deoxyribose with organic bases A, G, C and T, but never uracil.

Q29

The biochemical analysis of a sample of DNA shows that 32% of the nitrogenous bases are cytosine.

What is the total percentage of adenine and uracil in mRNA transcribed from this DNA?

A 16% **B** 18%

C 32% **D** 36%

HELP

32% cytosine → 32% guanine

18% adenine → 18% uracil

Total percentage of A and U = 18 + 18 = 36%

(DNA does not contain uracil)

Q30

How many different polypeptides, each consisting of r amino acids, can be made if the number of different amino acids available is n?

A n^r
B r^n
C nr
D n

HELP

For example, if there were 3 different amino acids available, and each polypeptide consists of 2 amino acids, the number of different polypeptides possible is $3^2 = 9$.

Q31

Which process does **not** occur during the formation of messenger RNA?

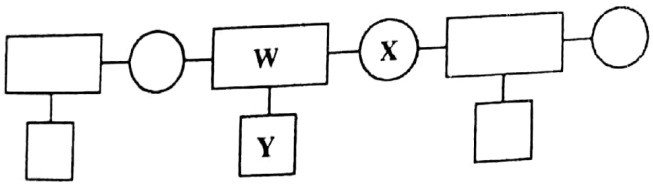
A condensation
B polymerisation
C replication
D transcription

HELP

During the formation of the mRNA, there is no replication. The codons of the mRNA serve as codon sites for the formation of an amino acid that corresponds with the bases on it. Condensation occurs between the nucleotides to form a polynucleotide, i.e. the mRNA strand.

Q32

The diagram represents an anticodon.



What do **W**, **X** and **Y** represent?

	W	X	Y
A	deoxyribose	base	phosphate
B	deoxyribose	phosphate	base
C	ribose	base	phosphate
D	ribose	phosphate	base

HELP

X is a phosphate group. It should be connected to the sugar group, with in turn, is connected to the base group. The base should be left 'open' to allow for pairing. Therefore, Y should be the base. The sugar must be ribose because anticodons are found in tRNA.

Q33

If there were 34 amino acids and DNA only contained two types of nitrogenous bases, what would be the minimum number of bases per codon that could code for proteins?

A 3
B 4
C 6
D 8

HELP

As there are 2 types of bases, 2^6 would provide 64 combinations, which is more than sufficient. 2^4 would only provide 16 combinations, which would be insufficient to code for 34 amino acids.

Q34

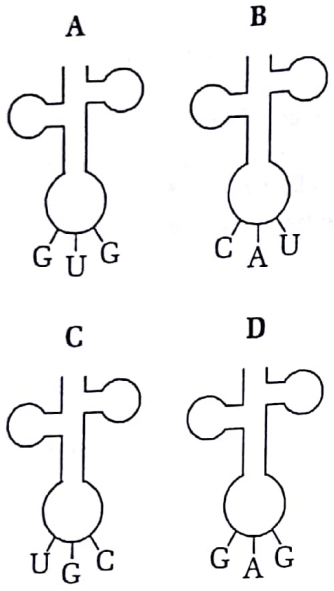
Part of the amino acid sequences in normal and sickle cell haemoglobin are shown.

normal haemoglobin	sickle cell haemoglobin
thr-pro-glu-glu	thr-pro-val-glu

mRNA codons for these amino acids are

glutamine (glu)	GAA	GAG
proline (pro)	CCU	CCC
threonine (thr)	ACU	ACC
valine (val)	GUA	GUG

Which transfer RNA molecule is involved in the formation of this part of the sickle cell haemoglobin?



HELP

CAU in tRNA is the only one that can compliment the valine in the sickle cell haemoglobin.

Q35

What is carried by a molecule of transfer RNA?

A an amino acid molecule

B enzymes for protein synthesis

C information from the DNA

D sequence of codons

HELP

Translation is the means by which a specific sequence of an amino acid is formed in accordance with the codons of the mRNA. tRNA-amino acid complex is attracted to the codon of the mRNA.

Q36

Which statement correctly describes the transcription of DNA?

A It is a semi-conservative process.

B It occurs at the surface of the ribosome.

C It produces messenger RNA.

D It produces polypeptides.

HELP

DNA replication is a semi-conservative process and translation produces polypeptides with the help of the ribosome.

Q37

The sequence of bases on a messenger RNA molecule is shown.

A U C G A A G U U C G U

It was transcribed from one strand of DNA.

What is the sequence of bases on the complementary, non-transcribed strand?

A	A	A	C	G	A	A	C	T	T	C	G	A T
B	A	T	C	G	A	A	G	T	T	C	G	T
C	T	A	G	C	T	T	C	A	A	G	C	A
D	U	G	C	U	U	G	A	A	G	C	U	A

HELP

The DNA sense strand would have the bases TAGCTTCAAGCA. Therefore, the non-transcribed strand would be ATCGAAGTTCGT, where thymine is used instead of uracil.

Q38

In genetic engineering, polymers may be artificially produced using a molecular template and appropriate enzymes.

Which product **cannot** be formed in this way from the template?

	template	*product*
A	DNA	RNA
B	polypeptide	RNA
C	RNA	DNA
D	RNA	polypeptide

HELP

It would not be possible for a polypeptide to serve as a template since it is made up only of amino acids and there are no bases in order to transcribe an RNA strand.

Q39

In most organisms, all possible triplets of bases in DNA code for an amino acid, except for the coding strand 'stop' triplets ATT, ATC, ACT. The coding strand is complementary to mRNA.

In the prokaryote, *Methanosarcina barkeri*, the coding strand triplet ATC codes for an unusual amino acid, pyrrolysine.

The non-coding strand of a section of DNA in *M.barkeri* has the following sequence of bases.

TTTTTATTGTATTACTAGTGTTAATGA

How many amino acids can be made into a peptide by *M.barkeri* from the **coding** strand of this region of DNA?

A 5

B 6

C 7

D 9

HELP

The 1st 7 triplets can eventually be translated into 7 amino acids.

Triplet:	1	2	3	4	5	6	7	8	9
non-coding strand:	TTT	TTA	TTG	TAT	TAC	TAG	TGT	TAA	TGA
coding strand:	AAA	AAT	AAC	ATA	ATG	ATC	ACA	ATT	ACT
								↓	
								'stop' triplet	

Q40

Which of the following catalyses the formation of a peptide bond during translation?

A Aminoacyl-tRNA synthetase

B DNA polymerase

C Peptidyl transferase

D RNA polymerase

HELP

The enzyme, peptidyl transferase resides in the large ribosomal subunit and catalyses the formation of the peptide bond during translation.

Q41

Part of a prokaryotic gene is 228 base pairs long. What is the length of amino acids synthesized by this DNA sequence?

A 38 B 76

C 228 D 456

HELP

A triplet of bases in the DNA molecule is the code for one amino acid in a polypeptide chain. Thus, the amino acids synthesized = 228/3 = 76.

Q42

A peptide consists of ten amino acids of four different kinds. What is the theoretical minimum number of tRNA molecules required to translate the mRNA for this peptide?

A 4 B 10

C 12 D 30

HELP

A tRNA molecule has an anticodon loop that base pairs with a particular codon on the mRNA and a CCA stem where the tRNA attaches covalently to amino acid coded for by the anticodon of the tRNA. There are twenty different amino acids and each tRNA carries a different amino acid.

If there are four different kinds of amino acids in the peptide, there will thus be four different tRNA molecule required.

Q43

A student just learnt about the fact that mature mRNAs have poly-A-tails about 100 nucleotides long.

He reasoned that he should be able to find a sequence of 100 nucleotides with adenine at the end of each eukaryotic gene sequence.

However he was unable to find such sequences of nucleotides when he observed the eukaryotic DNA. Why was this so?

A He should have been looking for multiple nucleotides with thymine instead.

B He was looking at the wrong complementary strand of DNA.

C The DNA had been degraded and so lacked the poly-A-tails.

D Poly-A-tails only exist in mature mRNA but not in DNA.

HELP

In post-transcriptional control, three processing events: 1) capping, 2) poly-A tailing and 3) pre-mRNA splicing occur in the nucleus before the genetic messages are dispatched to the cytoplasm as mature mRNA. In poly-A tailing, the completely transcribed pre-mRNA contains a polyadenylation sequence near the 3′ end. An enzyme recognizes the polyadenylation sequence, and adds a poly-A tail consisting of 50-250 adenine nucleotides to the 3′ end of the mRNA before the mRNA exits the nucleus. Thus poly-A-tails only exist in mature mRNA but not in DNA.

Q44

How many different polypeptides, each consisting of 3 amino acids, can be made if the number of different amino acids available is 10?

A 30

B 1000

C 3000

D 59049

HELP

There is a possibility of any 1 of the 10 amino acid in the 1st, 2nd and 3rd position in the amino acid.

Thus there can be a total of: 10 × 10 × 10 = 1000 polypeptides possible.

Q45

A pentapeptide has the following amino acid sequence:

H_2N – Met-Leu-Trp-Ala-Phe – COOH

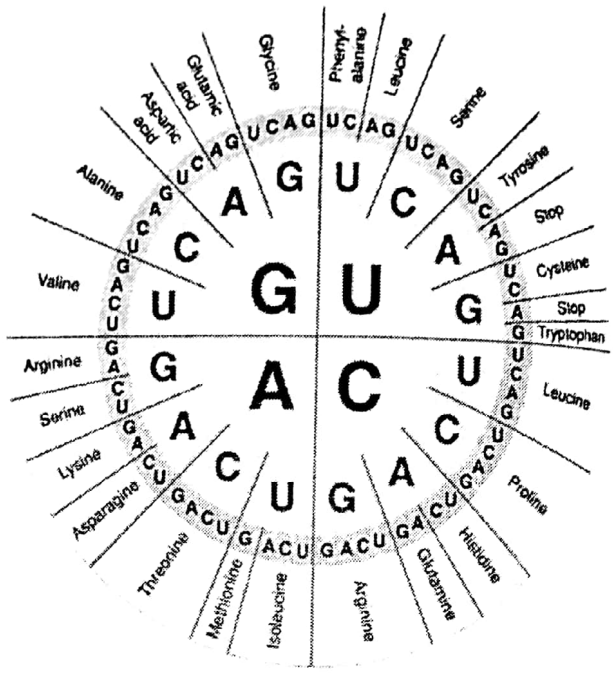
where Met: Methionine

Leu: Leucine

Trp: Tryptophan

Ala: Alanine

Phe: Phenylalanine



Using the genetic code shown in the diagram above, deduce the corresponding template strand sequence during transcription.

A 5′ – GAA GGC CCA CAA CAT – 3′

B 5′ – AUG CUG UGG GCA UUC – 3′

C 5′ – ATG TTG TGG GCC TTT TAG – 3′

D 5′ – TTA GAA GGC CCA CAA CAT – 3′

HELP

Transcription is the synthesis of an mRNA molecule with a base sequence complementary to a section of DNA.

mRNA:

5′ – AUG UUG UGG GCC UUC UAA – 3′

template strand:

5′ – TAC AAC ACC CGG AAG ATT – 3′

Q46

Choose the answer that has these events of protein synthesis in the proper sequence.

1. An aminoacyl-tRNA binds to the A site.
2. A peptide bond forms between the new amino acid and a polypeptide chain.
3. Protein release factor binds to A site.
4. A small ribosomal subunit binds with mRNA.
5. tRNA translocates to the P site from the A site.

A 1, 3, 2, 4, 5

B 4, 1, 2, 5, 3

C 4, 1, 3, 2, 5

D 2, 4, 5, 1, 3

HELP

A small ribosomal subunit recognizes and binds to the start codon of the mRNA molecule. The initiator tRNA fits into the P site of the large ribosomal subunit, and the next aminoacyl tRNA fits into the A site of the large ribosomal subunit. A peptide bond is formed between the amino end of the amino acid in the A site and the carboxyl end of the growing chain in the P site. Peptidyl transferase in the large ribosomal subunit catalyses the formation of the peptide bond. The ribosome moves down the mRNA in a 5′ to 3′ direction, that is, the tRNA, carrying the growing polypeptide in the A site is moved to the P site. This process continues until a stop codon reaches the A site of the ribosome and a protein release factor binds to the stop codon on the mRNA.

Q47

An mRNA is 336 nucleotides long, including the initiator and termination codons.

The number of amino acids in the protein translated from this mRNA is

A 10. **B** 111.

C 112. **D** 330.

HELP

An mRNA of 336 nucleotides has 336/3 codons = 112 codons. The initiator codon codes for amino acid, Met while the termination codon do not code for any amino acid. Thus, the number of amino acids in the protein translated from this mRNA = 112 – 1 = 111 amino acids.

Q48

If proteins were composed of only 12 different kinds of amino acids, what would be the smallest possible codon size in a genetic system with four different nucleotides?

A 2

B 3

C 4

D 12

HELP

There are four different nucleotides in the DNA molecule. The four nucleotides in DNA must be able to code for the 12 different kinds of amino acids used to make proteins.

If two bases code for each amino acid, then $4^2 = 16$ amino acids could be specified into the protein molecule. This is more than enough to incorporate all the 12 amino acids into the structure of protein molecules. Hence, the smallest codon size in this genetic system is 2.

Q49

A gene that was 5055 base pairs resulted in the expression of functional proteins that were 350, 450 and 1500 amino acids long. What could be most likely reason for this?

A mRNA degradation

B Gene amplification

C Alternative splicing

D **Mutations resulting in early termination signals**

HELP

Alternative RNA splicing is a form of regulation of gene expression where different mRNA molecules are produced from the same primary transcript, depending on which RNA segments are treated as exons and which as introns.

This enables the single gene of 5055 base pairs to code for more than one kind of polypeptide, depending on which segments are spliced together during RNA processing.

Q50

Assume that the average amino acid residue has a molecular weight of 110. The DNA strand coding for a polypeptide chain of molecular weight 20,000 has a length of

A 182 nucleotides.

B 252 nucleotides.

C 540 nucleotides.

D 760 nucleotides.

HELP

Average amino acid residue's molecular weight of = 110

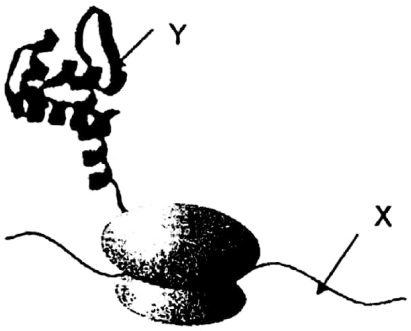
Polypeptide chain of molecular weight 20,000 = 20,000/110 = 182 amino acids

A triplet of bases in the DNA molecule codes for one amino acid in a polypeptide chain.

To translate 182 amino acids, there must be a minimum of: 182 × 3 = 546 nucleotides.

Q51

Below is a diagram showing a particular stage in protein synthesis.



Which of the following statement is **TRUE** of structures X and Y?

A Structure X is double stranded whereas Structure Y is single stranded.

B There is hydrogen bond interaction between the subunits of both Structures X and Y.

C Information on Structure Y is used to synthesize Structure X.

D The coiling of Structure Y is a direct result of the information on Structure X.

HELP

X refers to the mRNA and Y refers to the polypeptide. The codons in the mRNA acts as template for protein synthesis and contains information for the protein's folding into a specific shape.

Q52

Genetic drugs are short sequences of nucleotides. One example is an anti-sense drug made from RNA nucleotides that are complementary to the protein-coding mRNA.

Which is the process that is affected by the anti-sense drug and what is its most probable mode of action?

A It prevents DNA replication by binding to the anti

B It prevents transcription by binding to the sense strand of DNA that codes for the disease

C It prevents translation by binding to the mRNA that contains information for the disease

D It prevents the normal functioning of disease

HELP

The anti-sense drug binds by complementary base pairing via hydrogen bonds between complementary bases with the mRNA to form double stranded RNA. This prevents ribosome from binding to the mRNA, hence preventing translation.

Q53

The following coding sequence is taken randomly from a bacterial genome.

3' – TTACGCTTCGAAATAGGAATATCATAGGCT – 5'

Arg	CGU, CGC, CGA, CGG, AGA, AGG	Leu	UUA, UUG, CUU, CUC, CUA, CUG
Asp	GAU, GAC	Lys	AAA, AAG
Ile	AUU, AUC, AUA	Phe	UUU, UUC
Start	AUG	Ser	UCU, UCC, UCA, UCG, AGU, AGC
Stop	UAG, UGA, UAA	Tyr	UAU, UAC

This sequence is cloned into a plasmid and transformed into a suitable host. What would be the first four amino acids of a peptide generated from this sequence as expressed by the host?

A Met-Arg-Ser-Phe
B Met-Arg-Ser-Lys
C Met-Ile-Phe-Leu
D Met-Tyr-Lys-Asp

HELP

Coding sequence :	3' – T	TAC	GCT	TCG	AAA	TAG	GAA	TAT	CAT	AGG	CT – 5'	
mRNA :	5' – A	AUG	CGA	AGC	UUU	AUC	CUU	AUA	GUA	UCC	GT	
1st four amino acids :		↓ Met	↓ Arg	↓ Ser	↓ Phe							

Q54

A student obtained a sample of DNA. mRNA was transcribed from this DNA and the two samples were subsequently purified. He then separated the two strands of the DNA sample.

The base compositions of each strand and that of the mRNA were analysed. The results of the analysis are shown in the table below.

	A	G	C	T	U
DNA strand 1	19.1	26.0	31.0	23.9	0.0
DNA strand 2	24.2	30.8	25.7	19.3	0.0
DNA strand 3	20.5	25.2	29.8	24.5	0.0
mRNA	19.0	25.9	30.8	0.0	24.3

Which strand of DNA is the coding stranding, serving as a template for mRNA synthesis?

A Strand 1
B Strand 2
C Strand 3
D Strand 2 and 3

HELP

Transcription is the synthesis of an mRNA molecule with a base sequence complementary to a section of DNA. Due to the complementary relationship between the bases in DNA and in the free RNA nucleotides, cytosine in the DNA pairs with guanine, guanine pairs with cytosine, thymine pairs with adenine and adenine with uracil.

Topic 2(b) Protein Synthesis

Q1 D	Q2 B	Q3 D	Q4 B	Q5 A	Q6 D	Q7 D	Q8 C
Q9 A	Q10 C	Q11 B	Q12 D	Q13 D	Q14 A	Q15 D	Q16 B
Q17 B	Q18 D	Q19 D	Q20 D	Q21 D	Q22 A	Q23 D	Q24 B
Q25 B	Q26 C	Q27 B	Q28 D	Q29 D	Q30 A	Q31 C	Q32 D
Q33 C	Q34 B	Q35 A	Q36 C	Q37 B	Q38 B	Q39 C	Q40 C
Q41 B	Q42 A	Q43 D	Q44 B	Q45 D	Q46 B	Q47 B	Q48 A
Q49 C	Q50 D	Q51 D	Q52 C	Q53 A	Q54 B		

TOPIC 2

2(c) Gene Mutation and Chromosome Aberration

You should try to answer on your own before resorting to **HELP**

Q1

In the DNA sequence for sickle cell anaemia, adenine replaces thymine in a CTT triplet, forming the triplet CAT. During translation of the mutant mRNA, the amino acid valine is incorporated into the haemoglobin molecule instead of glutamic acid.

What is the anticodon in the transfer RNA molecule carrying this valine?

A CAT **B** CAU

C GTA **D** GUA

HELP

The codon on the mutant mRNA would be GUA, thus the anticodon is CAU. Candidates should remember that in RNA, uracil is present instead of thymine.

Q2

A mutation is a change produced by an alteration in the genetic mechanism and

A may arise spontaneously.

B is always induced by the environment.

C is never advantageous.

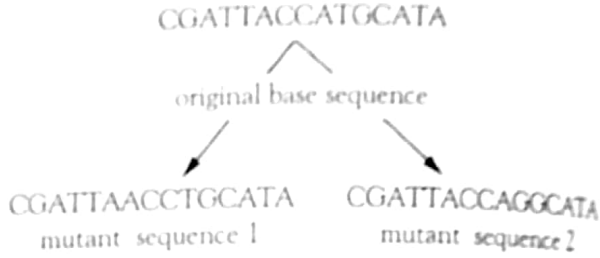
D is not inherited.

HELP

A mutation is a change in the DNA that changes the physiological effect of the DNA on the cell. Such phenomenon may be caused by radiation, chemical carcinogens or may occur spontaneously.

Q3

The diagrams below show the results of two types of gene mutation.



Which one of the following shows the types of gene mutation producing mutant sequence 1 and 2?

	1	2
A	deletion	insertion
B	insertion	deletion
C	inversion	substitution
D	substitution	insertion

HELP

Sequence 1 possesses a mutation in the third codon, whilst sequence 2 possess mutation in the fourth codon. In sequence 1, CCA from the original sequence has inverted into ACC; whilst in sequence 2, T of TGC from the original sequence has been substituted by G.

Q4

Hydroxylamine is a mutagen. It converts cytosine to a compound which pairs with adenine. If DNA is treated with hydroxylamine, the mutation which results is an example of

A a deletion. **B** an insertion.

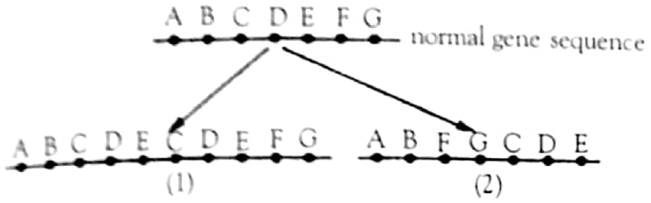
C an inversion. **D** a substitution.

HELP

If DNA is treated with hydroxylamine, the cytosine bases will be substituted with another compound which will pair with adenine.

Q5

The diagrams below show two types of chromosomal mutation producing changes from the normal gene sequence.



Which one of the following shows the two forms of chromosome mutation shown above?

	(1)	(2)
A	deletion	duplication
B	duplication	inversion
C	duplication	translocation
D	inversion	duplication

HELP

(1) shows a duplication of the genes C to G, occupying a position adjacent to the normal sequence of A to E. (2) shows a change in the position (translocation) of the genes FG, so they are inserted between B and C.

Q6

During the formation of an ovum, non-disjunction of the sex chromosomes occurred. The ovum was then fertilised by a normal, Y-bearing sperm cell.

Which one of the following shows the sex chromosome complement of the resulting zygote?

A XO
B XY
C XXY
D XXXY

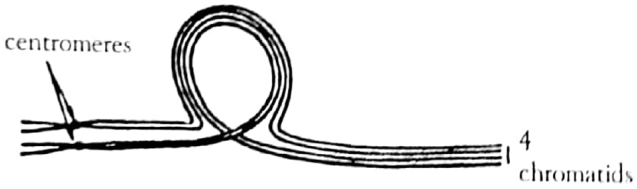
HELP

Non-disjunction occurs when paired chromosomes do not separate properly to the poles during meiosis.

	Ovum XX	×	Sperm XY
Gametes:	XX		X Y
F_1:	XXX or XXY		

Q7

The diagram below shows a pair of homologous chromosomes at prophase.



What type of chromosome mutation has occurred?

A deletion
B duplication
C insertion
D inversion

HELP

The mutation shown is an inversion of the base sequences.

Q8

Which of the following results in the addition of an extra chromosome to the chromosome complement of a cell, as in Down's syndrome?

A allopolyploidy
B autopolyploidy
C chromosome translocation
D non-disjunction

HELP

Non-disjunction occurs when paired chromosomes do not separate properly to the poles during meiosis, resulting in an extra chromosome in Down's syndrome.

Q9

A small proportion of men have the genotype **XYY**.

Such a genotype is possible if one contributory gamete to the zygote is

A an egg produced by non-disjunction in meiosis.

B an egg containing an **X** and a **Y** chromosome.

C a sperm produced by non-disjunction at meiosis **I**.

D a sperm produced by non-disjunction at meiosis **II**.

HELP

The extra Y chromosome comes from the male parent, where the paired chromosomes in the sperm nucleus fails to separate properly to the poles during meiosis II.

Q10

Which of the following is an example of a gene mutation?

A Polyploidy

B Substitution

C Crossing over

D Non-disjunction

HELP

Option A is incorrect. Polyploidy is a form of chromosome aberration. Polyploidy is a condition of the nucleus where there are three or more times the haploid number of chromosomes.

Option C is incorrect. Crossing over is a process that may occur between non-sister chromatids of homologous chromosomes in prophase I of meiosis II.

Option D is incorrect. Non-disjunction refers to the failure of chromosomes to separate during anaphase I or anaphase II, resulting in chromosomal aberration.

Q11

Down's syndrome can exist in two forms.

Classic Down's syndrome affects all cells and is very severe. The mosaic form arises from the presence of two or more cell types in the body with differences in chromosome number and structure.

How does the mosaic condition arise?

A non-disjunction of chromosomes in mitosis in early fetal development

B non-disjunction of chromosomes in meiosis during formation of ova

C non-disjunction of chromosomes in meiosis during formation of sperm

D translocation of chromosomes at maturation of the ovum

HELP

The mosaic condition can occur in 2 or more cell types as a result of non-disjunction in mitosis, i.e. the paired chromosomes fail to separate properly during mitosis of the nucleus in somatic cells.

Q12

Occasionally, non-disjunction of the entire genome occurs during meiosis producing abnormal gametes.

Which type of genetic variation may result when one such gamete is fertilised by a normal gamete?

A aneuploidy

B deletion

C inversion

D triploidy

HELP

Non-disjunction occurs when paired chromosomes do not separate properly to the poles during meiosis, resulting in an extra chromosome, or a triploid condition.

Q13

Which of the following statements about gene mutation is **incorrect**?

A It can occur in both somatic and sex cells.

B It can cause Down's syndrome in humans.

C It can change a dominant allele into a recessive one.

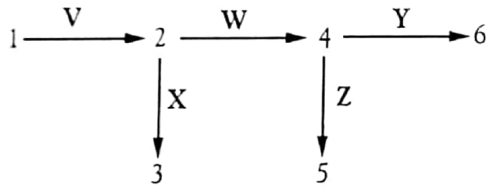
D It can be brought about by exposure to ionising radiation.

HELP

A gene mutation cannot cause a dominant allele to become recessive, but can disallow it from being expressed phenotypically.

Q14

The diagram represents a sequence of reactions taking place in a bacterium in which amino acids are produced from one another by the action of specific enzymes. Numbers 1 to 6 represent different amino acids; letters V to Z represent different enzymes. All the amino acids are essential for survival.



The original strain of the bacterium required only amino acid 1.

A mutant strain of this bacterium could only survive when provided with amino acids 1, 2 and 5 in its culture medium.

Which enzymes were missing in the mutant strain?

A V and Z only

B W and Z only

C X and Y only

D V, W and Z

HELP

The enzyme V is responsible for making amino acid 2 from 1, whilst Z is responsible for the conversion of 4 to 5.

Q15

Ozone is a gas in the upper atmosphere which absorbs ultraviolet radiation from the Sun.

Which of the following would increase as a direct consequence of the thinning of the ozone layer?

A cancers due to mutation in cells exposed to sunlight

B photosynthesis due to increase in the spectrum of radiation reaching Earth

C rate of carbon fixation due to increased levels of atmospheric CO_2

D sea level due to expansion of water and melting of polar ice caps

HELP

When the ozone layer thins, there is increased exposure to UV radiation, resulting in chromosomal mutations that can cause cancers.

Q16

Which of the following results in the addition of an extra chromosome to the chromosome complement of a cell, as in Down's syndrome?

A allopolyploidy

B autopolyploidy

C non-disjunction

D polygenic inheritance

HELP

Non-disjunction occurs when paired chromosomes do not separate properly to the poles during meiosis, resulting in an extra chromosome, or a triploid condition such as Down's syndrome.

Q17

The sex chromosome combination XYY is found in a small proportion of men.

Such a combination is possible if one contributory gamete to the zygote is

A a sperm produced by a father whose cells lack an X chromosome.

B a sperm produced by non-disjunction at meiosis II.

C an egg containing an X and a Y chromosome.

D an egg produced by non-disjunction at meiosis I.

HELP

The extra Y chromosome comes from the sperm nucleus. This occurs as a result of non-disjunction, where the paired chromosomes fail to separate properly during meiosis II.

Q18

The human inherited diseased phenylketonuria (PKU) is due to the absence of the enzyme which metabolises the amino acid phenylalanine.

What is the most probable cause of this disease?

A deletion of bases within a gene

B duplication of a gene on a chromosome

C inversion of genes within a chromosome

D translocation of a gene to another chromosome

HELP

The deletion of bases within a gene would result in the absence of some amino acids. Furthermore, if the number of bases deleted is not a multiple of 3, then there will be a frameshift mutation, where all bases downstream from the mutation would code for the wrong amino acids. This would cause a change in the shape and hence function of the enzyme.

Q19

Induced chromosome mutations produced a fertile hybrid species from cabbage and radish. The table shows the chromosome numbers in the parental species and the hybrids.

type of cell	number of chromosomes per cell
parental cabbage	18
parental radish	18
parental gametes	9
F_1 hybrids	18
F_1 gametes	18
F_2 hybrids	36
F_2 gametes	18
F_3 hybrids	36

At which stage did the chromosome mutation occur?

A during formation of the F_1 gametes

B during formation of the F_2 gametes

C during fusion of the parental gametes

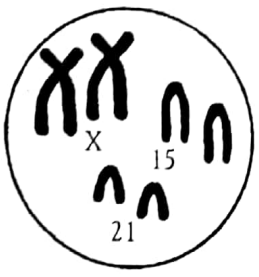
D during fusion of the F_1 gametes

HELP

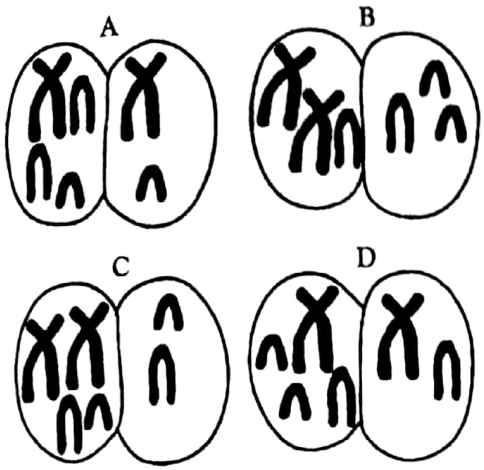
During formation of the F_1 gametes, the number of chromosomes in the hybrid cell were not halved. This is where the chromosome mutation occurred.

Q20

The diagram shows three of the 23 pairs of chromosomes found in a human cell.



Which diagram shows an example of non-disjunction in the formation of an egg, that could lead to the formation of a Down's syndrome zygote?



HELP

Down's syndrome is caused by a duplicate copy of part of chromosome 21. Hence the zygote that could lead to Down's syndrome is one where non-disjunction of chromosome 21 has occurred.

Q21

Newborn babies are screened for the presence of high levels of the amino acid phenylalanine in the blood, which indicates the hereditary disease phenylketonuria. Pale skin also occurs in sufferers from this disease.

The following series of reactions occurs in normal metabolism.

$$\text{protein} \xrightarrow{\text{enzyme 1}} \text{phenylalanine} \xrightarrow{\text{enzyme 2}} \text{tyrosine} \xrightarrow{\text{enzyme 3}} \text{other metabolites}$$

$$\text{tyrosine} \xrightarrow{\text{enzyme 4}} \text{melanin}$$

Which enzyme is lacking in persons with phenylketonuria?

A 1 B 2
C 3 D 4

HELP

The lack of enzyme 2 would effectively stop the conversion of phenylalanine to tyrosine, causing a build up of phenylalanine in the blood.

Q22

Which combination of chromosomes would result in a zygote showing polyploidy, if the parental chromosome number is 36?

	sperm	*ovum*
A	9	9
B	18	18
C	18	19
D	18	36

HELP

Polyploidy refers to the presence of additional whole sets of chromosomes. Normally, each gamete should have 18 chromosomes. Polyploidy occurs when at least one of the gametes has a number that is a multiple of 18.

Q23

Sickle cell haemoglobin differs from normal haemoglobin because of a single change in an amino acid; valine replaces glutamic acid.

Coding triplets in DNA for glutamic acid are CTT and CGT.

Coding triplets in DNA for valine are CAA and CAG.

Which mRNA codon would produce sickle cell haemoglobin if substituted for the normal mRNA codon?

A GAA
B GTC
C GTT
D GUC

HELP

GUC on the mRNA would correspond to the coding triplet of CAG on the DNA. This codes for valine, the amino acid responsible for sickle cell haemoglobin.

Q24

A mutation results in the substitution of thymine for cytosine in the base sequence ATC in a section of a DNA molecule.

What are the base sequences on the mRNA and tRNA corresponding to the new triplet?

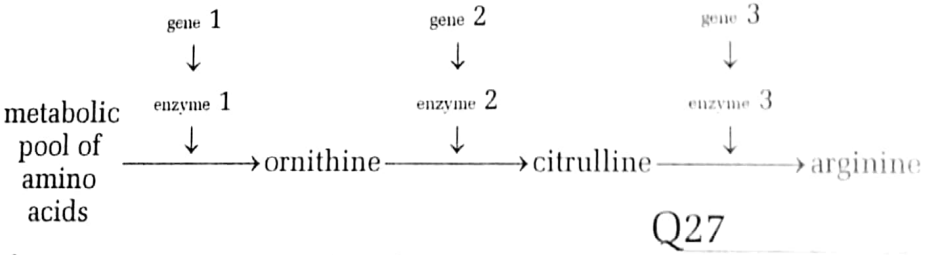
	mRNA	*tRNA*
A	TAG	ATC
B	TGG	ACC
C	UAG	AUC
D	UGG	ACC

HELP

The new triplet on the DNA molecule is ACC. This corresponds to UGG on the mRNA and ACC on the tRNA.

Q25

The diagram shows a metabolic pathway involving some amino acids.



Three mutant strains of *Escherichia coli* each fail to produce a different enzyme in the pathway.

What should be supplied to the culture medium to enable growth of all three mutant strains?

A arginine

B citrulline

C citrulline and arginine

D citrulline and ornithine

HELP

As arginine is the end-product of the metabolic pathway, it should be supplied to the medium to ensure the growth of the strains that depend on this end-product.

Q26

During transcription of the DNA fragment shown, a single base is paired incorrectly.

–C–T–A–A–C–T sense strand

–G–A–T–T–G–A anti-sense strand

Which mRNA strand results?

A C–A–T–T–G–A

B G–A–U–U–C–A

C G–A–U–U–G–A

D G–T–U–U–G–U

HELP

The correct mRNA strand should be G–A–U–U–G–A in order to be complementary to the sense strand of the DNA fragment. However, with a single cytosine base incorrectly paired, the mRNA would end up as G–A–U–U–C–A.

Q27

A mutation event inserts an extra nucleotide pair near the beginning of a gene coding for a particular protein.

What would be the effect of this on the primary structure of the protein synthesised?

A No amino acid is changed.

B One amino acid is changed.

C Two amino acids are changed.

D Most of the amino acid are changed.

HELP

Since gene coding for amino acids depend on the correct sequence of nucleotides, the insertion causes a shift in the sequence. This means that different amino acids would probably be coded.

Q28

The table describes different kinds of mutations in DNA.

mutation	name
from purine to other purine	transition
from pyrimidine to other pyrimidine	transition
from purine to pyrimidine	transversion
from pyrimidine to purine	transversion

The diagram represents part of a DNA molecule.

A – T
A – T
C – G
C – G

Which diagram shows the DNA molecule after a transition has occurred?

A

T – A
A – T
C – G
C – G

B

A – T
A – T
C – G
G – C

C

A – T
A – T
T – A
C – G

D

A – T
A – T
A – T
C – G

HELP

In transition, the bases that mutate could be A–T or C–G. The bases do not invert to form T–A or G–C.

Q29

The table below shows some amino acids and their DNA genetic code.

Amino acid	DNA code
Alanine	CGG
Lysine	TTT
Arginine	GCG
Phenylalanine	AAA
Glycine	CCA
Valine	CAA

A DNA sequence codes for a polypeptide arginine-glycine-phenylalanine-valine-alanine.

The following mRNA molecule was transcribed from the DNA sequence above. Which mRNA triplet contains a single transcription error?

CGCGUUUUUGUUGCC

A The first

B The second

C The third

D The fourth

HELP

DNA sequences coding for polypeptide arginine-glycine-phenylalanine-valine-alanine:

→ 3′ - GCG CCA AAA CAA CGG - 5′

mRNA for the above DNA sequence based on A-U and C-G pairing should be:

→ 5′ - CGC GGU UUU GUU GCC - 3′

The second mRNA triplet contains a single transcription error, instead of coding for GGU, it coded for GUU.

Q30

One individual, organism P, in a sexually-reproducing population of mammals has two forms of a protein in its heart muscle. The normal form is identical to that in most other members of the population, while the variant form differs by one amino acid.

The diagram shows the amino acid sequences in part of the normal protein and in the same part of the variant protein.

Normal protein	Variant protein
-gly-lys-lys-gly-glu-	-glu-lys-gly-gly-glu-

What could account for the presence of the normal protein and the variant protein in P?

1 The sequence of amino acids was altered in a cell in the heart muscle of P's mother.

2 The sequence of amino acids was altered in a cell in the ovaries of P's mother.

3 The sequence of bases was altered in the DNA in a cell in the heart muscle of P.

4 The sequence of bases was altered in the DNA in a cell in an ovary of P.

5 The sequence of bases was altered in the DNA in a cell in a testis of P's grandfather.

A 1, 2 and 4 only

B 1 and 3 only

C 2, 4 and 5 only

D 3 and 5 only

HELP

Statements 1 & 2: When the sequence of amino acids was altered in a cell in the heart muscle of P's mother or in the ovaries of P's mother, this can be due to a transcriptional or translational error. The sequence of bases in the DNA is not necessarily altered. Thus only P's mother will be affected. P will not be affected.

Statement 4: When the sequence of bases was altered in the DNA in a cell in an ovary of P, this can be passed on the P's offspring. Thus, this will affect P's offspring and not P.

Q31

The mRNA triplet UGA acts as a stop codon to terminate the synthesis of a polypeptide. The diagram shows a strand of DNA coding for 4 amino acids. Where would a mutation, involving the insertion of a thymine nucleotide, result in the termination of translation?

T T C A C G A C A A G T
↑ ↑ ↑ ↑
A **B** **C** **D**

HELP

If the T is inserted into position C, the DNA strand will be read as:

TTC ACG ACT AAG T

When transcripted, the mRNA coded for will be: AAG UGC UGA UUC → UGA is a stop codon and will result in termination of translation.

Q32

RNA viruses appear to have higher rates of mutation because

A RNA nucleotides are more unstable than DNA nucleotides.

B replication of their nucleic acid does not involve the proofreading steps of DNA replication.

C RNA viruses replicate faster.

D RNA viruses respond more to mutagens.

HELP

Both prokaryotes and eukaryotes have proofreading mechanisms to locate and correct mutations and replication errors. Enzymes find and bind to faulty or damaged sequences and cut out the faulty sequences. The intact complementary strand guides the repair of the faulty or damaged sequences. This process is absent in the replication of nucleic acid of RNA viruses.

Q33

Below is part of the DNA genetic code for six amino acids.

CGG codes for alanine

TTT codes for lysine

GCG codes for arginine

AAA codes for phenylalanine

CCA codes for glycine

CAA codes for valine

The diagram shows part of a mRNA molecule, but the corresponding part of the protein formed was found to be:

arginine–glycine–lysine–valine–alanine

C G C C G U U A A A G U U G C C

Which triplet contains a single transcription error?

A the first **B** the second

C the third **D** the fourth

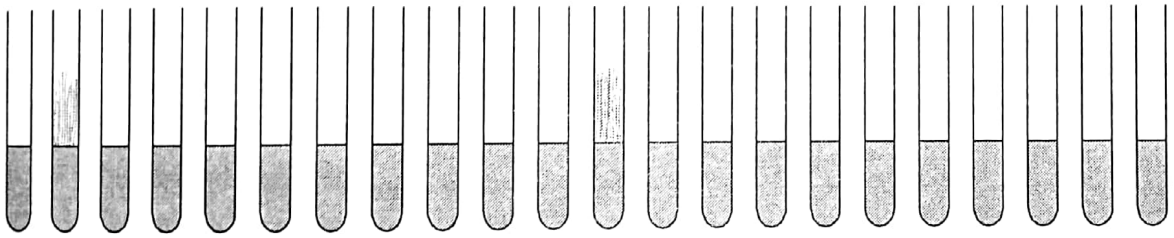
HELP

DNA triplet	mRNA triplet	Amino acid coded for
CGG	GCC	alanine
TTT	AAA	lysine
GCG	CGC	arginine
AAA	UUU	phenylalanine
CCA	GGU	glycine
CAA	GUU	valine

The second triplet contains a single transcription error. GGU instead of GUU codes for glycine.

Q34

Fungi can make their own amino acids and are able to grow on a substance called minimal media. An abnormal strain of fungus that could not grow on minimal media was discovered. An experiment was designed and the results are outlined in the following diagram. The fungus grew in tube 12. The amino acid histidine had been added to this tube.



Tube 1: Minimal media

Tube 2: Minimal media + all 20 different amino acids added

Tubes 3 to 22: Minimal media + one of the 20 amino acids. Each tube contained a different amino acid.

Spore of abnormal fungus was added to surface of media in each tube. All tubes were incubated under the same conditions for several days and then examined.

From this experiment, what conclusions can be made about the ability of the abnormal fungus to produce amino acids?

I The abnormal fungus cannot produce histidine.

II The abnormal fungus can produce the other 19 amino acids.

III The control tubes present in this experiment were not necessary.

A I and II only

B II and III only

C I and III only

D All of the above

HELP

Statements I and II: Growth of fungus is only observed in Tube 2 and Tube 12 where the amino acid, histidine, is provided. In all the other tubes, no growth is observed. This proved that the fungus requires histidine for growth and that this abnormal strain of fungus is unable to make its own histidine.

Statement III: Control tubes present are necessary to prove that the changes observed in the experiment is due to results of the reactions being investigated, and not due to other external factors.

Q35

The DNA code for glutamic acid is CTC or CTT. The code for valine is CAA or CAT. In sickle cell haemoglobin, valine is present instead of glutamic acid. Assuming a single base pair substitution has occurred, what is the mRNA code in the affected mutant?

A CUU

B GAA

C GUU

D GUA

HELP

In sickle cell haemoglobin, valine coded for has the code, CAA or CAT. After transcription, this will code for GUU or GUA respectively.

Q36

The condition in which a zygote contains three copies of a particular chromosome as a result of nondisjunction is called

A trisomy.

B monosomy.

C polyploidy.

D monoploidy.

HELP

Non-disjunction is the failure of chromosomes to separate, resulting in chromosome aberration.

A trisomy is a type of polysomy in which there are three copies, instead of the normal two, of a particular chromosome. A trisomy is a type of aneuploidy (an abnormal number of chromosomes).

Q37

What do chromosomal aberrations and gene mutations have in common and how are they different?

	Similarity	Difference
A	Both may involve addition of nucleotides.	Gene mutations always produce dominant alleles but not chromosomal aberrations.
B	Both may not result in disorders.	Gene mutations do not involve inversions but inversion of segments of chromosomes do occur.
C	Both affect DNA sequence.	Gene mutations occur within a chromosome but chromosomal aberrations may occur across chromosomes.
D	Both may not result in a difference in protein expression.	Chromosomal aberrations are more harmful than gene mutations.

HELP

Gene mutation is defined as the changes in the nucleotide base sequence of the genes within a chromosome.

Chromosomal mutation is defined as changes in chromosome number or structural alteration to chromosomes and may occur across chromosomes.

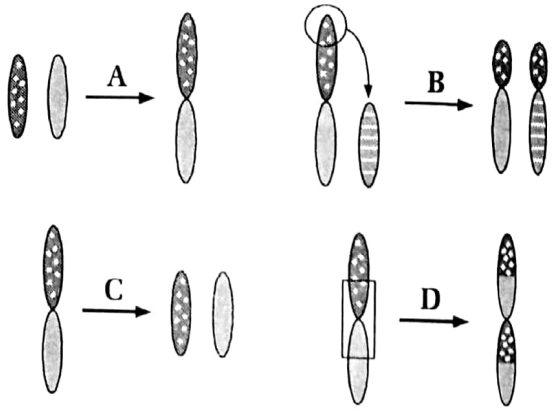
Option A: Gene mutation can produce both dominant and recessive allele.

Option B: Gene mutation can involve inversions.

Option D: Both gene mutation and chromosomal aberrations can be equally harmful.

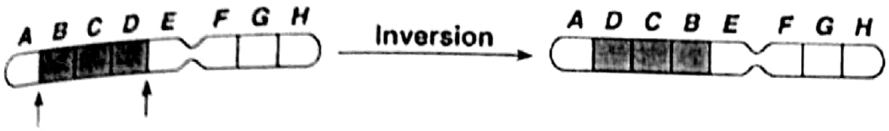
Q38

Which of the following illustrates chromosomal inversion?



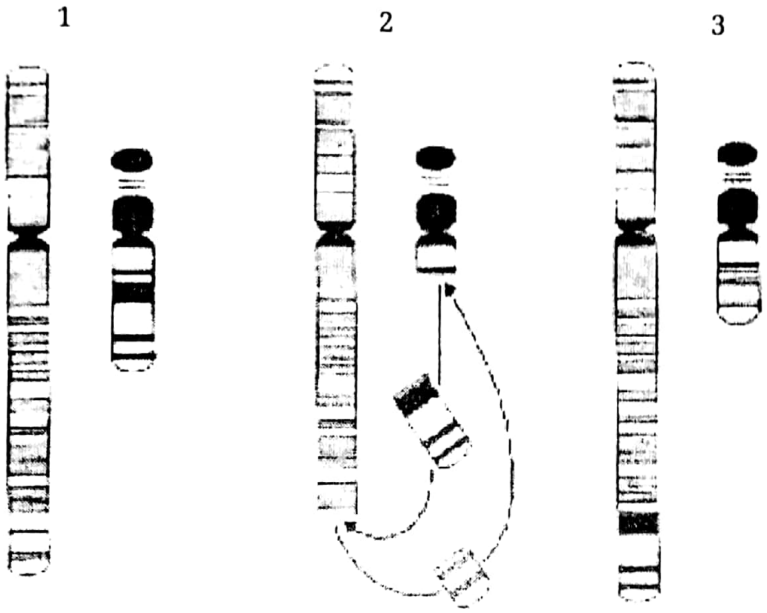
HELP

Chromosomal Inversion occurs when a chromosome breaks at two locations, and the middle portion flips through 180° before re-joining.



Q39

Diagram below shows chromosomal structure alteration as seen from 1 to 3.



What type of chromosomal structure alteration is seen above?

A Chromosome duplication

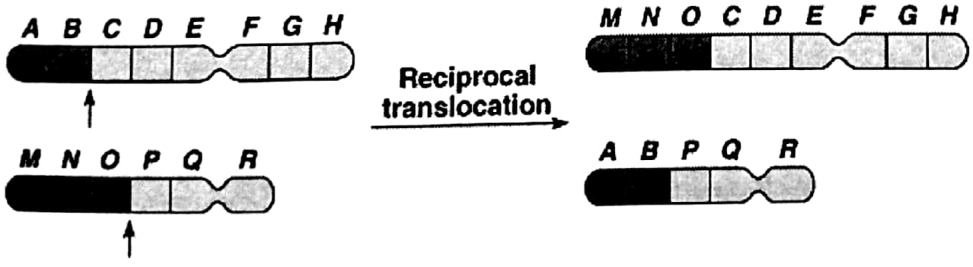
B Chromosome deletion

C Chromosome inversion

D Chromosome translocation

HELP

Chromosome translocation is defined as a section of chromosome breaks off and becomes attached to another chromosome, leading to new combination of alleles.



Q40

The table shows the mRNA codons for 11 different amino acids.

Amino acid	mRNA codon	Amino acid	mRNA codon	Amino acid	mRNA codon
Ala	GCG	Lys	AAG	Arg	CGC
Glu	GAG	Pro	CCU	Phe	UUC
His	CAC	Thr	ACU	Gly	GGA
Leu	CUG	Val	GUG		
	CUC				

The first seven DNA triplets coding for a protein are shown below.

These are DNA triplets from the coding strand, complementary to the mRNA.

CAC GAG GCG AAG GGA CAC CGC

A mutation occurs when the seventeenth nucleotide in the DNA sequence is changed to G.

What is the amino acid sequence for the mutated section of DNA?

A His Glu Ala Lys Gly Arg Arg

B Val Leu Arg Phe Pro Ala Ala

C His Glu Ala Lys Gly His Arg

D Val Leu Arg Phe Pro Val Ala

HELP

After mutation occurs when the seventeenth nucleotide in the DNA sequence is changed to G,

DNA: CAC GAG GCG AAG GGA C<u>G</u>C CGC

mRNA: GUG CUC CGC UUC CCU G<u>C</u>G GCG

Topic 2(c) Gene Mutation and Chromosome Aberration

Q1 B	Q2 A	Q3 C	Q4 D	Q5 C	Q6 C	Q7 D	Q8 D
Q9 D	Q10 B	Q11 C	Q12 D	Q13 C	Q14 A	Q15 A	Q16 C
Q17 B	Q18 A	Q19 A	Q20 D	Q21 B	Q22 D	Q23 D	Q24 D
Q25 A	Q26 B	Q27 D	Q28 D	Q29 B	Q30 D	Q31 C	Q32 B
Q33 B	Q34 A	Q35 D	Q36 A	Q37 C	Q38 D	Q39 D	Q40 B

TOPIC 3

Genetics of Viruses and Bacteria

You should try to answer on your own before resorting to **HELP**.

Q1

Which combination correctly identifies a type of virus?

	DNA	RNA	Protein	Phospholipids
A	✓	✓	✓	–
B	✓	–	✓	–
C	–	✓	–	✓
D	–	–	✓	✓

HELP

A virus is a infectious particle consisting of:

A viral genome – It can be DNA or RNA but never both.

A capsid – A capsid is a protein shell enclosing the viral genome, and,

A membranous envelope (in some cases) – The envelope is composed of phospholipids and glycoprotein.

The combined structure formed by the genome and capsid is called nucleocapsid. Some viruses consist of no more than the nucleocapsid and are called naked viruses.

Q2

Genetic recombination in bacteria leads to variation.

Which process leading to genetic recombination in bacteria involves a virus?

A Conjugation

B Plasmid replication

C Transduction

D Transformation

HELP

Three processes – conjugation, transduction and transformation, lead to genetic recombination in bacteria. Of the 3 processes, only transduction involves a virus.

Q3

Which feature occurs only in the life cycle of the influenza virus?

A Host cell DNA is destroyed by lytic enzymes.

B Host cell ribosomes are used to synthesise viral proteins.

C Viral RNA acts as templates for viral DNA synthesis.

D Viruses enter the host cell by endocytosis.

HELP

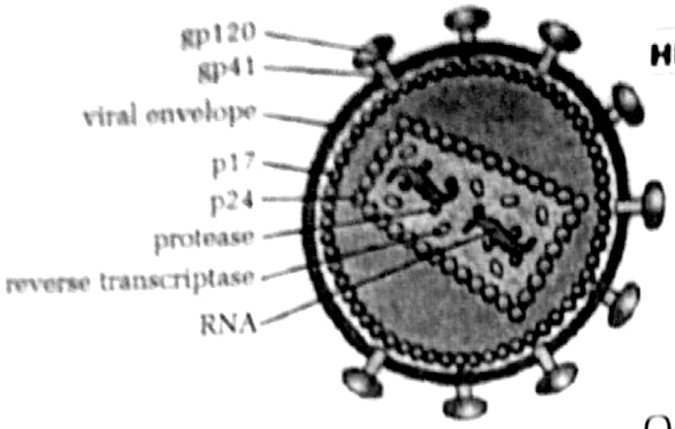
Option A: It describes the life cycle of the T4 bacteriophage. T4 Phage lytic enzymes (nucleases) hydrolyse the host cell DNA into small pieces of DNA.

Option B: Host cells ribosomes are used during the life cycle of all viruses to synthesis viral proteins and not only by influenza virus.

Option C: This is applicable only for retrovirus. Retrovirus contains reverse transcriptase, an enzyme that synthesizes DNA from RNA template.

Option D: The influenza virus enters host cells by receptor-mediated endocytosis.

Q4



Virus X is a/an

A bacteriophage lambda.

B Orthomyxovirus.

C herpes virus.

D human immunodeficiency virus.

HELP

Human immunodeficiency virus has 2 copies of single-stranded RNA which is enclosed by a conical capsid. The capsid is in turn surrounded by a plasma membrane. Within the capsid are 2 molecules of enzyme reverse transcriptase. In order to enter the cell, the glycoprotein 120 (gp120) on the HIV envelope must bind to a CD4 molecule on the plasma membrane of the host cell. All of the above features are seen in the diagram above.

Q5

The tobacco mosaic virus has RNA rather than DNA as its genetic material. In a hypothetical situation, RNA from a tobacco mosaic virus is mixed with proteins from a related DNA virus Z, resulting in a hybrid virus.

If this hybrid virus were to infect a cell and reproduce, what would the resulting 'offspring' viruses be like?

A Tobacco mosaic virus.

B Virus Z.

C A hybrid virus with tobacco mosaic virus RNA and virus Z protein.

D A hybrid virus with virus Z DNA and tobacco mosaic virus protein.

HELP

When the hybrid virus infect a cell, only it's genetic material (RNA from a tobacco mosaic virus) will be transported into the cell's cytoplasm. The RNA from the tobacco mosaic virus will then code for the synthesis of tobacco mosaic viral components resulting in the synthesis of more tobacco mosaic virus.

Q6

A gene transfer occurred between two strains of bacteria. It was observed that cell-cell contact is NOT required, and a filter that removes viruses eliminates transfer. This would mean that the transfer occurred by

A conjugation.

B transformation.

C transposition.

D transduction.

HELP

Option A: Conjugation requires cell-cell contact. The donor bacteria cell produce an appendage called sex pili to attach itself to the recipient bacteria cell to form a temporary cytoplasmic mating bridge between itself and the recipient cell to provide an avenue for gene transfer.

Option B: Transformation occurs when there is uptake of naked, foreign DNA from the surrounding environment by a bacterium. It requires neither cell-cell contact nor the presence of viruses.

Option D: Transduction is the process by which bacterial DNA is transferred from one bacterium to another by a virus eg. T4 bacteriophage.

Q7

A virus has a base ratio of $\frac{(A+G)}{(U+C)} = 1$.

What type of virus is this?

A A single-stranded DNA virus.
B A double-stranded DNA virus.
C A single-stranded RNA virus.
D A double-stranded RNA virus.

HELP

The presence of U indicates a RNA virus.

A and G are purines while U and C are pyrimidines. When ratio of purines : pyrimidines = 1, this suggest that there is complementary base pairing between the bases. Thus, this must be a double-stranded virus.

Q8

A group of scientists uses modified viruses as vectors for the introduction of foreign genes into bacteria.

In one experiment, a bacteriophage was put together with the protein coat of T4 phage and the DNA of a lambda phage. If this composite phage was allowed to infect bacteria, the phages produced in the bacteria will have

A the protein of lambda phage and the DNA of T4.
B the protein of T4 and the DNA of lambda phage.
C the protein and DNA of lambda phage.
D the protein and DNA of T4.

HELP

When the composite phage was allowed to infect bacteria, only the DNA of a lambda phage will be injected into the bacteria's cytoplasm. The DNA of the lambda phage will use the bacterium's metabolic machinery and resources to synthesize lambda phage's DNA, enzymes and phage structural components eg. protein coat resulting in the synthesis of more lambda phage.

Q9

Viruses have some of the properties of living organisms. Which of the following is a characteristic of all organisms, but *not* of viruses?

A **Ability to control metabolism.**
B Ability to reproduce.
C Genetic information stored as nucleic acid.
D Possess plasma membrane.

HELP

A virus is a genome (complete set of genes) enclosed in a protein coat (capsid). The combined structure formed by the genome and capsid is called nucleocapsid. Some viruses consist of no more than the nucleocapsid, thus not all viruses have plasma membrane.

Q10

Some events that take place during generalized transduction are listed below

I Bacterial host DNA is fragmented.
II Bacterial DNA may be packaged in a phage capsid.
III Recombination between donor DNA and recipient DNA.
IV Phage infects a bacterial cell.
V Phage DNA and proteins are made.

Which sequence of events is correct?

	First ⟶ Last				
A	IV,	I,	III,	V,	II
B	IV,	I,	V,	II,	III
C	IV,	III,	I,	V,	II
D	IV,	V,	I,	III,	II

HELP

In generalized transduction, when a phage undergoes the lytic cycle, the phage enzymes hydrolyse the host cell's chromosome into small pieces of DNA. During the assembly of the phage genome within the phage capsid, a small piece of the host cell's degraded DNA gets mistakenly packaged

within the capsid. This defective phage is released. It can attach to another bacterium and inject the piece of bacterial DNA acquired from the donor cell. The foreign bacterial DNA can then be incorporated into the recipient cell's DNA through homologous recombination.

Q11

Which process in bacteria always allows chromosomal and non-chromosomal DNA to be transferred?

A Binary fission

B Conjugation

C Transduction

D Transformation

HELP

Binary fission is the division of a single parent bacterial cell into two genetically identical daughter cells. DNA replication of the chromosomal and non-chromosomal (plasmid) DNA occurs, followed by the newly synthesized DNA moving to opposite ends of the cell. After the completion of the chromosome segregation, the plasma membrane starts to invaginate and eventually divides the parent cell into two daughter cells. Each daughter cell inherits a complete genome.

For conjugation, transduction and transformation, only a small piece of the bacterium's DNA is transferred.

Q12

In Generalised Transduction, defective virus are formed as a result of

A viral enzymes cutting the host DNA such that the host DNA is assembled into the new virus.

B production of host enzymes by virus which nicks its own DNA such that it can be assembled into the new virus.

C no shut down of host DNA production such that either host DNA or the virus DNA can be assembled into the new virus.

D integration of virus DNA into host DNA and during excision the viral genome carries along with it the host DNA to be assembled into the new virus.

HELP

In generalized transduction, when a phage undergoes the lytic cycle, the phage enzymes hydrolyse the host cell's chromosome into small pieces of DNA. During the assembly of the phage genome within the phage capsid, a small piece of the host cell's degraded DNA gets mistakenly packaged within the capsid. This results in a defective phage.

Q13

Which of the following viral structures are not completely coded by the virus' own nucleic acids?

A Capsid

B Glycoprotein gp120 of HIV

C Viral envelope

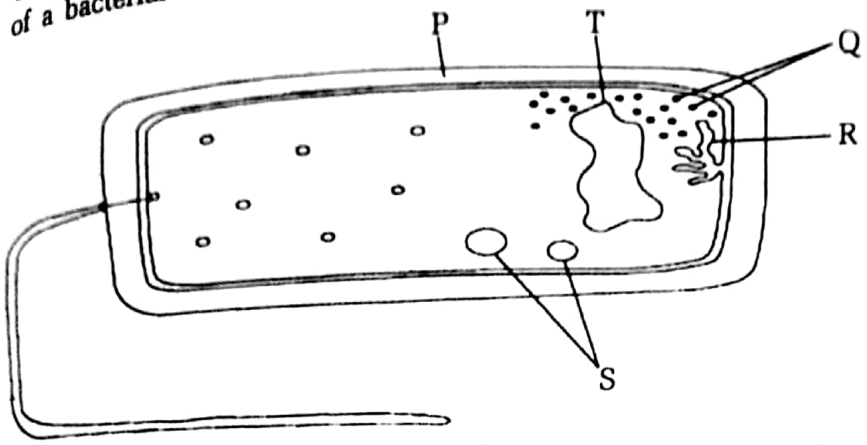
D Tail sheath of T4 bacteriophage

HELP

Enveloped viruses have an envelope surrounding the nucleocapsid. The envelope is composed of phospholipids and glycoprotein. For most viruses, the viral envelope is derived from host cell membranes by a process called budding. The envelope may come from the host cell's nuclear membrane, vacuolar membrane (packaged by the Golgi apparatus), or outer cytoplasmic membrane. The virus does incorporate proteins of its own, often appearing as glycoprotein spikes, into the envelope.

Q14

The figure below shows the general structure of a bacterial cell.



Use the letters on the diagram to identify the structures described below.

	contains advantageous genes	sites of protein synthesis	prevents cell lysis	contains enzymes for respiration
A	S	Q	P	R
B	S	T	R	Q
C	T	R	P	Q
D	T	S	P	R

HELP

P is the cell wall. Function: helps the bacterium maintain its shape and protect the cell from osmotic lysis.

Q is the ribosomes. Function: formation of polypeptides. (Ribosome is the site for protein synthesis).

R is the Mesosome. Function: aids in compartmentalization and contains enzymes for aerobic cellular respiration.

S is the plasmids. Function: contains advantageous genes that provide some benefits to the bacterial cell e.g. genes encoding for enzymes that inactivate antibiotics and make the bacterial cells resistant to antibiotics.

T is the bacterial chromosome, i.e. a double-stranded circular DNA molecule.

Q15

An *E. coli* cell, which carries a lambda prophage, is immune to a lytic infection by a second lambda virus because

A proteins from the prophage's lytic genetic program prevent replication of the second virus.

B the second virus cannot inject its DNA.

C proteins from the prophage's lysogenic genetic program prevent replication of the second virus.

D the second virus cannot adsorb to the cell.

HELP

The lambda prophage within the *E. coli* contains a prophage gene that codes for a repressor protein that is able to represses most of the other prophage genes, inclusive that of the second lambda virus. Hence, the expression of the second lambda virus' genes controlling lambda phage replication is blocked.

Q16

Which of the following correctly describes the characteristics of a virus?

	Obligate parasitism	Involvement of host enzyme	Involvement of host cell ribosomes	Entry of nucleic acid into a cell
A	✓	–	✓	–
B	✓	–	✓	✓
C	✓	✓	–	–
D	✓	✓	✓	✓

HELP

Viruses are obligate intracellular parasites. They can only survive and reproduce/replicate in the host cell, at the expense of the host.

Viruses lack most of the structures and metabolic machinery found in cells. Thus viruses use the host cell's enzymes for metabolism and host cell's ribosomes for protein synthesis.

Q17

Generalized transduction is distinguishable from specialized transduction by the fact that

A generalized transduction may be used to move any gene, whereas specialized transduction moves only certain genes.

B selective medium is required for generalised transduction, whereas selective medium is not required for specialized transduction.

C donor DNA must be purified from the donor for generalised transduction, whereas specialized transduction involves movement of DNA by phages.

D generalized transduction is possible in generally all organisms, whereas specialized transduction is possible only in special groups of organisms.

HELP

Generalized transduction requires infection of a bacterium by a lytic phage. In generalized transduction, any random portion of the bacterial DNA/any gene may be transferred.

Specialised transduction requires infection of a bacterium by a temperate phage.

Specialised transduction is restricted to bacterial genes adjacent to the integrated prophage whereby only certain genes near the prophage site on the bacterial chromosome is transferred. Thus only certain portion of the bacteria DNA/certain genes may be transferred.

Q18

Viruses are classified according to several characteristics, which includes all EXCEPT

A DNA or RNA as the genetic material.

B single or double-stranded nucleic acids.

C circular or linear nucleic acid.

D presence or absence of metabolic machinery.

HELP

All viruses are obligate intracellular parasites. This means that they cannot live independently of its host. Viruses lack most of the structures and metabolic machinery found in cells (i.e. they lack enzymes for metabolism and ribosomes or other components for protein synthesis).

Q19

During bacterial conjugation mediated by the F-plasmid, the function of the pilus is to

A synthesize the DNA single stranded prior to transfer.

B draw the donor and recipient cells in contact prior to DNA transfer.

C facilitate transfer of single-stranded DNA across the cell membrane.

D facilitate transfer of double-stranded DNA across the cell membrane.

HELP

In bacteria conjugation, the donor cells possess a segment of DNA called an F factor.

The F factor carries genes for sex pilus production. The sex pilus allows the donor cell to attach itself to the recipient cell and forms a temporary cytoplasmic mating bridge between itself and the recipient cell. This provides an avenue for the donor cell to transfer its F plasmid to the recipient cell.

During the transfer, a single strand of F plasmid breaks at a specific point and moves 1 of the strands across the mating bridge, into the recipient cell.

Q20

Bacterial Strain A has been infected with viruses. Upon lysis, the virions produced are introduced to Bacterial Strain B. After a short period of time, a new strain of bacteria is detected that is very similar to Strain A but has a few characteristics of Strain B. Which is the process that leads to the production of the new strain?

A Transduction

B Transposition

C Transformation

D Conjugation

HELP

As the new strain of bacteria detected is very similar to Strain A but has a few characteristics of Strain B, this indicates that genetic recombination has taken place. The three processes that lead to genetic recombination are transduction, transformation and conjugation. Of these three processes, only transduction requires the presence of viruses.

Q21

Which of the following would be the first step in the biosynthesis of a virus with reverse transcriptase?

A A complementary strand of DNA must be synthesized from an DNA template.

B **Double-stranded RNA must be synthesized.**

C A complementary strand of DNA must be synthesized from an RNA template.

D A complementary strand of RNA must be synthesized.

HELP

The function of reverse transcriptase is to catalyse the synthesis of a DNA strand complementary to viral RNA template. This strand is termed as cDNA.

Q22

Which of the following statements about bacteria is true?

A Bacteria possess 80s ribosomes, introns and RNA processing.

B Bacteria possess 70s ribosomes, introns and no RNA processing.

C Bacteria possess 70s ribosomes, no introns and no RNA processing.

D Bacteria possess 80s ribosomes, RNA processing and no introns.

HELP

Prokaryotes, i.e., bacteria possess 70s ribosomes, no introns and no RNA processing. Only eukaryotes possess 80s ribosomes, has non-coding DNA sequences such as introns and requires RNA processing.

Q23

What is present in a bacteriophage but not in an influenza virus?

A DNA **B** RNA

C Glycoprotein **D** Viral capsid

HELP

The influenza virus is an enveloped virus with an RNA nucleocapsid. The influenza genome is organised into 8 pieces of single stranded RNA and the genes in the RNA segments are used as a template for mRNA production. It has 2 types of protein spikes – Hemagglutinin and Neuraminidase projecting from the outer surface of the envelope. Thus of all the above options, only DNA is missing in an influenza virus.

Q24

During a viral infection, attachment is usually specific to a particular cell type because

A the virus is attracted to the appropriate host cells by proteins secreted into the extracellular fluid.

B the virus recognises and binds to specific molecules in the cytoplasm of the host cell.

C the virus recognises and binds to specific molecules on the surface of the host cell.

D the host cell produces channel proteins that provide passageways for the viruses to enter the cytoplasm.

HELP

Specific strains of viruses can only adsorb to specific hosts cells. This is known as viral specificity. This is because specific glycoprotein spikes are present on specific virus and these glycoprotein spikes function in attaching the virus to specific surface receptor molecules on membranes of specific susceptible host cells.

Q25

Which of the following statements about the life cycle of the Human Immunodeficiency Virus are FALSE?

I The HIV particles recognise the host cell through the sialic-acid containing proteins or lipids on the membrane of the host cell.

II Upon entry of the HIV into the host cell, a drop in pH will result in a conformational change in the HIV structure, consequently releasing the viral genome into the host cell.

III The viral DNA which enters the host cell's nucleus will be integrated into the genetic material of the host cell using the host cell's enzyme, integrase.

IV The viruses are released from the host cell by exocytosis.

A I and III

B II and IV

C I, III and IV

D All of the above

HELP

Statement I & II: The glycoprotein 120 on the HIV envelope must attach to both a CD4 molecule and a chemokine receptor. The interaction between gp120 and chemokine receptor brings about a conformation change in gp41 on the HIV virion, allowing the fusion of the HIV envelope and host cell membrane. The fusion allows the nucleocapsid to enter the host cell. The capsid is removed by cellular enzymes and the viral RNA genome and various enzymes is released into the host cell.

Statement III: The viral DNA which enters the host cell's nucleus will be integrated into the genetic material of the host cell using the HIV virus's enzyme, integrase and not the host cell's enzyme.

Statement IV: The viruses 'bud' from the host cell's plasma membrane and are not released by exocytosis.

Q26

Which statement correctly describes the control of transcription of the genes involved in the breakdown of lactose in *Escherichia coli*?

A A repressor protein binds to the operator and the genes are switched on.

B A repressor protein binds to the operator and the genes are switched off.

C A transcription factor binds to the promoter and the genes are switched on.

D A transcription factor binds to the promoter and the genes are switched off.

HELP

The *lac* operon consist of:

Promoter: binding site of RNA polymerase

Operator: binding site of the *lac* repressor protein

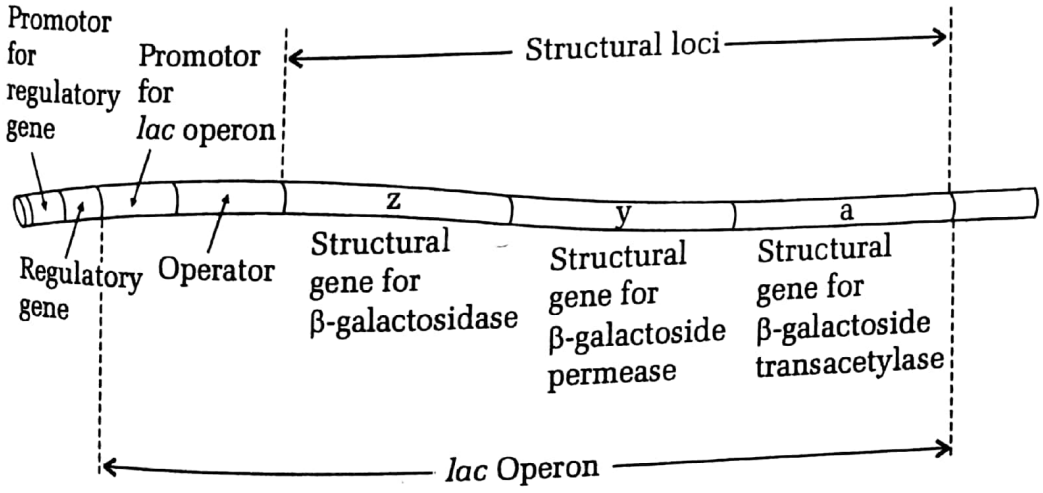
CAP Binding Site: binding site of catabolite activator protein

3 structural genes: *lac Z*, *lac Y* and *lac A*

When *lac* repressor protein is synthesised in its active conformation, it binds to the operator and the operon is switched off. That is, the 3 structural genes are switched off.

Q27

The figure below is a diagram of the *lac* operon. This structure explains the mechanism of gene expression in the presence of lactose in *E. coli*.



Which of the following best describes what happens in the presence of lactose?

A The repressor proteins binds to the *lac* operator.

B Transcription is prevented.

C The repressor cannot bind to the operator.

D RNA polymerase cannot bind to the operon.

HELP

When lactose enters the cell and is cleaved by β-galactosidase into allolactose. Allolactose binds to the lac repressor. The repressor changes its conformation and becomes inactive. It is unable to bind to the operator. RNA polymerase is able to bind to the promoter, and able to transcribe the three structural genes of the operon. β-galactosidase, *lac* permease and β-galactoside transacetylase are produced.

Q28

An mRNA molecule transcribed from the *lac* operon contains nucleotide sequences complementary to

A structural genes coding for the enzymes.

B the operator region.

C the promoter region.

D the repressor gene.

HELP

Only the structural genes of an operon are transcribed into mRNA molecule. Structural gene is a region of DNA that codes for a protein or RNA molecule that forms part of a structure or has an enzymatic function. In the case of *lac* operon, the structural genes are *lac Z*, *lac Y*, *lac A* which codes for β-galactosidase, *lac* permease and β-galactoside transacetylase respectively.

Q29

What are the correct characteristics for a prokaryotic genome?

	Promoters	DNA always bound to histone proteins	Plasmids often present	Repeat sequences absent or uncommon
A	✓	–	–	–
B	–	✓	✓	✓
C	–	✓	–	–
D	✓	–	✓	✓

HELP

In prokaryotes, the DNA complexes with nucleoid-associated proteins (H-NS proteins) and not histone proteins. In addition to the bacterial chromosome, many bacterial also have one or more extrachromosomal plasmids which contain a small number of genes which, are not necessary for survival, but may confer selective advantages. Repeat sequences are absent or uncommon in prokaryotes and are normally found in eukaryotes.

Q30

The *trp* operon lowers the rate of transcription when

A the repressor binds to RNA polymerase.

B the repressor binds to the structural gene.

C tryptophan binds to the repressor.

D tryptophan binds to the promoter.

HELP

Tryptophan functions as a co-repressor, a small molecule that binds with a repressor protein to switch an operon off. The binding of a tryptophan molecule to the trp repressor changes the conformation of the trp repressor to an active conformation which is able to bind to the operator and prevents RNA polymerase from binding to promoter and transcribing the genes of the *trp* operon.

Q31

A repressible operon, such as the *trp* operon, is 'off' when

A the gene that codes for the repressor is expressed constitutively.

B the repressor-corepressor complex binds to the operator.

C the repressor binds to structural genes.

D the corepressor binds to RNA polymerase.

HELP

The trp repressor is synthesised in its inactive conformation which is unable to bind to the operator and hence the trp operon is transcribed. Tryptophan functions as a co-repressor, a small molecule that cooperates with a repressor protein to switch an operon off. The *trp* operon is repressed in the presence of tryptophan.

When tryptophan is present in the medium surrounding the bacterium, the binding of a tryptophan molecule to the trp repressor changes the conformation of the trp repressor from an inactive to an active conformation which is able to bind to the operator and prevents RNA polymerase from binding to promoter and transcribing the genes of the *trp* operon.

Q32

A mutation of the *lac* repressor protein renders it being unable to bind to allolactose. When *E. coli* is being grown and incubated in a medium with only lactose, what will be the effect of this mutation on the bacteria population after 16 hours?

A Remain constant.

B Increase slowly.

C Increase exponentially.

D Decrease sharply.

HELP

lac repressor is synthesised in its active conformation and binds to the operator. As the *lac* repressor protein is unable to bind to allolactose, it remains in its active conformation. Thus, RNA polymerase is unable to bind to the promoter, and unable to transcribe the genes of the *lac* operon. β-galactosidase, lac permease and β-galactoside transacetylase are not produced.

As there is an absence of β-galactosidase, lactose is not hydrolysed into glucose and galactose. The bacteria population is unable to use the respiratory substrates as source of energy for growth. Thus the population will decrease sharply.

Q33

Which of the following is false regarding the bacterial chromosome?

A It consists of a single, circular DNA molecule.

B DNA replication begins at the origin of replication.

C Its centromeres uncouple during metaphase of mitosis.

D It is highly folded within the cell.

HELP

Centromeres are only found in eukaryotic chromosomes and not in prokaryotes.

Q34

If the *trp* operon were unable to produce any enzymes regardless of the presence or absence of the amino acid tryptophan, what could be the likely reason for this?

A Tryptophan is always bound to repressor.

B Operator sequence has been deleted.

C Repressor is unable to bind to operator.

D *trp R* has been deleted.

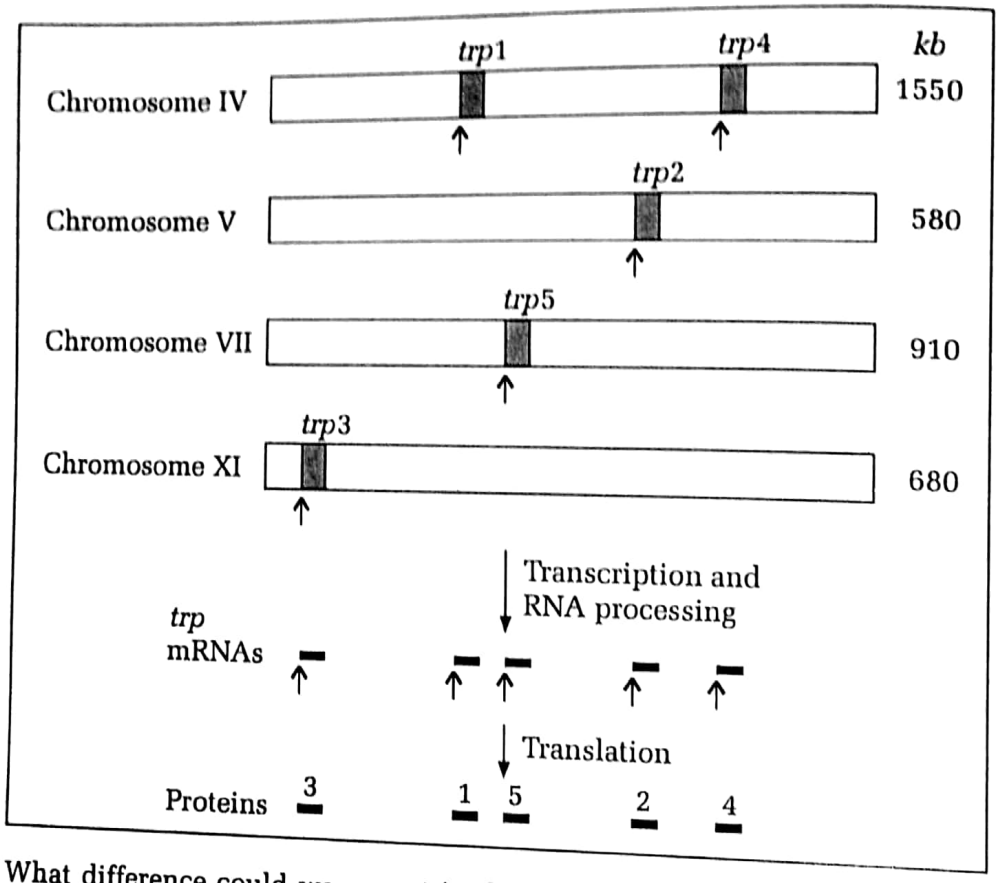
HELP

Option B, C and D will result in the continuous transcription of the *trp* operon, as the RNA polymerase will be able to bind to the promoter and carry out transcription. This will lead to the continuous production of the enzymes.

Only option A turns off the *trp* operon and prevents RNA polymerase from carrying out transcription.

Q35

trp1 **to 5 (shaded in diagram) are five genes coding for five different enzymes involved in tryptophan synthesis in yeast cells.**



What difference could we expect in the organization of the *trp* genes in a bacterial cell?

A Each *trp* gene would be on a different circular chromosome rather than a linear chromosome.

B Each *trp* gene would have their own promoter and terminator.

C *trp* genes would produce polycistronic mRNA.

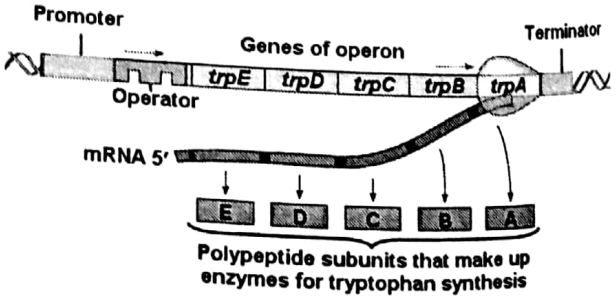
D *trp* genes would give rise to more types of mRNA.

HELP

Option A: There is only circular chromosome in a bacteria cell.

Option B: All the trp genes are arranged in an operon. An operon is a cluster of genes that make up a single transcription unit i.e. these genes are transcribed as a single mRNA molecule and controlled by the same promoter and operator.

Option C: The mRNA transcribed is a polycistronic mRNA



Option D: The *trp* genes would not give rise to more types of mRNA.

Topic 3 Genetics of Viruses and Bacteria

Q1 B	Q2 C	Q3 D	Q4 D	Q5 A	Q6 D	Q7 D	Q8 C
Q9 D	Q10 B	Q11 A	Q12 A	Q13 C	Q14 A	Q15 C	Q16 D
Q17 A	Q18 D	Q19 C	Q20 A	Q21 C	Q22 C	Q23 A	Q24 C
Q25 D	Q26 B	Q27 C	Q28 A	Q29 D	Q30 C	Q31 B	Q32 D
Q33 C	Q34 A	Q35 C					

TOPIC

4

Organisation and Control of Prokaryotic and Eukaryotic Genome

You should try to answer on your own before resorting to **HELP**.

Q1

Which of the listed features are characteristic of a eukaryotic genome?

1. circular DNA
2. DNA associated with histone
3. DNA may be transferred to new cells by mitosis

A 1 only

B 2 only

C 1 and 3

D 2 and 3

HELP

Statement 1: Each eukaryotic chromosome consists of one linear, double-stranded DNA.

Statement 2: Two major types of proteins (histones and non-histones) are associated with DNA of eukaryotes.

Statement 3: In mitosis, DNA is replicated before the cell divides. At the end of mitosis, the dividing cell transmits copies of its DNA to its daughter cells.

Q2

One stage during protein synthesis in eukaryotic cells involves preliminary mRNA, known as pre-mRNA. The pre-mRNA is made up of exons and introns.

What describes the next stage in the process?

A All the exons are removed, so that the introns can be translated.

B All the introns are removed, so that the exons can be translated.

C Some of the introns and exons are removed, so that the remaining exons and introns can be translated.

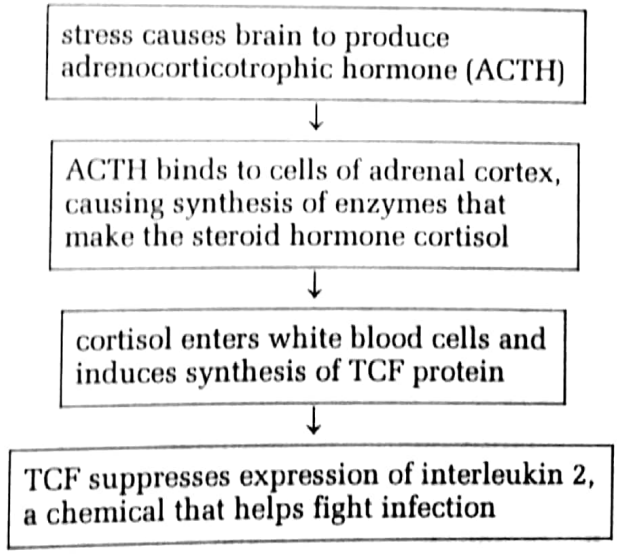
D All the exons and introns are translated.

HELP

Through the mechanism called RNA splicing, introns that are interspersed within pre-mRNA are excised and removed while the exons are spliced together. The exons are expressed by translation into polypeptide.

Q3

When a person undergoes a stressful experience, the immune system can be depressed too and become more susceptible to infection. Some of the elements involved in this chain of events are shown in the diagram below.



Which combination correctly shows the genes that have transcription-enhancing factors bound to their control elements during the above sequence of events?

	gene for ACTH	gene for TCF	gene for interleukin 2
A	✓	–	–
B	–	✓	✓
C	✓	✓	–
D	–	–	✓

HELP

Transcription-enhancing factors bind to the control element, the enhancers, of the genes. Binding of transcription-enhancing factor to enhancer accelerates the assembly of a transcription initiation complex at the promoter and increases the rate of transcription of the gene. This results in the synthesis of a specific protein.

From the diagram, there is increase production of ACTH, the enzymes that make the steroid hormone cortisol and TCF protein, while there is a decrease in the production of interleukin 2. This suggests that only the genes for ACTH and TCF have transcription-enhancing factors bound to their control elements – enhancer.

Q4

Four different genes are regulated in different ways.

Gene 1 undergoes tissue-specific patterns of alternative splicing. Gene 2 is part of a group of structural genes controlled by the same regulatory sequences. Gene 3 is in some circumstances subjected to methylation. Gene 4 codes for a repressor protein which acts at an operator site close by.

Which row of the table correctly identifies which genes are prokaryotic and which are eukaryotic?

	prokaryotic	eukaryotic
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 3	1 and 4
D	2 and 4	1 and 3

HELP

Alternative splicing takes place only in the eukaryotic nucleus before the mRNAs are dispatched to the cytoplasm.

Only prokaryotic genes are organised into operons. An operon is a cluster of structural genes that make up a single transcription unit i.e. these genes are transcribed as a single mRNA molecule and controlled by the same promoter and operator.

DNA methylation is catalyzed by DNA methyltransferase on the DNA of eukaryotes.

A repressor protein is specific for the operator of a particular operon in the prokaryotes.

Q5

Seeds from a pure breeding plant were planted in identical pots of compost and watered regularly. Sets of ten pots were placed in different light conditions and left until the first leaves had developed.

The table shows the mean height for the young stems, mean length of first leaf and the colour of the leaves.

	no light	dim light	bright light
mean height / cm	8	6	4
mean leaf length / cm	1.5	1.4	1.4
colour of leaves	pale yellow	pale green	dark green

Which explains the effect of light on the phenotype of the young plants?

A The activity of genes involved in chlorophyll synthesis and stem growth varies with light intensity.

B The activity of genes involved in stem and leaf growth is decreased by light.

C The genes involved in chlorophyll synthesis and stem growth are activated by light.

D The genes involved in chlorophyll synthesis and stem growth are inactivated by light.

HELP

From the table, as light intensity increase from no light to bright light, the colour of leaves changes from pale yellow to dark green. The green in the leaves is a result of the presence of chlorophyll. This suggests that the gene involved in chlorophyll synthesis increases in activity as the light intensity increases.

From the table, as light intensity increase from no light to bright light, the mean height of the stem decreases from 8 cm to 4 cm. This suggests that the gene involved in stem growth decreases in activity as the light intensity increases.

Q6

These statements describe types of DNA.

1. DNA with two 5' and two 3' ends
2. DNA not packaged with proteins
3. coding DNA interrupted by non-coding DNA
4. DNA with no 5' and 3' ends

Which combination of statements describes the DNA characteristics of a eukaryotic genome?

A 1 and 2

B 1 and 3

C 2 and 3

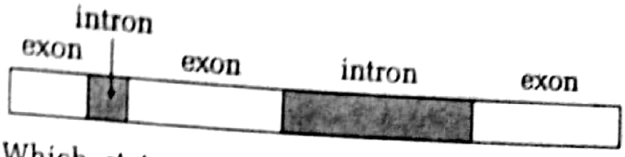
D 2 and 4

HELP

Each eukaryotic chromosome consists of one linear DNA complexed with proteins – histones and non-histones. The DNA consists of two DNA chains coil round each other to form a double helix. Each chain has two distinct ends: a 3' end and a 5' end. The proteins help to pack the DNA into highly compact structures. Eukaryotic chromosome has coding sequence (exons) interspersed with non-coding DNA sequences (introns).

Q7

The diagram represents the region of DNA that codes for β haemoglobin.



Which statement about the transcription and translation of exons and introns is correct?

A Exons and introns are both transcribed but only the exons are translated.

B Exons and introns are both transcribed but only the introns are translated.

C Only the exons are transcribed and translated.

D Only the introns are transcribed and translated.

HELP

Transcription is the synthesis of an mRNA molecule with a base sequence complementary to a gene which specifies the amino acid sequence of polypeptides and proteins. Most eukaryotic genes and their pre-mRNA have long non-coding stretches of nucleotides (introns) that are not translated.

Most of these introns are interspersed between coding segments (exons) of the gene, and thus between coding segments of the pre-mRNA.

Through a mechanism called RNA splicing, introns that are interspersed within RNA transcript are excised and exons are spliced together. The exons are expressed by translation into polypeptide.

Q8

What are the correct characteristics for a prokaryotic genome?

	Promoters	DNA always bound to histone proteins	Plasmids often present	Repeat sequences absent or uncommon
A	✓	–	–	–
B	–	✓	✓	✓
C	–	✓	–	–
D	✓	–	✓	✓

HELP

Option A: Plasmids are often present in prokaryotes and repeat sequences are absent or uncommon in prokaryotes.

Option B and C: Prokaryotic genome is not complexed with proteins – histones and non-histones.

Q9

Promoters and control elements work together to regulate transcription. What shows the possible locations of these in relation to a transcription start site on the DNA molecule?

	promoters	*control elements*
A	downstream	distal or proximal
B	upstream	distal or proximal
C	distal or proximal	downstream
D	distal or proximal	upstream

HELP

The promoter is made up of a basal promoter which is usually located within 40 base pairs from the transcription start site, and an upstream promoter (proximal control element) which may be located as far as 200 base pairs from the transcription start site.

Control elements can be divided into two kinds, depending on the distance from the basal promoter: proximal control elements and distal control elements. Enhancers and silencers are distal control elements.

Q10

What prevents simultaneous transcription and translation in eukaryotes?

A The absence of three different RNA polymerases.

B The lack of gene clusters into operons.

C The nuclear membranes around DNA.

D The requirement to remove exons.

HELP

In eukaryotes, transcription occurs in the nucleus while translation occurs in the cytoplasm. The matured mRNA has to be transported to the cytoplasm for translation to take place. This is because, in eukaryotic cells, the translation machineries are found in the cytoplasm and are separated from the nucleus by the nuclear membrane.

Q11

Transcription in eukaryotes may involve the use of an enhancer.

What describes the role of an enhancer?

A It is a binding site for an activator protein.

B It is a gene that increases the production of an activator protein.

C It is a promoter that increases the activity of RNA polymerase.

D It is a protein that activates a specific promoter.

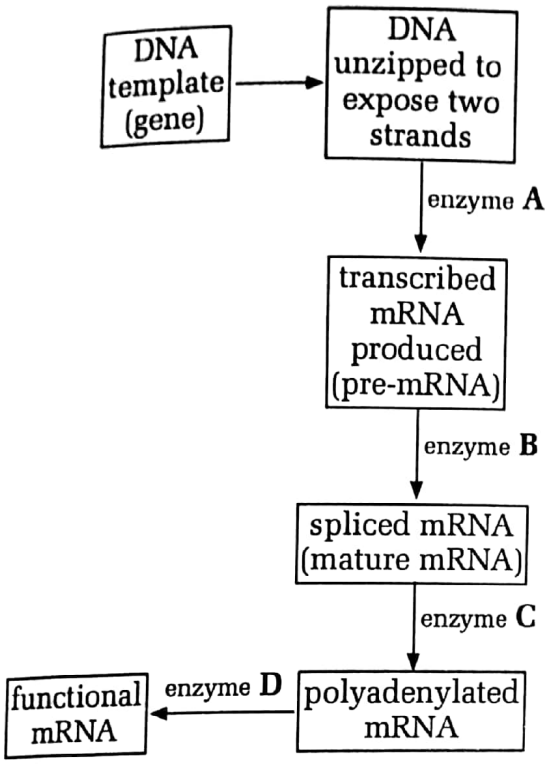
HELP

Enhancers are positive regulatory elements (segments of non-coding DNA that help regulate transcription of a gene) that can be located upstream, downstream of start site or even within the gene they control. An enhancer region may contain one or more elements recognized by transcriptional activator proteins.

Q12

The production of functional mRNA is controlled by a series of enzymes.

Which enzyme catalyses the removal of introns during the production of functional mRNA?



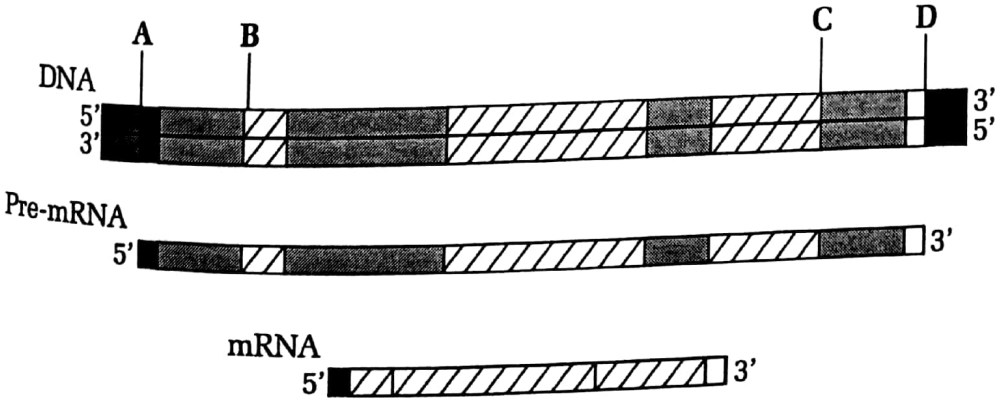
HELP

Enzyme B: spliceosome (a complex of proteins and small nuclear RNA). Pre-mRNA undergoes RNA splicing by spliceosome to become matured mRNA.

Q13

The diagram shows the processing of transcribed pre-mRNA from a eukaryote.

At which part of the DNA molecule does transcription start?



HELP

Option A is the transcription start site.

Option B & C are the exons.

Option D is special sequence of bases in the DNA template called a terminator. This sequence signals the RNA polymerase to stop the transcribing process.

Q14

A region of eukaryotic DNA consists of over fifty repeats of the same sequence of twelve bases. Where is this repetitive region least likely to be found?

A an exon

B an intron

C a polymerase binding site

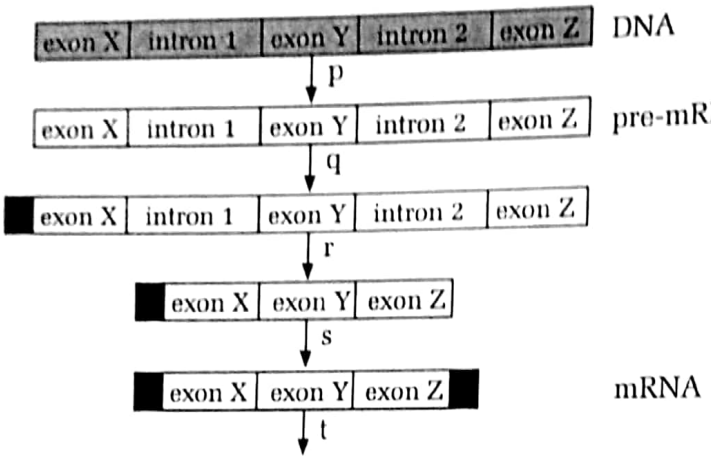
D satellite DNA

HELP

An exon is the coding segment of the gene that is eventually translated into amino acid sequences. Repetitive region are least likely to be found in the exon.

Q15

The diagram represents the processing of pre-messenger RNA.



During the processing of pre-messenger RNA each of the listed events occurs.

1. capping
2. polyadenylation
3. splicing
4. transcription
5. translation

Which correctly identifies the processes p, q, r, s and t?

	p	q	r	s	t
A	5	1	3	2	4
B	4	1	3	2	5
C	5	2	1	3	4
D	4	2	1	3	5

HELP

Event p is transcription. It is the synthesis of an mRNA molecule with a base sequence complementary to a section of DNA.

Event q is capping.

Event r is splicing. The introns that are interspersed within pre-mRNA are excised and removed while the exons are spliced together.

Event s is polyadenylation. An enzyme adds a poly-A tail to the 3′ end of the mRNA.

Event t is translation.

Q16

Which of the following is **NOT** true about cancerous cells?

A ability to divide for a certain number of times

B ability to divide further when in contact with neighbouring cells

C inability to differentiate properly

D inability to exhibit anchorage dependence

HELP

Cancer is a condition of uncontrolled proliferation of cells. Cancerous cells are able to divide infinitely.

Q17

What causes cancer in cells?

I Damage to genes

II Chemical damage to cell membranes

III UV damage to transport proteins

A I only.

B III only.

C I and III only.

D All of the above.

HELP

Cancer occurs as a result of:

1) mutations in proto-oncogenes, tumour suppressor genes and genes leading to the activation of telomerase
2) aberration of genes that regulate apoptosis
3) sustained angiogenesis
4) tissue invasion and metastasis

Q18

All of the following scenarios describe gene amplification except for

A During amphibian development, millions of additional rDNA exist as circular DNA in nucleoli separated from the chromosomes.

B Proto-oncogene replicates many copies of itself resulting in excessive amount of normal growth-stimulating protein.

C Proto-oncogene duplicates itself and transposes to a new locus under new gene regulatory control system.

D Primers that flank a portion of DNA sequence, oligonucleotides, Taq polymerase are added to a reaction mixture and put through cycles of three different temperatures.

HELP

Gene amplification refers to the process by which a cell specifically increases the number of copies of a particular gene to a greater extent, without a proportional increase in the number of copies of other genes composing the remainder of the genome. These amplified genes can be transcribed and translated, leading to an overproduction of the corresponding mRNAs and proteins.

In option C, there is only 1 addition copy of the proto-oncogene and there is no overproduction of the corresponding protein.

Q19

The table shows changes that may occur to genes associates with the development of cancer.

Which combination of changes leads to the development of cancer?

Type of gene	proto-oncogene	tumour suppressor gene	programmed cell death gene
A	activated	activated	activated
B	activated	inactivated	inactivated
C	inactivated	activated	activated
D	inactivated	inactivated	activated

HELP

Activation of proto-oncogene produces protein products that stimulate cell division in a normal cell.

Tumour suppressor gene inhibits cell division in a normal cell to prevent inappropriate growth. Inactivation of tumour suppressor gene leads to absence of suppression.

Inactivation of programmed cell death gene cause cells to evade programmed cell death, even when the cells are irreparably damaged, making them immortal.

All of the above allows the cells to maintain proliferation leading to the development of cancer.

Q20

Which of the following protein groups contain examples of oncogene products?

(i) transcription factors

(ii) cell surface receptors

(iii) peptide hormones

(iv) protein kinases

A (i) and (iv)

B (i), (ii) and (iii)

C (ii) and (iv)

D All of the above

HELP

Proto-oncogenes undergo mutation to become oncogenes. Proto-oncogenes code for proteins that stimulate normal cell growth and division. These gene products include transcription factors, growth factors such as peptide hormones, cell surface receptors such as growth factors receptors, protein kinases, inhibitors of apoptosis, etc.

Q21

Which of the following is NOT a mechanism whereby a proto-oncogene is converted to an oncogene?

A methylation of bases

B point mutation

C gene transposition

D chromosome translocation

HELP

Mechanisms whereby a proto-oncogene is converted to an oncogene includes:

1) Point mutation in a proto-oncogene – A point mutation can change the gene's protein product to one that is more active or more resistant to degradation than normal protein.

2) Gene transposition or chromosome translocation – Translocation of either the gene or promoter within a chromosome. The translocation can result in the proto-oncogene to be situated adjacent to an active promoter, resulting in increased transcription of the gene and hence overproduction of the protein.

Q22

Which of the following does NOT lead to cancer formation?

A Both tumour suppressor alleles are knocked out by mutation.

B Infection by viruses.

C Gene for telomerase is inactivated.

D Production of Ras oncogene.

HELP

Mutations in both tumour suppressor genes lead to the decrease in the activity of tumour suppressor proteins. This results in cancer as growth is stimulated when there is absence of suppression.

Some viruses when introduced into cells have the ability to transform a benign cell to a malignant cell via the integration of the viral nucleic acid into the DNA of host cell.

Mutations in Ras proto-oncogene to become Ras oncogenes. Mutated Ras protein increase cell division even in the absence of growth factors resulting in cancer formation.

Q23

Which of the following statements concerning proto-oncogenes is FALSE?

A They can code for proteins associated with cell growth.

B They are produced by somatic mutations induced by carcinogenic substances.

C They can be involved in producing proteins for cell adhesion.

D They can code for proteins involved in cell division.

HELP

Proto-oncogenes code for proteins that stimulate normal cell growth and division. These gene products include transcription factors, growth factors such as peptide hormones, cell surface receptors such as growth factors receptors, protein kinases, inhibitors of apoptosis, etc.

Oncogenes and not proto-oncogenes are produced by somatic mutation.

Q24

Control of gene expression in eukaryotes includes all of the following EXCEPT

A alternative splicing of RNA transcripts.

B transcription factors.

C feedback inhibition of enzyme activity by allosteric control.

D DNA methylation.

HELP

Gene expression in eukaryotes is controlled at:

1) chromatin level via Chromatin modification such as histone acetylation and DNA methylation
2) transcriptional level through the activity of regulatory transcriptional factors
3) post-transcriptional level e.g. 5′ capping, poly-A tailing and pre-mRNA splicing
4) translational e.g. half life of RNA, initiation of translation, and
5) post-translational level e.g. biochemical modification and protein degradation

Q25

The major control of gene expression in mammalian cells is

A effected through different levels of polyadenylation of the mRNA.
B at the transcriptional level.
C at the translational level.
D at the post-translational level.

HELP

The major control of gene expression in mammalian cells is at transcriptional level through the activity of regulatory transcriptional factors. Transcription factors is able to gain access to and bind to their target sequences in the basal promoter region, transcription also involves and depends on the activity of regulatory transcriptional factors.

Q26

Closely-coupled transcription-translation is possible in prokaryotes because

A there is no nuclear membrane separating the prokaryotic DNA from the cytoplasm.
B the prokaryotic genome is more complex than the eukaryotic genome.
C the methylated 5' guanine end of prokaryotic mRNA is transcribed first.
D there is an absence of an origin of replication.

HELP

In prokaryotes, control of transcriptional initiation is the major point of regulation. This is due to the absence of a nuclear envelope in prokaryotes which allows concurrent transcription and translation to occur.

Q27

Which of the following is an example of a possible step in the post-transcriptional control of gene expression?

A Gene amplification during a stage in development.
B The removal of introns and splicing together of exons.
C The binding of transcription factors to a promoter.
D The addition of methyl groups to cytosine bases of DNA.

HELP

Post-transcriptional control of gene expression includes 5′ capping, poly-A tailing and pre-mRNA splicing. In pre-mRNA splicing, removal of introns and splicing together of exons occurs.

Q28

Which of the following statements concerning telomeres is/are true?

A Telomeres are made up of a repetitive DNA sequence at the ends of each chromosome.

B Telomeres protect cells from losing vital chromosomal DNA sequences during DNA replication.

C Telomeres are lost in cells that don't express telomerase, limiting the number of cell divisions a cell can undergo.

D All of the above.

HELP

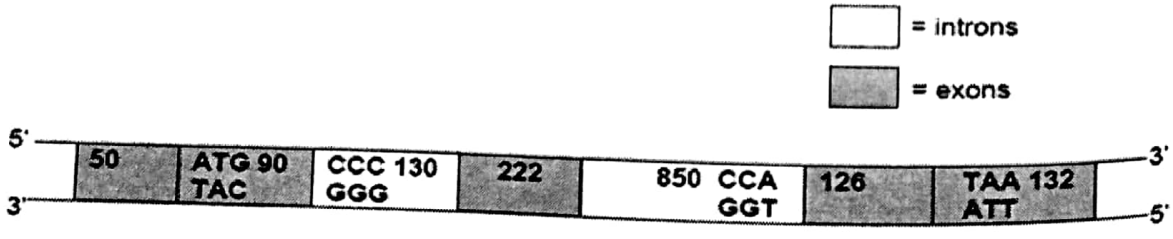
Option A: Telomeres are made of tandem repeats of 5' TTAGGG 3' minisatellites. The repeat sequence is hundreds to as many as 2000 repeats of the six nucleotide sequence.

Option B: Telomeres prevent lost of genes as the DNA shortens with each round of DNA replication.

Option C: Inability of DNA polymerase to replicate to the end of chromosome. Hence in cells that don't express telomerase, telomeres shorten with each round of DNA replication. Telomeres that are critically short trigger apoptosis (programmed cell death), hence limiting the number of cell divisions a cell can undergo.

Q29

Shown in the figure below is the genomic structure of the wild-type human β-globin gene. The numbers within the boxes indicate the length of nucleotides of each region, INCLUSIVE of bases stated in the diagram. The DNA sequences corresponding to the start codon and the stop codon are indicated.



What is the length (in nucleotides) of the wild-type β-globin primary RNA transcript (pre-mRNA) and how many amino acids are present in the wild type β-globin protein?

	Length of β-globin primary RNA transcript	No. of amino acid in wild-type β-globin protein
A	1600	146
B	620	146
C	1600	206
D	620	206

HELP

To calculate the length of the wild-type β-globin primary RNA transcript (pre-mRNA), sum up all the length of nucleotides of all the introns and exons.

50 + 90 + 130 + 222 + 850 + 126 + 132 = 1600

To calculate the number of amino acids present in the wild type β-globin protein, sum up all the length of the length of nucleotides of all the exons, beginning with the exon with ATG (which will code for AUG-start codon) and stopping before the exon with TAA (which will code for UAA-stop codon).

(90 + 222 + 126) / 3 = 146

Q30

A gorilla mRNA differs from *E. coli* mRNA in that

A the 5' end of the gorilla mRNA is processed.

B the 3' end of the *E. coli* mRNA is processed.

C only the gorilla mRNA contains a start codon.

D only the gorilla mRNA can be translated into a polypeptide.

HELP

In prokaryotes eg. *E. coli*, there is absence of post-transcriptional control of gene expression 1) 5′ capping, 2) poly-A tailing and 3) pre-mRNA splicing. Both prokaryotes and eukaryotes (such as gorilla) mRNA contains a start codon and can be translated into a polypeptide.

Q31

The table below shows some of the events which take place in protein synthesis.

1 tRNA molecules bring specific amino acids to the ribosome.

2 Ribonucleotides join with exposed DNA bases and form a molecule of mRNA.

3 Release factor binds to mRNA.

4 Peptide bonds formed between amino acids.

5 mRNA molecule leaves the nucleus.

6 mRNA undergoes capping and addition of poly(A) tail.

List down the correct sequence of occurrence of these events.

A 2 5 6 1 4 3

B 2 6 5 1 4 3

C 2 6 5 1 3 4

D 2 5 6 1 3 4

HELP

In protein synthesis, transcription occurs where ribonucleotides join with exposed DNA bases and form a molecule of pre-mRNA. This is followed by post-transcription modification, 5′ capping, poly-A tailing and pre-mRNA splicing of pre-mRNA to mature mRNA. The mature mRNA leaves the nucleus. Translation next takes place where tRNA molecules bring specific amino acids to the ribosome and peptide bonds formed between amino acids. Translation occurs till one of the stop codon is in the A site of the ribosome. Release factor will bind to the stop codon of the mRNA and translation stops.

Q32

Which of the following statement about chromosome structure is true?

1 Linker DNA refers to the linear double-stranded DNA between adjacent nucleosomes.

2 The 30 nm chromatin fibre has a solenoid structure.

3 The 300 nm chromatin fibre is attached to multiple locations on a central protein scaffold.

4 Euchromatin is the more diffuse region of the interphase chromosome and is transcriptionally inactive.

A 1 and 2 B 1 and 4

C 2 and 3 D 3 and 4

HELP

Nucleosome is the most basic level of DNA packing in eukaryotes. DNA wound around a histone octamer consisting of 2 molecules of H2A, H2B, H3 and H4 each to form a nucleosome.

Statement 1: Individual nucleosomes are connected by strands of linker DNA and H1 histones to give a nucleohistone complex.

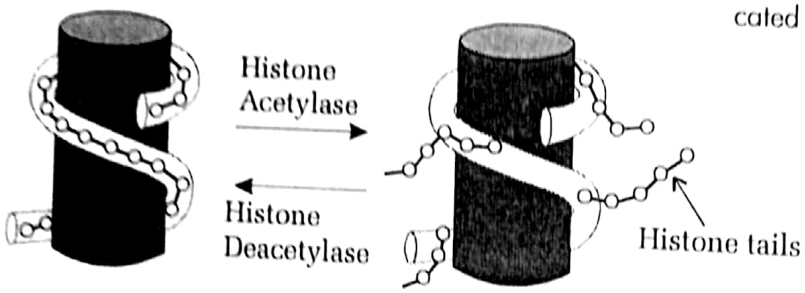
Statement 2: With the aid of H1 histones, the string of nucleosomes coils to form a 30 nm wide chromatin fibre that has a solenoid structure.

Statement 3: The 30 nm chromatin fibre folds to form looped domains (300 nm chromatin fibre) that are attached to a base of scaffolding proteins (non-histones).

Statement 4: Euchromatin refers to the regions of chromatin that are loosely packed. Genes within these regions are transcriptionally active and can be expressed.

Q33

As shown in the diagram below, acetylation of histones promotes loose chromatin structure. Recent evidence has shown that chemical modifications of histones play a direct role in regulation of gene transcription. Suggest how this works.



A Helicase action is enhanced with acetylation of the histones.

B Acetylation of histone tails neutralises their negative charges and encourage binding of DNA polymerase I.

C When nucleosomes are highly acetylated, the chromatin becomes less compact and DNA is more accessible for transcription.

D RNA polymerase work better by binding to acetylated groups.

HELP

When histones of a nucleosome are acetylated, the affinity of histone for DNA is reduced. The histones change shape and results in the loosening of histone complex from DNA. As a result, transcription factors have easier access to genes in the acetylated region and increasing the rate of transcription.

Q34

Which of the following is false regarding the bacterial chromosome?

A It consists of a single, circular DNA molecule.

B DNA replication begins at the origin of replication.

C Its centromeres uncouple during metaphase of mitosis.

D It is highly folded within the cell.

HELP

A centromere is the specialized constricted region on eukaryotic's chromosome where two sister chromatids are joined in a replicated chromosome.

Q35

Which of the following structures of a eukaryotic chromosome is not primarily composed of DNA?

A telomeres

B origin of replication

C kinetochore

D centromeres

HELP

The DNA in the centromeric region is often heavily methylated and includes satellite sequences. They consist of specific DNA sequences to which a number of centromere-associated proteins bind, forming a specialized structure called the kinetochore.

Q36

Which of the following are properties of enhancers?

(i) **They are located away from the gene they control.**

(ii) **They are recognized by transcriptional activators.**

(iii) **They decrease the expression of the gene they control.**

(iv) **They increase the expression of the gene they control.**

A (iv) only.

B (i) and (iv) only.

C (i), (ii) and (iii).

D (i), (ii) and (iv).

HELP

Statement (i): Enhancers are normally located upstream of start site. (Most of them are located thousands of nucleotides upstream and could be far from promoter.)

Statement (ii): An enhancer region may contain one or more elements recognized by specific transcriptional factors called transcriptional activators.

Statement (iii) and statement (iv): Binding of activators to enhancers accelerates the assembly of a transcription initiation complex at the promoter and increases the rate of transcription of the gene.

Topic 4 Organisation and Control of Prokaryotic and Eukaryotic Genome

Q1 D	Q2 B	Q3 C	Q4 D	Q5 A	Q6 B	Q7 A	Q8 D
Q9 B	Q10 C	Q11 A	Q12 B	Q13 A	Q14 A	Q15 B	Q16 A
Q17 A	Q18 C	Q19 B	Q20 D	Q21 A	Q22 C	Q23 B	Q24 C
Q25 B	Q26 A	Q27 B	Q28 D	Q29 A	Q30 A	Q31 B	Q32 A
Q33 C	Q34 C	Q35 C	Q36 D				

TOPIC 5

Genetic Basis for Variation

You should try to answer on your own before resorting to **HELP**.

Q1

In Man, the **A**, **B**, **AB**, **O** blood groupings are controlled by a system of multiple alleles. A man of blood group **A** marries a woman of blood group **B** and they have one child. Which one of the following statements about the child's blood is correct?

A It could only be group **A**.

B It could only be group **A** or group **B**.

C It could only be group **AB**.

D It could be any of the groups **A**, **B**, **AB**, **O**.

HELP

	Possibility 1:	Possibility 2:
Blood group:	A × B	A × B
Genotype:	$I^AI^A \times I^BI^B$	$I^AI^O \times I^BI^O$
Gametes:	I^A I^B	I^A I^O I^B I^O
Child's Blood group:	AB	AB, A, B or O

Q2

In domestic cats the genes for yellow fur and black fur are an allelic pair which are sex-linked and codominant.

When black females are mated with yellow males, which one of the following is the expected proportion of heterozygotes in the offspring?

A 0%

B 25%

C 50%

D 75%

HELP

B: allele for black fur

Y: allele for yellow fur

Phenotype:	Black	×	Yellow
	X^BX^B	×	X^YY
Gametes:	X^B X^B		X^Y Y
F_1:	X^B X^Y	X^BY	X^B X^Y X^BY
i.e.	X^B X^Y :	X^BY	

Q3

A pure-breeding plant with the dominant phenotype of character **P** and the recessive phenotype of character **Q** was crossed with another pure-breeding plant with the recessive phenotype of character **P** and the dominant phenotype of **Q**. The offspring of this cross were crossed with a double homozygous recessive for **P** and **Q** and the following results obtained:

— 22 were phenotypically dominant for **P** and recessive for **Q**.

— 5 were phenotypically dominant for both **P** and **Q**.

— 4 were phenotypically recessive for both **P** and **Q**.

— 24 were phenotypically recessive for **P** and dominant for **Q**.

Which one of the following types of inheritance is illustrated by these results?

A gene linkage of **P** and **Q**

B independent segregation of **P** and **Q**

C Mendelian dihybrid inheritance

D multiple alleles

HELP

1st crossing			
Parental phenotype:	Pq	×	pQ
Parental genotype:	PPqq	×	ppQQ
Meiosis Gametes:	Pq		pQ
Fertilisation F_1 genotype:		PpQq	

2nd crossing			
F_1 phenotype:	PQ	×	pq
F_1 genotype:	PpQq	×	ppqq
Meiosis Gametes:	PQ Pq pQ pq	×	pq
Fertilisation F_2 genotype:	PpQq : Ppqq : ppQq : ppqq		
F_2 phenotype:	PQ : Pq : pQ : pq		

Hence, if the P and Q genes are not linked and there is independent assortment, the ratios of the four phenotypes should be 1:1:1:1. However, since P is linked to q and p is linked to Q (deduced from the original parental genotypes), there is significantly more Pq and pQ phenotypes. The small numbers of pq and PQ phenotypes obtained are due to crossing over during meiosis I.

Q4

Which one of the following phenotypic features of Man can be affected **only** by the genotype?

A height

B intelligence

C skin colour

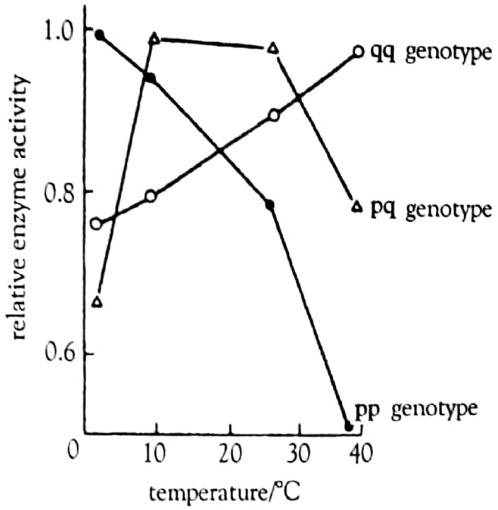
D number of different blood group antigens

HELP

All the above choices are phenotypic characteristics which can be affected by the environment. The number of different blood group antigens is only affected by the genotype.

Q5

In the North American catfish *Catostomus clarki*, two alleles, represented by **p** and **q**, control the synthesis of a vital enzyme. The three possible genotypes (**pp**, **pq**, **qq**) lead to the synthesis of variations of the same enzyme with different temperature optima as shown in the graph below.



When the mean annual temperature is 5 °C, which one of the following is correct?

A Allele **p** will be positively selected for.

B Allele **q** will be positively selected for.

C Allele **p** will become dominant and **q** recessive.

D The heterozygotes will have a selective advantage over the homozygotes.

HELP

At 5 °C, the genotype pp has the highest relative enzyme activity. Such optimum function will be favourable at this temperature.

Q6

In a certain species, the density of hairs on the upper epidermis of the leaf is believed to be determined entirely by a single pair of alleles which show incomplete dominance.

Which one of the following is the maximum number of different hair densities consistent with the view that environmental factors have no influence?

A 1 B 2
C 3 D 4

HELP

Assuming that the genotype for hair density on the upper epidermis is AB, where both alleles show incomplete dominance. The maximum number of different hair densities will be AA, AB and BB.

Q7

An entomologist collected from one habitat four types of black, white and red ladybird beetle (Coccinellidae) illustrated below.

Each of the forms were of both sexes and when crossed together with the other colour forms produced fertile offspring in one or more of these discrete colour forms without intermediates. What conclusion can be made from this investigation?

A The beetles are from four closely related species.

B The species has colours forms that are continuously variable.

C The colour forms are influenced by environment and are not under genetic control.

D The species shows a discontinuous variation due to genetic polymorphism.

HELP

There is no clear transition between the different coloured beetles, a phenomenon known as discontinuous variation. Although they are different in appearance, the offspring produced are still fertile in that they are of the same species.

Q8

Which one of the following genotypes cannot occur amongst the offspring from a mating between a person of blood group **A** and a person of blood group **B**?

A AA **B** AB
C AO **D** BO

HELP

Phenotypes: A × B
Genotypes: I^AI^O × I^BI^O
F_1 genotypes: I^AI^B I^AI^O I^BI^O I^OI^O

Thus, the F_1 generation can be AB, AO, BO or OO, but not AA.

Q9

In mice, the gene for 'dappled' coat (**D**) and its recessive allele, the gene for 'plain' coat (**d**), are located on the **X**-chromosome. The gene for 'straight' whiskers (**W**) and its recessive allele, the gene for 'bent' whiskers (**w**), are autosomal. A male mouse with plain coat and bent whiskers was mated on several occasions to the same female and the large number of offspring consisted of the following phenotypes in equal proportion:

dappled male with straight whiskers
dappled female with straight whiskers
dappled male with bent whiskers
dappled female with bent whiskers
plain male with straight whiskers
plain female with straight whiskers
plain male with bent whiskers
plain female with bent whiskers

If X^D represents an **X** chromosome carrying a gene for 'dappled' coat and X^d represents an **X** chromosome carrying a gene for 'plain' coat, what is the genotype of the female parent?

A X^DX^DWW
B X^DX^DWw
C X^DX^dWW
D X^DX^dWw

HELP

The genotype of the male mouse is X^dYww. Since there are offspring with dappled coat, the female must have the dominant allele X^D. Since there are females with plain coats, i.e. with genotype X^dX^d, the female parent must also have the recessive allele X^d. Since there are both straight and bent whiskers among the offspring, the female must have both the dominant and recessive alleles, W and w. Hence, the female is heterozygous for both alleles.

Q10

Haemophilia is caused by a sex-linked, recessive allele.

Two parents have a haemophiliac son, a normal son and a haemophiliac daughter.

What are the most likely genotypes of the parents?

	mother	*father*
A	X^HX^h	X^hY
B	X^HY^h	X^HY
C	X^hX^h	X^HY
D	X^HY^H	X^hY

HELP

Since there is both a haemophiliac and normal son, the mother must have a heterozygous genotype. Since there is a haemophiliac daughter, the X chromosome from the father must have the recessive allele.

Q11

In the construction of chromosome maps, the evidence is derived mainly from

A cross-over values.

B electron microscopy.

C hereditary effects of chromosome fragmentation.

D genetic ratios.

HELP

In chromosome maps, it is postulated that the relative frequency of crossing-over would be a measure of the distance apart of genes. This frequency is known as the cross-over value.

Q12

A woman who is a carrier of haemophilia had phenotypically normal parents and is married to a man without the recessive haemophilia gene. Which one of the following statements is true?

A Her father must have been a carrier of haemophilia.

B Her mother also possessed the gene.

C All of her sons will be haemophiliacs.

D All of her daughters will carry the recessive gene.

HELP

Her father has only one X chromosome, and hence could only be normal or haemophilic. Since he was normal, the gene must have been passed from her mother to her. She still has one normal X chromosome, so only 50% of her sons would be haemophilic and only 50% of her daughters will carry the recessive gene. Because males only have one X chromosome, 50% of her sons would express the recessive gene phenotypically.

Q13

A linkage group is composed of genes which

A affect the same characteristic.

B associate during prophase I.

C are in the same nucleus.

D are situated on the same chromosome.

HELP

Linked genes are those which are located on the same chromosome.

Q14

Genes **P**, **Q**, **R** and **S** occur on the same chromosome. Investigation of a large population produced the following cross-over values between pairs of genes.

P and **R**	34%
P and **Q**	59%
R and **S**	12%
S and **Q**	37%

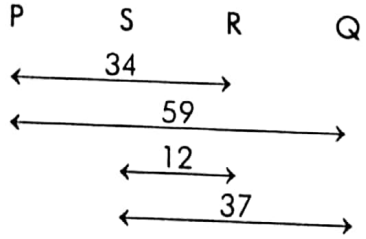
Which one of the following sequences of letters represents the sequence of genes on the chromosome?

A **PRSQ** **B** **PSRQ**

C **QSPR** **D** **RQSP**

HELP

In a linkage group, the relative frequency of crossing-over is a measure of the distance apart of genes. The higher the percentage, the further is the distance between the two genes. Therefore the sequence of the genes is PSRQ.



Q15

The following reaction sequence occurs in humans.

$$\text{phenylalanine} \xrightarrow{X} \text{tyrosine} \xrightarrow{Y} \text{carbon dioxide and water}$$

Phenylketonuria (PKU) is a disease caused by an enzyme deficiency in step X, and alkaptonuria (AKU) is due to an enzyme deficiency in step Y. Both conditions are rare and caused by recessive alleles.

A person with PKU marries a person with AKU. Which phenotypes would be expected for their children?

A all normal

B all AKU only

C all PKU only

D all both AKU and PKU

HELP

Assuming that since the conditions are rare, the person without the disease would probably have a homozygous dominant instead of a heterozygous dominant genotype. Hence all the children would have heterozygous genotypes for both diseases, which expresses as a normal phenotype.

Q16

In cats, the genes controlling coat-colour are co-dominant (incompletely dominant) and are carried on the X chromosomes. When a black female was mated with a ginger male the resulting litter consisted of black male and tortoise-shell female kittens. What phenotypic ratio would be expected in the F_2 generation?

A 1 black male: 1 ginger male: 2 tortoise-shell females

B 1 black male: 1 ginger male: 1 tortoise-shell female: 1 black female

C 2 black males: 1 tortoise-shell female: 1 ginger female

D 1 black male: 1 tortoise-shell male: 1 ginger female: 1 black female

HELP

B: allele for black coat
G: allele for ginger coat

Phenotype:	Black	×	Ginger
Genotype:	X^BX^B	×	X^GY
Gametes:	X^B X^B		X^G Y
F_1:	X^BX^G		X^BY
Gametes:	X^B X^G		X^B Y
F_2:	X^BX^B : X^BY : X^BX^G : X^GY		

Q17

Red-green colour blindness is a sex-linked recessive condition in Man. A man with normal vision and his colour-blind wife would expect to produce

A colour-blind sons and daughters with normal vision only.

B sons with normal vision and colour-blind daughters only.

C colour-blind sons, colour-blind daughters and daughters with normal vision only.

D sons with normal vision, colour-blind daughters and daughters with normal vision only.

HELP

b: allele representing red-green colour blindness

Phenotype: Normal × Colour blind

Genotype: X^BY × X^bX^b

Gametes: X^B Y X^b X^b

F_1 genotype: $X^B X^b$: X^bY

F_1 phenotype: Normal daughters and colour blind sons

Q18

Which one of the following features is an example of discontinuous variation in Man?

A blood group

B body mass

C height

D intelligence

HELP

All the above choices, except A, represent phenotypes which can be influenced by the environment, and hence show continuous variation. Blood group is a discontinuous trait and does not show a gradual transition between traits.

Q19

A woman with normal colour vision, whose father was red-green colour blind, married a red-green colour blind man. What is the probability of her first-born child being red-green colour blind?

A 1.0 B 0.75

C 0.66 D 0.50

HELP

X^r: recessive allele for red-green colour blindness

X^R: normal allele

Genotype: $X^R X^r$ × X^rY

F_1 genotype: $X^R X^r$: X^RY : $X^r X^r$: X^rY

The probability of the offspring being colour-blind is 0.50.

Q20

Polygenic inheritance forms the basis of

A codominance (incomplete dominance).

B continuous variation.

C discontinuous variation.

D linkage.

HELP

Continuous variation follows the Mendelian laws of inheritance. Polygenes are a collection of genes acting together and affecting variation in a continuous and inheritable way.

Q21

In the F_2 generation of a dihybrid cross between yellow, round seeded and green, wrinkled seeded pea plants, 17 out of 254 pea seeds were green and wrinkled. Other seeds were:

yellow and round;
green and round;
yellow and wrinkled.

What do these results indicate?

A Crossing-over has occurred.

B Green and wrinkled are both recessive characters.

C The alleles for green and wrinkled are linked.

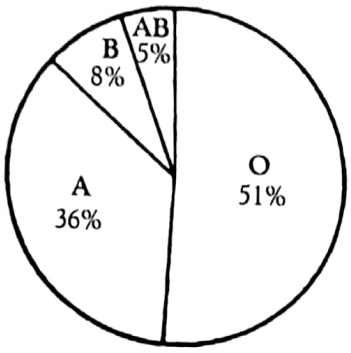
D The allele for green is recessive but not the allele for wrinkled.

HELP

The proportion of seeds that turn out to be green and/or wrinkled was very little, indicating that these two are both recessive characters, which are phenotypically expressed only if they are present in homozygous condition.

Q22

The pie chart shows the results of a survey of the incidence of blood groups **A**, **B**, **AB** and **O** amongst people in Britain.



Which of the following conclusions can be deduced from the diagram?

A Only 5% of individuals are heterozygous for blood group alleles.

B Group **O** is the most common as it is the homozygous recessive group.

C Group **O** is most common because it has the selective advantage of being the universal donor.

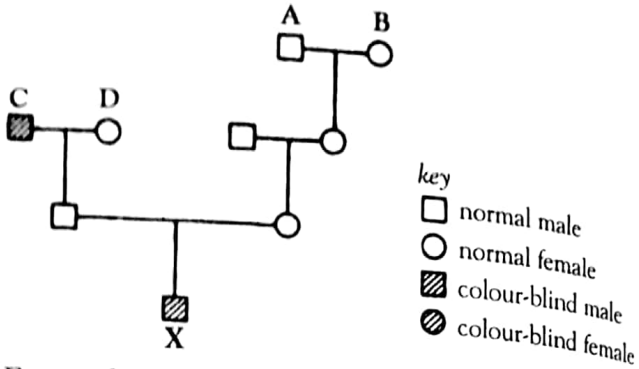
D Any individual, selected at random from the sample population, has a 1 in 20 chance of being blood group **AB**.

HELP

5% of the population are of blood group AB, i.e. 1 out of every 20 individuals is AB.

Q23

The diagram shows the pedigree of a family carrying the sex-linked allele for colour-blindness.



From which labelled member of his family did **X** inherit this disorder?

HELP

A normal male cannot be a carrier of the colour-blindness gene.

Q24

In the human **ABO** blood group system, there are six possible genotypes but only four phenotypes.

An explanation of this is that the **ABO** blood groups are controlled by

A one gene locus with three codominant alleles.

B one gene locus with two codominant alleles and two recessive alleles.

C one gene locus with two codominant alleles and one recessive allele.

D two unlinked gene loci each with two alleles, one dominant and one recessive.

HELP

The alleles A and B are co-dominant, and dominant over the O alleles. The O blood group can only be expressed when present in the homozygous condition.

Q25

Which of the following would cause phenotypic variation among organisms of the same genotype?

A continuous variation within the species
B different varieties of the same species
C different sexes
D exposure to different environments

HELP

Some phenotypes are influenced by the environment even if they are individuals of the same species, e.g. height and skin colour in humans.

Q26

In which of the following examples of human inheritance is the inheritance pattern explained by multiple alleles on an autosomal chromosome?

A the ABO blood group system
B cystic fibrosis
C Down's syndrome
D haemophilia

HELP

The ABO blood group system consists of alleles found on a gene locus. The rest of the choices below are sex-linked genes, i.e. genes found on the X or rarely on the Y chromosome.

Q27

What are the phenotypes of the parents of a colour-blind son and a non-carrier daughter with normal colour vision?

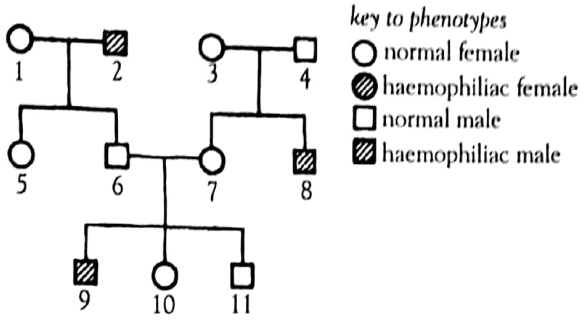
	father	*mother*
A	carrier	normal
B	colour-blind	carrier
C	colour-blind	colour-blind
D	normal	carrier

HELP

If b represents the allele for red-green colour-blindness and B the normal allele, the son's genotype will be X^bY and the daughter X^BX^B. Both parents must have at least an X^B allele since the daughter is homozygous dominant. The father is thus X^BY, i.e. normal, and the mother must be X^BX^b, a carrier.

Q28

The diagram shows the inheritance of haemophilia in a family.



key to chromosome types

X^H : normal X chromosome

X^h : X chromosome carrying allele for haemophilia

Y : normal Y chromosome

What is the genotype of person 7?

A X^HX^H B X^HY

C X^HX^h D X^hX^h

HELP

Normal males cannot be carriers of the haemophilia gene since they only have one X chromosome. Thus, male 6 is normal and 9 must have inherited the gene from his mother, 7. Since 7 is normal, she must be heterozygous for the gene, i.e. X^HX^h.

Q29

In the F_2 generation of a dihybrid cross, the phenotypes occurred in the ratio 3 : 1. What does this result indicate?

A the alleles were segregating independently.
B Polygenic inheritance was involved.

C Codominance was being shown.

D The gene loci were linked.

HELP

A normal dihybrid cross of autosomal genes will result in the dihybrid ratio of 9 : 3 : 3 : 1. However, because the genes are linked, the resulting ratio is 3 : 1, i.e. they occur on the same gene locus.

Q30

In birds, the male is the homogametic sex. A male bird showing the recessive trait was mated with a female showing the dominant trait of a characteristic governed by a pair of alleles which are sex linked.

What is the probability that the male offspring will show the dominant trait?

A zero B 0.25

C 0.50 D 1.00

HELP

Let X^A represent the dominant trait and X^a the recessive trait.

	Female	×	Male
Genotype:	X^AY	×	X^aX^a
F_1 genotype:	X^aY	:	X^AX^a

Thus all the males will be heterozygous dominant for the trait and the probability that the trait will be expressed phenotypically is 1.00.

Q31

A red-flowered plant crossed with a white-flowered plant of the same species, produced F_1 plants which all had pink flowers.

Self-pollination of the F_1 plants produced an F_2 generation in which 39 plants had red flowers, 83 had pink flowers and 40 had white flowers.

What does this experiment demonstrate?

A codominance

B continuous variation

C a dihybrid cross

D linkage

HELP

The alleles for red and white flowers are co-dominant, resulting in pink flowers when both are present in the genotype.

Q32

A cross between a round-leafed, tall plant and a round-leafed, dwarf plant produced the following offspring:

	key
121 round-leafed, tall plants	**R**: round leaf
124 round-leafed, dwarf plants	**r**: oval leaf
42 oval-leafed, tall plants	**T**: tall
37 oval-leafed, dwarf plants	**t**: dwarf

What were the genotypes of the parents?

A **RrTt × Rrtt**

B **RrTt × RRtt**

C **RrTT × Rrtt**

D **RrTT × RRtt**

HELP

In order for the expression of double recessive genotypes in the offspring, e.g. rrtt (oval-leafed, dwarf plants), both parents must have at least one recessive allele.

Q33

Why does haemophilia usually affect only males, although females may carry the gene responsible for the disease?

A The gene is inactive in the female.

B The gene is dominant only in males.

C The gene is carried on the **X** chromosome.

D The gene is carried on the **Y** chromosome.

HELP

The gene for haemophilia is carried on the X chromosome. A female will only be haemophilic of she has this gene in both her X chromosomes. A male, however, who carries one haemophilic gene together with a Y chromosome, will be haemophilic.

Q34

Which parental phenotypes would produce offspring with blood group phenotypes in the expected ratio of 1 type A : 1 type B?

	blood group of mother	*blood group of father*
A	A	B
B	AB	AB
C	AB	B
D	AB	O

HELP

The mother would have genotype I^AI^B and the father would have genotype I^OI^O. Thus, the two genotypes possible for their offspring would be I^AI^O and I^BI^O, with equal probability. Hence, the expected phenotypes would be 1 type A : 1 type B.

Q35

A cross between a tall plant with round leaves and a dwarf plant with round leaves produced the following offspring:

		key	
121	round leaf, tall	**R**	round leaf
124	round leaf, dwarf	**r**	oval leaf
42	oval leaf, tall	**T**	tall
37	oval leaf, dwarf	**t**	dwarf

What were the genotypes of the parents?

A **RrTt × Rrtt**

B **RrTt × RRtt**

C **RrTT × Rrtt**

D **RrTT × RRtt**

HELP

	RR	Rr	Rr	rr
Tt	RRTt Round leaf, tall	RrTt Round leaf, tall	RrTt Round leaf, tall	rrTt Oval leaf, tall
Tt	RRtt Round leaf, dwarf	Rrtt Round leaf, dwarf	Rrtt Round leaf, dwarf	rrtt Oval leaf, short

Q36

Why is haemophilia more likely to occur in human males than in human females?

A Females are the heterogametic sex.

B Females can only act as carriers.

C The allele for haemophilia is carried only on the X chromosome.

D The allele for haemophilia is carried only on the Y chromosome.

HELP

Females have chromosomes XX and males have chromosomes XY. Haemophilia is caused by a recessive allele on the X chromosome. Males only need one recessive allele for haemophilia to be expressed while females need two copies of the recessive allele before the disease is manifested.

Q37

Two parents, both of blood group A, have a daughter of blood group O.

What is the probability that their next child will be a boy who has blood group O?

A 0.125 B 0.375

C 0.50 D 0.75

HELP

The probability of the next child being a boy is 0.5 the probability that the child has blood group O is 0.25. Hence the probability that the next child will be a boy with blood group O is 0.5 × 0.25 = 0.125. These probabilities are independent of the sex and blood group of the first child.

Q38

The four children of two parents each have a different blood group of the ABO series. What were the blood groups of the parents?

A A and AB

B A and B

C A and O

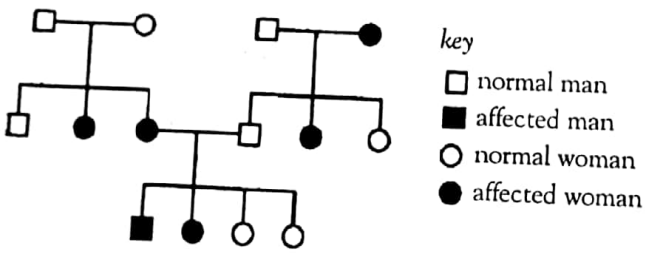
D B and AB

HELP

If the children have each of the 4 different blood groups, then the genotypes of the parents must be I^AI^O and I^BI^O, which correspond to blood groups A and B respectively.

Q39

The family tree shows the inheritance of a skin condition.



What is the genetic basis of the skin condition?

A autosomal dominant

B sex-linked dominant

C autosomal recessive

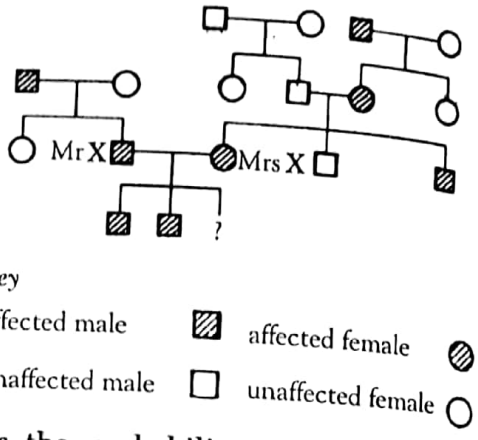
D sex-linked recessive

HELP

If the condition is X-linked, then every father of an affected child should be affected. If it is Y-linked, then no women should be affected. Hence, the condition must be autosomal. If the condition is dominant, then every affected person should have at least one affected parent, but this is not so, hence it is recessive.

Q40

The family tree was assembled by a genetic counsellor for Mr and Mrs X who suffer from heart disease due to hypercholesterolaemia. Children who inherit the dominant mutant allele from both parents rarely survive beyond puberty.



What is the probability that Mr and Mrs X's third child will be unaffected?

A 0.75 **B** 0.50

C 0.25 **D** 0.00

HELP

Both Mr and Mrs X have a heterozygous dominant genotype since both are affected and have survived beyond puberty. The probability that the third child will inherit the recessive allele from both parents, and hence is unaffected, is 0.25. This probability is independent of the genotypes of their previous children.

Q41

Red-green colour-blindness is a sex-linked recessive trait.

A colour-blind man marries a woman with normal vision, whose father is colour-blind. If they have a daughter, what is the probability that she will be colour-blind?

A 0

B 0.25

C 0.50

D 0.75

HELP

The man's genotype is X^cY and the woman's genotype is XX^c. If the have a daughter, the two possible genotypes are XX^c and X^cX^c, which correspond to the phenotypes normal vision and colour-blind.

Q42

Haemophilia is caused by a sex-linked, recessive allele. Two parents have a haemophiliac son, a normal son and a haemophiliac daughter.

What are the most likely genotypes of the parents?

	mother	*father*
A	X^HX^h	X^hY
B	X^HY^h	X^HY
C	X^hX^h	X^HY
D	X^HY^H	X^hY

HELP

Since they have both a normal and haemophiliac son, the mother must have a heterozygous genotype. Since they have a haemophiliac daughter, the father must have the recessive h allele on his X chromosome.

Q43

In fruit flies a sex-linked gene controls the development of eye colour. The eyes are either red or white. The male is the heterogametic sex.

What will be the expected percentage of eye colours in the progeny when a heterozygous red-eyed female is crossed with a white-eyed male?

	red eyes		white eyes	
	males	females	males	females
A	25.0	25.0	25.0	25.0
B	37.5	37.5	12.5	12.5
C	12.5	12.5	37.5	37.5
D	0	50.0	50.0	0

HELP

Phenotype: red-eyed female (F) × white-eyed male (M)

Genotype: X^RX^r × X^rY

Gametes: X^R X^r X^r Y

F_1 Genotypes: X^RX^r X^rX^r X^RY X^rY

F_1 Phenotype: red F, white F, red M, white M

Q44

Two animals are mated. One is homozygous dominant for one character and homozygous recessive for another. The other animal is heterozygous for both characters.

How many phenotypes are expected in the offspring of this cross?

A 1 B 2

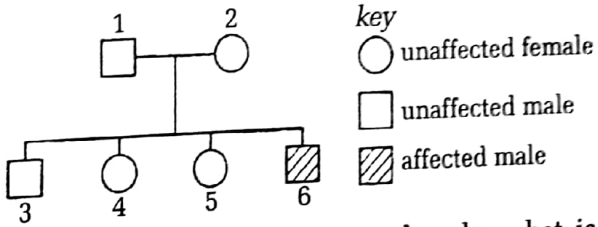
C 3 D 4

HELP

The animal which is homozygous dominant will produce similar alleles, e.g. AAbb – all Ab. Crossing with the other animal (AaBb – AB, Ab, aB, ab) will produce 4 different genotypes of offspring (AABb, AAbb, AaBb, Aabb). However there are only two phenotypes.

Q45

The diagram shows the inheritance of haemophilia in a family.



If daughter 4 married a normal male, what is the probability that their first child would suffer from haemophilia?

A 0

B 0.125

C 0.25

D 0.5

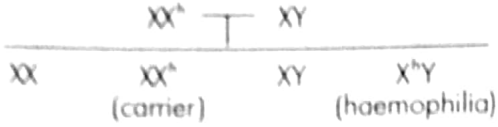
HELP

Daughter 4

XX^h , XX where X^h is the gene for haemophilia.

Probability of her being a carrier = 0.5

Normal Male XY

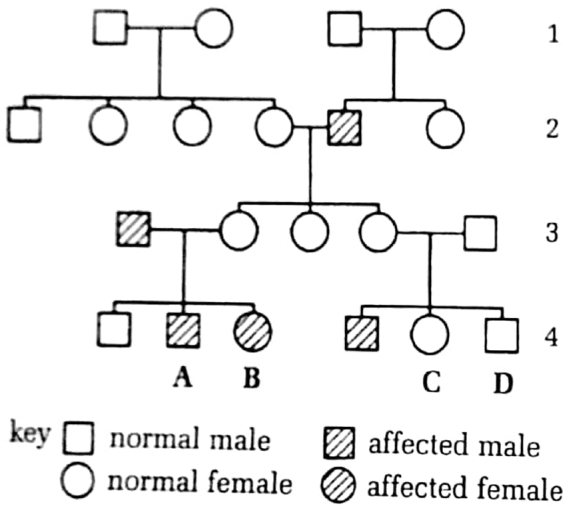


Probability of a haemophiliac = 0.25

Therefore, probability of daughter 4 having a haemophiliac child = 0.5 × 0.25 = 0.125

Q46

The diagram shows the inheritance of an X-linked recessive trait in humans. Which individual is homozygous recessive?



HELP

The homozygous recessive will show the characteristics involved. Therefore the answer should be A or B. In males, the recessive gene is in the X chromosome, not the Y chromosome. Since the female (B) exhibits the characteristics, then both her X-chromosomes would be recessive. If only one of her X chromosome was recessive, then she would be a carrier who does not exhibit the characteristics.

Q47

A plant is heterozygous for a pair of alleles that are codominant. This plant is self-pollinated and the resulting seeds are germinated and allowed to grow.

Which ratios are expected in the offspring?

	ratio of phenotypes	ratio of genotypes
A	1 : 2 : 1	1 : 2 : 1
B	1 : 2 : 1	3 : 1
C	3 : 1	1 : 2 : 1
D	3 : 1	3 : 1

HELP

For a plant with codominant alleles, both characteristics will show unless the plant has identical alleles. In this case, both the phenotypic and genotypic ratios will be the same. Therefore the answer could be either A or D. In the case of D, there is only 2 types of outcome, but with 2 alleles, the outcome should be 3 different types. Hence the answer should be A.

Q48

How many different genotypes can be found in the offspring of the cross BbCc × BbCc?

A 2

B 4

C 9

D 16

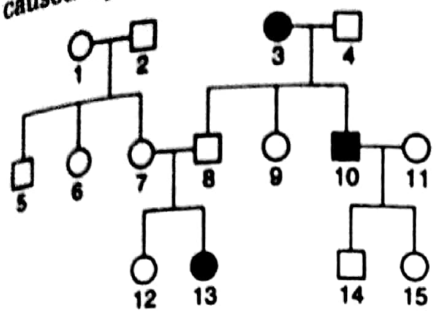
HELP

	BC	Bc	bC	bc
BC	BBCC	BBCc	BbCC	BbCc
Bc	BBCc	BBcc	BbCc	Bbcc
bC	BbCC	BbCc	bbCC	BbCc
bc	BbCc	Bbcc	bbCc	bbcc

The different genotypes include BBCC, bbCC, BBCc, BBcc, BbCC, BbCc, Bbcc, bbCc and bbcc = 9 genotypes

Q49

The family tree shows the inheritance of a condition caused by the recessive allele r.



key
- ○ normal female
- □ normal male
- ● affected female
- ■ affected male

Which of the females are certain to have the genotype **Rr**?

A 1, 6 and 7

B 1, 7 and 12

C 7, 9 and 15

D 9, 12 and 15

HELP

Parent 3 is certain to have the genotype rr. Since the male 10 is also having the genotype rr, this means that parent 4 must have the genotype Rr. Therefore, female 9 must have the genotype Rr. As female 13 has the genotype rr, both her parents (7 and 8) must have the genotypes Rr. Female 15 must have the genotype Rr because her father (male 10) has the genotype rr and her mother (female 11) is normal.

Q50

A man has normal red-green colour vision. His blood group is rhesus negative (homozygous recessive). His wife also has normal colour vision but is rhesus positive. She is heterozygous at both the red-green colour vision locus and the blood group locus.

What is the probability that their first child will be a rhesus negative, red-green colour blind boy?

A 0

B 0.0625

C 0.125

D 0.25

HELP

Probability of their first child being a rhesus negative = 0.5

Probability of their first child being a red-green colour blind boy = 0.25

Therefore, probability of their first child being both = 0.5 × 0.25 = 0.125

Q51

In a small mammal, the allele for grey fur, **G**, is dominant to that for white fur, **g**. The allele for long tail, **T**, is dominant to the allele for short tail, **t**. Animals with grey fur and long tails were crossed with those having white fur and short tails. The table shows the phenotypes of the 55 offspring.

number of offspring	fur	tail
15	grey	long
14	grey	short
14	white	long
12	white	short

What were the genotypes of the parents?

A **Ggtt × ggtt**

B **GGTt × Ggtt**

C **GgTt × GgTt**

D **GgTt × ggtt**

HELP

Father
ggtt (white fur and short tails)

Mother
GgTt / GGTT (grey fur and long tails)

Q52

A girl has blood group A and her brother has blood group B.

Which combination of genotypes **cannot** belong to their parents?

	mother	father
A	I^AI^A	I^BI^O
B	I^AI^B	I^AI^B
C	I^OI^O	I^AI^B
D	I^BI^O	I^AI^O

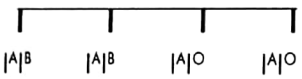
HELP

Girl I^AI^A or I^AI^O

Boy I^BI^B or I^BI^O

Mother I^AI^A and Father I^BI^O

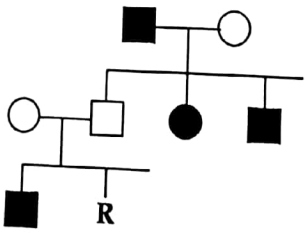
$I^AI^A \times I^BI^O$



There is no combination here to account for the boy.

Q53

The diagram shows the inheritance of red-green colour blindness in a family. This condition is caused by a sex-linked recessive allele.



○ female, normal colour vision
● female, colour blind
□ male, normal colour vision
■ male, colour blind

What is the probability that individual **R** will be a colour-blind boy?

A 0 **B** 0.125
C 0.25 **D** 0.5

HELP

The mother of R should be a carrier, as her other son exhibits colour blindness, and her husband has normal colour vision. The son stands a 1/4 chance of being colour-blind.

Q54

A tall, pink-flowered plant is self-fertilised and produces the offspring shown.

	flower colour		
	red	pink	white
tall plants	73	157	67
dwarf plants	21	53	25

When self-fertilised, which type of plant will only produce identical offspring?

A dwarf, pink-flowered
B dwarf, white-flowered
C tall, red-flowered
D tall, white-flowered

HELP

From the data, there are three times as many tall plants as there are dwarf plants. This shows that the tall gene is dominant over the dwarf gene. However, in the case of the colour of the flowers, there exhibits a codominance between the genes, as the alleles express themselves equally in the phenotype. Therefore, a pure breeding plant will produce identical offspring if it were homozygous recessive for height (i.e. dwarf) and homozygous for colour (i.e. either red or white)

Q55

In *Drosophila*, ebony body colour and vestigial wings are recessive to the wild type and are not linked. Crossing two flies, heterozygous for both characters, produced 256 offspring.

How many offspring would be expected to have ebony body colour and normal wings?

A 16 **B** 48
C 96 **D** 144

HELP

e: ebony recessive

v: vestigial wings recessive

	EE	Ee	Ee	ee
VV				eeVV
Vv				eeVv
Vv				eeVv
vv				

The number of offspring with ebony body and normal wings (indicated in table), is 3 out of a possible 16 offspring.

Number of offsprings expected to have ebony body and normal wings from the population

$$= \frac{3}{16} \times 256 = 48$$

Q56

Potato plants are propagated asexually by tubers. Twenty tubers are collected from one plant and are grown, producing 20 second generation plants. All the tubers from these plants are collected and weighed. The twenty largest are grown under the same conditions as before. All the third generation tubers are collected and are weighed.

How will the mean mass of these tubers and their genetic variation compare with the second generation?

	third generation tubers	
	mean mass	*genetic variation*
A	greater	increased
B	greater	unchanged
C	unchanged	reduced
D	unchanged	unchanged

HELP

By the time the tubers reach the third generation, the recessive gene can be almost eliminated as only the largest tubers are propagated at each stage.

Q57

Red-green colour blindness is caused by an X-linked recessive allele.

What would be the expected phenotypes of the offspring of a colour blind woman and a man with normal colour vision?

	% colour blind offspring	
	female	*male*
A	0	100
B	25	50
C	50	50
D	50	100

HELP

As the father provides only the Y chromosome to his sons, all his male offspring must receive the X-linked recessive allele from the mother. None of the female offspring will be colour-blind as they would receive one X chromosome from the father, which carries the dominant allele for normal colour vision.

Q58

The table shows the blood group phenotypes resulting from crosses between different genotypes.

genotype of 1st parent	genotype of 2nd parent	
	I^AI^A	I^AI^O
I^AI^O	A	A and O
I^BI^O	A and AB	A, B, O and AB

Two parents have a son who has blood group A and phenylketonuria. One parent has blood group O and the other has blood group AB. Neither parent has phenylketonuria.

What is the probability that the second child of these parents will be a girl with blood group B who does not have phenylketonuria?

A 1 in 16 **B** 1 in 8

C 3 in 16 **D** 3 in 8

HELP

The probability of getting a girl is ½, the probability of getting blood group B is also ½ and the probability of getting the disease is ¾ (both parents must be heterozygous as they have a son with the disease). Therefore, the final probability is ½ × ½ × ¾ = 3/16.

Q59

There are two hypotheses to explain the production of white, pale pink or dark pink flowers in a species of plant.

hypothesis 1 There are two codominant alleles.

hypothesis 2 There are three alleles, one for each flower colour.

Which procedure is the best way of testing these hypotheses?

A Analysis of the flower pigments in several different flowers by chromatography to find whether some plants contain more than one pigment.

B Controlled cross-pollination of all the different colour varieties available, in all possible combinations, and recording the colours shown by the offspring.

C Controlled self-pollination of several individuals of each of the colour varieties and recording the colours shown by the offspring of each individual plant sampled.

D Surveying large wild populations and finding the ratios of the different colours in these populations.

HELP

Recording colours of the offspring alone would not differentiate between the presence of codominant alleles and multiple alleles. If the ratios of the different colours are surveyed, codominance would show a 1 : 2 : 1 phenotypic ratio. Multiple alleles would show other ratios.

Q60

Which one of the following would cause phenotypic variation among organisms of the same genotype?

A mutation

B different sexes

C exposure to different environments

D continuous variation within the species

HELP

Some phenotypes, e.g. skin colour and height, can be influenced by the environment, resulting in organisms of the same species having large phenotypic variation.

Q61

A strain of toad has only one nucleolus in the nucleus of each cell, instead of the usual two. When toads with one nucleolus per cell are mated, approximately a quarter of the offspring have two nucleoli per nucleus, half have one nucleolus per nucleus and a quarter have no nucleoli.

What is the most likely explanation of these results?

A The allele for the presence of two nucleoli is dominant.

B The allele for the presence of two nucleoli is recessive.

C The possession of one nucleolus is due to the effect of crossing over.

D The possession of one nucleolus is due to the heterozygous condition.

HELP

It is unlikely that allele for the presence of two nucleoli is dominant or recessive since there are offspring with no nucleoli. Crossing-over also would not produce such results as it is a random process.

Q62

Two genes, Q and R, affect the size of the petals of a flower.

Gene Q has two alleles, Q^L and Q^A. The genotype Q^LQ^L produces large petals, Q^LQ^A produces small petals and in Q^AQ^A, petals are absent.

Gene R has two alleles. **R** produces a red pigment and is dominant over the allele **r** that produces no pigment.

Two plants, both heterozygous for both genes, are crossed. How many phenotypes are expected in the next generation?

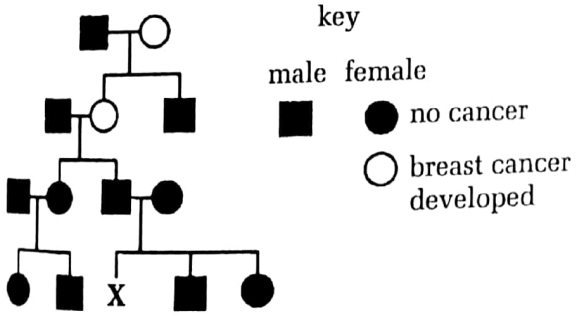
A 4
B 6
C 9
D 12

HELP

The genotype of the heterozygous parents would be $Q^LQ^AR^Rr^r$, thus have four types of gametes (Q^LR^R, Q^Lr^r, Q^AR^R and Q^Ar^r). Therefore, a Punnet square would provide the results of the cross between two such parents and six different phenotypes would be obtained.

Q63

The diagram shows the inheritance of a form of breast cancer associated with the presence of just one allele of the autosomal gene BRCA 1.



What is the probability that woman **X** inherits the BRCA 1 allele associated with breast cancer?

A 0.00
B 0.25
C 0.50
D 1.00

HELP

Woman X will never inherit the BRCA 1 allele since her father has inherited only normal genes from his parents.

Q64

In a species of plant, the allele for tall stems is dominant over that for short stems and the allele for purple flowers is dominant over that for white flowers.

A cross between two plants produced the following phenotypic ratio:

tall, purple-flowered	3
tall, white-flowered	3
short, purple-flowered	1
short, white-flowered	1

What are the phenotypes of the parents?

A	short, purple-flowered	tall, purple-flowered
B	short, white-flowered	tall, purple-flowered
C	tall, purple-flowered	tall, white-flowered
D	tall, white-flowered	short, white-flowered

HELP

From the cross, it can be seen that the first two phenotypes have a bigger ratio compared the third and fourth phenotypes. This shows that the first two phenotypes are the same as the parental phenotype, whereas the third and fourth phenotypes are recombinants.

Q65

In Shorthorn cattle, the allele for hornless is dominant to the allele for the presence of horns. Coat colour can be red (genotype C^RC^R), roan (genotype C^RC^W) or white (genotype C^WC^W).

A roan bull, heterozygous for the hornless trait, is crossed with a cow of the same genotype.

What is the probability that a calf from this cross would have the same genotype as its parents?

A $\frac{1}{4}$

B $\frac{3}{8}$

C $\frac{1}{2}$

D $\frac{3}{4}$

HELP

There would be 4 combinations with the same genotype as the parents out of a possible 16 combinations. This result can be obtained from a Punnet square of the cross.

Q66

The following reaction sequence occurs in humans.

phenylalanine $\xrightarrow{X}$ tyrosine $\xrightarrow{Y}$ CO_2 and water

Genetic disease **P** is caused by an enzyme deficiency in step **X** and genetic disease **Q** is caused by an enzyme deficiency in step **Y**. Both conditions are rare and are caused by recessive alleles.

A person with genetic disease **P** marries a person with genetic disease **Q**.

Which phenotypes would be expected for their children?

A all have neither genetic disease

B all have genetic disease **P** only

C all have genetic disease **Q** only

D all have both genetic diseases

HELP

Since both the genetic diseases are due to recessive alleles, a person with a heterozygous condition would not have either disease. Thus, the phenotype of the children would all be heterozygous for each disease since their parents only contribute one recessive allele each.

Q67

The allele for an enzyme involved in the production of chlorophyll in geraniums is C^g. A mutant allele C^w codes for a defective enzyme, resulting in no pigment. A cross between two heterozygotes produced pale green plants and dark green plants in the ratio 2 : 1.

What is the most likely explanation for this ratio?

A C^g is a dominant allele.

B C^w is a dominant allele.

C C^wC^g is a lethal genotype.

D C^wC^w is a lethal genotype.

HELP

The heterozygous parents would have the genotype C^gC^w. The resultant offspring would have to be C^gC^g, C^gC^w, C^wC^g and C^wC^w, whereby the 2 heterozygotes are pale green and C^gC^g is dark green. The C^wC^w must be lethal, so that there would be no offspring able to exhibit this phenotype.

Topic 5 Genetic Basis for Variation

Q1 D	Q2 C	Q3 A	Q4 D	Q5 A	Q6 C	Q7 D	Q8 A
Q9 D	Q10 A	Q11 A	Q12 B	Q13 D	Q14 B	Q15 A	Q16 B
Q17 A	Q18 A	Q19 D	Q20 B	Q21 B	Q22 D	Q23 B	Q24 C
Q25 D	Q26 A	Q27 D	Q28 C	Q29 D	Q30 D	Q31 A	Q32 A
Q33 C	Q34 D	Q35 A	Q36 C	Q37 A	Q38 B	Q39 C	Q40 C
Q41 C	Q42 A	Q43 A	Q44 B	Q45 B	Q46 B	Q47 A	Q48 C
Q49 C	Q50 C	Q51 D	Q52 A	Q53 C	Q54 B	Q55 B	Q56 C
Q57 A	Q58 C	Q59 D	Q60 C	Q61 D	Q62 B	Q63 A	Q64 C
Q65 A	Q66 A	Q67 D					

You should try to answer on your own before resorting to **HELP**.

Q1

The data below show the result of an investigation to determine whether increasing the carbon dioxide concentration in the immediate atmosphere would affect the total yield and nitrogen content of soya bean plants. The soya bean is a legume and has nitrogen-fixing bacteria in its root nodules.

	Air (0.03% CO_2)	Enriched air (0.06% CO_2)
Dry mass / g		
Plant body	11.8	15.0
Pods and beans	8.8	15.7
Nitrogen content / g		
Plant body	0.27	0.30
Pods and beans	0.38	0.70
Nitrogen content in plants / kg hectare^{-1}		
Total	295	511
Obtained from solid as nitrates, etc.	219	84
Obtained from nitrogen-fixing bacteria	76	427

Which one of the following accurately describes the effect on this crop of enriching the air with more carbon dioxide?

A Mass gain and nitrogen content are uniformly increased in plants and fruits.

B The mass gained by the plant is not significantly altered.

C The number of hectares planted with the crop can be reduced.

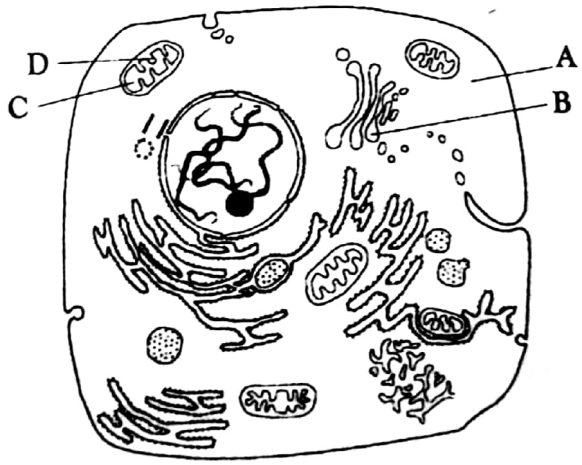
D Mass gain and nitrogen content of the pod and beans are almost doubled.

HELP

With the increase in CO_2 to 0.06%, the nitrogen content in pods and beans has doubled from 0.38 g to 0.70 g. This is due to an increase in photosynthesis, leading to an increase in the formation of nitrogen used in the formation of amino acids and proteins, and for the synthesis of nitrogenous bases such as purines and pyrimidines.

Q2

The diagram shows the ultrastructure of a cell. Where does glycolysis occur?



HELP

Glycolysis occurs in the cytosol, A. The Golgi apparatus, B, processes cell materials and transports them to other parts of the cell or to the cell surface membrane for secretion. The mitochondrial matrix, C, is where the Krebs cycle occurs. The inner mitochondrial membrane, D, has a built-in electron transport chain and this is where oxidative phosphorylation occurs.

Q3

Removal of the source of carbon dioxide from photosynthesising chloroplasts results in rapid changes in the concentration of certain chemicals. Which one of the following represents the correct combination of concentration changes?

	ATP	ribulose diphosphate (bisphosphate)	phosphoglyceric acid (PGA)
A	decreases	decreases	increases
B	decreases	increases	no change
C	increases	increases	decreases
D	increases	no change	increases

HELP

The initial reaction that fixes CO_2 into organic compounds involves a condensation with ribulose 1,5-bisphosphate (RuBP) to form two molecules of 3-phosphoglyceraldehyde (3-PGA). With the substrate CO_2 removed, PGA decreases whilst RuBP increases. Since no energy is expended into photosynthesis, ATP also increases.

Q4

In a classic experiment on photosynthesis, R. L. Hill demonstrated that an illuminated *in vitro* suspension of isolated chloroplasts could produce oxygen in the presence of a hydrogen acceptor such as methylene blue. In this case methylene blue is reduced. Which one of the following compounds replaces methylene blue in the intact photosynthesising plant?

A adenosine triphosphate (ATP)

B carbon dioxide

C nicotinamide adenine dinucleotide phosphate (NADP)

D phosphoglyceric acid (PGA)

HELP

In photosynthesis, light energy trapped by chlorophyll is used to excite electrons in the chlorophyll. (An electron extracted from water by photolysis fills the electron hole.) The excited electrons are then transferred through the electron transport chain in the thylakoid membrane to $NADP^+$, forming NADPH in the stroma.

Q5

Which one of the following is a correct outline of the main events in photosynthesis?

A Oxygen reacts with a carbohydrate to produce water and carbon dioxide in the presence of light.

B Light joins carbon dioxide to an acceptor compound which is then reduced by hydrogen obtained from water.

C Light splits water and the resulting hydroxyl group combines with a compound which has incorporated carbon dioxide.

D Carbon dioxide combines with an acceptor compound and this is reduced by hydrogen split from water by light.

HELP

Photosynthesis is the process by which plants manufacture food. This occurs when CO_2 combines with ribulose 1,5-bisphosphate (RuBP) to form the products of photosynthesis.

Q6

A small aquatic plant was put in each of three petri dishes, **X**, **Y**, **Z**, containing different culture solutions. After six weeks the plant in dish **X** had the same number of leaves as it had previously and they were all small and yellowish. The plant in dish **Y** had more leaves and they were of normal size and much darker green. The plant in dish **Z** also had more leaves, of normal size but very pale.

Which one of the following shows which elements were missing from the culture solutions?

	X	Y	Z
A	magnesium	nitrogen	phosphorus
B	magnesium	phosphorus	nitrogen
C	nitrogen	phosphorus	magnesium
D	phosphorus	magnesium	nitrogen

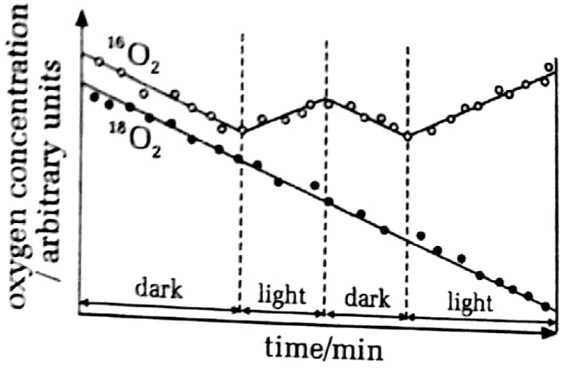
HELP

Nitrogen is an essential component of all amino acids and proteins, amines, amides, purines, pyrimidines, porphyrins and many other substances. Lack of nitrogen causes small and yellowish leaves. Phosphorus is an essential constituent of all living cells, for lipoprotein structure and for nucleic acids. Phosphorus compounds play a vital part in carbohydrate metabolism. Magnesium helps maintain tissue excitability, and is a constituent of the chlorophyll molecule, where magnesium ions are activators of phosphate enzymes.

Q7

The graph below shows the result of an experiment in which isotopes of oxygen were used to distinguish between oxygen absorbed by plants and oxygen given out.

A mixture of the oxygen isotopes $^{16}O_2$ and $^{18}O_2$ was supplied to a suspension of the unicellular alga *Chlorella* which had previously been exposed to $^{16}O_2$ only. During the following hour changes in the concentration of these gases in the suspension were measured.



The $^{18}O_2$ concentration fell in light because it was

A undergoing radioactive decay to form $^{16}O_2$.

B absorbed in respiration but was not being produced in photosynthesis.

C absorbed in respiration slower than it was being produced in photosynthesis.

D absorbed as $C^{18}O_2$ in photosynthesis.

HELP

The oxygen produced in photosynthesis is produced from the splitting of a water molecule by light energy, and not directly from the oxygen taken in during respiration.

Q8

During the light stage of photosynthesis, the photo-activated pigment removes an electron from the hydroxylation derived from the water molecule.

The fate of the free hydroxyl radical is that it

A is broken down into oxygen and a free radical of hydrogen.

B is used to raise the activation level of chlorophyll by donating a positive charge.

C is used to produce adenosine triphosphate from adenosine diphosphate.

D reduces carbon dioxide to sugar.

HELP

The water molecule is split as shown in the equation $H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$, forming oxygen and hydrogen radicals.

Q9

The increase in dry mass of a leaf can be used to measure the rate of photosynthesis if suitable adjustments are made. Which one of the following adjustments is necessary?

A Allowance must be made for the rate of transpiration only.

B Allowance must be made for any changes in the moisture content of the leaf.

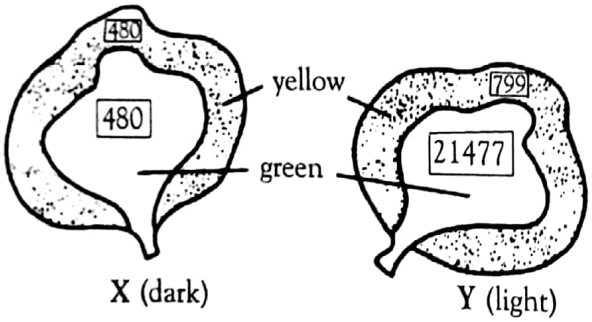
C Allowance must be made for the oxygen evolved during photosynthesis.

D Allowance must be made for the rate of respiration and the translocation of materials out of the leaf.

HELP

The important processes that occur within a leaf are photosynthesis, where organic solutes are synthesised; respiration, where these solutes are oxidised to release energy, and translocation, where the solutes are transported from the site of manufacture to other parts of the plant.

Q10



radioactivity is shown in arbitrary units in boxes ☐

Variegated leaves of a plant were supplied with radioactive carbon dioxide ($^{14}CO_2$) during an experiment. Leaf **X** was kept in the dark and leaf **Y** was kept in the light.

At the end of the experiment the radioactivity in the leaves was measured and found to be as shown on the diagram.

What is the most likely explanation for the level of radioactivity found in the yellow zone of leaf **Y**?

A Photosynthesis occurs but no storage of starch occurs in this zone.

B Photosynthesis proceeds slowly in the absence of chlorophylls a and b.

C Products of photosynthesis diffuse into the yellow zone.

D Products of respiration accumulate in the yellow zone.

HELP

In the light, only the green area of the leaf, which contain chlorophyll, can photosynthesise. Some of the photosynthates produced from the radioactive CO_2 diffuse from the green areas to the yellow ones, resulting in the low radiation detected there.

Q11

In non-cyclic photophosphorylation, water molecules are split, oxygen is released and hydrogen is taken up by an acceptor molecule.

Which one of the following is the hydrogen acceptor?

A flavine adenine dinucleotide (FAD)

B nicotinamide adenine dinucleotide (NAD)

C nicotinamide adenine dinucleotide phosphate (NADP)

D phosphoenolpyruvic acid (PEP)

HELP

Electrons excited by photosystem I during photosynthesis may undergo cyclic or non-cyclic photophosphorylation. In the latter, the reduced molecule NADPH is formed when NADP accepts a hydrogen molecule.

Q12

Which metal atom is present in chlorophyll?

A copper

B iron

C magnesium

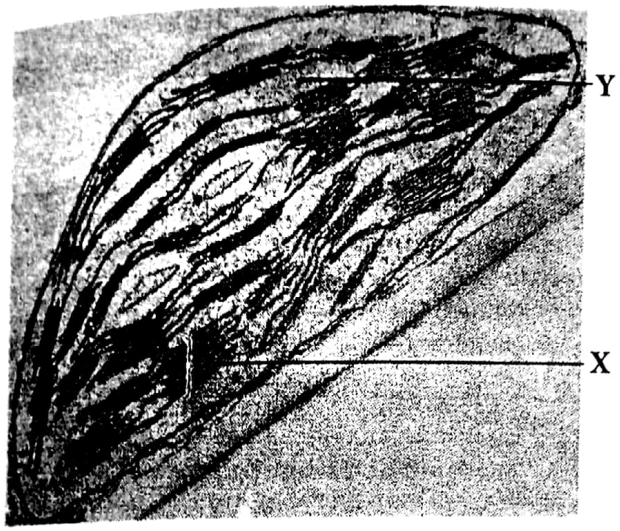
D phosphorus

HELP

Chlorophyll is a ringed compound with a magnesium atom in the centre of five rings.

Q13

The electromicrograph shows a chloroplast.



What are the structures labelled **X** and **Y** and what are their main functions?

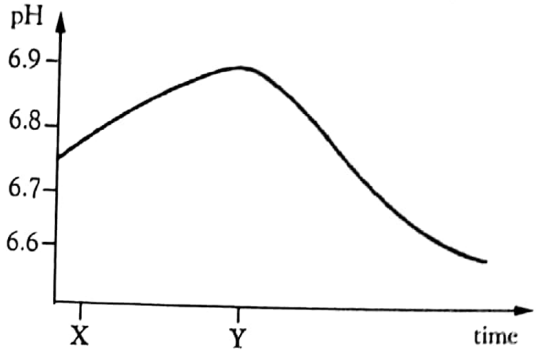
	X		Y	
	structure	*function*	*structure*	*function*
A	granum	photolysis of water	stroma	fixation of CO_2
B	granum	fixation of CO_2	lamellae	photolysis of water
C	granum	fixation of CO_2	stroma	photolysis of water
D	lamellae	fixation of CO_2	granum	photolysis of water

HELP

X shows stacks of grana, known as the thylakoid, which is the site of the splitting of water by light photons. Y is the stroma, where carbon dioxide fixation occurs to form sugars.

Q14

The graph shows changes in the pH of water in a fresh water lake on a summer day.



What is the probable cause of the rise in pH between times **X** and **Y**?

A decreased levels of mineral nutrients in the water

B decreased levels of carbon dioxide due to photosynthesis

C increased levels of carbon dioxide due to respiration

D increased oxygen released by the producers

HELP

The increased pH means that the water is less acidic. This is because carbon dioxide is taken up from the water for photosynthesis.

Q15

Why is RuBP important in the process of photosynthesis?

A It is a source of phosphate ions.

B It is an intermediate in sucrose formation.

C It is an acceptor molecule for hydrogen.

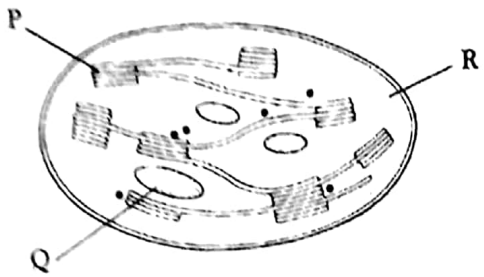
D It is an acceptor molecule for carbon dioxide.

HELP

Ribulose 1,5-bisphosphate (RuBP) is a 5-carbon compound which is the first acceptor of CO_2, resulting in the formation of 3-phophoglyderaldehyde (3-PGA).

Q16

The diagram shows the ultrastructure of a chloroplast as seen in section. What are the function of **P**, **Q** and **R**?



	P	Q	R
A	carbohydrate storage	carbohydrate synthesis	light absorption
B	carbohydrate synthesis	carbohydrate storage	light absorption
C	carbohydrate synthesis	light absorption	carbohydrate storage
D	light absorption	carbohydrate storage	carbohydrate synthesis

HELP

P represents the thylakoid membrane, where light energy is harnessed for the photosynthetic process. Q is a starch grain which is the site of carbohydrate storage, whilst R is the stroma, where CO_2 fixation occurs.

Q17

Which of the following describes conditions in a photosynthesising cell, exposed to high light intensity and low carbon dioxide concentration?

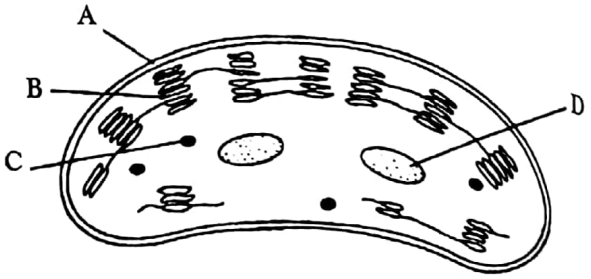
	concentration of CO_2 acceptor	concentration of ATP	concentration of GP (PGA)
A	high	high	high
B	high	high	low
C	high	low	low
D	low	high	high

HELP

The photosynthesising cell will have a high concentration of the CO_2 acceptor, RuBP, and a high ATP concentration, and low amounts of PGA, which is the first product of photosynthesis.

Q18

The diagram represents a section through a chloroplast.



In which labelled part are the enzymes concerned with the reduction of carbon dioxide found?

HELP

The compound must accept the electron released from the excitation of the photosystem, and under blue and red light, where chlorophyll absorbs maximally.

Q19

Which statement only applies to carbon fixation in photosynthesis?

A GP (PGA) is reduced to carbohydrate.

B The reactions are not dependent on temperature.

C At low light intensity these reactions limit the rate of photosynthesis.

D A 2-carbon compound is the acceptor for carbon dioxide.

HELP

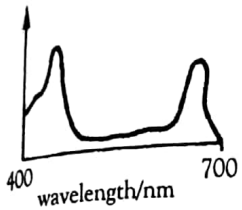
Carbon fixation occurs during the Calvin cycle in photosynthesis, where 3-phosphoglyceraldehyde (PGA) is reduced to form carbohydrates.

Q20

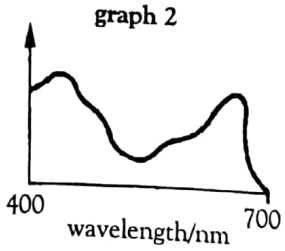
Three of the graphs below show the absorption spectra of photosynthetic pigments. One graph shows the action spectrum of photosynthesis for a plant containing the pigments.

All the *x* axes show wavelength. Three of the *y* axes show light absorption. One *y* axis shows the rate of photosynthesis.

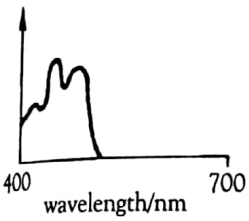
graph 1



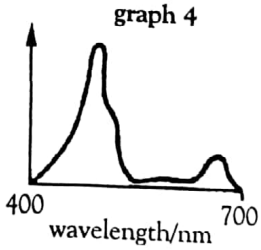
graph 2



graph 3



graph 4



Which of the following identifies the four graphs?

	chlorophyll a	absorption chlorophyll b	spectra carotenoids	action spectrum
A	1	4	3	2
B	2	1	3	4
C	2	4	3	1
D	3	2	4	1

HELP

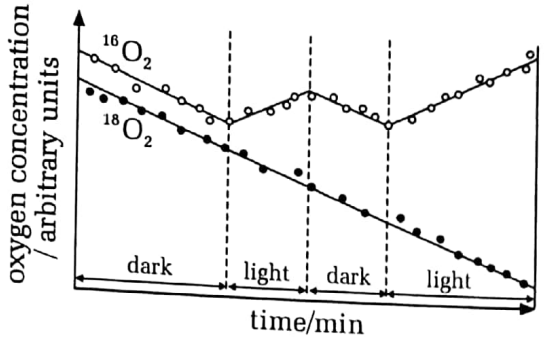
The action spectrum is a measure of the ability of light of different wavelengths to support photosynthesis. Chlorophyll a absorbs light of wavelengths 680 nm, chlorophyll at 650 nm and carotenoids at shorter wavelengths.

Q21

Isotopes of oxygen can be used to distinguish between oxygen absorbed by plants and oxygen evolved.

A mixture of oxygen isotopes $^{16}O_2$ and $^{18}O_2$ was supplied to a suspension of the unicellular alga *Chlorella* which had previously been exposed to $^{16}O_2$ only. During the following hour, changes in concentration of these gases in the suspension were measured in light and dark conditions.

The graph shows the results:



What caused the concentration of $^{16}O_2$ to rise in light?

A $H_2{}^{18}O$ was being photolysed more rapidly than $H_2{}^{16}O$.

B $^{18}O_2$ formed a decreasing proportion of the oxygen evolved.

C $^{16}O_2$ was absorbed at different rates in light and dark.

D $^{16}O_2$ was being produced in photosynthesis faster than was being absorbed in respiration.

HELP

In the light, both photosynthesis and respiration are occurring simultaneously. But radioactive oxygen is produced in photosynthesis at a faster rate than it is absorbed in respiration.

Q22

In the conversion of RuBP to GP (PGA)

A a molecule of carbon dioxide is accepted.

B a stable six-carbon molecule is produced.

C ATP is generated.

D hydrogen is combined with oxygen to form water.

HELP

Ribulose 1,5-bisphosphate (RuBP) is the first acceptor of CO_2 in the formation of two molecules of 3-phosphoglyceraldehyde (PGA) during the Calvin cycle of photosynthesis.

Q23

Which of the following occurs in the light reaction of photosynthesis?

A ADP is phosphorylated.

B Hexose phosphates are hydrolysed

C Reduced NADP is oxidised.

D RuBP is carboxylated.

HELP

During the light reaction of photosynthesis, ADP is phosphorylated to form energy-rich ATP, which will be used in CO_2 fixation and form carbohydrates.

Q24

If light intensity is uniformly high, under which of the following conditions is carbon dioxide most likely to be the main limiting factor upon the rate of photosynthesis?

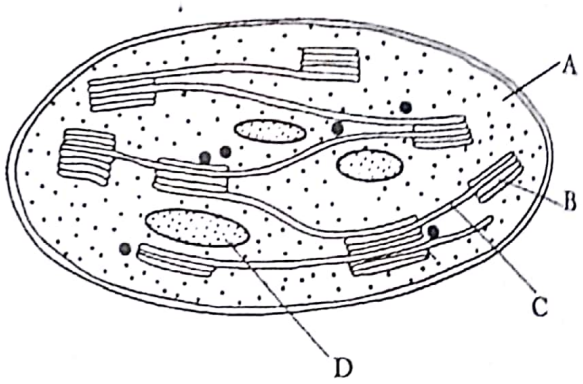
	temperature / °C	% *carbon dioxide*
A	25	4.00
B	25	0.04
C	15	0.04
D	5	0.01

HELP

Carbon dioxide uptake is favoured in high temperatures and when it is present in relatively high concentrations in the atmosphere. Thus, the lowest temperature and lowest CO_2 percentage will significantly lower the rate of photosynthesis.

Q25

The diagram shows the main structures in a chloroplast.



Which part is the site of carboxylation of RuBP?

HELP

The carboxylation of ribulose 1,5-bisphosphate (RuBP) occurs during the Calvin cycle, which is carried out in the stroma.

Q26

For every 100 units of sunlight falling on a chloroplast of a green plant, 50 units are not used for photosynthesis.

Why is this?

A The wavelengths are inappropriate.

B They are converted into heat energy.

C They are used to evaporate water vapour.

D They fall on non-photosynthetic structures.

HELP

Photosynthesis occurs most efficiently at wavelengths of red and blue light, because the chlorophyll pigments absorb light maximally at these wavelengths.

Q27

The rate of photosynthesis of a freshwater plant is measured using five spectral colours.

Which sequence of colours would give an increasing photosynthetic response?

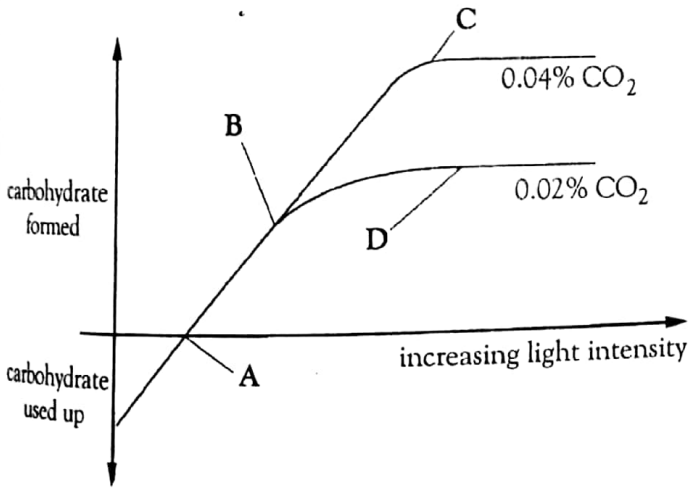
	smallest →				*largest response*
A	blue	green	yellow	orange	red
B	green	yellow	orange	red	blue
C	red	orange	yellow	green	blue
D	yellow	green	orange	blue	red

HELP

Photosynthesis occurs most efficiently with red or blue light because the chlorophyll pigments can absorb light maximally at these wavelengths and the least at green light.

Q28

The graph shows the effect of increasing light intensity on the rate of photosynthesis at two different CO_2 concentrations.



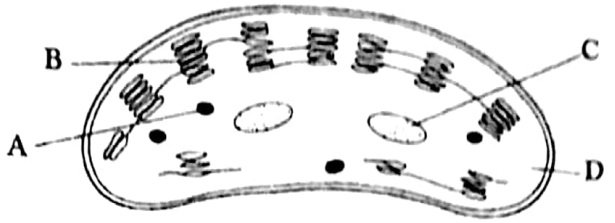
Which label shows the compensation point?

HELP

The light intensity at which the intake of carbon dioxide for photosynthesis exactly balances its output from respiration, is called the compensation point.

Q29

The diagram shows the ultrastructure of a chloroplast as seen in section.



In which labelled part does carbon fixation during photosynthesis take place?

HELP

Carbon dioxide fixation occurs in the chloroplast stroma, where the enzyme Rubisco occurs. Carbohydrates are formed as a result.

Q30

What happens during the light phase of photosynthesis?

A ADP is hydrolysed and reduced NADP is oxidised.

B ADP is phosphorylated and NADP is reduced.

C ATP is hydrolysed and NADP is reduced.

D ATP is phosphorylated and NADP is reduced.

HELP

During the light stage, photophosphorylation occurs. ADP is phosphorylated to ATP as electrons are passed down the electron transport chain. NADP is the final electron acceptor of non-cyclic photophosphorylation, it is converted to reduced NADP by NADP reductase.

Q31

Which statement only applies to carbon fixation in photosynthesis?

A A 2-carbon compound is the acceptor for carbon dioxide.

B At low light intensity the reactions limit the rate of photosynthesis.

C GP (PGA) is reduced to carbohydrate.

D The reactions are not dependent on temperature.

HELP

GP (phosphoglyceric acid, PGA) is reduced to triose phosphate, a carbohydrate. Ribulose biphosphate (RuBP) is the 5-carbon compound that accepts carbon dioxide. B refers to photophosphorylation. The enzyme Rubisco is involved in carbon fixation, hence it is temperature dependent.

Q32

What are the products of the light-dependent reactions of photosynthesis in green plants?

A ATP and reduced NADP

B GP (PGA) and reduced NADP

C GP (PGA) and RuBP

D triose phosphate and NADP

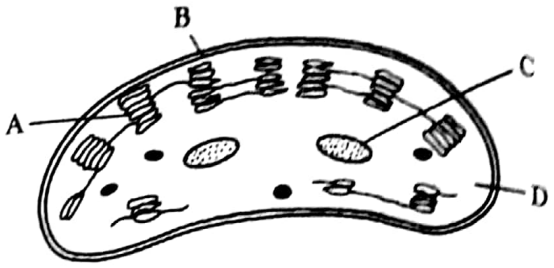
HELP

ATP and reduced NADP are produced in photophosphorylation in the light-dependent stage of photosynthesis. These are passed on to the Calvin cycle, where it is used in carbon fixation.

Q33

The diagram represents a section through a chloroplast.

In which part are the enzymes associated with photosynthetic phosphorylation found?

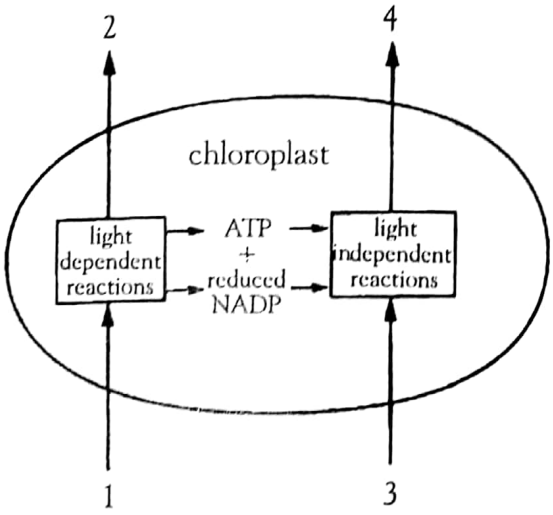


HELP

A is the thylakoid membrane of the granum, where photophosphorylation occurs.

Q34

The diagram shows the movement of substances into and out of a chloroplast.



What do labels 1 to 4 represent?

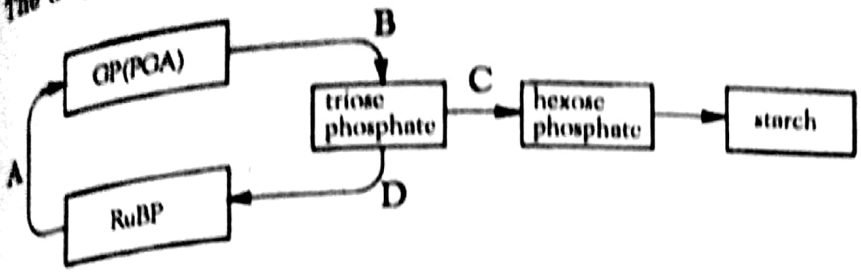
	1	2	3	4
A	CO_2	ATP	H_2O	starch
B	CO_2	H_2O	sugars	O_2
C	H_2O	O_2	CO_2	sugars
D	sugars	H_2O	ATP	O_2

HELP

In the light-dependent reactions, photolysis of water occurs to release electrons, hydrogen ions and oxygen. Oxygen is released as oxygen gas. In the light-independent reactions, carbon dioxide is fixed, producing carbohydrates.

Q35

The diagram represents the Calvin cycle.



At which stage is CO_2 incorporated?

HELP

Carbon dioxide combines with Ribulose biphosphate (RuBP) to form GP (phosphoglyceric acid, PGA) which is subsequently converted to triose phosphate.

Q36

What is the outline sequence by which carbon dioxide may be incorporated into starch by photosynthesis?

A GP (PGA) + CO_2 → RuBP → triose phosphate → hexose phosphate → starch

B GP (PGA) + CO_2 → RuBP → hexose phosphate → triose phosphate → starch

C RuBP + CO_2 → GP (PGA) → hexose phosphate → triose phosphate → starch

D RuBP + CO_2 → GP (PGA) → triose phosphate → hexose phosphate → starch

HELP

This is the sequence followed for carbon fixation and carbohydrate production.

Q37

The weedkiller DCMU blocks the flow of electrons from the electron transport chains in photophosphorylation.

Why does this kill the plant?

A Active transport of mineral ions is prevented.

B ATP and reduced NADP are not produced.

C Photoactivation of the chlorophyll cannot occur.

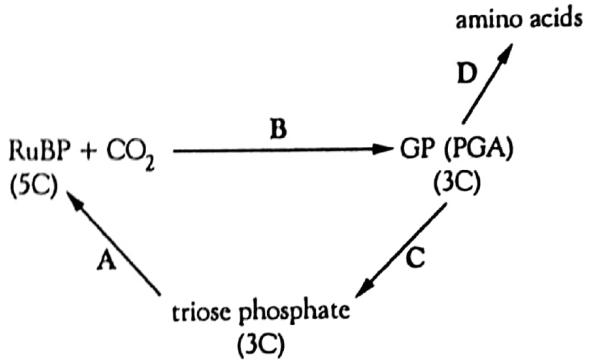
D Photolysis of water does not occur.

HELP

Only the electron transport system produces ATP and reduced NADP in the plant. Without these compounds, the Calvin cycle cannot proceed and carbon fixation cannot occur and there is no respiratory substrate available for respiration.

Q38

The diagram shows stages in the light-independent reactions of photosynthesis.



At which stage is most of the reduced NADP oxidised?

HELP

ATP and reduced NADP are used in stage C and are converted to ADP and NADP respectively. Stage A also involves the conversion of relatively less ATP to ADP.

Q39

What are the products of the light-dependent reactions of photosynthesis?

A oxygen, ATP and NADP

B oxygen, ATP and reduced NADP

C water, ATP and NADP

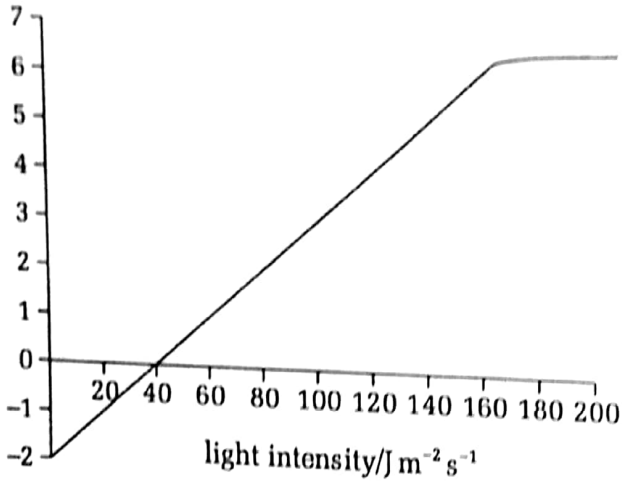
D water, ATP and reduced NADP

HELP

Photolysis of water produces oxygen and hydrogen which would combine with NADP to produce reduced NADP. ATP is generated during photophosphorylation as electrons are passed along the chain of electron carriers.

Q40

The graph shows the relationship between oxygen production in photosynthesis and light intensity for a unicellular green organism in 0.02% sodium hydrogencarbonate solution.



The most likely explanation of the fact that the graph levels off at 180 J m^{-2} s^{-1} is that the system is

A light limited and carbon dioxide saturated.

B light limited and the temperature is below optimum.

C light saturated and carbon dioxide limited.

D light saturated and the temperature is above optimum.

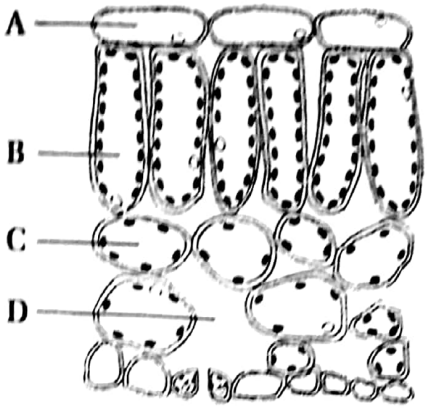
HELP

The amount of light given is saturated, not limited. Therefore, the answer could be C or D. The concentration of carbon dioxide is in short supply, hence limiting the rate of photosynthesis.

Q41

The diagram represents a transverse section of a leaf.

Which region is the main site of carbon fixation?



HELP

A: upper epidermis

B: palisade mesophyll cell

C: spongy mesophyll cell

D: air space

Carbon fixation occurs during the light independent reactions of photosynthesis. Palisade mesophyll is the main photosynthetic tissue.

Q42

It has been found that an aqueous suspension of isolated chloroplasts will evolve oxygen if illuminated in the presence of a certain type of compound.

Which type of compound and which colours of light are required for maximum oxygen evolution?

	type of compound	colours of light at which maximum evolution occurs
A	electron acceptor	blue and green
B	electron acceptor	blue and red
C	electron donor	blue and green
D	electron donor	blue and red

HELP

At the light dependent stage, electrons from chlorophyll are passed into the light independent reaction. Chlorophyll absorbs light in the blue-violet and red regions of the visible spectrum. The green region is reflected off, giving it its characteristic colour. An electron acceptor is required to receive the electron from the chlorophyll (in PS I and PS II).

Q43

During photosynthesis, which process releases electrons that return chlorophyll molecules to their reduced state?

A activation of photosystem I

B oxidation of reduced NADP

C phosphorylation of ADP

D photolysis of water

HELP

Cyclic- or non-cyclic-phosphorylation can generate ATP. In non-cyclicphosphorylation, electrons from the splitting of water returns to the chlorophyll to replace the electrons lost in P 680 to the electron acceptor.

Q44

Carbon dioxide labelled with ^{14}C has been used to identify the intermediate compounds in the Calvin cycle, the light-independent stage in photosynthesis.

Which compound would be the first to contain the ^{14}C?

A glucose

B GP (PGA)

C RuBP

D triose phosphate

HELP

Candidates must take note that RuBP would not contain the ^{14}C as it is not formed from absorbing the ^{14}C. Instead, GP (PGA) would be the first to contain the ^{14}C since it is formed from the combination of the labelled carbon dioxide with RuBP.

Q45

The table shows two measurements of production in birch and pine forests in England.

type of forest	production of oganic matter / tonnes per unit area per year	carbon dioxide fixation during growing season / grammes of carbon fixation per unit area per day
birch	8.5	2.2
pine	16.0	2.0

What is the most likely reason for the higher annual production of the pine forest?

A Pine trees have a faster daily rate of photosynthesis than birch trees.

B Pine trees have a larger total leaf surface than birch trees.

C Pine trees have a longer growing season than birch trees.

D Pine trees have a lower light compensation point than birch trees.

HELP

As the carbon fixation is less for the pine trees compared to the birch trees, the pine trees would need to have a longer growing season in order to produce more organic matter. The larger total leaf surface and faster rate of photosynthesis is not likely true for the pine trees since their carbon fixation per unit area per day is lower than the birch trees.

Q46

Which process is the link between the light dependent and the light independent stages of photosynthesis?

A photolysis of water

B production of carbon dioxide acceptor molecules

C production of reduced hydrogen carrier and ATP

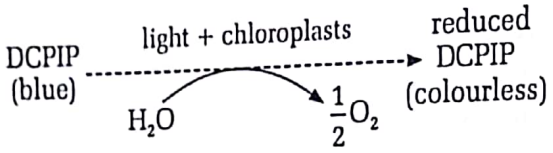
D reduction of carbon dioxide

HELP

Photolysis of water refers to the breakdown of water during the light dependent stage. It does not connect both stages. The production of reduced hydrogen carrier is necessary for the reduction of glycerate phosphate to triphosphate. The ATP produced is also needed for the energy required for the conversion to starch.

Q47

Isolated chloroplasts liberate oxygen when illuminated in the presence of a hydrogen or electron acceptor. DCPIP is such an acceptor and the following change occurs.



For which naturally occurring compound is the DCPIP substituting?

A ATP
B NAD
C NADP
D RuBP

HELP

This represents the NADP that is reduced in the light dependent stage (non-cyclic phosphorylation) to release a reduced hydrogen carrier to be used in the light independent stage of the plant cycle.

Q48

Which of the following is a stage in the light independent reactions in photosynthesis (the Calvin cycle)?

A carboxylation of a five-carbon sugar
B photolysis of water
C photophosphorylation of ADP
D release of oxygen

HELP

The 5-C sugar is combined with carbon dioxide by NADPH and H^+ and ATP from the light dependent stage. Answers B, C and D are all stages of the light dependent reactions in the plant. Photolysis of water is the breakdown of water in the presence of light. Photophosphorylation of ADP is required in the light stage to supply ATP for the light independent stage. And finally, oxygen is released in the light dependent stage as the plant takes up carbon dioxide.

Q49

Which reactants are used in the Calvin cycle?

A carbon dioxide, ADP and NADP
B carbon dioxide, ATP and reduced NADP
C oxygen, ADP and reduced NADP
D oxygen, ATP and NADP

HELP

Calvin cycle reactants are:

1. CO_2
2. Reduced NADP
3. ATP

} involved in the light independent reactions

The fixation of CO_2 and reduction of GP using NADPH + H^+ and ATP from the light dependent reaction will produce a triose phosphate (TP).

Q50

Which of the following is the source of high-energy electrons in the light-dependent reactions of photosynthesis?

A ATP
B chlorophyll
C hydroxyl ions
D reduced NADP

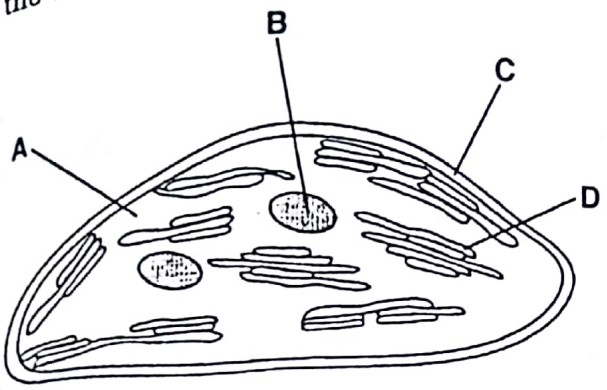
HELP

The chlorophyll molecule has two reaction centres (PS I and PS II) that will trap light energy to boost electrons to a higher energy level and does not produce electrons itself.

Q51

The diagram shows a chloroplast.

Which region contains electron carriers involved in the reduction of NADP?

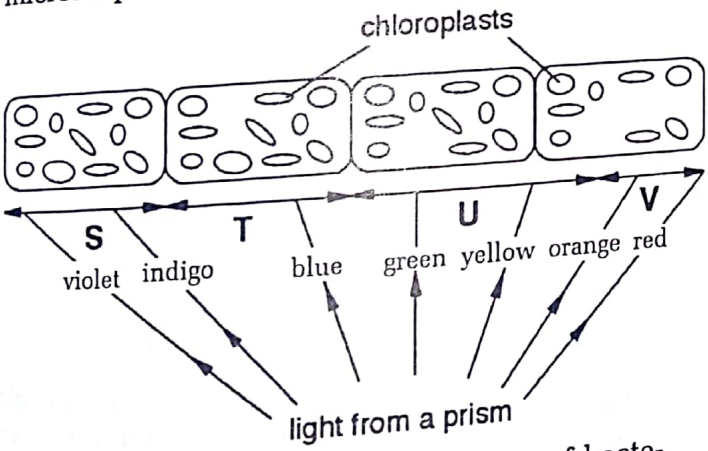


HELP

Electron carriers are found in the thylakoids of the chloroplast in order to accept the electrons during the light-dependent reactions.

Q52

A filament of the alga *Cladophora* was illuminated as shown. At the same time, motile, aerobic bacteria were placed in the water with the alga and their position was determined by microscopic examination after 10 minutes.



In which two regions will the number of bacteria be highest?

A S and T
B S and U
C T and V
D U and V

HELP

Chlorophyll absorbs red and blue light better, so the rate of photosynthesis would be faster in region T and V. This helps produce more oxygen in these areas where the aerobic bacteria would be attracted to.

Q53

What occurs in the conversion of RuBP to GP (PGA)?

A A molecule of carbon dioxide is accepted.
B A stable six-carbon molecule is produced.
C ATP is generated.
D Two three-carbon compounds combine.

HELP

RuBP is a 5-carbon molecule that accepts carbon dioxide to combine and produce an intermediate 6-carbon molecule. This intermediate then breaks down into two 3-carbon molecules known as glycerate-3-phosphate (GP).

Topic 6(a) Photosynthesis

Q1 **D**	Q2 A	Q3 C	Q4 C	Q5 D	Q6 C	Q7 **B**	Q8 **A**
Q9 **D**	Q10 C	Q11 C	Q12 C	Q13 A	Q14 B	Q15 **D**	Q16 **D**
Q17 **B**	Q18 B	Q19 A	Q20 A	Q21 D	Q22 A	Q23 A	Q24 **D**
Q25 A	Q26 A	Q27 B	Q28 A	Q29 D	Q30 B	Q31 C	Q32 **A**
Q33 A	Q34 C	Q35 D	Q36 D	Q37 B	Q38 C	Q39 B	Q40 **C**
Q41 B	Q42 B	Q43 D	Q44 B	Q45 C	Q46 C	Q47 C	Q48 **A**
Q49 B	Q50 C	Q51 D	Q52 C	Q53 A			

TOPIC 6

6(b)

Respiration

You should try to answer on your own before resorting to **HELP**

Q1

Which substances enter and leave a mitochondrion during aerobic respiration?

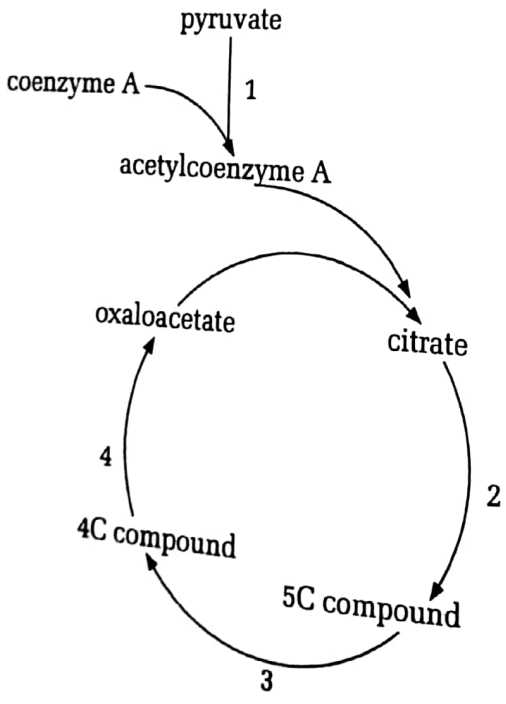
	enters	leaves
A	acetylcoenzyme A	carbon dioxide
B	ADP	lactate
C	glucose	reduced NAD
D	pyruvate	ATP

HELP

Pyruvate enters the mitochondria to combine with O_2 to take part in the Kreb's cycle. The release of energy in the various cycles is also present.

Q2

The diagram shows the Krebs cycle.



At which numbered stages does decarboxylation take place?

A 1 and 2 **B** 1, 2 and 3

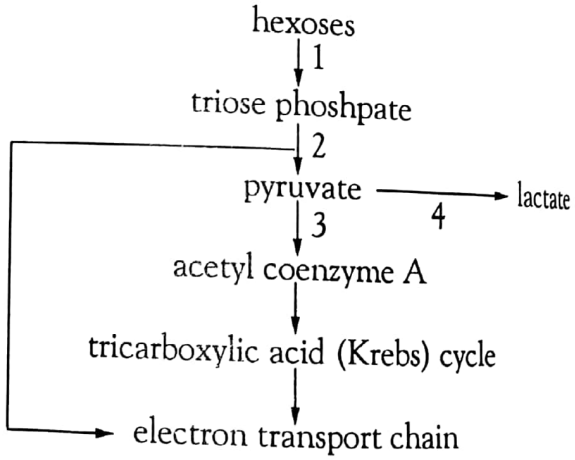
C 1, 3 and 4 **D** 1, 2, 3 and 4

HELP

During the Kreb's cycle, there is release of ATP and CO_2. The release of CO_2 is decarboxylation. It is present in stages 1, 2 and 3.

Q3

The diagram below summarises the stages involved in respiratory metabolism of mammalian skeletal muscle.



Stage 4 in the diagram occurs in mammalian muscle cells under anaerobic conditions. Why is stage 4 necessary?

A To detoxify pyruvate.

B To form lactate which is immediately reconverted to glycogen.

C To oxidise the reduced nicotinamide adenine dinucleotide facilitating stage 2.

D To reduce the oxidised nicotinamide adenine dinucleotide facilitating stage 2.

HELP

The enzyme phosphorylase attaches an inorganic phosphate molecule to sugar molecules, forming glucose 1-phosphate. This process occurs during glycolysis.

Q4

The amount of energy released from a given quantity of glucose is greater in aerobic respiration than in anaerobic respiration. By approximately how much is the energy yield increased in animals?

A 3 times
B 9 times
C 12 times
D 18 times

HELP

36 molecules of ATP are generated in aerobic respiration whilst only 2 molecules of ATP are produced in aerobic respiration. The energy yield in the former is this 18 times more than the latter.

Q5

Which one of the following is the main biochemical process which takes place inside the mitochondrial matrix?

A photophosphorylation
B the formation of lactic acid
C the translation of messenger RNA
D the tricarboxylic (citric) acid cycle.

HELP

The tricarboxylic acid cycle (TCA) follows glycolysis and occurs in the matrix. The 2-carbon acetyl residue from acetyl CoA condenses with the 4-carbon compound, oxaloacetate (OAA), to form the 6-carbon molecule, citrate.

Q6

What is the approximate ratio of ATP synthesised during anaerobic respiration compared with aerobic respiration?

A 1 : 2
B 1 : 10
C 1 : 20
D 1 : 30

HELP

36 molecules of ATP are produced during aerobic respiration, whilst only 2 ATP molecules are released in aerobic respiration. The approximate ratio is thus 1 : 20.

Q7

Which molecule is common to both glycolysis and the Calvin cycle?

A hexose phosphate
B NADP
C pentose phosphate
D triose phosphate

HELP

Glycerate 3-phosphate (GP) is reduced to produce triose phosphate in the Calvin cycle. Fructose bisphosphate splits into two triose phosphate molecules (PGAL) during glycolysis.

Q8

Before entering the tricarboxylic acid cycle, the pyruvate produced by the glycolytic pathway is first converted to

A acetyl-coenzyme A.
B citrate.
C coenzyme A.
D ethanol.

HELP

On entering the matrix from the cytosol, pyruvate reacts with coenzyme A to form CO_2 and the intermediate acetyl CoA.

Q9

Lactic acid is produced when muscle contracts. Frog muscle can contract in the absence of oxygen and lactic acid accumulates until fatigue sets in. On return to aerobic conditions, the muscle can contract again and the lactic acid is metabolised.

Which of the following is the best interpretation of these observations?

A Lactic acid is produced only in anaerobic conditions.

B In anaerobic conditions, lactic acid is produced faster than it can be removed.

C In aerobic conditions the muscle will not fatigue.

D Formation of lactic acid is oxygen-dependent.

HELP

Lactic acid is produced during anaerobic respiration, resulting in the production of 2 molecules of ATP. The lactic acid is metabolised as soon as oxygen is available again.

Q10

How many moles of carbon dioxide are produced by the complete oxidation of 1 mole of pyruvate?

A 1 B 2

C 3 D 4

HELP

Pyruvate is a three-carbon compound, ($CH_3C[O]C[O]OH$), which on complete oxidation releases three moles of CO_2.

Q11

When mitochondria are extracted from cells for biochemical study, they are usually kept in a 0.25 mol dm^{-3} sucrose solution.

Why is the sucrose solution used?

A To act as a solvent.

B To provide a source of food.

C To assist in the extraction of enzymes.

D To prevent the mitochondria from changing in structure.

HELP

The osmotic pressure of 0.25 mol dm^{-3} sucrose solution approximates that of the internal environment of the mitochondria, thus this solution is applied to prevent the mitochondria from undergoing structural changes.

Q12

Where are the enzymes located which are involved in the chemical reactions which occur during glycolysis?

A In the fluid matrix of cytoplasm.

B In the mitochondrial matrix.

C In the nuclear sap.

D On the cristae of a mitochondrion.

HELP

Glycolysis occurs in the cytosol, where the glucose molecule is converted into two molecules of the three-carbon compound, pyruvate. The enzymes are located here.

Q13

Six tubes containing preparations from animal tissue were set up as shown in the table.

tube	*contents*
1	glucose + homogenised cells
2	glucose + mitochondria
3	glucose + cytoplasm lacking organelles
4	pyruvic acid + homogenised cells
5	pyruvic acid + mitochondria
6	pyruvic acid + cytoplasm lacking organelles

After incubation, in which three tubes would carbon dioxide be produced?

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

HELP

Glucose and pyruvic acid serve as sources of substrates which the homogenised cells can oxidise in glycolysis and Krebs cycle respectively. Mitochondria however, can only oxidise pyruvic acid via the Krebs cycle.

Q14

Which of the following releases most energy during respiration?

A conversion of glucose to ethanol and carbon dioxide
B oxidation of pyruvate to carbon dioxide and water
C oxidation of those phosphate to pyruvate
D phosphorylation of glucose

HELP

The most energy is released at the Krebs cycle, where about 30 molecules of ATP are produced in the mitochondria.

Q15

What is the final pathway followed by all carbon atoms derived from carbohydrates, lipids and proteins when they are oxidised during respiration?

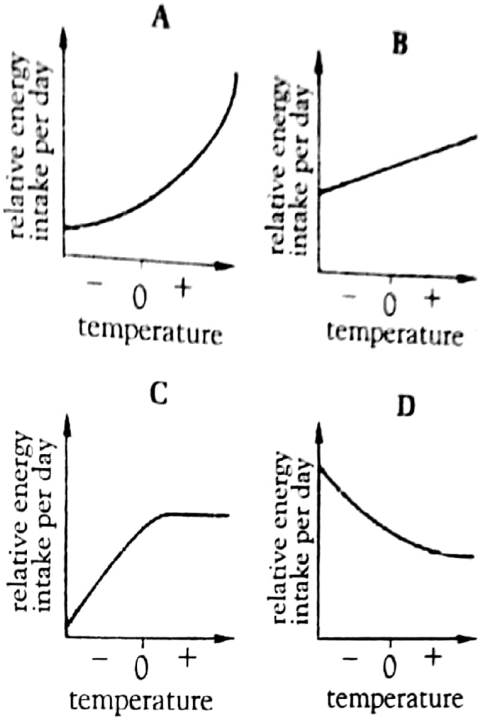
A the Calvin cycle
B the electron transport system
C the Krebs cycle
D the ornithine cycle

HELP

The Krebs cycle is a complex of nine reactions where two molecules of acetyl CoA are oxidised to CO_2.

Q16

Which graph represents the relationship between the relative energy intake of a person and temperature over a range of environmental temperatures from –40 °C to +38 °C?

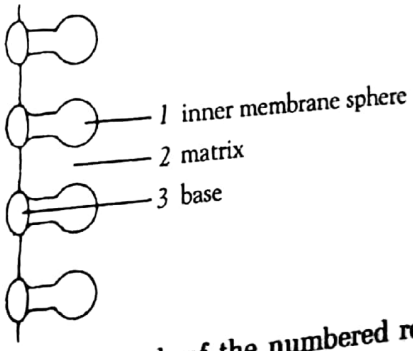


HELP

At lower temperatures, there is a need for a higher relative energy intake in order to carry on his metabolic processes and to generate heat in his body for enzyme activities. This need decreases as the temperature increases.

Q17

The diagram shows stalked particles on part of a crista membrane in a mitochondrion.



What occurs in each of the numbered regions?

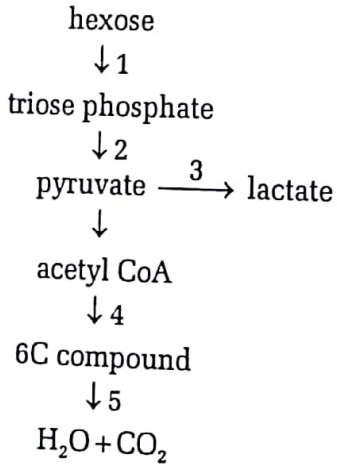
	1	2	3
A	ADP synthesis	electron transport	Krebs cycle
B	ADP synthesis	glycolysis	Krebs cycle
C	ATP synthesis	Krebs cycle	electron transport
D	ATP synthesis	Krebs cycle	glycolysis

HELP

The electron transport system occurs in 3, and is coupled to proton transport across the inner membrane (1), generating the proton-motive force, powering ATP synthesis. Krebs cycle occurs in the matrix, where two molecules of acetyl CoA are oxidised.

Q18

The diagram summarises the pathway of glucose breakdown.



Which two steps result in a net increase of ATP?

A 1 and 3 B 1 and 4

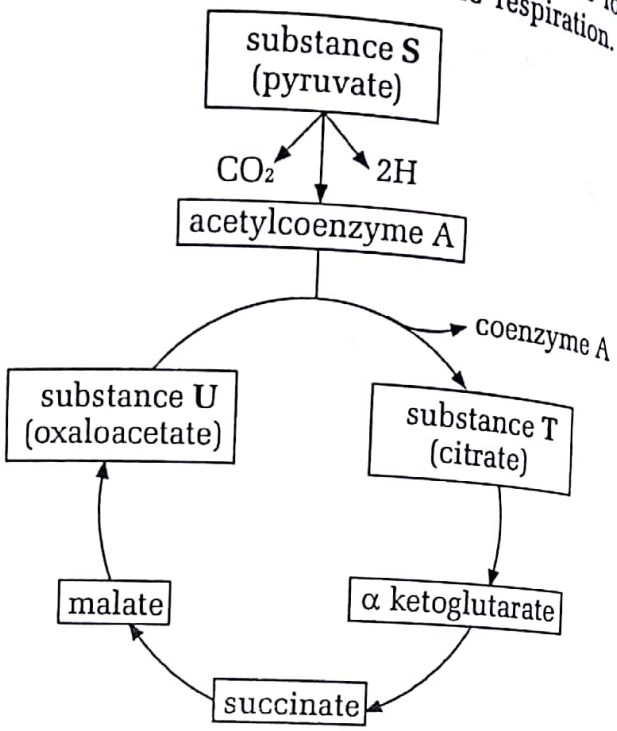
C 2 and 4 D 2 and 5

HELP

ATP formation occurs both at 2, where glyceraldehyde-3-phosphate is converted to pyruvate; and at 5, where the six-carbon compound, citrate, releases water and CO_2 in the Krebs cycle.

Q19

The diagram shows some of the reactions following glycolysis during aerobic respiration.



How many carbon atoms are in each of the substances **S**, **T** and **U**?

	S	T	U
A	2	5	3
B	2	6	4
C	3	4	6
D	3	6	4

HELP

Pyruvate is a three-carbon compound. Oxaloacetate, a four-carbon compound, combines with acetyl coenzyme A (two-carbon) to form citrate, a six-carbon compound.

Q20

Both glucose and appropriate enzymes are necessary for the process of glycolysis to begin.

Which additional compound must also be present?

A acetylcoenzyme A

B ATP

C pyruvate

D reduced NAD

HELP

In glycolysis, 2 ATP must be hydrolysed for the phosphorylation of glucose to fructose 1,6-bisphosphate.

Q21

After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions what will the changes be?

	glycogen	*ATP*	*lactate*	*pH*
A	decreased	decreased	increased	decreased
B	decreased	increased	increased	increased
C	increased	increased	increased	increased
D	increased	decreased	decreased	increased

HELP

During vigorous exercise, the glycogen store in the muscle will be used to produce more ATP, depleting the store of energy in the muscles. Lactate in the muscles will increase because some anaerobic respiration will occur, resulting in a decreased pH because of the presence of lactic acid.

Q22

Which substances enter and leave a mitochondrion during aerobic respiration?

	enters	*leaves*
A	acetyl-CoA	carbon dioxide
B	ADP	lactate
C	glucose	reduced NAD
D	pyruvate	ATP

HELP

Pyruvate is the end-product in glycolysis, enters the mitochondrion and then is converted into acetyl CoA, which undergoes Krebs cycle and finally results in ATP formation.

Q23

The complete oxidation of one mole of glucose yields 2880 kJ of energy. The addition of one phosphate molecule to ADP requires 30.6 kJ of energy per mole. In aerobic respiration, 38 molecules of ATP are formed as a result of the breakdown of each glucose molecule.

Which figure best represents the efficiency of aerobic respiration in trapping the energy released by the glucose molecule?

A 23%
B 36%
C 40%
D 45%

HELP

The total amount of energy used in forming 38 ATP = 38 × 30.6 kJ = 1162.8 kJ. Thus, the efficiency of aerobic respiration is 1162.8/2880 × 100% = 40%.

Q24

In mitochondria, where do the reactions of the electron transfer chain occur?

A in the inner membranes
B in the outer membranes
C in the matrix
D between inner and outer membranes

HELP

The electron transfer chain occurs in the inner mitochondrial membrane, where the components such as coenzyme Q occur.

Q25

Six tubes were set up as shown in the table.

tube	*contents*
1	glucose + homogenised animal cells
2	glucose + mitochondria
3	glucose + cytoplasm lacking organelles
4	pyruvate + homogenised animal cells
5	pyruvate + mitochondria
6	pyruvate + cytoplasm lacking organelles

After incubation, each sample was analysed to determine the presence of carbon dioxide and lactate.

In which tubes is lactate most likely to be present?

A 1 and 3 only

B 2, 3, 5 and 6 only

C 3 and 6 only

D 4, 5 and 6 only

HELP

Lactate is produced in anaerobic respiration which occurs when aerobic respiration is inhibited. Aerobic respiration requires mitochondria which is present in homogenised animal cells but absent in cells lacking organelles.

Q26

The electron transport system in cells is directly coupled with

A hydrolysis of hexose phosphates.

B production of pyruvate.

C reduction of NAD.

D synthesis of ATP.

HELP

The reactions in the electron transport chain pumps protons (H^+ ions) across the inner mitochondrial membrane, setting up a proton gradient. ATP synthase couples the diffusion of protons down their concentration gradient to the phosphorylation of ADP to ATP.

Q27

How many moles of carbon dioxide are produced by the complete oxidation of one mole of pyruvate?

A 2 B 3

C 4 D 6

HELP

One mole of pyruvate contains 3 moles of carbon atoms, and hence would produce 3 moles of carbon dioxide.

Q28

What happens to most of the reduced NAD molecules in cell metabolism?

A They act as oxidising agents in glycolysis.

B They are oxidised in mitochondrial ATP formation.

C They are oxidised in the Calvin cycle.

D They combine with succinic acid as part of the Krebs cycle.

HELP

Reduced NAD are oxidised via reactions in the electron transport chain, which is coupled with ATP production.

Q29

Which of the following pathways outlines the order of events during aerobic cellular respiration?

first ——————→ *last*

A glucose → triose phosphate → pyruvate → Krebs cycle → CO_2 + H_2O + ATP

B glucose → triose phosphate → pyruvate → Krebs cycle → CO_2 + H_2O + ADP + Pi

C glucose → hexose phosphate → pyruvate → Krebs cycle → CO_2 + H_2O + ADP + Pi

D glucose → hexose phosphate → pyruvate → Krebs cycle → ethanol + CO_2 + ATP

HELP

Glucose is converted to hexose phosphate, which is broken down to triose phosphate, which is subsequently converted to pyruvate. Pyruvate enters the Krebs cycle, producing carbon dioxide, reduced NAD and ATP. Reduced NAD enters the electron transport chain, where oxygen is reduced to water and ATP is produced.

Q30

What is oxidative phosphorylation?

A addition of phosphate to ADP using energy gained by transferring electrons along a chain of carriers

B addition of phosphate to ADP using energy gained by transferring electrons between chlorophyll molecules

C addition of phosphate to glucose in the first step of glycolysis

D removal of phosphate from ATP with the release of energy for work within the cell

HELP

A is oxidative phosphorylation. B is photophosphorylation, C does not involve redox reactions and D is dephosphorylation.

Q31

Where are the enzymes located which are involved in the chemical reactions which occur during glycolysis?

A in the fluid matrix of the cytoplasm

B in the mitochondrial matrix

C on the cristae of a mitochondrion

D on the smooth endoplasmic reticulum

HELP

Glycolysis occurs in the cytoplasm, Krebs cycle occurs in the mitochondrial matrix and the electron transport chain is sited in the cristae of a mitochondrion.

Q32

What is the function of molecular oxygen in cellular respiration?

A to combine with carbon to produce carbon dioxide

B to combine with glucose to produce carbon dioxide

C to combine with hydrogen to produce water

D to oxidise ADP to ATP

HELP

Molecular oxygen is the final electron acceptor of electrons that are passed down the electron transport chain of oxidative phosphorylation, combining with hydrogen ions to form water.

Q33

Which changes occur when the electron transfer system in animals is inhibited?

	lactate concentration	*oxygen consumption*	*Krebs cycle activity*
A	decreased	decreased	increased
B	decreased	increased	increased
C	increased	decreased	decreased
D	increased	increased	decreased

HELP

When the electron transfer system is inhibited, aerobic respiration cannot occur and anaerobic respiration occurs instead. Anaerobic respiration does not make use of oxygen and it makes use of pyruvate, which occurs at a stage before the Krebs cycle, to make lactate.

Q34

Which type of mammalian cell does **not** carry out oxidative phosphorylation?

A cardiac muscle cells

B liver cells

C neurones

D red blood cells

HELP

Red blood cells have no nucleus and no mitochondria to make more room for haemoglobin, hence increasing the carrying capacity for oxygen. Without mitochondria, oxidative phosphorylation cannot occur.

Q35

In the conversion of glucose to two molecules of pyruvate, what does **not** occur?

A hydrolysis of ATP

B phosphorylation of hexose

C reduction of NAD

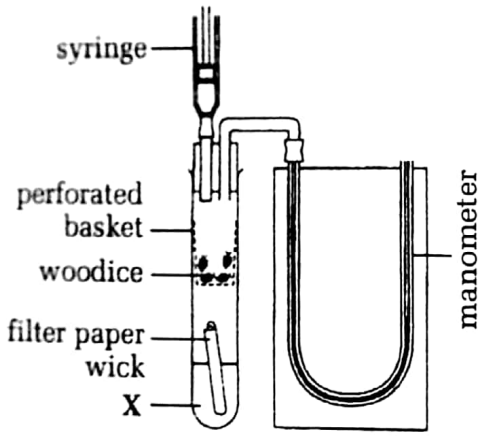
D release Of CO_2

HELP

The release of one CO_2 occurs in the conversion of pyruvate to acetyl CoA. The release of two CO_2 occurs in the Krebs cycle.

Q36

The diagram shows a respirometer used to measure oxygen uptake by woodlice.



What is **X**?

A buffer solution to control the pH

B lime water to indicate the presence of carbon dioxide

C potassium hydroxide solution to absorb carbon dioxide

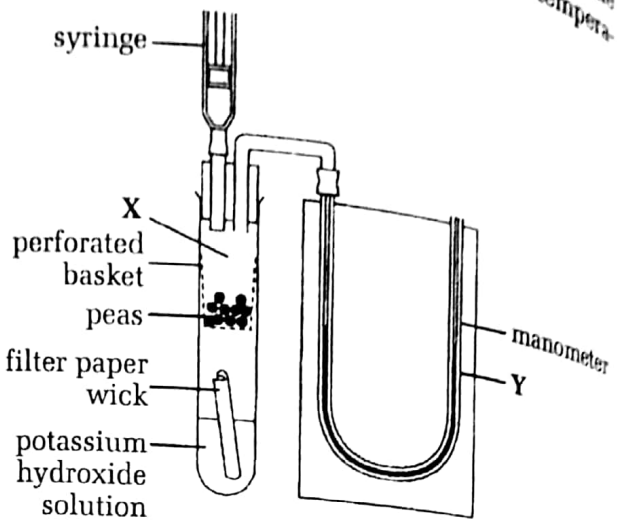
D water to control the humidity

HELP

The woodlice take up oxygen and then they give out carbon dioxide. To prevent this build up of CO_2, potassium hydroxide will absorb it. Thus the movement in the manometer would indicate the amount of oxygen loss from the air around the woodlice, instead of complication from the CO_2 coming out of the woodlice.

Q37

The diagram shows a respirometer that is used to measure gaseous exchange in pea seeds. The apparatus is maintained at a constant temperature.



What happens to the gas pressure at **X** and to the fluid level at **Y**?

	gas pressure at X	fluid level at Y
A	falls	rises
B	falls	falls
C	rises	rises
D	rises	falls

HELP

Potassium hydroxide absorbs whatever carbon dioxide is released during respiration. The gas pressure at X will fall as O_2 is absorbed during respiration. This would cause the fluid level at Y to fall and try to fill the loss of pressure at X.

Q38

Where does ethanol formation occur in a yeast cell?

A cell vacuole

B cytoplasm

C Golgi apparatus

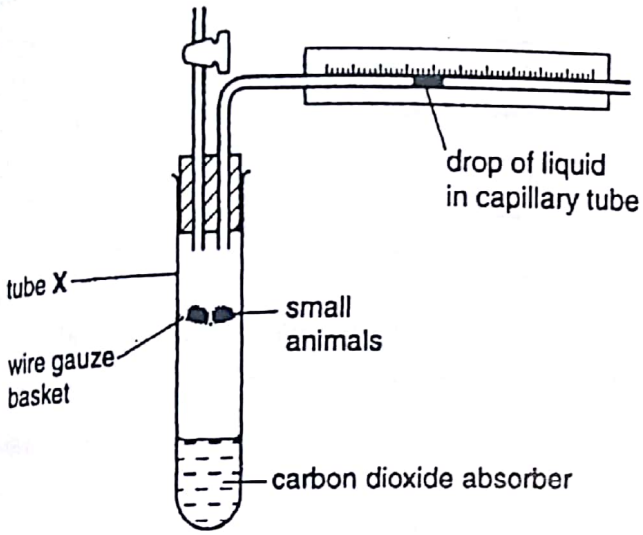
D mitochondrion

HELP

Since glycolysis occurs in the cytoplasm of cells and not the mitochondria, the pyruvate would remain in the cytoplasm for the conversion to ethanol during anaerobic respiration.

Q39

The diagram shows a simple respirometer.



The changes in gas volume in the tube are measured at intervals.

time (minutes)	gas volume with carbon dioxide absorber (cm^3)	gas volume without carbon dioxide absorber (cm^3)
0	0.0	0.0
10	−0.4	−0.1
20	−0.8	−0.2
30	−1.2	−0.3

Tube X contains 2 g of small animals. What is the carbon dioxide output per g per hour for these organisms?

A 0.9 cm^3 B 1.8 cm^3

C 2.4 cm^3 D 4.8 cm^3

HELP

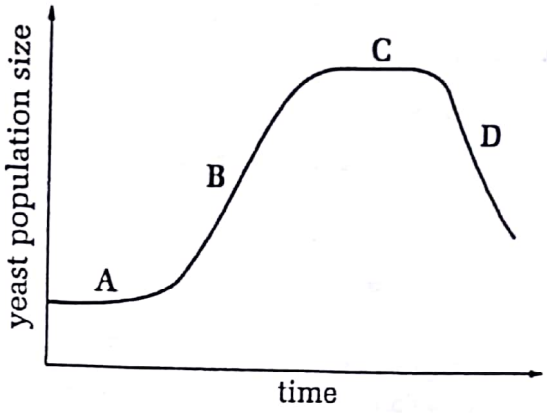
1.8 cm^3 of carbon dioxide output for 60 minutes from 2 small animals (2 g).

For 1 g, there would be 0.9 cm^3 of gas.

Q40

The growth curve shows the change in the size of a yeast population maintained under anaerobic conditions.

In which stage of growth is there the greatest mean rate of ethanol production per cell?



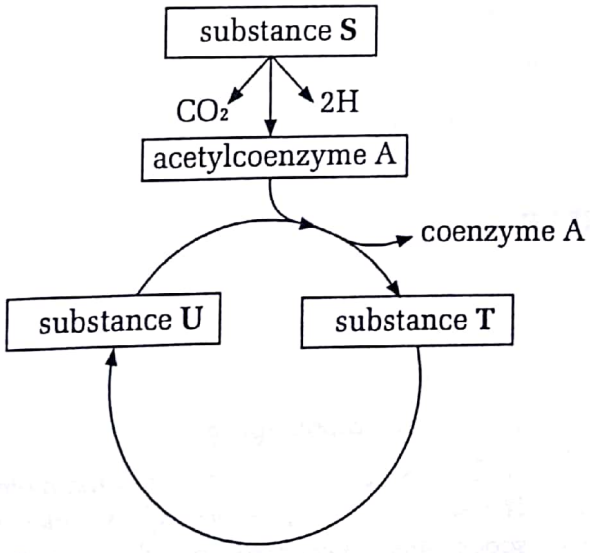
HELP

Ethanol is produced by yeast in the main growth phase of the yeast population. After that, the ethanol accumulates around the yeast until its concentration rises to a level that prevents further growth. At this stage, the ethanol will start to kill the yeast.

Q41

The diagram shows some of the reactions following glycolysis during aerobic respiration.

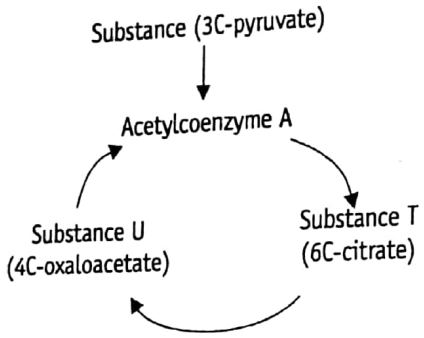
How many carbon atoms are in each of the substances **S**, **T** and **U**?



	S	T	U
A	2	4	6
B	2	6	4
C	3	4	6
D	3	6	4

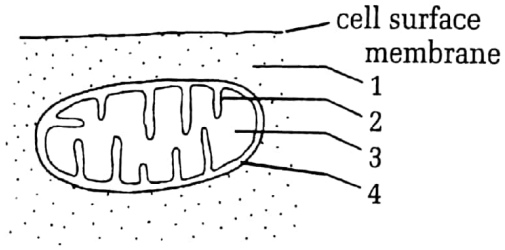
HELP

Kreb's cycle:



Q42

The diagram shows a mitochondrion in a cell.



Where is ATP produced from ADP during respiration?

A 1 and 2 only

B 1, 2 and 3

C 2 and 3 only

D 2, 3 and 4

HELP

1: Cytoplasm

2: Crista

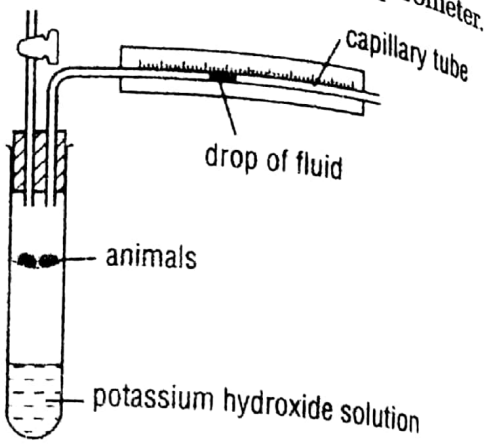
3: Matrix

4: Inter-membrane space

NAD picks up hydrogen atoms in the matrix. The split produces protons, which enter the space, then flows back into the matrix via the stalked granules. This flow acts as a driving force to combine ADP with the inorganic phosphate to form ATP.

Q43

The diagram shows a simple respirometer.



What is being measured by this apparatus?

A carbon dioxide production

B carbon dioxide production minus oxygen uptake

C oxygen uptake

D oxygen uptake minus carbon dioxide production

HELP

Potassium hydroxide absorbs carbon dioxide. Therefore the instrument measures the oxygen uptake by the animal without the carbon dioxide produced by respiration.

Q44

Intact mitochondria are mixed with a solution containing DCPIP, succinate and sucrose. The enzyme succinate dehydrogenase in the mitochondria oxidises the succinate and the DCPIP is a hydrogen acceptor.

Why is the sucrose added to the reaction medium?

A To act as a hydrogen donor.

B To act as a reducing agent.

C To maintain the osmotic balance.

D To provide energy for the reaction.

HELP

Sucrose is a non-reducing sugar that can help maintain osmotic balance. DCPIP accepts hydrogen from the oxidation of succinate, which is the hydrogen donor.

Q45

Which of the following is a molecule formed in metabolic pathways by the equal splitting of a phosphorylated hexose into two halves?

A acetyl coenzyme A

B fructose 1,6-bisphosphate

C ribulose bisphosphate (RuBP)

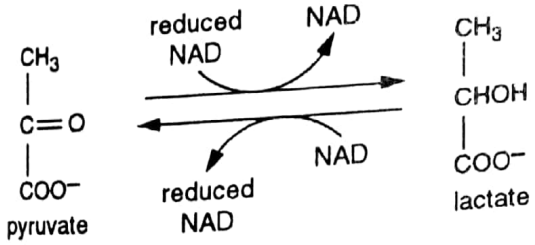
D triose phosphate

HELP

Acetyl coenzyme A is a two-carbon compound that is formed from combining pyruvate with coenzyme A. Fructose 1,6-bisphosphate and RuBP are both not formed from splitting of hexose sugars.

Q46

The diagram shows the reversible conversion of pyruvate to lactate by the enzyme lactate dehydrogenase.



What would be the effect of inhibition of lactate dehydrogenase in a mammalian cell under anaerobic conditions?

A A decrease in cell pH, due to the accumulation of lactic acid.

B A decrease in glycolysis, due to the lack of NAD.

C An increase in ATP production, due to increased amounts of reduced NAD.

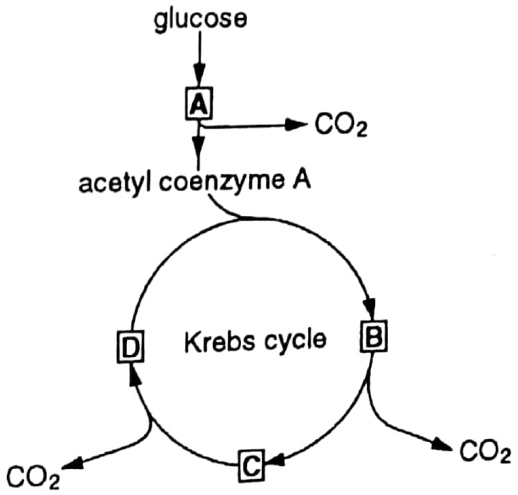
D An increase in activity of the Krebs cycle, due to increased amounts of pyruvate.

HELP

Unlike glycolysis, the Krebs cycle and subsequent ATP production will not occur under anaerobic conditions as oxygen has to be present to be the final hydrogen acceptor. However, without lactate dehydrogenase, glycolysis cannot occur since the reduced NAD is not converted back to NAD. Thus, there is insufficient NAD as hydrogen carriers.

Q47

The diagram shows some of the stages of respiration. Which molecule contains four carbon atoms?

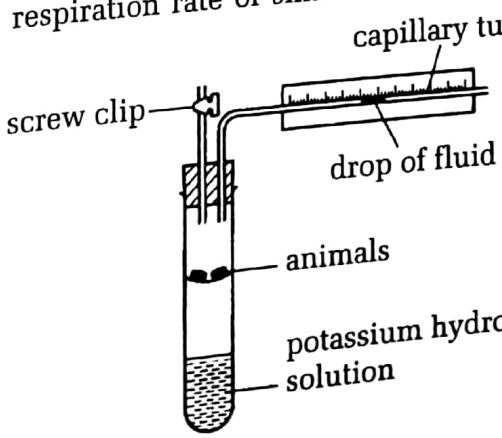


HELP

Molecule D has to have 4 carbons so that it can combine with the 2-carbon acetyl coenzyme A to obtain a 6-carbon compound, which is molecule B.

Q48

The diagram shows apparatus used to measure the respiration rate of small animals.



Should the screw clip be left open or closed, and why?

	screw clip	why
A	open	to allow entry of air
B	open	to allow for temperature fluctuations
C	closed	to measure output of carbon dioxide
D	closed	to measure uptake of oxygen

HELP

If the screw was left open, oxygen from the atmosphere would enter the tube and influence the reading of the fluid movement in the capillary tube.

Q49

ATP can be formed by oxidative phosphorylation in the electron transport system and by glycolysis.

In the complete oxidation of one molecule of glucose, approximately what percentage of ATP is formed by oxidative phosphorylation?

A 10% **B** 25%

C 75% **D** 90%

HELP

Oxidative phosphorylation contributes 34 ATP out of the 38 ATP produced per glucose molecule, which is 89.98%. Glycolysis and the Krebs cycle contribute 4 ATP.

Q50

The table shows events that may occur in the Calvin cycle, the Krebs cycle or in glycolysis.

In which of these processes do the events occur?

	ATP used	dehydrogenation	reduced NADP used
A	Calvin cycle	glycolysis	Kerbs cycle
B	glycolysis	Calvin cycle	Kerbs cycle
C	glycolysis	Kerbs cycle	Calvin cycle
D	Kerbs cycle	glycolysis	Calvin cycle

HELP

Candidates are reminded that reduced NADP is used in photosynthesis only, whereas NAD is used in respiration. Only glycolysis uses ATP, whereas the Krebs cycle generates ATP.

Q51

During anaerobic respiration in mammals, the pairs of hydrogen atoms released during glycolysis are accepted by NAD.

To which molecule are the pairs of hydrogen atoms then transferred?

A coenzyme A

B lactate

C oxygen

D pyruvate

HELP

Lactate is only formed after the pyruvate molecule accepts the hydrogen atoms from the reduced NAD.

Q52

At which stage in the oxidation of glucose are both ADP and NAD required?

glucose $\xrightarrow{A}$ hexose phosphate $\xrightarrow{B}$ triose phosphate

$\downarrow$ **C**

pyruvate

$\downarrow$ **D**

acetyl coenzyme A

HELP

NAD is required to accept the hydrogen produced when glyceraldehyde-3-phosphate (PGAL) is converted to glycerate-3-phosphate (PGA). ADP is required to accept the phosphates that will form ATP when PGA converts to pyruvate.

Q53

What is the precise role of oxygen in cell respiration?

A **to act as the final hydrogen acceptor in the electron transport chain**

B to combine with acetyl coenzyme A to form citrate in the Krebs cycle

C to combine with carbon from carbohydrates to form carbon dioxide

D to oxidise reduced NAD in oxidative phosphorylation

HELP

Oxygen serves as an acceptor of hydrogen so that water is formed at the end of the electron transport chain.

Q54

Which statement about anaerobic respiration is correct?

A Animals are unable to use lactate for the production of ATP.

B From one molecule of glucose, ethanol and lactate production yield the same amounts of ATP.

C **From one molecule of glucose, ethanol production yields more energy than lactate production.**

D Yeast is able to respire ethanol for the production of ATP.

HELP

Candidates are reminded that ethanol cannot be further broken down to produce ATP. The only ATP produced is through glycolysis, thus ethanol and lactate production during anaerobic respiration yields the same 2 ATP molecules.

Topic 6(b) Respiration

Q1 D	Q2 B	Q3 C	Q4 D	Q5 D	Q6 C	Q7 D	Q8 A
Q9 B	Q10 C	Q11 D	Q12 A	Q13 B	Q14 B	Q15 C	Q16 D
Q17 C	Q18 D	Q19 D	Q20 B	Q21 A	Q22 D	Q23 C	Q24 A
Q25 C	Q26 D	Q27 B	Q28 B	Q29 A	Q30 A	Q31 A	Q32 C
Q33 C	Q34 D	Q35 D	Q36 C	Q37 B	Q38 B	Q39 A	Q40 B
Q41 D	Q42 D	Q43 D	Q44 C	Q45 D	Q46 B	Q47 D	Q48 D
Q49 D	Q50 C	Q51 D	Q52 C	Q53 A	Q54 B		

TOPIC 6

6(c)

CELLULAR PHYSIOLOGY AND BIOCHEMISTRY

Structure, Roles and Functions of Membrane

You should try to answer on your own before resorting to **HELP**

Q1

The approximate width of a cell membrane is

A 0.01 nm

B 0.10 nm

C 1.0 nm

D 10.0 nm

HELP

The cell membrane consists of a protein and bilipid layer, with a thickness of about 80 μ. The best electron micrographs of animal cells reveal 2 dense lines (lipid layer) of about 20 μ each, separated by a lighter band (protein layer) of about 35 μ.

$1\ \mu = 1^{-10}$ m

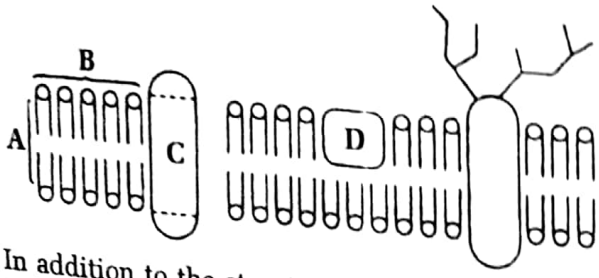
1 nm = 10^{-9} m

therefore, $1\ \mu = 10^{-1}$ nm

$80\ \mu = 8$ nm $\approx$ 10.0 nm

Q2

The diagram below represents a current model of the structure of a biological membrane.



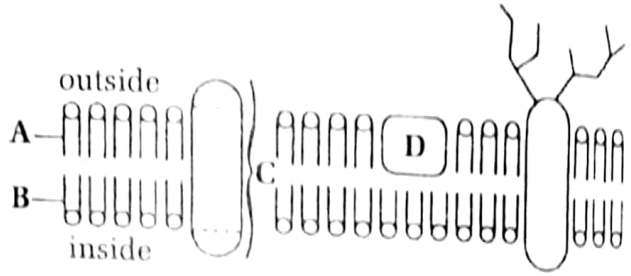
In addition to the structures shown, cholesterol is also present. In which one of the areas, **A**, **B**, **C**, or **D**, is this found?

HELP

Cholesterol occurs in the hydrophobic tails of the membrane's phospholipid bilayer, and helps to maintain membrane structure.

Q3

The diagram below represents a model of the structure of a biological membrane.



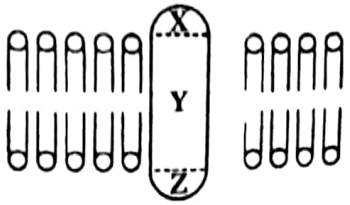
Which one of the structures, **A**, **B**, **C** or **D**, will carry out active transport from the cell?

HELP

The transport protein C spans the membrane and consists of 2 binding sites at the exterior and the interior, each being capable of binding the substrate that is to be transported. When binding occurs at one side, a conformational change in the protein occurs, allowing the substrate through to the other side.

Q4

The diagram shows three zones, **X**, **Y** and **Z**, of a membrane protein in the phospholipid layer.



What enables the protein to maintain its relative position in the membrane?

A covalent bonds between zone Y and the phospholipids

B ionic bonds between zone Z and the cytoplasm

C large numbers of hydrophobic amino acids in zone Y

D large numbers of hydrophobic amino acids in zone X

HELP

The phospholipid membrane has a hydrophobic interior. The intrinsic protein shown has the most hydrophobic amino acids in zone Y so as to maintain its position in the membrane.

Q5

Which cell component forms pinocytic vesicles?

A cell surface membrane (plasma membrane)

B endoplasmic reticulum

C lysosome

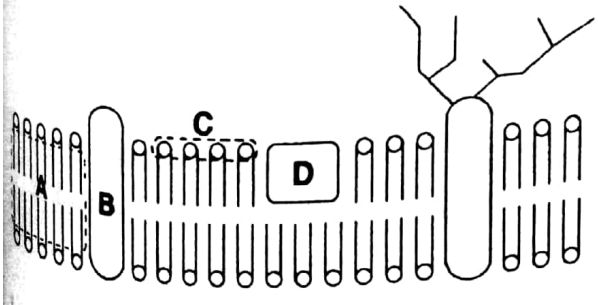
D nucleolus

HELP

Pinocytosis is the non-specific uptake of small droplets of extracellular fluid by vesicles that arise from the invagination of the plasma membrane. This process occurs so that substances may be exchanged between the intracellular and extracellular environment.

Q6

The diagram shows a model of the structure of a biological membrane.



Which labelled part would restrict the movement of small, lipid-insoluble molecules?

HELP

A represents the hydrophobic interior of the bilipid membrane, restricting the entry of small, lipid-insoluble (non-hydrophobic) molecules.

Q7

Which technique provided the primary evidence for the fluid mosaic model of the cell membrane?

A cell fractionation

B chemical analysis of membrane proteins

C chemical analysis, microscopic staining

D freeze-fracture

HELP

The freeze-fracture technique allows the 2 faces of the cell membrane to be separated and examined under electron microscopy. The membrane is frozen and fractured by a sharp blow, splitting the membrane into the two phospholipid leaflets, showing the membrane model.

Q8

By which process does glucose move into red blood cells from the plasma?

A active transport

B endocytosis

C facilitated diffusion

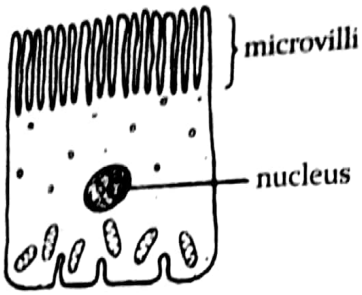
D osmosis

HELP

Glucose transport occurs by the glucose transporter (a carrier protein), which moves glucose down its concentration gradient from the plasma into the cytoplasm of the cell.

Q9

The diagram shows a cell found in an organ in the body.



From its structure, what are the functions of this cell?

A uptake and transport of fluids against a concentration gradient

B intracellular digestion and transport of products

C phagocytosis, pinocytosis and secretion

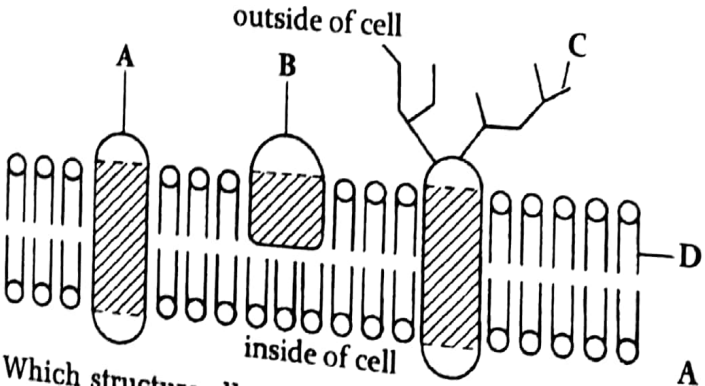
D secretion and transport of mucus

HELP

Microvilli are extensions of the cell surface which greatly increase the surface area and enhance the absorption of fluids to the cells, e.g. glucose. The abundance of mitochondria shows that the cell uses a lot of energy to serve this purpose of uptake against a concentration gradient.

Q10

The diagram represents a cell membrane.



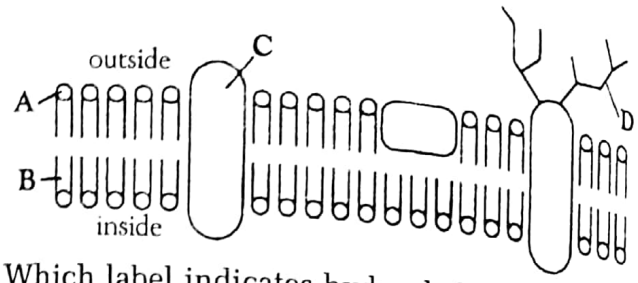
Which structure allows the diffusion of Cl^- ions between the outside and the inside of the cell?

HELP

Charged ions like Cl^- ions and polar molecules are repelled by the hydrophobic regions in the middle of the membrane. Hence, they can only travel through integral proteins such as A that span across the whole membrane.

Q11

The diagram represents a model of the structure of a biological membrane.



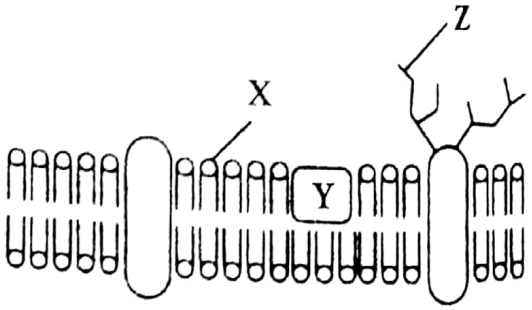
Which label indicates hydrophobic hydrocarbon chains?

HELP

The hydrophobic tails of the lipid membrane are represented by B. These restricts the entry of small lipid-insoluble molecules, and maintain the membrane structure.

Q12

The diagram shows the fluid-mosaic model of membrane structure. What are X, Y and Z?



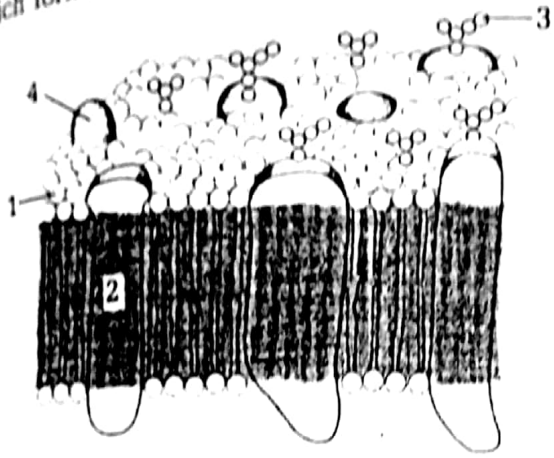
	X	Y	Z
A	lipid	carbohydrate	protein
B	lipid	protein	carbohydrate
C	protein	carbohydrate	lipid
D	protein	lipid	carbohydrate

HELP

X refers to the hydrophilic heads of the phospholipid molecules. Y shows a peripheral protein, whilst Z is a carbohydrate chain on an integral protein.

Q13

The diagram shows some of the main structures which form the cell surface membrane.



Which two structures, when hydrolysed, would release amino acids only?

A 1 and 2
B 1 and 3
C 2 and 4
D 3 and 4

HELP

2 and 4 are proteins, and hence would break down to from amino acids only. 1 is phospholipid, which consists of fatty acids, glycerol and a phosphate group. 3 is glycoprotein, which has carbohydrate as well as protein components.

Q14

Four identical samples of plant tissue, each with a water potential (ψ) of –700 kPa, are placed in four different solutions. Which solution induces full plasmolysis within the tissue?

solution	ψ
A	–700 kPa
B	–1000 kPa
C	–400 kPa
D	–200 kPa

HELP

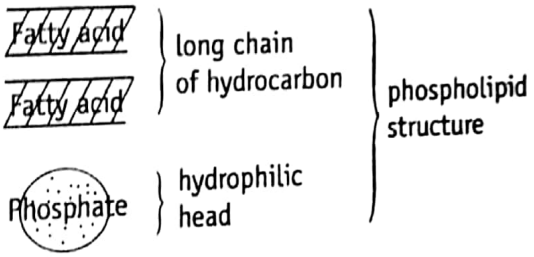
The tissue has a water potential of –700 kPa. A is isotonic to the tissue. Addition of solute tends to lower the water potential. Therefore the most negative (hypertonic) will have more solutes in it, causing water to move out of the tissue into the solute. This would be the answer B (–1000 kPa). C and D are both hypotonic to the tissue, causing water to move in, making it more turgid instead.

Q15

Which part of a phospholipid molecule contributes most to the thickness of a cell surface membrane?

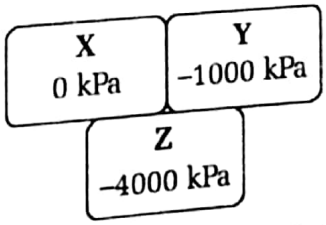
A glycerol
B hydrocarbon chain
C hydrophilic head
D phosphate group

HELP



Q16

The water potential of three adjacent plant cells is shown.



In which direction will water move?

A from cell X to cells Y and Z
B from cell Y to cells X and Z
C from cell Z to cell X
D from cell Z to cell Y

HELP

Candidates should well remember that water molecules always move from an area of higher water potential (0 kPa) to areas of lower water potential (more negative, i.e. -1000 kPa and -4000 kPa).

Q17

Potassium cyanide is known to interfere with the formation and use of ATP in cell metabolism.

If the use of potassium cyanide resulted in an accumulation of a solute in a cell, it may be deduced that the solute normally enters by

A active transport.

B diffusion.

C osmosis.

D pinocytosis.

HELP

As potassium cyanide caused the solute to remain in the cell, it can be deduced that the solute is no longer actively transported out of the cell. Therefore, the solute would enter the cell via diffusion down a concentration gradient, since it normally has to be actively transported out of the cell against a concentration gradient.

Q18

A plant cell is placed in a solution with a less negative water potential. Which change occurs in the cell and what causes the change?

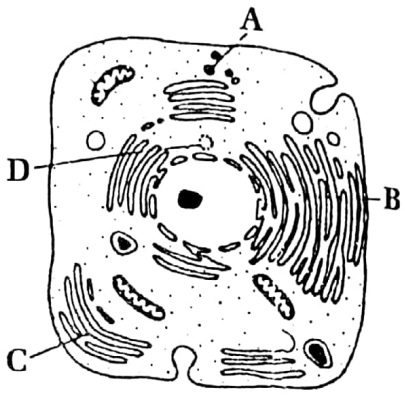
	change	cause
A	cell becomes more flaccid	solution diffuses out of the cell
B	cell becomes more flaccid	water diffuses out of the cell
C	cell becomes more turgid	solution diffuses into cell
D	cell becomes more turgid	water diffuses into cell

HELP

If the solution has less negative water potential, then there are less solutes in the solution and a higher concentration of water. This will induce movement of water from the solution into the plant cell. Thereby, making the cell turgid. The movement of molecules here would refer to water molecules, not the solution itself.

Q19

The diagram shows a generalised animal cell.



Which structure would be involved in the final secretion of digestive enzymes from this cell?

HELP

The digestive enzymes are formed in the cytoplasm on the ribosomes, and then localised in the lumen of the rough ER. These proteins them migrate to the Golgi apparatus in the membrane-bound vesicles, A, ready to be secreted.

Q20

What is the role of cholesterol in the cell surface membrane?

A to assist active transport

B to assist facilitated diffusion

C to provide hydrophilic channels

D to regulate fluidity of the membrane

HELP

Cholesterol makes the membrane less fluid at higher temperatures and more fluid at lower temperatures. Proteins play a role in assisting active transport across the membrane.

Q21

Which process enables proteins to enter cells?

A active transport

B diffusion

C endocytosis

D osmosis

HELP

Diffusion involving the movement of ions and polar molecules through the cell membrane is slow. Proteins can be broken down to such a form. Endocytosis involves uptake of materials in bulk, osmosis is in reference to the passage of water. Active transport enables proteins (in the form of amino acids) to enter cells faster.

Q22

What is the approximate width of the cell surface membrane?

A 7.5 nm

B 75 nm

C 7.5

D 75 μm

HELP

The cell wall is 10-80 nm.

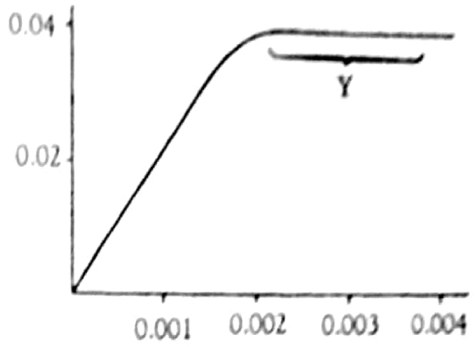
The cell membrane is thinner than that, about 7.5 nm.

A measurement in μm will be considered to be too thick for a cell membrane.

Questions 23 and 24 refer to the following information.

Substance **X** (a mineral ion) is actively transported into cells. Equal-sized samples of cells were placed in media containing different concentrations of **X** for an hour.

The intracellular concentration of **X** was then measured. All other metabolic conditions were maintained at the optimum level. The graph below shows the results.



Q23

From the information given above, which one of the following would account for the level region of the graph indicated by the letter **Y**?

A A respiratory inhibitor had been introduced.

B As the internal concentration of **X** rose, more of the substance was metabolised.

C The active transport carriers had been inactivated by a non-competitive inhibitor.

D All the active transport carriers had been operating at their maximum rate.

HELP

The region Y on the graph indicates that the maximum amount of **X** that can be transported is 0.04. This is because all the binding sites on the active transport carriers for the mineral ions have been occupied thus there is a saturation of the carriers.

Q24

Which one of the following is the maximum concentration of **X** in the intracellular solution relative to the external solution that can be maintained by active transport in these conditions?

A 4 times
B 5 times
C 10 times
D 20 times

HELP

Under such saturating conditions, the intracellular concentration of **X** is 0.04, whilst the concentration of **X** in the external is 0.002. Thus the ratio of the 2 values is 0.04/0.002 = 20 times.

Q25

The table summarises methods of movement of substances.

	movement does not always involve passage of substance through membrane	movement always involve passage of substance through membrane
energy provided only by kinetic energy of particles	1	2
energy provided by hydrolysis of ATP	3	4

What do the numbers in the table represent?

	1	2	3	4
A	active transport	diffusion	osmosis	pinocytosis
B	diffusion	osmosis	pinocytosis	active transport
C	osmosis	pinocytosis	active transport	diffusion
D	pinocytosis	diffusion	active transport	osmosis

HELP

Diffusion and osmosis is the movement of molecules down their concentration gradient and does not require energy provided by ATP. Osmosis refers specifically to the movement of water molecules across a membrane. Phagocytosis and active transport require energy provided by the hydrolysis of ATP. Active transport occurs through protein channels or transporters, and hence must necessarily occur across a membrane.

Q26

Potassium cyanide is known to interfere with the formation and use of ATP in cell metabolism.

If the use of potassium cyanide resulted in an accelerated entry of a solute into a cell, it may be reasonably assumed that, under normal circumstances, the solute enters by

A active transport.
B osmosis.
C passive diffusion.
D pinocytosis.

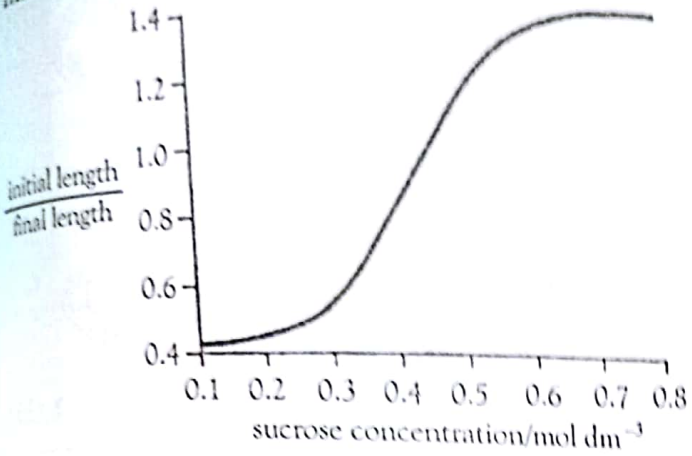
HELP

Under normal circumstances, the cell must have sodium pumps (Na^+/K^+ ATPase) which actively transport ATP into the cell. When KCN is added, the carriers are destroyed, thus ATP can enter freely.

Q27

Strips of plant tissue were immersed in a range of sucrose solutions of different concentrations. Their lengths were measured before immersion and after 30 minutes in the different solutions.

The graph shows the ratio of initial length to final length.



Which concentration of sucrose solution has the same water potential as the cell sap?

A 0.1

B 0.25

C 0.45

D 0.6

HELP

When the concentration of sucrose solution has the same water potential as the cell sap, there would be no net movement of water across the cell membranes of the plant tissue and there would be no change in the length of the strip. For the 0.45 mol dm^{-3} sucrose solution, the ratio of initial length : final length was 1.0, which means that the length of the strip of plant tissue was unchanged.

Q28

By which process does glucose move into red blood cells from the plasma?

A active transport

B endocytosis

C facilitated diffusion

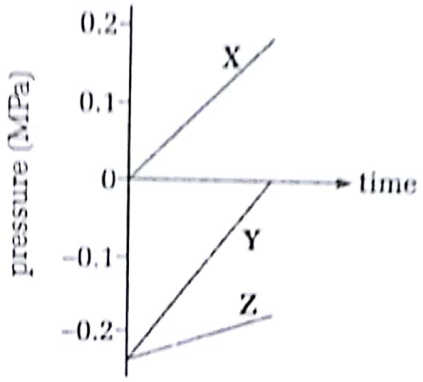
D osmosis

HELP

Glucose moves into red blood cells down a concentration gradient, thus the process is passive diffusion. However, as it is an important respiratory substrate for cells, more rapid movement is required, hence the process is facilitated diffusion.

Q29

The graph shows the relationship between ψ (water potential), ψ_s (solute potential) and ψ_p (pressure potential) for a plant cell placed in pure water.



What are the correct labels for the graph?

	X	Y	Z
A	ψ	ψ_p	ψ_s
B	ψ	ψ_s	ψ_p
C	ψ_p	ψ	ψ_s
D	ψ_p	ψ_s	ψ

HELP

If the plant cell is placed in water, it will become turgid as the water from the solution moves into it. X should be the pressure potential as it is positive. As the water moves into the cell, the water potential would increase greater than the solute potential.

Q30

The table shows the results of an experiment on the rate of uptake of sugars by rat intestine.

sugars	rate of absorption relative to glucose	
	under aerobic contitions	under anaerobic contitions
hexose sugars		
glucose	100	30
galactose	106	32
pentose sugars		
xylose	32	32
arabinose	30	30

Which conclusion may be drawn from the results?

A All four sugars can be absorbed by active transport.

B Only hexose sugars can be metabolised by the rat.

C The intestine is freely permeable to hexose sugars.

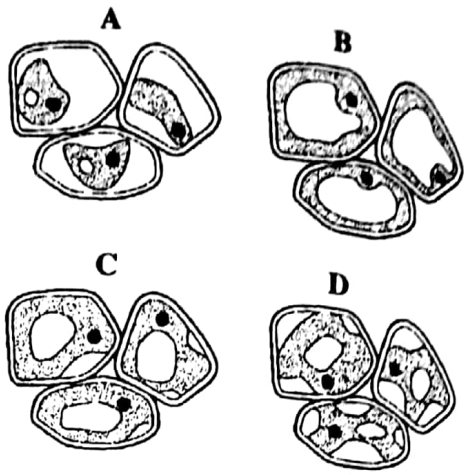
D The rate of passive diffusion of all four sugars into the gut is similar.

HELP

Passive diffusion does not require energy, thus it can occur under anaerobic conditions where there is no oxygen to drive the oxidative phosphorylation process to produce ATP. From the results, it can be seen that the rates under anaerobic conditions are similar.

Q31

Which group of cells, taken from the same plant, has been placed in a solution with a less negative water potential than the cell contents?



HELP

Water always moves from an area of less negative water potential to an area of more negative water potential. Therefore, water from the solution would enter the cells and make them more turgid.

Q32

Which pair of factors is *inversely* proportional to the rate of diffusion?

A Concentration gradient and size of diffusing molecule.

B Distance over which diffusion occurs and surface area over which diffusion occurs.

C Size of diffusing molecule and distance over which diffusion occurs.

D Surface area over which diffusion occurs and concentration gradient.

HELP

Small molecules diffuse faster than large ones, that is, the smaller the molecule, the greater the rate of diffusion. The rate is proportional to the reciprocal of the size of the molecule.

The shorter the distance between two regions of different concentration, the greater the rate of diffusion. The rate is proportional to the reciprocal of the square of the distance.

Q33

Plant tissue was moved from solution X to solution Y and the cells became less turgid.

Compared with solution X, what was the relative water potential of solution Y and what caused the change in the cells?

	water potential of solution Y	cause of change in cells
A	less negative	water diffused in
B	less negative	water diffused out
C	more negative	water diffused in
D	more negative	water diffused out

HELP

Solution Y has to be more negative since water diffusing out of the cells will make them less turgid. Candidates are reminded that water always moves from areas of less negative water potential to a more negative water potential.

Q34

Which statement about the phospholipids in the phospholipid bilayer is correct?

A They are made up of three fatty acids combined with glycogen.

B They are made up of three fatty acids combined with glycerol.

C They form a bilayer in the membranes of cells.

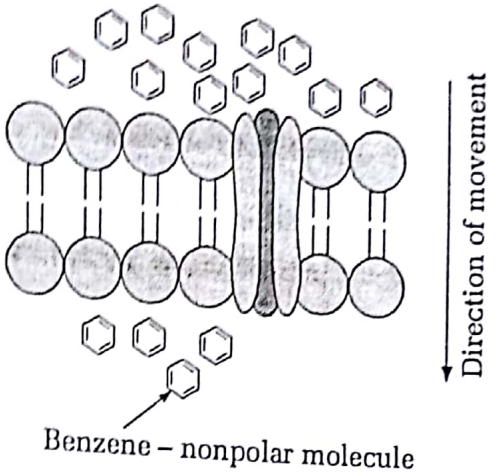
D They form a single layer in the membranes of cells.

HELP

The phospholipids of cell membranes align with one another, such that their hydrophobic tails are buried inside the two hydrophilic layers formed by the phosphate groups. This produces a sheet composed of two parallel molecular layers called a phospholipid bilayer that forms the fundamental structure of membranes.

Q35

The diagram represents part of a cell surface membrane through which benzene molecules are moving.



Which correctly explains this movement?

A active transport through a carrier protein

B facilitated diffusion through a channel protein

C pinocytosis through the cell surface membrane

D simple diffusion through the phospholipid bilayer

HELP

Benzene is a non-polar molecule and is able to move down its concentration gradient across the hydrophobic core of the phospholipid bilayer via simple diffusion.

Q36

Which combination would increase the fluidity of a cell surface membrane?

	saturated fatty acids	non-saturated fatty acids	cholesterol
A	decrease	increase	decrease
B	decrease	increase	increase
C	increase	decrease	decrease
D	increase	decrease	increase

HELP

Kinks are present in the hydrocarbon chains of the non-saturated fatty acids and absent in the hydrocarbon chains of the saturated fatty acids

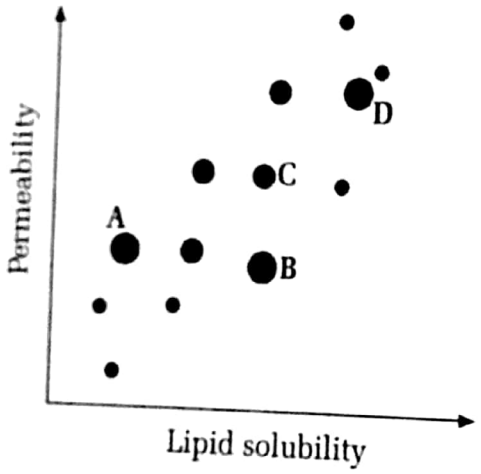
Kinks prevent the molecules of unsaturated lipids from packing together closely enough to solidify. Hence the presence of kinks increase the fluidity of the cell surface membrane while the absence of kinks decrease the fluidity of the membrane.

Cholesterol present in the membrane increases membrane fluidity by hindering the close packing of phospholipids.

Q37

The diagram shows the relationship between the size, lipid solubility of molecules and their ability to cross cell membranes. The diameter of the circles proportional to the size of the molecules.

Which circle represents a substance that has a large molecule size, a low solubility and a permeability that is greater than might be expected?



HELP

large molecule size – option C is out

low solubility – option D is out

greater permeability – option B is out

Q38

Phospholipid molecules are present as a bilayer in the plasma membrane because

A the polar groups are hydrophobic, thus they are confined to the center of the membrane.

B the fatty acid chains are hydrophilic, thus they are confined to the center of the membrane.

C non-polar groups are hydrophobic, thus they are confined to the center of the membrane.

D polar groups with opposite charges are attracted to each other.

HELP

Phospholipids have hydrophilic phosphate heads that seek water and hydrophobic hydrocarbon tails that exclude water.

The phospholipids of cell membranes align with one another, such that their hydrophobic tails are buried inside the two hydrophilic layers formed by the phosphate groups, that is they are confined to the center of the membrane.

Q39

In an investigation into the properties of membranes, washed beetroot cells were shaken for five minutes in different solvents. The intensity of the red colour of the solvent was then measured. Which of the following is possible?

	tube conditions	*intensity of colour (arbitrary units)*
A	tap water at 20 °C	10
B	ethanol at 20 °C	35
C	tap water at 35 °C	35
D	distilled water at 45 °C	50

HELP

Ethanol dissolved the phospholipid bilayer and resulted in damage to membrane. Thus the red pigment leaked out of the beetroot cells into the solvent.

Q40

The components of the membrane found within and at the surface of cells contribute to their functions. Examples of components are found below:

1 glycolipids
2 glycoproteins
3 phospholipids
4 proteins

Which row matches the components with their functions?

	bind cells together into tissues	separating dissolved ions	recognizing self or non-self	enzymes
A	1	4	2	3
B	1	3	2	4
C	2	4	1	3
D	2	1	3	4

HELP

Function of components of membrane are as follows:

1 glycolipids: bind cells together into tissues or recognizing self or non-self

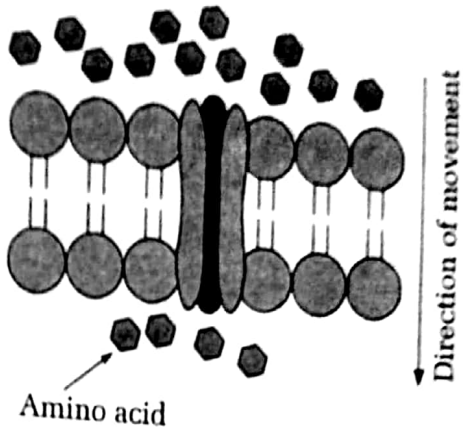
2 glycoproteins: bind cells together into tissues or recognizing self or non-self

3 phospholipids: forms the fundamental structure of membranes – the phospholipid bilayer and aids in separation of dissolved ions

4 proteins: proteins can function as enzymes to catalyse reactions

Q41

The diagram represents part of a cell surface membrane through which amino acid molecules are moving.



Which correctly explains this movement?

A **active transport through a carrier protein**

B facilitated diffusion through a channel protein

C pinocytosis through the cell surface membrane

D **simple diffusion through the phospholipid bilayer**

HELP

Amino acid molecules will be repelled by the hydrophobic core of the phospholipid bilayer. Thus, for amino acid molecules to move across the membrane and down its concentration gradient (seen in the diagram), it has to diffuse through the channel protein (seen in the diagram) via facilitated diffusion.

Q42

The components of the membrane found within and at the surface of cells contribute to their functions.

Examples of components are found below:

1 cholesterol
2 glycolipids
3 glycoproteins
4 phospholipids
5 proteins

Which row matches the components with their functions?

	binding sites for toxins	recognizing self or non-self	separating dissolved ions	stabilizing the hydrophobic layer	transporting ions through membranes
A	1	3	5	2	4
B	2	3	4	1	5
C	3	1	2	5	4
D	3	2	1	4	5

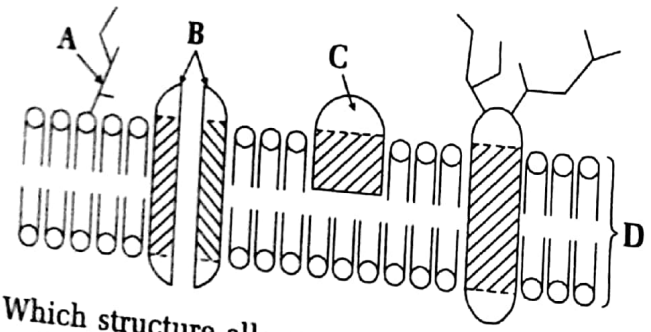
HELP

Function of components of membrane are as follows:

1 cholesterol: stabilizing the hydrophobic layer, increasing the fluidity and stability of the membrane
2 glycolipids: recognizing self or non-self or binding sites for toxins
3 glycoproteins: recognizing self or non-self or binding sites for toxins
4 phospholipids: forms the fundamental structure of membranes – the phospholipid bilayer and aids in separation of dissolved ions
5 proteins: transmembrane proteins are responsible for transporting ions through membranes via facilitated diffusion or active transport

Q43

The diagram represents a cell membrane.



Which structure allows movement of non-polar molecules across the membrane?

HELP

Option A is glycolipid.

Option B and C are integral proteins.

Option D is the hydrophobic core of the phospholipid bilayer.

Non-polar molecules are able to move down its concentration gradient across the hydrophobic core of the phospholipid bilayer via simple diffusion.

Topic 6(c) Structure, Roles and Functions of Membrane

Q1 **D**	Q2 **A**	Q3 **C**	Q4 **C**	Q5 **A**	Q6 **A**	Q7 **D**	Q8 **C**
Q9 **A**	Q10 **A**	Q11 **B**	Q12 **B**	Q13 **C**	Q14 **B**	Q15 **B**	Q16 **A**
Q17 **B**	Q18 **D**	Q19 **A**	Q20 **D**	Q21 **A**	Q22 **A**	Q23 **D**	Q24 **D**
Q25 **B**	Q26 **A**	Q27 **C**	Q28 **C**	Q29 **C**	Q30 **D**	Q31 **B**	Q32 **C**
Q33 **D**	Q34 **C**	Q35 **D**	Q36 **B**	Q37 **A**	Q38 **C**	Q39 **B**	Q40 **B**
Q41 **B**	Q42 **B**	Q43 **D**					

You should try to answer on your own before resorting to **HELP**.

Q1

Protein was the only food available to a mammal. If this supply of protein was only half the minimum required to supply its energy needs, the mammal would show an increase in the

A concentration of amino acids in the blood.

B concentration of insulin in the blood.

C synthesis of glycogen.

D hydrolysis of glycogen.

HELP

Glycogen is stored in the lover and muscles. When the external nutrition source is inadequate, glycogen is hydrolysed to provide the energy required in its metabolic processes.

Q2

Energy can be made available to the body in the following ways:

1 conversion of surplus amino acids and glycerol to blood glucose and the mobilisation of fat deposits which pass to the tissues for oxidation;

2 breakdown of liver and muscle glycogen to form glucose;

3 breakdown of tissue proteins to release amino acids which are then converted into glucose.

In which order does the body draw on potential energy when it is being starved of food?

A 1 → 2 → 3

B 1 → 3 → 2

C 2 → 1 → 3

D 2 → 3 → 1

HELP

The body usually uses surplus, circulating stores before oxidising stored substrates such as glycogen. The last substrate source is amino acids and proteins.

Q3

Which hormones promote the processes shown?

	conversion of glycogen to glucose in liver cells	*respiration of glucose in liver cells*	*uptake of glucose by muscle cells*
A	insulin	glucagon	glucagon
B	insulin	glucagon	insulin
C	glucagon	insulin	glucagon
D	glucagon	insulin	insulin

HELP

The conversion of glycogen to glucose in liver cells is promoted by glucagon. The opposite conversion applies to insulin. Therefore the answer is either C or D. This answer also applies to insulin for respiration of glucose in liver cells. However, for the uptake of glucose by muscle cells, it is the presence of insulin that allows for this. Hence, the answer is D.

Q4

A person has poorly functioning β-cells in the islets of Langerhans.

What will be the concentration of glucose, insulin and glucagon in the blood after that person has eaten a meal rich in carbohydrates?

	glucose	insulin	glucagon
A	high	low	high
B	high	low	low
C	low	high	high
D	low	high	low

HELP

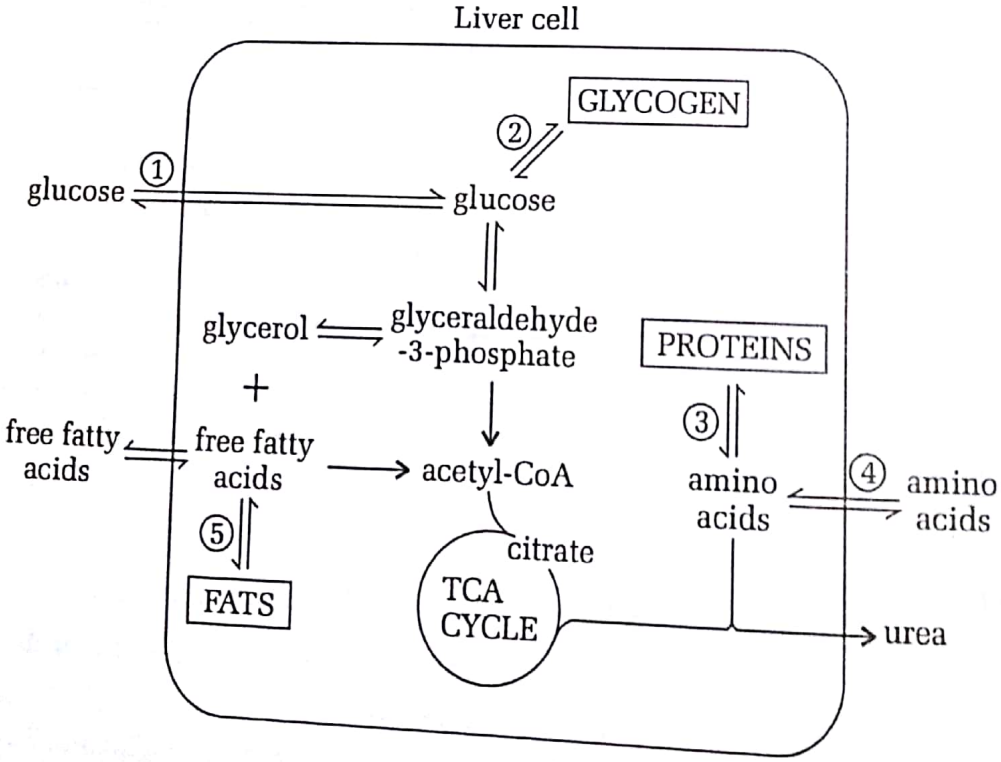
α – produces glucagon

β – produces insulin

After a meal, the carbohydrates are converted in the liver by insulin to glucose-6-phosphate and finally glycogen. If the insulin is insufficient, the glucose levels will remain high. This would indicate answers A or B. As the glucose levels in the blood are high, glucagon is not required to be produced in high amounts.

Q5

The diagram below shows some biochemical pathways in a liver cell. Some of the points where hormones affect the pathways are labelled 1 to 5.



At which numbered points would the hormone insulin accelerate the pathways in the directions indicated?

A 1, 2 and 3 B 1, 2 and 5

C 1, 3 and 4 D 2, 3 and 4

HELP

Insulin serves to increase the rate of glucose uptake by increasing the number of glucose transporters in the plasma membrane (1), increasing the activities of liver enzymes that synthesize glycogen (2), and of enzymes in adipose cells that synthesize triacylglycerols.

Q6

In a healthy mammal, which one of the following will lead indirectly to increased production of glycogen in liver cells?

A a reduction in insulin output

B a high glucose content in the diet

C an increase in thyroxine production

D a reduction in the amino acid concentration in the blood

HELP

Insulin is produced by the Islets of Langerhans when the blood glucose level increases, and serves to increase the rate of glucose uptake from the blood into muscle cells by increasing the number of glucose transporters in the plasma membrane. It also increases the activities of liver enzymes that synthesize glycogen.

Q7

As a result of the activity of insulin there is

A increased uptake of glucose by muscles.

B decreased uptake of glucose by cells.

C the presence of glucose in the urine.

D deposition of fat in blood vessels.

HELP

Insulin produced increases the rate of glucose uptake from the blood into muscle cells by increasing the number of glucose transporters in the plasma membrane.

Q8

Under which of the following circumstances will insulin be secreted?

A The blood sugar level in the liver is low.

B The blood sugar level in the hepatic portal vein is low.

C The blood sugar level in the islets of Langerhans is high.

D The glycogen level in the skeletal muscle is high.

HELP

Insulin is secreted by the Islets of Langerhans in the pancreas when the blood sugar level is high. This increases the rate of glucose uptake from the blood into the muscle cells.

Q9

What does an increase in the secretion of insulin produce?

A a decrease in glucose metabolism

B an increase in blood sugar level

C an increase in glucose permeability of cells

D an increase in the conversion of glycogen to glucose

HELP

Insulin is secreted by the Islets of Langerhans in the pancreas when the blood sugar level is high. This increases the rate of glucose uptake from the blood into the muscle cells.

Q10

Two organs secrete substances which affect the body.

organ 1 ⟶ product 1

organ 2 ⟶ product 2

Negative feedback control of product 2 would be achieved if

A product 1 counteracts product 2.

B product 1 reinforces the effect of product 2.

C product 2 inhibits organ 1 and product 1 stimulates organ 2.

D product 2 stimulates organ 1 and product 1 stimulates organ 2.

HELP

For negative feedback, the presence of more product inhibits the production of it. In C, the presence of excess product 2 would inhibit organ 1, causing less product 1 to be produced. This in turn inhibits organ 2, resulting in less product 2 being produced.

Q11

Which homeostatic function of the liver is controlled and monitored in the pancreas?

A deamination of amino acids

B release of glucose

C release of iron

D removal of toxins

HELP

Glucose is stored in the liver as glycogen. Glycogen can be converted to free glucose by the process of glycogenolysis, which involves the activation of a phosphorylase enzyme by the hormone glucagon. Glucagon is made by the pancreas and is released when the blood sugar levels fall.

Q12

Homeostasis in a mammal is defined as the maintenance of a

A constant internal environment, providing a degree of independence from the external environment.

B constant internal environment, resulting in complete dependence on the external environment.

C variable internal environment, resulting from a variable external environment.

D constant internal and external environments resulting from temperature fluctuations.

HELP

Homeostasis is the maintenance of a constant internal environment within an external environment that can change. This is achieved through structural, physiological and behavioural mechanisms that develop in the organism.

Q13

How does insulin act on its target cells?

A It activates enzyme conversion of glycogen to glucose.

B It alters specific receptor sites on the cell surface membrane.

C It enters the cell and stimulates transcription of DNA.

D It stimulates the intracellular hydrolysis of lipids.

HELP

β-cells of the Islet of Langerhans produce insulin directly into the blood. Receptor sites on cell surface membranes bind insulin and this leads to changes in the permeability of the membranes to glucose.

Q14

Which function is carried out by the hormone insulin?

A It breaks down blood glucose.

B It catalyses the condensation of glucose to form glycogen.

C It enables glucose to enter cells.

D It prevents glucose from being excreted by the kidney.

HELP

Insulin increases the uptake rate of glucose by cells, as well as converts glucose into glucose-6-phosphate. It is not a catalyst, as it is not an enzyme.

Q15

Which one of the following describes the chemical nature of insulin?

A a pentose sugar

B a phospholipid

C a polypeptide

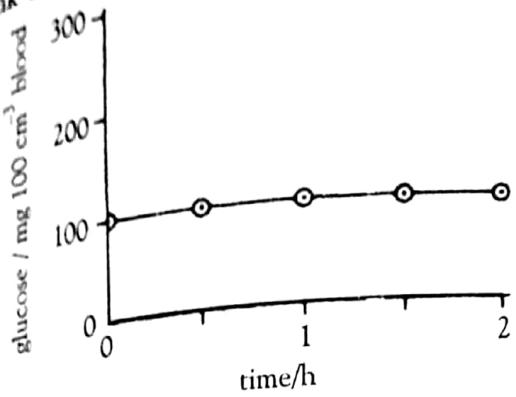
D a polysaccharide

HELP

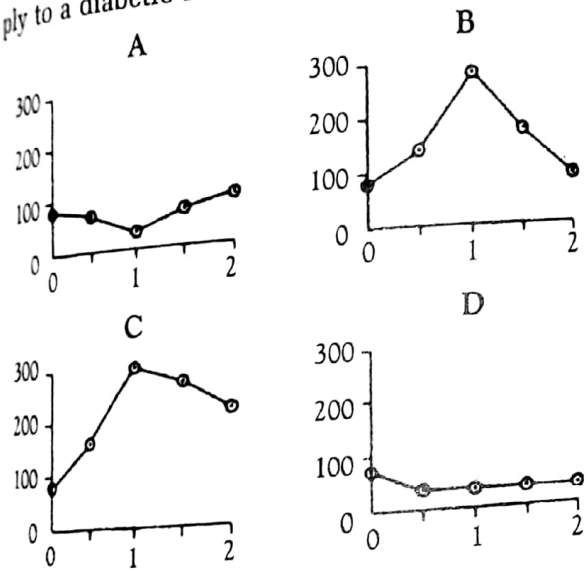
Insulin, from the Islets of Langerhans in the pancreas, is an albumin protein containing up to 12% of the amino acid tyrosine.

Q16

The graph below illustrates the changes in blood sugar concentration after a healthy man has drunk a glucose solution.



Which one of the following graphs would apply to a diabetic man in similar circumstances?



HELP

In diabetics, the rise in blood glucose above the normal level of 80—90 mg/100 ml fails to stimulate the production of insulin from the pancreatic β-cells of the Islets of Langerhans. As a result, the glucose is not removed from the blood to be stored in muscle cells as glycogen, resulting in a high blood glucose level for a long period of time.

Q17

Which change contributes to the lowering of the blood sugar level, if a person is injected with insulin?

A decrease in the permeability of cells to glucose

B decrease in the rate of absorption of glucose from the gut

C increase in the rate of excretion of glucose

D increase in the synthesis of glycogen

HELP

Insulin is a hormone produced by the pancreas and it catalyses the phosphorylation of glucose to glucose phosphate, which is subsequently converted to glycogen by condensation.

Q18

As a result of the activity of insulin there is

A increased uptake of glucose by muscles.

B decreased uptake of glucose by liver cells.

C the presence of glucose in urine.

D depletion of fat stores.

HELP

Insulin is produced by the beta cells in the Islet of Langerhans in the pancreas. The hormone produces several responses. In the liver, it increases glycolysis and glycogen synthesis. In the skeletal muscle, it increases glucose uptake, glycolysis and glycogen synthesis. In adipose tissue, it increases the storage of fat and the conversion of glucose to fat. All these have a general effect of lowering blood glucose.

Q19

Which of the following is a sign of insulin deficiency?

A a low blood sugar level

B an increased ability of the tissues to oxidise glucose

C an increased amount of glycogen stored in the liver

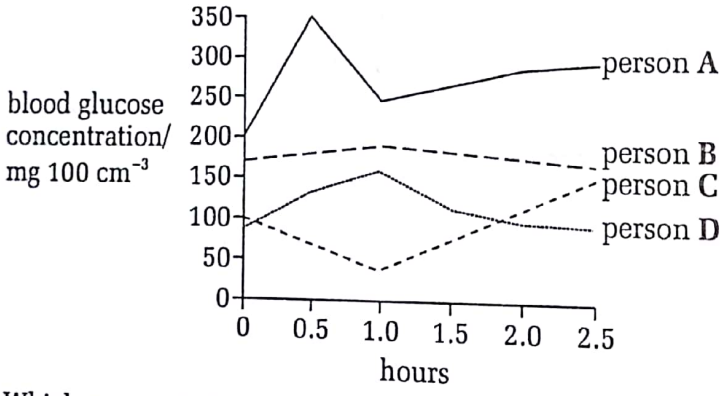
D the excretion of sugar in the urine

HELP

If there is insulin deficiency, then excess glucose due to an intake of food or glucose would not be converted to glycogen and stored. Thus, the blood glucose levels would be very high and this glucose is excreted in the urine at the kidney.

Q20

The blood glucose concentration of four people was measured over a 2.5 hour period after drinking a concentrated glucose solution. The graph shows the results.



Which person is **least** likely to have problems associated with insulin secretion?

HELP

After drinking a concentrated glucose solution, the glucose would be absorbed at the small intestine. The blood is then carried directly to the liver by the hepatic portal vein, where it is converted to glycogen by insulin and stored. Thus, in a person with no problems with insulin secretion, the blood glucose concentration would remain constant.

Q21

Which responses are promoted by the recognition and operation of insulin at the cellular level?

	conversion of glycogen to glucose	rate of ATP formation	uptake of glucose
A	decreased	increased	decreased
B	decreased	increased	increased
C	increased	decreased	decreased
D	increased	decreased	increased

HELP

Insulin stimulates the conversion of glucose into glycogen and also makes the cell membrane more permeable to glucose for faster uptake.

Q22

How does injection of insulin into diabetics lead to a lowering of blood glucose concentration?

A by decreasing the permeability of cells to glucose

B by increasing the excretion of glucose

C by promoting the formation of the hormone glucagon

D by promoting the synthesis of polysaccharides

HELP

Insulin stimulates the conversion of glucose into glycogen, which is a type of polysaccharide. This helps reduce the amount of glucose in the blood.

Q23

What happens in a biological control system?

A The effector regulates the receptor.

B The monitor fluctuates about a norm.

C The output is modified according to the input.

D The receptor and effector are maintained in equilibrium.

HELP

A biological system is regulated by feedback control, which is usually negative feedback. The input is a substance that has an effect on the amount of the product, which is the output.

Q24

The hormone insulin binds to the tyrosine kinase receptors and initiates various signal transduction pathway to generate cellular responses. Which of the following shows the correct sequence of events, following the binding of insulin to the receptor?

i) phosphorylation of tyrosine kinases

ii) dimerization of tyrosine kinase receptor

iii) activation of enzyme

A i, ii, iii

B iii, ii, i

C ii, i, iii

D iii, i, ii

HELP

Insulin binds to a tyrosine-kinase receptor the cell membrane. The binding causes:

1) tyrosine kinase receptor to dimerize

2) the tyrosine kinase parts of the receptor add phosphates to the tyrosine tail of the receptor

3) activation of insulin response protein that eventually leads to the activation of the enzyme glycogen synthase

Q25

Which of the following can inactivate a protein by its enzymatic action?

I phosphodiesterase

II protein phosphatase

III protein kinase

IV GTPase

A I and III only

B I, II and IV

C II, III and IV only

D all of the above

HELP

Phosphodiesterase converts cAMP to AMP.

Protein phosphatase removes phosphate from protein.

Protein kinase transfers phosphate groups from ATP to a protein.

GTPase hydrolyses the bound GTP on G protein.

Q26

Blood samples were taken from an individual who had just completed a run.

Which of the following statements describes hormone levels found in his blood?

A High levels of glucagon

B High levels of glucose

C High levels of glycogen

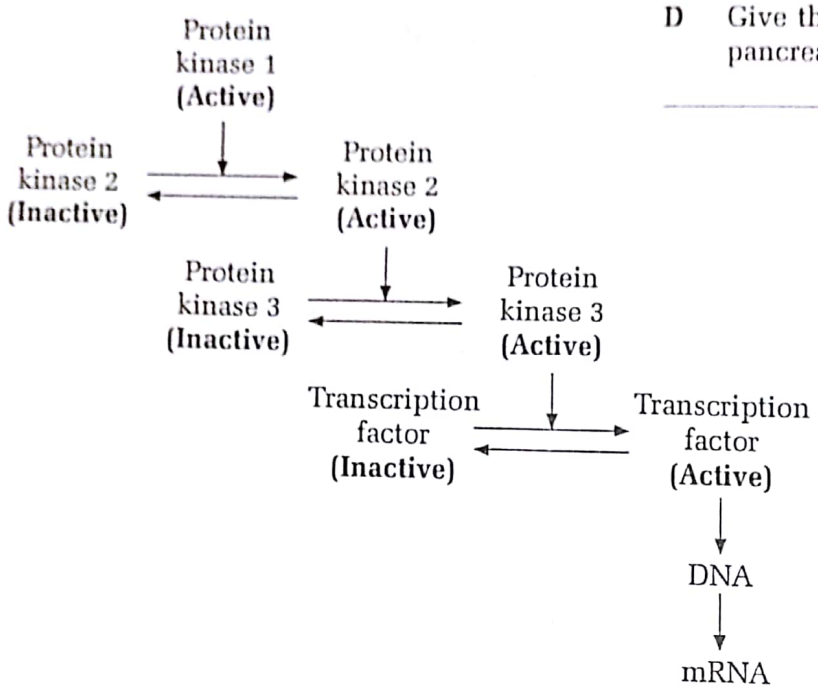
D High levels of insulin

HELP

An individual who had just completed a run will experience a fall in the blood glucose level. The fall in blood glucose level will stimulate the secretion of glucagon. The glucagon activity will result in the blood glucose level increases back to 90 mg per 100 cm^3 of blood.

Q27

The figure below shows part of a signalling pathway in a cell. The pathway leads to the activation of a gene that codes for a molecular inhibitor of a cyclin-dependent kinase responsible for moving a cell into the S phase of the cell cycle. How would a mutation that results in a non-functional Protein kinase 3 affect the cell's rate of division?



A Cell division would proceed at a rapid rate.

B Cell division would proceed at the normal rate.

C Cell division would proceed, but at a decreased rate.

D Cell division would be completely inhibited.

HELP

There will be an absence of the molecular inhibitor of a cyclin-dependent kinase responsible for moving a cell into the S phase of the cell cycle. Cell will continuously move into S phase of the cell cycle, thus cell division would proceed at a rapid rate.

Q28

A diabetic patient has accidentally given himself an overdose of insulin. What is the most logical treatment for this patient?

A Give the patient intravenous insulin.

B Give the patient intravenous glucose.

C Give the patient a drug that blocks the action of glucagon.

D Give the patient a drug that stimulates the pancreatic beta cells.

HELP

When there is an excessive amount of insulin in the body, it will result in the blood glucose level decreasing below 90 mg per 100 cm^3 of blood (set point).

A low blood glucose level may result in fainting but the glucose level can be raised by the consumption of carbohydrate-rich food which will be digested into monosaccharides, mostly glucose and be absorbed into the blood. Hence, the most logical treatment is to provide the patient with intravenous glucose.

Q29

Which of the following statements correctly describes the effect of blood insulin?

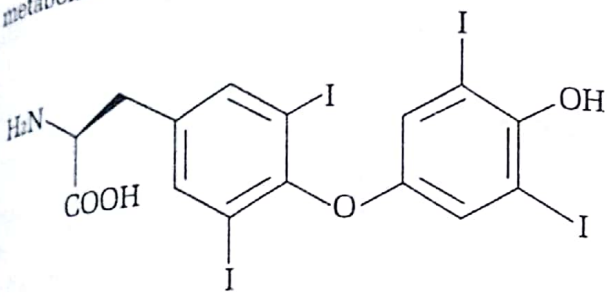
	Insulin level in blood	Effect
A	high	a decrease in glucose metabolism
B	high	an increase in conversion of glycogen to glucose
C	low	a decrease in glucose permeability of cells
D	low	an increase in uptake of glucose by muscle cells

HELP

High insulin level in blood leads to an increase in glucose metabolism, an increase in conversion of glucose to glycogen and an increase in the uptake of glucose by muscle cells.

Q30

The diagram shows a hormone which affects metabolism in humans.



How does this hormone act on its target cell?

A It activates an enzyme cascade that amplifies the hormone signal.

B It alters specific receptor sites on the cell surface membrane.

C It enters the cell and binds to nuclear receptors.

D It inhibits the synthesis of cholesterol molecules.

HELP

The hormone shown in the diagram is a non-polar molecule. As such, it can diffuse across the hydrophobic core of the phospholipid bilayer into the cytoplasm and bind with nuclear receptors.

Q31

Blood samples taken from an individual who had been fasting for 24 hours would have which of the following?

A high levels of insulin

B high levels of glucagon

C high levels of glycogenesis

D low levels of glucagon

HELP

An individual who has been fasting for 24 hours will experience a fall in the blood glucose level. The fall in blood glucose level will stimulate the secretion of glucagon. The glucagon activity will result in the blood glucose level increases back to 90 mg per 100 cm^3 of blood.

Q32

Which of the following describes correctly the action of G-protein?

A Intracellular signal molecule activates G-protein resulting in a change in surface configuration.

B G-protein acts as GTPase enzyme and hydrolyses GDP to GTP.

C G-protein linked receptor is inactivated when the activated G-proteins binds to a membrane protein.

D G-protein mechanism results in multiple cellular responses.

HELP

When a specific signal molecule binds to the G-protein-linked receptor at the surface of a cell, the receptor changes configuration, binds and activates the G protein. A molecule of GTP replaces the GDP on the G protein. The activated G protein binds to and activates the enzyme which triggers the next step in the pathway leading to the cell's response.

Q33

Which of the following can activate a protein by transferring a phosphate group to it?

1 cAMP

2 Phosphodiesterase

3 Phosphotransferase

4 protein kinase

A 1 and 3 B 2 and 3

C 2 and 4 D 3 and 4

HELP

Cyclic AMP is a second messenger of many G-protein-signalling pathways.

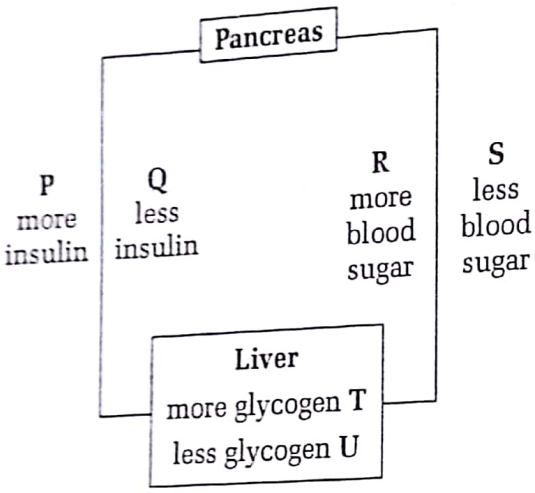
Phosphodiesterase converts cAMP to AMP.

Phosphotransferase refers to any of a class of enzymes that catalyze the transfer of a phosphate group.

Protein kinase transfers phosphate groups from ATP to a protein.

Q34

Which of the following responses below would occur in a human body as a direct result of eating a school lunch?



A R, P and T

B S, P and T

C R, Q and T

D R, P and U

HELP

Food consumed will be digested into monosaccharides, mostly glucose and be absorbed into the blood. A rise in blood glucose concentration stimulates the secretion of insulin. When bound to receptor sites of receptors on the surface membrane of cells throughout the body, insulin stimulates an increase in the rate of conversion of glucose to glycogen in liver and muscle cells.

Q35

Many signal transduction pathways use second messengers to

A transport a signal through the plasma membrane.

B relay a signal from the outside to the inside of the cell.

C relay a signal from the inside of the membrane throughout the cytoplasm.

D amplify the message by phosphorylating proteins.

HELP

Signal transduction occurs when an extracellular signalling molecule activates a cell surface receptor. In turn, this receptor alters intracellular molecules creating a response.

Secondary messengers are a component of signal transduction pathway. Signals received at the surface of a cell by either G-protein-linked or enzyme-linked receptors are relayed into the cell interior (cytoplasm) by second messengers.

Q36

Protein phosphorylation is commonly involved with all of the following except

A activation of G-protein linked receptors.

B enzyme activation.

C regulation of transcription by extracellular signal molecules.

D activation of protein kinase molecules.

HELP

There is no protein phosphorylation in the activation of G-protein linked receptors. When a specific signal molecule binds to the G-protein-linked receptor at the surface of a cell, the receptor changes configuration, binds and activates the G protein.

Q37

Which of the following statements BEST describes the outcome of the negative feedback loop in a homeostatic mechanism?

A Glucagon is released by the pancreas in response to a drop in blood glucose concentration below the normal level.

B The liver cells break down glycogen to glucose in response to glucagon.

C Blood glucose level increases to the normal level in response to the release of glucagon.

D Release of glucagon is stopped in response to blood glucose concentration returning to the normal level.

HELP

Negative feedback loop refers to a type of control circuit where any fluctuation from the set point activates the control system resulting in a series of process which ultimately returns conditions towards their optimum level. That is, a change in the variable being monitored triggers the control mechanism to counteract the initial fluctuation.

Q38

Which of the following gives an accurate comparison between intracellular receptors and cell surface receptors?

	Intracellular receptors	Cell surface receptors
A	Their ligands can either be water-soluble or lipid-soluble because they do not need to bind with the cell membrane.	Their ligands must be lipid-soluble because they need to bind with the cell membrane.
B	All are single-pass transmembrane proteins.	All are multi-pass transmembrane proteins.
C	They may bind to DNA and act as gene regulators.	They may catalyze the phosphorylation of intracellular proteins.
D	None of them act as enzymes.	Some of them act as enzymes.

HELP

For intracellular receptors, the signalling molecules that are hydrophobic can diffuse across the hydrophobic core of the phospholipid bilayer and bind with nuclear receptor (forming a hormone-receptor complex) in the cytoplasm. The hormone-receptor complex, acts as a transcription factor, then enters the nucleus and bind with DNA, switching on genes and regulating transcription.

For cell surface receptors, the signal molecule is complementary in shape to a specific binding site on the cell surface receptor and binds to it. The binding of a ligand generally causes the receptor protein to undergo a change in shape. For many receptor proteins, this conformation change directly activates the receptor proteins so that it can interact with another cellular molecule such as catalyzing the phosphorylation of intracellular proteins.

Topic 6(d) Homeostasis, Hormonal Control and Cell Signalling

Q1 D	Q2 A	Q3 D	Q4 B	Q5 B	Q6 B	Q7 A	Q8 C
Q9 C	Q10 C	Q11 B	Q12 A	Q13 B	Q14 C	Q15 C	Q16 C
Q17 D	Q18 A	Q19 D	Q20 B	Q21 B	Q22 D	Q23 C	Q24 C
Q25 C	Q26 A	Q27 A	Q28 B	Q29 C	Q30 C	Q31 B	Q32 D
Q33 D	Q34 A	Q35 C	Q36 A	Q37 D	Q38 C		

TOPIC 6

CELLULAR PHYSIOLOGY AND BIOCHEMISTRY

6(e) **Nervous Control**

You should try to answer on your own before resorting to **HELP**.

Q1

Which one of the following identifies the role of acetylcholine in nerve physiology?

A It increases the resting potential of the cell.

B It increases the selective permeability of the cell membrane.

C It activates the sodium pump mechanism of the cell.

D It increases the potassium concentration inside the cell.

HELP

Acetylcholine molecules released from the axon terminal diffuse across the synaptic cleft and combine with the receptor molecules in the membrane of the postsynaptic neuron or muscle cell. This interaction increases the permeability of the membrane to sodium and potassium ions, producing a net depolarization to about −15 mV from the resting potential of about −60 mV. An action potential is thus generated.

Q2

Impulses travel very rapidly along nerves from the leg muscles of a mammal because

A there is a high concentration of Na^+ ions inside the axons.

B the nerves contain myelinated fibres.

C there is a potential difference across the axon membranes.

D the cell bodies of the fibres are contained within the dorsal root ganglion.

HELP

Myelin is a stack of specialized plasma membrane sheets produced by a glial cell that wraps itself around the axon. The myelin sheath acts as an electric insulator of the axon by preventing the transfer of ions between the axonal cytoplasm and the extracellular fluids. Thus, all electrical activities in axons are confined to the nodes of Ranvier, the sites where ions can flow across the axonal membrane.

Q3

Certain nerve gases developed for military purposes work by producing convulsive muscular contractions upon the slightest stimulation. This suggests that their function is to inhibit the action of

A acetylcholine.

B atropine.

C cholinesterase.

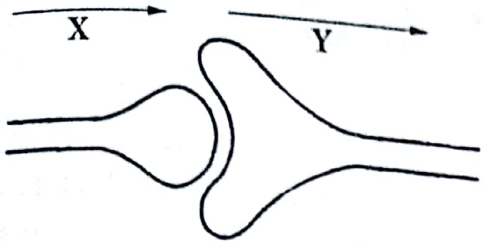
D eserine.

HELP

Acetylcholine is released from an excited terminal axon depolarizes the membrane, and is then very rapidly inactivated by the enzyme cholinesterase, which is present in great concentrations in the neuromuscular junction. The inhibition of cholinesterase will result in the muscle being unable to restore the state of polarization.

Q4

The diagram below represents the synapse between two mammalian myelinated neurones, X and Y. The arrows show the direction of impulses.



The transmission of impulses across the synapse is brought about by the

A breakdown of the terminal membrane of X.

B passage of an electric current between X and Y.

C release of sodium ions from X.

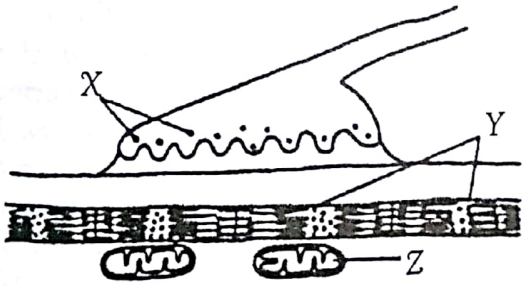
D secretion of a chemical from X.

HELP

Acetylcholine is released from X on excitation of the neurone X, and binds to the receptor molecules on neurone Y, increasing Na^+ permeability of Y. The membrane is thus depolarized and an action potential is generated.

Q5

The diagram shows the synaptic junction at a muscle end plate.



Which chemical substances were released from the regions labelled *X*, *Y* and *Z*?

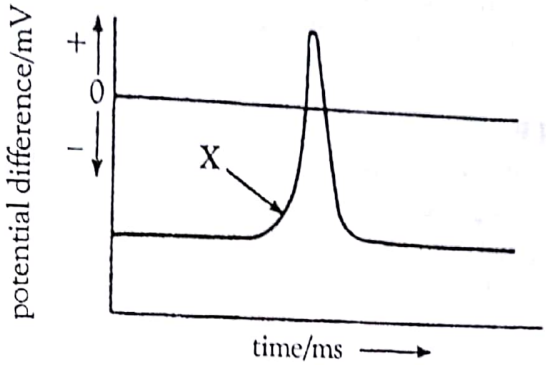
	X	*Y*	*Z*
A	acetylcholine	calcium ions	ATP
B	acetylcholine	sodium ions	pyruvate
C	adrenaline	potassium ions	pyruvate
D	calcium ions	sodium ions	pyruvate

HELP

Acetylcholine is released from the neuromuscular junction, triggering off an action potential following membrane depolarization. This stimulates the release of calcium ions from the sarcoplasmic reticulum (Y), leading to the ultimate release of energy from ATP hydrolysis.

Q6

The diagram below represents the electrical events within a neurone during the passage of an action potential.



What causes the initial rising phase of an action potential in a neurone? (See X in diagram.)

A Chloride ions leaving the neurone.

B Potassium ions leaving the neurone.

C Potassium ions entering the neurone.

D Sodium ions entering the neurone.

HELP

When the neurone receives the excitatory stimulus, there is an increase in sodium permeability in the membrane, allowing the entry of more sodium ions, resulting in membrane depolarization.

Q7

Curare causes paralysis of striated muscle. When curare is applied to a nerve-muscle preparation,

(i) the muscle does not contract when the nerve is stimulated, but

(ii) if a stimulus is applied directly to the muscle, contraction occurs.

When curare is applied only to the nerve, the muscle will contract when the nerve is stimulated.

Which one of the following correctly explains the effect of curare?

A It inhibits the development of an action potential in the nerve fibre.

B It makes the nerve cell end-plate more permeable to acetylcholine.

C It prevents the depolarisation of the postsynaptic membrane.

D It stimulates the formation of acetylcholine at the nerve cell end-plate.

HELP

Curare prevents the increase in membrane permeability of the postsynaptic membrane to sodium ions, thus preventing its depolarization.

Q8

The following sequence of events occurs at the neuromuscular junction.

nerve impulse → *release of* **V** → *end plate potential* → **W** *produced in muscle fibre* → **X** *released from sarcoplasmic reticulum* → *formation of* **Y** → *muscle contraction*

Which one of the following shows the correct sequence from **V** — **Y**?

	V	W	X	Y
A	acetylcholine	action potential	calcium ions	actomyosin
B	acetylcholine	action potential	actomyosin	calcium ions
C	actomyosin	acetylcholine	calcium ions	action potential
D	calcium ions	action potential	acetylcholine	actomyosin

HELP

The excitatory stimulus brings about the release of acetylcholine, which produces an action potential, causing the release of more Ca^{2+} ions. Actomyosin is then formed, which is directly responsible for muscle contraction, with energy from ATP.

Q9

Certain drugs act at synapses and affect the action of neurotransmitter substances. The table shows the effects of four different drugs.

drug	*effect*
1	inhibits the enzyme cholinesterase
2	prevents the release of acetylcholine
3	competes with acetylcholine at receptor sites
4	inhibits the enzyme which destroys noradrenaline

Which two drugs would prevent a skeletal muscle from responding to an electrical stimulus in the presynaptic neurone?

A 1 and 2

B 1 and 4

C 2 and 3

D 2 and 4

HELP

The drugs will only prevent the response of the muscle to an electrical stimulus if it prevents the release of acetylcholine and so inhibit the increase in membrane permeability to sodium ions; and if the drug competes with acetylcholine at the receptor sites.

Q10

Which of the following describes the state of a non-propagating (resting) mammalian axon?

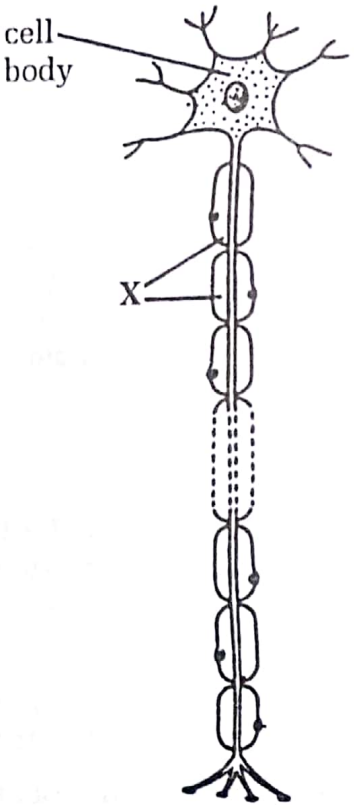
	concentration in axoplasm Na^+	K^+	*relative permeability of axon membrane*	*condition of cation pumps in axon membrane*
A	high	low	low	active
B	high	low	high	inactive
C	low	high	high	active
D	low	high	low	active

HELP

The sodium ion concentration is low, whilst that of potassium ions is high. The membrane permeability remains low to sodium ions. The cation pumps are active so that sodium ions are not allowed to accumulate.

Q11

The diagram below shows a motor nerve cell.



What is the function of the structures labelled X?

A to assist in the metabolism of the cell body

B to enable the cell to regenerate after damage

C to facilitate rapid transmission of impulses

D to supply nutrients to the cell body

HELP

The myelin sheath, X, serves as an insulator to prevent the transfer of ions between the axonal cytoplasm and the extracellular fluid, thus facilitating the rapid transmission of impulses.

Q12

After the initial membrane depolarisation, which of the following is the first event leading to muscle fibre contraction?

A calcium ions flooding into the muscle fibres

B hydrolysis of glycogen reserves

C movement of actin-myosin bonds, with hydrolysis of ATP

D release of energy from mitochondria

HELP

An action potential is generated after membrane depolarization, which increases the membrane permeability to sodium ions. Calcium ions are released from the sarcoplasmic reticulum.

Q13

Which of the following is common to all neurones?

A a cell body which contains a nucleus

B a thick myelin sheath

C presence of nodes of Ranvier

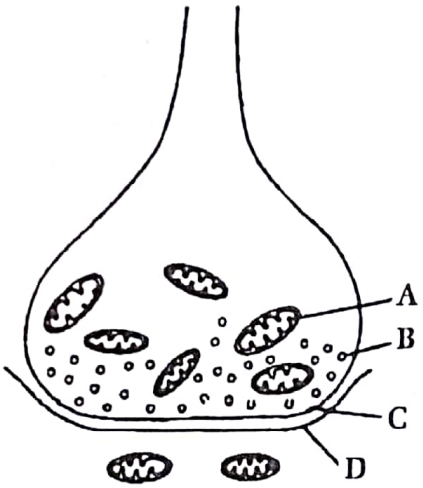
D presence of Schwarnn cells

HELP

All neurones contain a cell body which bears a nucleus and most of the ribosomes, lysosomes and ER. This is the site of synthesis of all neuronal proteins and membranes.

Q14

The diagram shows the structure of a synapse.



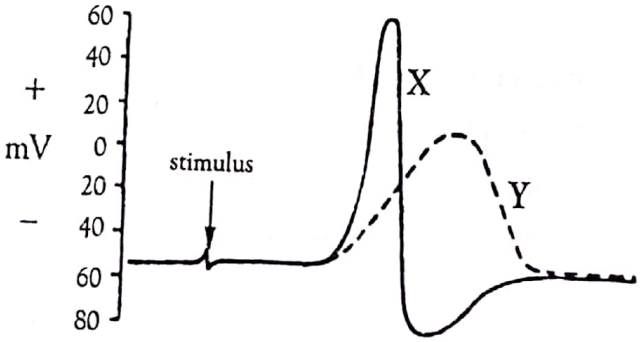
Which membrane can produce either a depolarisation or a hyperpolarisation in response to a chemical stimulus?

HELP

The postsynaptic membrane (D) can produce either a depolarization or hyperpolarization depending on which neurotransmitters are released from the presynaptic membrane, C.

Q15

The diagram shows action potentials recorded from an axon of a marine invertebrate. The action potential **X** was recorded in normal sea-water.



In what conditions was action potential Y recorded?

A sea-water containing excess potassium ions

B sea-water containing insufficient potassium ions

C sea-water containing excess sodium ions

D isotonic saline containing insufficient sodium ions

HELP

Sodium ions are responsible for the depolarization of the membrane. But because the surrounding medium is an isotonic saline deficient in sodium ions, there is entry of a lower amount of sodium ions into the axon, resulting in a lower depolarization voltage.

Q16

What will occur if the receptor sites on the postsynaptic membrane are blocked by a drug at the neuromuscular junction?

A inhibition of acetylcholine release

B inhibition of cholinesterase

C muscle contraction

D muscle paralysis

HELP

The acetylcholine that is released from the presynaptic membrane will not be able to bind the receptor sites on the postsynaptic membrane and trigger off the appropriate contraction. This results in muscle paralysis.

Q17

Victims of curare poisoning die of asphyxiation because the poison causes a synaptic block at junctions between nerves and muscles involved in breathing.

The postsynaptic membranes fail to become depolarised because curate inhibits the action of

A acetylcholine. **B** adrenaline.

C cholinesterase. **D** noradrenaline.

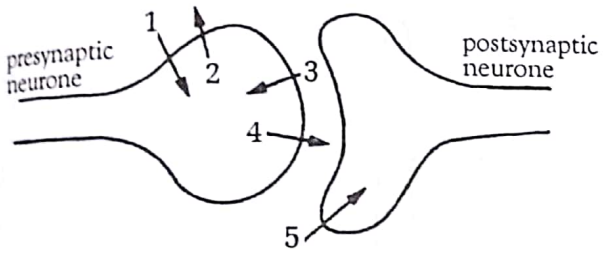
HELP

Acetylcholine is normally released from the presynaptic membrane into the synaptic cleft. It then diffuses across the synaptic cleft and attaches to specific receptor sites on the postsynaptic membrane, depolarising them. Cholinesterase breaks down acetylcholine to prevent over-stimulation of the postsynaptic membrane. Adrenaline and noradrenaline are hormones produced by the adrenal medulla that affects the circulatory system.

Q18

The diagram shows the sequence of events occurring as an action potential arrives at a synapse.

The numbered arrows represent the movement of substances across the membranes.



What are the substances moving across the membranes?

	1	2	3	4	5
A	K^+	Na^+	acetylcholine	Ca^{2+}	K^+
B	K^+	Na^+	K^+	Ca^{2+}	acetylcholine
C	Na^+	K^+	Ca^{2+}	acetylcholine	Na^+
D	Na^+	K^+	Na^+	acetylcholine	Ca^{2+}

HELP

As the action potential reaches the synapse, the presynaptic membrane is depolarised due to the entry of sodium ions (1). The membrane is subsequently repolarized by the exit of potassium ions (2). The arrival of the action potential causes calcium channels in the membrane to open, thus calcium ions rush into the synaptic knob (3). This causes the synaptic vesicles to fuse with the presynaptic membrane, releasing acetylcholine into the synaptic cleft (4). Acetylcholine binds to specific receptor sites on the postsynaptic membrane, opening ion channels and causing sodium ions to enter (5), depolarising the membrane.

Q19

Impulses travel very rapidly along nerves to the leg muscle of a mammal.

Which fact accounts for the speed at which they travel?

A A nerve impulse is an all-or-nothing phenomenon.

B The nerves contain myelinated fibres.

C There is a high concentration of Na^+ ions inside the axons.

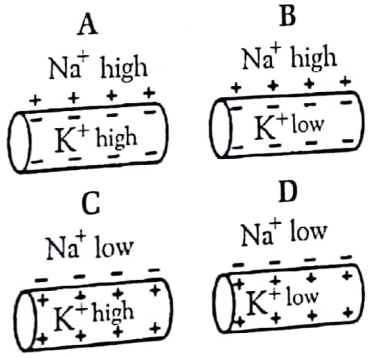
D There is a potential difference across the axon membranes.

HELP

The nerves are myelinated, with unmyelinated segments called nodes of Ranvier. The high phospholipid content of the myelin sheath offers electrical insulation, thus saltatory conduction occurs as impulses 'jump' from one node to the next. This form of conduction facilitates a very rapid transmission of impulses.

Q20

Which diagram illustrates the distribution of sodium and potassium ions in a section of an axon which is at resting potential?



HELP

At resting potential the extracellular concentration of sodium ions is high while the intracellular concentration of potassium ions is high. Also, the intracellular potential is negative with respect to the extracellular potential. These are results of the action of the sodium-potassium pump which transports 3 sodium ions out for every 2 potassium ions transported in.

Q21

The diagram shows the structure of a synapse.

What is **X**?

A acetylcholine receptor site

B acetylcholine release site

C vesicle containing acetylcholine

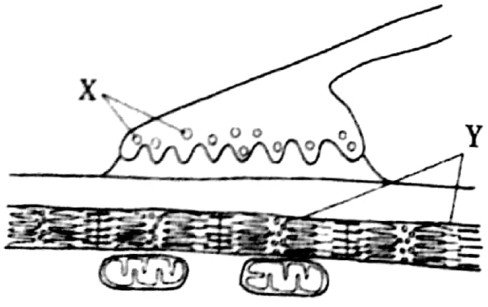
D presynaptic membrane

HELP

Acetylcholine released from synaptic vesicles in the presynaptic membrane into the synaptic cleft binds to these receptor sites (X) on the postsynaptic membrane, causing the depolarisation of the membrane.

Q22

The diagram shows the synaptic junction at a motor end plate.



Which chemical substances are released from regions **X** and **Y**?

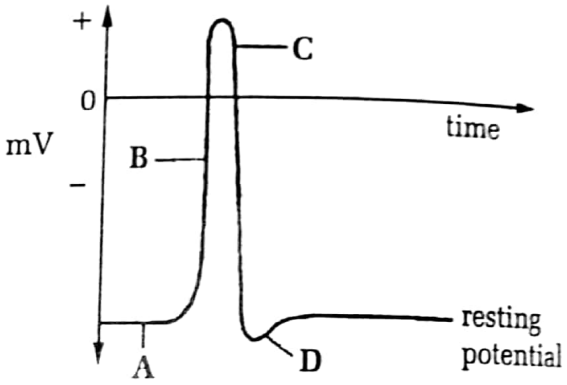
	X	Y
A	acetylcholine	calcium ions
B	acetylcholine	sodium ions
C	cholinesterase	calcium ions
D	cholinesterase	sodium ions

HELP

Acetylcholine is released from the synaptic vesicles, X, in the presynaptic membrane. Calcium ions are released from the sarcoplasmic reticulum, Y.

Q23

The diagram shows an action potential.



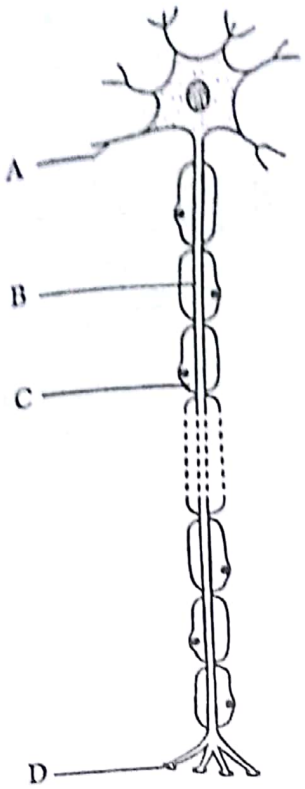
At which point on the graph is the membrane most permeable to sodium ions?

HELP

The opening of sodium ion gates increase the permeability of the axon membrane to sodium ions. As more sodium ions enter the axon, the membrane potential increases until it reaches a positive value.

Q24

The diagram shows a motor nerve cell.



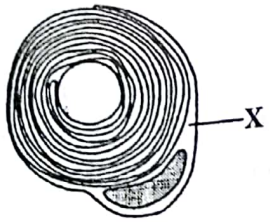
Which part of the cell contains a transmitter substance?

HELP

The synaptic end bulb contains synaptic vesicles which hold acetylcholine, a transmitter substance. When this synaptic end bulb synapses with a dendrite of another neurone, it is acetylcholine that sets up an action potential in the postsynaptic membrane in response to an action potential in the presynaptic membrane.

Q25

The diagram represents a transverse section through a neurone as seen under an electron microscope.



What is X?

A a dendron

B an axon

C a Schwann cell

D neurone cytoplasm

HELP

A Schwann cell wraps itself around the nerve axon to form the numerous concentric circles (characteristic feature for this cell) which comprise the myelin sheath. The space in the middle of the circles is the axon.

Q26

Four events in the transmission of nerve impulses across synapses are:

1 depolarisation of the presynaptic membrane

2 propagation of postsynaptic action potential

3 hydrolysis of transmitter substance

4 rupturing of synaptic vesicles

In which sequence do these events occur?

	first ⟶ last			
A	1	3	2	4
B	1	4	2	3
C	4	1	3	2
D	4	3	1	2

HELP

Depolarisation of presynaptic membrane is the first step in the sequence. This is followed by excitation-secretion coupling, which is, in effect, the rupturing of synaptic vesicles. (From these two steps, it is easy to make out that the answer is event 1, 4, 2 and 3).

Q27

During some surgical operations the drug curare, which has a similar shape to acetylcholine, is injected into the muscles to relax them.

Why do the muscles remain relaxed?

A calcium ions cannot be taken up by membrane vesicles

B cholinesterase cannot remove acetylcholine

C postsynaptic membrane receptors are blocked

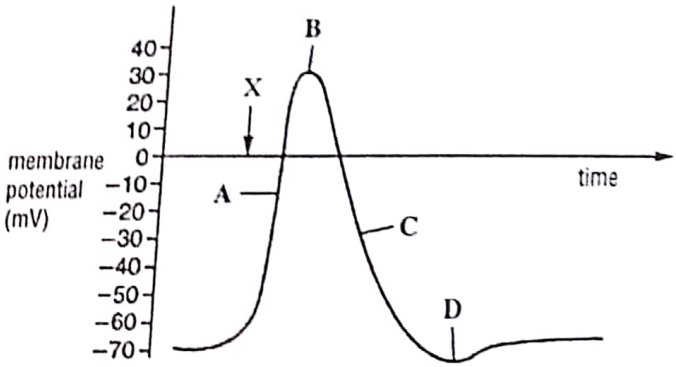
D sodium channels remain open

HELP

Acetylcholine is a neurotransmitter. It transmits messages across the synapse (excitary synapse). The drug curare blocks the postsynaptic membrane receptors so that the muscle will relax.

Q28

The graph shows the changes in membrane permeability when a stimulus X is applied to a neurone. Where is the point of maximum permeability to sodium ions?



HELP

A sodium ions moving in rapidly due to increased permeability

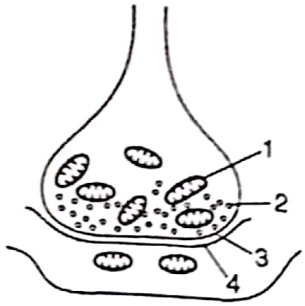
B no net movement of ions (sodium and potassium)

C potassium ions moving out rapidly

D ion exchange complete (sodium in, potassium out), sodium pumps working again

Q29

The diagram shows a synapse.



In people with low blood calcium levels, which structures will be unable to fuse?

A 1 and 2

B 2 and 3

C 2 and 4

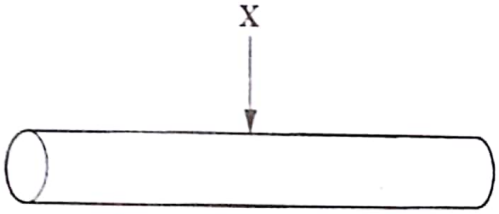
D 3 and 4

HELP

The transfer of nervous impulses across a synapse. Calcium ions are required to stimulate the fusion of the synaptic vesicles (structure 2) to the presynaptic membrane (structure 3) before releasing the neurotransmitter molecules.

Q30

The diagram shows part of an axon.



As an action potential reaches point X, in which direction do K^+ ions move and by what process?

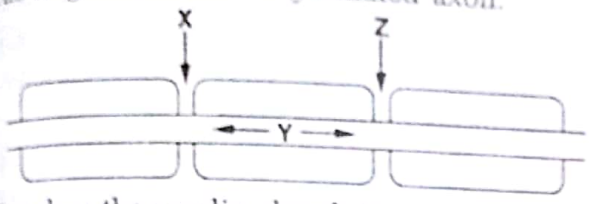
	X	*process*
A	into axon	active transport
B	into axon	diffusion
C	out of axon	active transport
D	out of axon	diffusion

HELP

When the action potential reaches X, the depolarisation of the axon membrane facilitates the K^+ ions to diffuse out of the axon as the sodium ions rush inwards.

Q31

The diagram shows a myelinated axon.



How does the myelin sheath increase the speed of the impulse transmission?

A It ensures that the ions are kept close to the axon membrane in region Y.

B It insulates the axon, so increasing the potential at regions X and Z.

C It promotes a change in potential difference in region Y.

D It restricts a change in potential difference to regions X and Z.

HELP

The myelin sheath is an electrical insulator that provides resistance to current flow between the axoplasm and external fluid. Thus, the action potential will move from region X to Z, without passing through Y. There is no increase in potential.

Q32

Four events in the transmission of nerve impulses across synapses are:

1. depolarisation of the presynaptic membrane
2. propagation of postsynaptic action potential
3. hydrolysis of transmitter substance
4. rupturing of synaptic vesicles

In which sequence do these events occur?

A	1	3	2	4
B	1	4	2	3
C	4	1	3	2
D	4	3	1	2

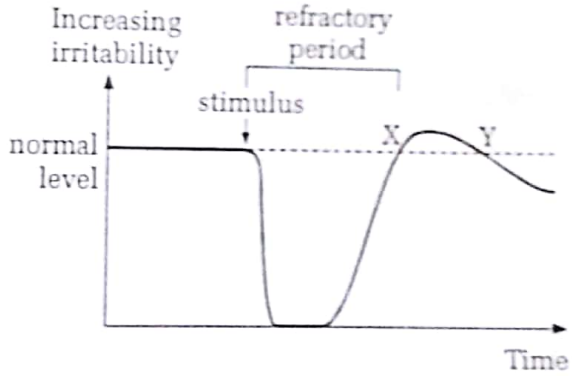
HELP

An action potential depolarises the presynaptic membrane and triggers an influx of Ca^{2+}. This causes the synaptic vesicles containing neurotransmitter to fuse with the presynaptic membrane and release the neurotransmitters into the synaptic cleft.

The binding of neurotransmitter to its specific receptors opens the ion channels and postsynaptic action potential is propagated in the postsynaptic membrane. The neurotransmitters are quickly degraded by enzymes, closing the ion channels and terminating the synaptic response.

Q33

The figure shows the relative irritability of stimulated nerve fibre.



What would happen if a second stimulus is applied during the period XY?

A A stimulus below the normal threshold will cause a response.

B The fibre will respond repeatedly to a single stimulus.

C The reaction to the stimulus will be greater than normal.

D The reaction will occur more quickly than normal.

HELP

Refractory period is the period following the passage of an action potential when the axon is no longer excitable or only excitable provided that the stimulus is stronger than normal. As shown in the figure, the irritability level of the nerve fibre is below its normal value.

Period X is after the refractory period and as shown in the figure, the irritability level of the nerve fibre is above its normal value. This suggested that a stimulus below the normal threshold will cause a response.

Q34

Dinitrophenol is a metabolic poison that prevents the production of ATP. What will happen if a resting axon is treated with such a poison?

A The charge inside the axon membrane becomes more negative.

B The charge outside the axon membrane becomes less positive.

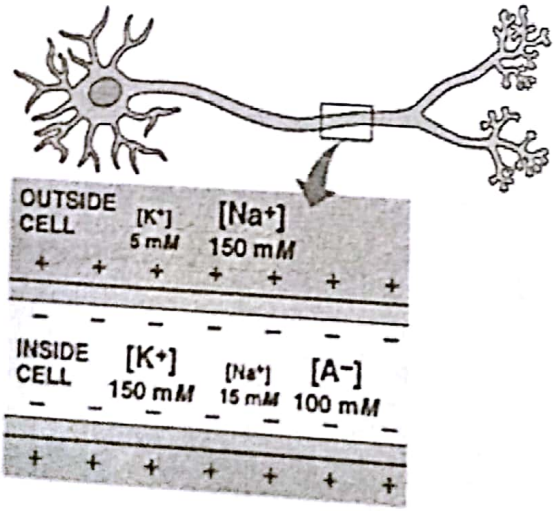
C The charge inside the axon membrane becomes less positive.

D The charge outside the axon membrane does not change.

HELP

In a resting axon, the sodium-potassium pump uses ATP to actively transport 3 Na^+ out of the cell and 2 K^+ into the cell. Thus the charge outside the axon membrane becomes more positive. In addition, the cytoplasm contains large, negatively charged protein molecules that cannot cross the surface membrane and thus are a pool of internal negative charge that remains in the cell.

Hence, in a resting axon, the charge distribution inside and outside the axon membrane is as follows:



When resting axon is treated with dinitrophenol that prevents the production of ATP, sodium-potassium pump is no longer able to actively transport 3 Na^+ out of the cell and 2 K^+ into the cell. Thus the charge outside the axon membrane becomes less positive.

Q35

The drug atropine binds antagonistically to acetylcholine receptors. Nerve gases inhibit the activity of cholinesterase.

What will be the effects of these substances on the rate of transmission of impulses across a synapse?

	atropine	*nerve gas*
A	increased	increased
B	increased	reduced
C	reduced	increased
D	reduced	reduced

HELP

When the drug atropine binds antagonistically to acetylcholine receptors, the Na^+ channels would remain closed, thus there will be no transmission of impulses across the synapse.

Nerve gases inhibit the activity of cholinesterase, an enzyme that splits each acetylcholine molecule into acetate and choline. Thus the acetylcholine remains bound to the receptors, the Na^+ channels would remain open, and action potentials would fire continuously. Hence, there will be increased transmission of impulses across the synapse.

Q36

When a stimulus arrives at a nerve ending, the membrane becomes depolarized. The events during depolarization are listed below.

1. K^+ channels open, Na^+ channels close.
2. Na^+ channels open and Na^+ floods in
3. Potential difference inside the membrane is +40 mV compared to the outside.
4. Potential difference inside the membrane is −65 mV compared to the outside.

What is the correct order of events?

A 1, 2, 3, 4
B 2, 4, 1, 3
C 3, 4, 1, 2
D 4, 2, 3, 1

HELP

At resting potential, the potential difference inside the membrane is –65 mV compared to the outside. When a stimulus arrives at a nerve ending, gated Na^+ channels open and Na^+ diffuse rapidly into the neurone down their electrochemical gradient. When the potential difference inside the membrane is +40 mV compared to the outside. The gated K^+ channels open and gated Na^+ channels close.

Q37

Which is a correct description of the role of calcium ions in the neuromuscular system?

A exchanged with sodium ions through co-transport channels at axon surfaces during the reestablishment of a resting potential after an action potential

B moved in by diffusion through gated ion channels in pre-synaptic membranes of excitatory neurones causing vesicles to move to pre-synaptic membrane as an impulse arrives

C exchanged with chloride ions at the post-synaptic membrane, in changing membrane potential in inhibitory neurones

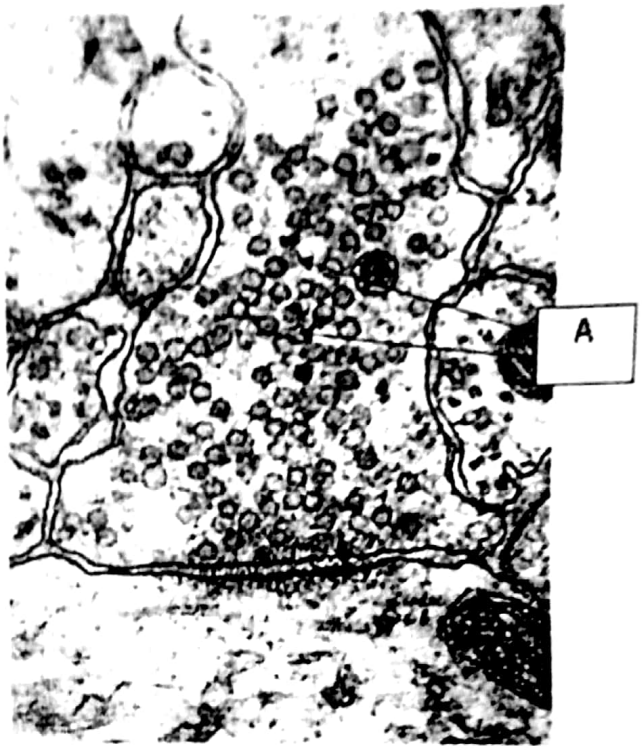
D actively pumped out of axons at nodes of Ranvier of myelinated neurones, being the main cause of the potential difference that is maintained during the resting potential

HELP

The arrival of an impulse at the synaptic knob causes gated Ca^{2+} channels in the presynaptic membrane to open. Ca^{2+} rush into the cytoplasm of the presynaptic neurone from the synaptic cleft. The influx of Ca^{2+} causes vesicles with neurotransmitters to move to the presynaptic membrane and fuse with it, emptying their contents into the synaptic cleft by exocytosis.

Q38

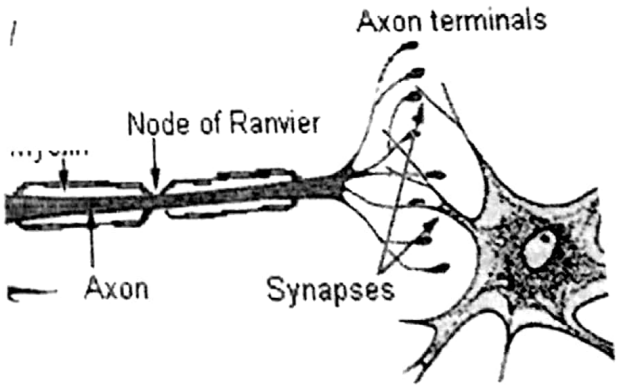
The diagram below shows part of an electron micrograph of a neuron. Name the portion of the neuron that forms the membrane which fuses with structures A.



A Terminal button
B Axon
C Dendrite
D Synapse

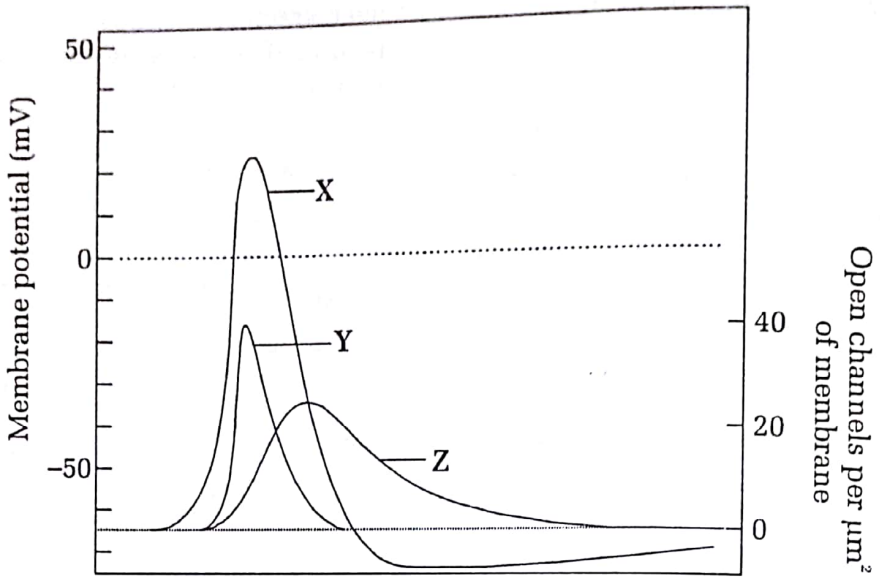
HELP

Structure A refers to synaptic vesicles containing neurotransmitters that fuse with the presynaptic membrane of the terminal buttons.



Q39

What do X, Y and Z in the above figure of an action potential represent?



	X	Y	Z
A	Change in membrane potential	Na^+ permeability	Resting membrane potential
B	Na^+ permeability	Change in membrane potential	Ca^{2+} permeability
C	Change in membrane potential	Na^+ permeability	K^+ permeability
D	Resting membrane potential	Ca^{2+} permeability	K^+ permeability

Q40

The vertebrate system conducts impulses in only one direction. This one-way conductance across synapse occurs

A because the Na^+-K^+ pump moves ions in one direction.

B as a result of voltage-gated sodium channels found in the vertebrate system.

C because only the postsynaptic membranes can bind neurotransmitters.

D because vertebrate nerve cells have dendrites.

HELP

Impulse is passed in one direction only, as neurotransmitter substance can only be released from one side of synapse from the pre-synaptic neuron to the post-synaptic neuron.

Q41

A particular type of autoimmune disease causes antibodies to destroy acetylcholine receptors of neurons.

What effect will this have on the functioning of the nervous system?

A Presynaptic neurons will be unable to release neurotransmitters into the synaptic clefts.

B Neurons will be unable to propagate action potentials along their axons.

C Depolarized neurons will be unable to reestablish an ionic gradient across their membranes.

D Postsynaptic neurons will be unable to detect signals from presynaptic neurons.

HELP

If acetylcholine receptors of neurons are destroyed, the postsynaptic neurons will be unable to detect signals from presynaptic neurons. This is because the acetylcholine is unable to bind to the acetylcholine receptors on the postsynaptic membrane, the Na^+ channels on postsynaptic membrane will remain close, and no action potentials will be generated at the postsynaptic neurons.

Q42

During an action potential, how is the resting potential restored?

A by an increase in the membrane's permeability to potassium and chloride ions

B by the opening of sodium activation gates

C by the action of the sodium-potassium pump

D by the opening of voltage-sensitive potassium channels and the closing of sodium activation gates

HELP

At the peak of the action potential, voltage-sensitive Na^+ channels close and the voltage-sensitive K^+ channels open allowing K^+ to flow out of the neurone down their electrochemical gradient. The outflow of K^+ restores the resting potential at that part of neurone and the membrane is said to be repolarised.

Q43

The post-synaptic membrane of a nerve may be stimulated by certain neurotransmitters to permit the influx of negative chloride ions into the cell. This process will result in

A membrane depolarization.

B an action potential.

C the production of an IPSP.

D the production of an EPSP.

HELP

At the inhibitory synapses, arrival of neurotransmitter at the postsynaptic membrane causes the entry of Cl^- and the efflux of K^+. The interior of the postsynaptic neurone becomes even more negative and the passage of an action potential is inhibited. This increased negativity is called an inhibitory postsynaptic potential (IPSP).

Q44

Which axon would transmit an action potential most rapidly?

A 1 mm diameter neuron lacking myelin.

B 1 mm diameter neuron with myelin.

C 2 mm diameter neuron lacking myelin.

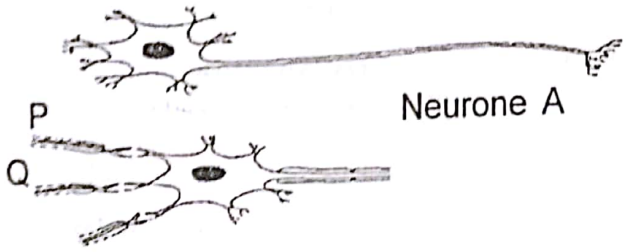
D 2 mm diameter neuron with myelin.

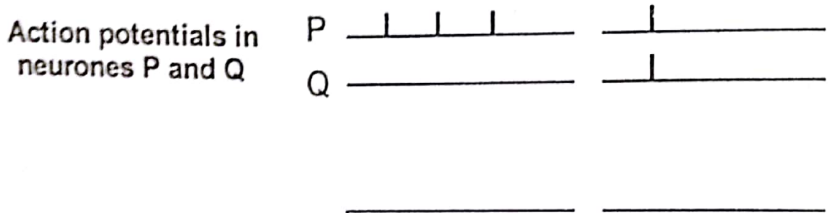
HELP

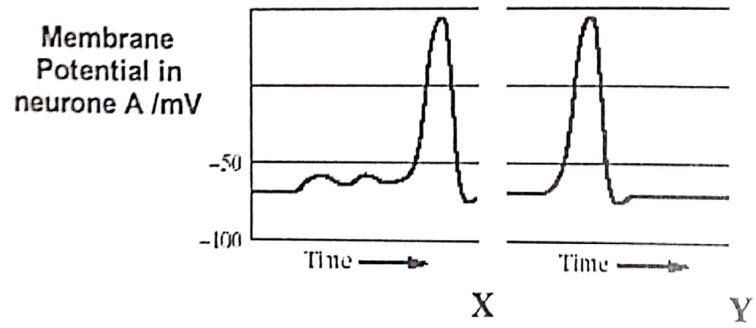
Speed of transmission of action potential in myelinated neurones is faster (by up to 50×) than continuous conduction in unmyelinated neurones of the same diameter. In addition, the wider the diameter of the axon, the lower is the resistance offered by its axoplasm and the faster the speed of transmission of the action potential.

Q45

The figure below shows the effect of impulses from neurones P and Q on the production of an action potential in neurone A.







Which of the following best describes X and Y?

	X	Y
A	IPSP	EPSP
B	EPSP	IPSP
C	Spatial summation	Temporal summation
D	Temporal summation	Spatial summation

HELP

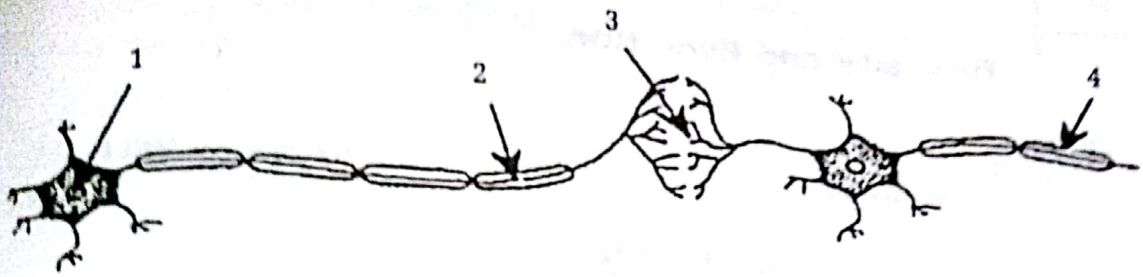
Neurones P and Q are the presynaptic neurones while neurone A is the postsynaptic neurone. The release of neurotransmitter in response to a single action potential is usually not sufficient to develop an action potential in a postsynaptic neurone. Normally several vesicles with neurotransmitters have to be released before the threshold potential required to propagate an action potential is achieved. This addition effect in the postsynaptic membrane is known as summation.

Graph X shows temporal summation. The synaptic knob of presynaptic neuron P does not release enough neurotransmitter for an action potential but a 2nd and 3rd impulse are released by the same knob quickly after the 1st. The EPSP created by successive impulses add together sufficiently for an action potential to be produced in postsynaptic neurone A.

Graph Y shows spatial summation. The synaptic knobs of presynaptic neuron P and Q release sufficient neurotransmitters to set up an action potential. The EPSPs produced by the different synapses add together at the same time, generating an action potential in postsynaptic neurone A.

Q46

The diagram below represents an impulse pathway.



Nerve gas interferes with the action of an enzyme that breaks down acetylcholine.

At which location does this inhibiting effect of the nerve gas occur?

A 1

B 2

C 3

D 4

HELP

Location 1 refers to the nucleus in the cell body of the presynaptic neuron.

Location 2 refers to the axon.

Location 3 refers to the synaptic cleft.

Location 4 refers to the myelin shealth.

Acetylcholinesterase is an enzyme that breaks down acetylcholine into acetate and choline. Acetylcholinesterase is found in the synaptic cleft.

Topic 6(e) Nervous Control

Q1 B	Q2 B	Q3 C	Q4 D	Q5 A	Q6 D	Q7 C	Q8 A
Q9 C	Q10 D	Q11 C	Q12 A	Q13 A	Q14 D	Q15 D	Q16 D
Q17 A	Q18 C	Q19 B	Q20 A	Q21 A	Q22 A	Q23 B	Q24 D
Q25 C	Q26 B	Q27 C	Q28 A	Q29 B	Q30 D	Q31 D	Q32 B
Q33 A	Q34 B	Q35 C	Q36 D	Q37 B	Q38 A	Q39 C	Q40 C
Q41 D	Q42 D	Q43 C	Q44 D	Q45 D	Q46 C		

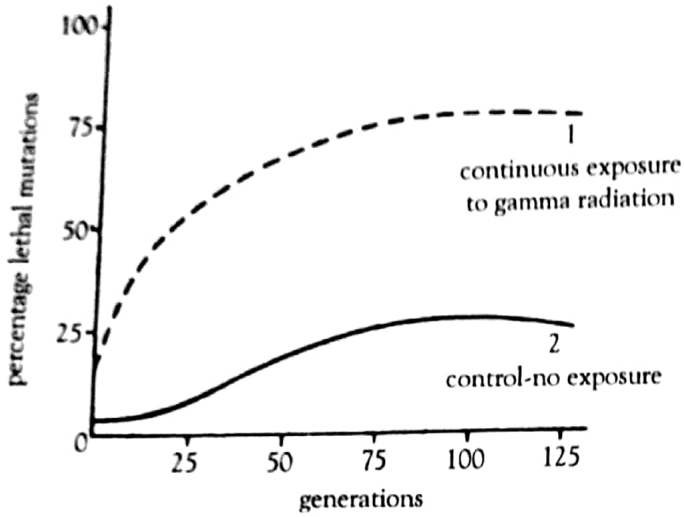
TOPIC 7

Diversity and Evolution

You should try to answer on your own before resorting to **HELP**.

Q1

The graph below shows the effect of radiation on two small inbreeding populations of *Drosophila*, derived from the *same* parental stock.



What causes the rise in graph 2?

A spontaneous mutation in a small gene pool

B natural selection

C a decrease in genetic drift

D an increase in the background radiation

HELP

Spontaneous mutations are those that occur without a known cause. They may be truly spontaneous, resulting from an inherent low level of metabolic errors, i.e. mistakes during DNA replication, or because of mutagenic agents in the environment, which is probably not the cause in this case.

Q2

The frequency of a mutant gene in a population would be likely to increase if

A the gene were selectively advantageous.

B the gene were dominant.

C the gene were sex-linked.

D the population increased.

HELP

Each gene probably has its own characteristic mutational behaviour. Some genes undergo mutations more frequently than others in the same organisation and are called unstable or mutable. This gene is likely to mutate if its mutant form will allow the population to adapt successfully in the environment.

Q3

Why are some antibiotics, such as penicillin, no longer effective in the treatment of certain diseases caused by bacteria?

A The antibiotic causes bacteria to mutate into resistant forms.

B Some bacteria possess inheritable resistance to the antibiotic.

C Human populations have developed antibodies which make the antibiotic ineffective.

D Through natural selection, human populations have become resistant to the effects of the antibiotic.

Some bacteria are capable of altering their genome to that which will code for proteins that can confer resistance to the antibiotics. A selection pressure (antibiotics) encourages this mutation.

Q4

Which of the following increases variation within a gene pool?

A chromosome inversion

B crossing over

C gene mutation

D random fusion of gametes

HELP

Gene mutations are spontaneous events which result in the alteration of existing genes and the occurrence of new sequences.

Q5

The decline in sickle cell anaemia among North Americans of African origin is thought to be due to an absence of selection pressure by malaria.

Which other factor has had the most influence in this decline?

A new mutations to the sickle cell allele

B outbreeding with other races

C new mutations from the sickle cell allele

D inbreeding within their community

HELP

Inbreeding weakens the genotype within a population. By outbreeding with other races, there is increased genetic variation, leading to higher chance of acquiring resistance to malaria.

Q6

Which of the following increases the number of different alleles in a population?

A crossing over

B gene mutation

C random fusion of gametes

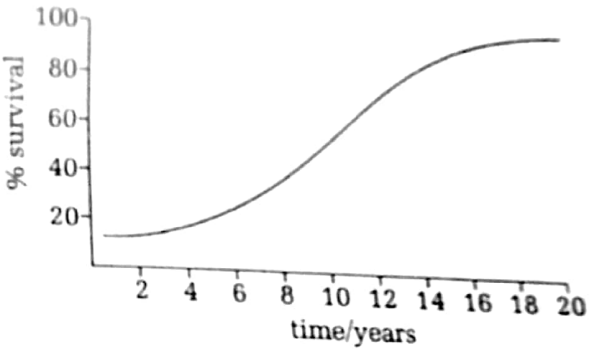
D reassortment of chromosomes in meiosis

HELP

All the other options increase the number of ways the alleles are combined but only gene mutation increases the number of different alleles in a population.

Q7

The graph shows the effect of pesticide treatment on houseflies over a number of years. A standard amount of pesticide was used each year in summer.



How is the effect of the pesticide best explained?

A A few resistant flies reproduced more successfully and the resistance allele increased in frequency.

B At every generation an increasing proportion of flies mutated to become resistant.

C Repeated exposure to the pesticide caused the flies to become more resistant.

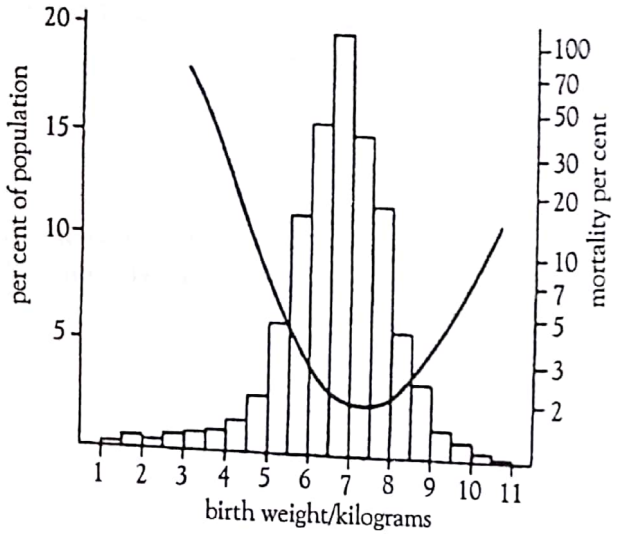
D The allele for resistance mutated from the recessive form to the dominant form.

HELP

Percentage of survival increases steadily from below 20% to a full 100% over a period of 20 years. This shows that the resistance was total by the end of the tests.

Q8

The diagram below represents the proportions of a population of new-born deer calves falling into various birth weight classes. The graph superimposed on the diagram represents mortality in relation to birth weight.



From the information given which one of the following interpretations is correct?

A Birth weight is undergoing stabilising selection.

B Birth weight is an example of discontinuous variation.

C Birth weight is inversely proportional to mortality.

D Birth weight is genetically linked to mortality.

HELP

The diagram and graph shows that newborn deer calves that fall within the 6-8 kg range have the lowest mortality. This results in stabilising selection, where a selection pressure towards a particular range exists.

Q9

Modifications in the organisation of the basic pentadactyl limb structure found in vertebrates provides good evidence for the principle of

A adaptive radiation.

B convergent evolution.

C genetic drift.

D inheritance of acquired characters.

HELP

The basic pentadactyl limb structure found in vertebrates subscribes to the idea that all members within each of these groups are in some way related to one another. The homologues of a single basic type, showing differences through adaptation to different environmental conditions and modes of life, are said to show divergent evolution or adaptive radiation.

Q10

Which one of the following pairs represents *analogous* features?

A elephant tusks and human incisors

B insect wing and bat wing

C teleost erythrocyte and mammalian erythrocyte

D mole fore-limb and bird wing

HELP

The insect wing and bat wing are similar by analogy, i.e. they serve only the same purpose. But the similarity ceases there because they have no common structural feature. (In contrast, homology implies structural and developmental likeness.)

Q11

In haemoglobin, the amino acid sequence of the beta (β) polypeptide chains differs among the species which possess the molecule. The beta chains of the species shown in the table below were analysed. The number of amino acid differences between Man and each of the species was counted and ranged between 8 and 127.

Which one of the following shows the differences which would be consistent with the proposed evolutionary relationships between the organisms?

	amino acid differences				
	dog	*earth-worm*	*frog*	*lamprey*	*rhesus monkey*
A	8	67	15	127	125
B	15	127	67	125	8
C	67	15	127	8	67
D	125	8	67	15	127

HELP

The proposed evolutionary relationship between the organism is such that the rhesus monkey is most closely related to man, followed by the dog, frog, earthworm, and the lamprey as the least related to man. The amino acid differences are thus the greatest for the least related organism.

Q12

Which one of the terms below correctly describes the relationships between the flight organs of the following animals: locust, bat, swallow and flying fish?

A analogous **B** homologous

C homozygous **D** monotypic

HELP

The flight organs of the locust, bat, swallow and fish are similar by analogy, i.e. they serve only the same purpose. But they have no common structural feature.

Q13

Which one of the following represents an homologous evolutionary feature?

A pentadactyl limb and arthropod claw

B molluscan eye and vertebrate eye

C sperm tail and tadpole tail

D fish haemoglobin and reptile haemoglobin

HELP

Homologous features imply structural and developmental similarities, where the parts concerned may not perform the same functions. This is as in the case of the fish and reptile haemoglobin.

Q14

Two populations of a given species will only evolve into two distinct species if they are subjected to

A geographical isolation.

B disruptive selection.

C genetic isolation.

D stabilising selection.

HELP

The evolution of a particular species into 2 distinct ones takes place over a very long period of time. In such an event, the DNA sequence of the species undergoes different mutations, ultimately acquiring its own distinct genotype.

Q15

Which one of the following describes the exploitation of new ecological niches by organisms?

A adaptive radiation

B conservative evolution

C convergent evolution

D natural selection

HELP

The homologous of a single basic type, showing differences through adaptation to different environmental conditions and modes of life, show divergent evolution, or adaptive radiation.

Q16

Three forms of the peppered moth, *Bistan betularia*, namely the melanic form, the pale form, and a form intermediate between these two, are found in Britain today.

The melanic form was first observed in 1848 and its frequency subsequently increased. This is thought to be the result of

A adaptive radiation.

B convergent evolution.

C divergent evolution.

D natural selection.

HELP

Natural selection occurs when a species changes by becoming increasingly adapted to its surroundings and ultimately becoming a new species. The melanic form increased because it could survive best in industrialised Britain.

Q17

An inter-breeding population of finches became separated geographically, forming two isolated groups. Each group then became subject to different selective pressures. One group was then introduced into the habitat of the other.

Which one of the following would determine whether they now formed two distinct species?

A They had been separated for more than three million years.

B They failed to produce fertile F_1 hybrids.

C They showed marked differences in the shape of their beaks.

D Their plumage had become markedly different.

HELP

Organisms belonging to different species will not be able to produce fertile offspring. Thus, by mating the two, it is possible to distinguish if they belong to the same species.

Q18

The following observations refer to evolution.

1 Inherited variations which are 'favoured' in particular environment are passed on.

2 There is a struggle for existence.

3 In time, 'favoured' inherited variations may accumulate causing gradual changes in the organism.

4 Although populations tend to overproduce, they remain more or less constant in numbers from generation to generation.

In what sequence should the statements be placed to support Darwin's theory of evolution?

A 1, 2, 3, 4 **B** 2, 1, 3, 4

C 3, 1, 4, 2 **D** 4, 2, 1, 3

HELP

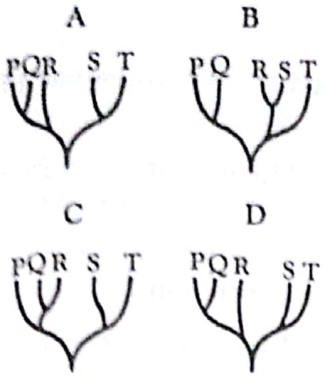
The sequence of the statements is in Darwin's theory of evolution, describing how natural selection in organisms ensures that only the fittest survive.

Q19

Five species, **P**, **Q**, **R**, **S** and **T**, possess the enzyme cytochrome c oxidase. The primary structure of the enzyme was determined for each species. The number of amino acid differences between species is given in the table.

	P	Q	R	S	T
P	0				
Q	7	0			
R	8	3	0		
S	20	19	18	0	
T	22	17	21	10	0

Which diagram represents the probable evolutionary relationships between these species?



HELP

The greater the number of amino acid differences between the species, the more different they are. Q and R bear the least number of amino acid differences and are the closest in the diagram.

Q20

Which one of the following lists three homologous structures?

A bird leg, dolphin flipper, fish pectoral fin

B whale flipper, bat wing, lizard front leg

C locust wing, bat wing, bird wing

D crab claw, human hand, scorpion pincer

HELP

Homologous features have structural and developmental similarities, but the parts concerned may not perform the same function.

Q21

Which one of the following statements describes a feature of a natural system of classification which an artificial system does not have?

A A natural system of classification is based on phenotypic characters.

B A natural system of classification is based on analogous structures.

C A natural system of classification is based on cytological characters.

D A natural system of classification is based on evolutionary relationships between organisms.

HELP

The natural system of classification traces the evolutionary relationships between organisms whilst the artificial system is based on phenotypic characters.

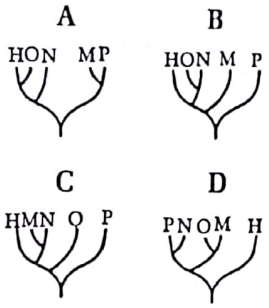
Q22

Human blood, when mixed with antibodies to human blood, will give maximum precipitation.

If another animal's blood is mixed with antibodies to human blood, the percentage of precipitation indicates how similar the animal is to a human. The following experimental results were obtained.

species: **H** 100%; **M** 37%; **N** 75%; **O** 79%; **P** 17%

Which phylogeny would fit these results?



HELP

The higher percentage of precipitation, the more similar it is to a human. Thus, H, O and N are the most closely related.

Q23

Which of the following statements could **not** be used to describe a species?

A a group of organisms showing distinctly similar autosomes

B a group of organisms showing analogous body structures

C a group of organisms capable of mating to produce viable offspring

D a group of organisms sharing the same ecological niche

HELP

Analogous structures only serve the same purpose but may not have any common structural feature. This alone cannot be used to describe a species.

Q24

Which of the following statements could explain the absence of native placental mammals in Australia?

A Marsupial mammals are well adapted to their niches.

B Geographical isolation prevented an invasion by placental mammals.

C The environmental conditions were unsuitable for the evolution of placental mammals.

D Widespread disease eradicated placental mammals in Australia at an early stage in their evolution.

HELP

The land bridge that connected North America and Australia was broken before the placental animals could establish themselves in Australia.

Q25

Which of the following ideas was **not** part of Charles Darwin's theory of evolution by natural selection?

A Organisms produce more offspring than the environment can support.

B Variation between individuals arises by gene mutation.

C Only those individuals best adapted to the environment survive and reproduce.

D Individuals compete for scarce resources.

HELP

Darwin did not describe natural selection as resulting in genetic variations between individuals due to mutations in the genome.

Q26

Some statements concerning evolution are listed below.

1 More offspring are produced than can possibly survive to sexual maturity.

2 Individuals in a sexually reproducing population are different.

3 The fossil record shows that many species have become extinct.

4 Offspring tend to resemble their parents.

5 Characteristics acquired during an organism's life time are passed to its offspring.

Which of these statements form the basis of Darwin's theory of evolution by natural selection?

A 1, 2 and 3 **B** 1, 2 and 4

C 1, 4 and 5 **D** 2, 3 and 4

HELP

Darwin's theory of evolution describes how organisms evolve certain characteristics that help them to adapt to their surroundings, where only the fittest will survive.

Q27

Which of the following statements about natural selection is **not** true?

A It can stabilize a gene pool.

B It can change a gene pool.

C It can improve the adaptation of species.

D It can increase mutation rate.

HELP

The mutation rate of a genome is not increased during natural selection. Note that mutation is a spontaneous event whereas a selection pressure is a constant factor imposed on a species.

Q28

All the alleles present in the gametes of a sexually reproducing population are known as the population's

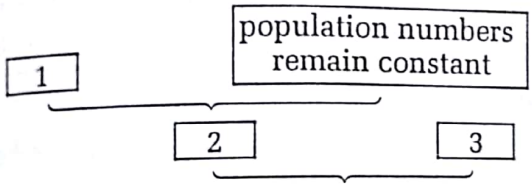
A gene complex.
B gene frequency.
C gene pool.
D genome.

HELP

The gene pool of a population represents all the alleles in the gametes responsible for the various genotypes possible in the population.

Q29

The diagram shows a summary of Darwin's theory of natural selection.



'Natural Selection'

Which statements should be placed in boxes 1, 2 and 3?

	There is a struggle for existence	Variation is shown in all populations	Individuals show great reproductive capacity
A	1	2	3
B	2	1	3
C	2	3	1
D	3	1	2

HELP

Darwin's theory of evolution of natural selection describes how there is variation among populations under the selection pressure of the various habitats, so that only the fittest will survive.

Q30

In which situation would evolution be slowest for an interbreeding population?

	migration	*selection pressure*	*variation due to mutation*
A	absent	high	high
B	absent	low	low
C	high	high	low
D	high	low	high

HELP

For the Hardy-Weinberg equilibrium to be maintained and evolution not to occur, there has to be a large population size, isolation from other populations (i.e. no migration), no net mutations, random mating and no selection pressure.

Q31

A single species evolves into several species which occupy different habitats. What describes this evolutionary process?

A adaptive radiation
B convergent evolution
C directional selection
D mutation

HELP

Adaptive radiation is the emergence of many diversely adapted species from a common ancestor.

Q32

In a given phylum, which group contains the greatest number of species?

A class
B family
C genus
D order

HELP

The levels of classification from the broadest to the narrowest are kingdom, phylum, class, order, family, genus, and species.

Q33

The Galapagos Islands are a group of volcanic islands in the eastern Pacific Ocean, about 1000 km from South America. Thirteen species of finch are found on the islands; they resemble each other closely but differ in their feeding habits and in the shape of their beaks.

Assuming that an ancestral stock of finches came from the mainland, what is the most likely explanation for the existence of similar but distinct species of Galapagos finches?

A Finches developed different kinds of beak in order to feed on different kinds of food.

B Finches evolved separately according to the habitat in which they settled.

C Finches from the mainland bred with a resident population of a related species and produced new genotypes.

D Finches underwent convergent evolution to produce very similar species.

HELP

This is a reasonable deduction since the various species differ in their feeding habits and hence the shape of their beaks, which were adapted to different kinds of food.

Q34

Which of the following describes the process of natural selection?

A change from simple to more complex organisms

B differential reproductive success between genotypes

C increase in the size of a population

D occurrence of new mutations

HELP

Natural selection is where certain genotypes that are better adapted to survive and reproduce in the environment have a higher reproductive success, hence increasing the frequencies of these genotypes.

Q35

The following observations refer to evolution.

1 Inherited variations which are 'favoured' in a particular environment are passed on.

2 There is a struggle for existence.

3 In time, 'favoured' inherited variations may accumulate causing gradual changes in the species.

4 Although populations tend to overproduce, they remain more or less constant in numbers from generation to generation.

In which sequence should these be placed to support Darwin's theory of evolution by natural selection?

	first ⟶			*last*
A	1	2	3	4
B	2	1	3	4
C	3	1	4	2
D	4	2	1	3

HELP

The observations in this order form the basis for Darwin's theory of evolution.

Q36

Which of the following has evolved mainly as a result of artificial selection?

A darker colouring of the peppered moth near industrial areas

B increased production of antibiotics by the fungus *Penicillium* sp.

C increased resistance of houseflies to the insecticide DDT

D increased tolerance of lichens to heavy metals on tree bark around mine workings

HELP

Artificial selection is the direct selective breeding of certain organisms that have certain properties. The other options are natural selection processes due to human factors.

Q37

In the classification of organisms, which of the following is the correct hierarchy of taxonomic groups?

	smallest ⟶				largest
A	family	genus	class	order	phylum
B	family	genus	order	phylum	class
C	genus	family	order	class	phylum
D	genus	phylum	order	family	class

HELP

The smallest group here should start with genus. The answer is either C or D. The next smallest cannot possibly be phylum, so D is also an incorrect answer.

Q38

In which taxonomic group are all the organisms most similar to each other?

A class
B family
C genus
D order

HELP

Candidates should remember that genus is the smallest of these taxonomic groups so more characteristics of the organisms in this group would be the most similar, rather than in the larger groups that would have more variety.

Q39

The chart shows the classification of two species of crocodile.

Animalia
Chordata
Reptilia
Loricata
Crocodylidae
Crocodylus
Crocodylus niloticus Nile crocodile
Crocodylus porosus Salt water crocodile

To which order do these crocodiles belong?

A Chordata
B Crocodylidae
C Loricata
D Reptilia

HELP

Kingdom	Animalia
Phylum	Chordata
Class	Reptilia
Order	Loricata
Family	Crocodylidae
Genus	*Crocodylus*

Q40

What is the best characteristic for determining whether sexually reproducing flowering plants from separate populations are members of the same species?

A ability to cross-fertilise
B ability to cross-pollinate
C occupation of similar niches
D similarity of flower structure

HELP

Flowering plants from the same species must be capable of interbreeding and having successful fertilisation to produce fertile offspring.

Q41

When organochlorine insecticides such as DDT were in widespread use, mosquitoes in malarial regions developed resistance more rapidly than did houseflies in Britain.

What could account for the difference in the rates of the development of resistance?

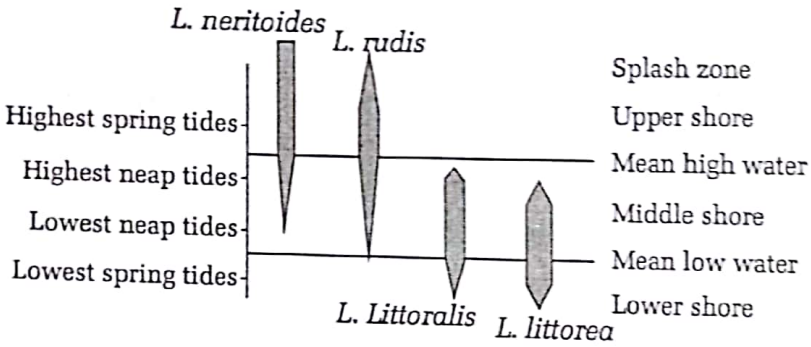
A Houseflies produce more generations a year.
B More insecticide was used in Britain.
C More insecticide was used in malarial regions.
D Mosquitoes show fewer random mutations per generation.

HELP

Candidates are reminded that increased use of insecticides causes the mosquitoes to evolve and develop better resistance. The increased use would happen in malarial regions where the mosquitoes are carriers of the malaria-causing parasite.

Q42

The diagram below shows the frequency and distribution of four *Littorina* species (periwinkles) on a rocky shore. All feed in a snail-like manner by grazing on algae.



Which one of the following factors could not directly contribute to this distribution pattern?

A variation in the tolerance of each species to desiccation

B competition between species for different feeding niches

C the photoperiod and seasonal change in day length

D the differential selection of periwinkles by predators

HELP

The distribution of the *Littorina* species is largely due to the interaction between this species and other organisms or the environment.

Topic 7 Diversity and Evolution

Q1 A	Q2 A	Q3 B	Q4 C	Q5 B	Q6 B	Q7 C	Q8 A
Q9 A	Q10 B	Q11 B	Q12 A	Q13 D	Q14 C	Q15 A	Q16 D
Q17 B	Q18 D	Q19 C	Q20 B	Q21 D	Q22 B	Q23 B	Q24 B
Q25 B	Q26 B	Q27 B	Q28 C	Q29 C	Q30 B	Q31 A	Q32 A
Q33 A	Q34 B	Q35 D	Q36 B	Q37 C	Q38 C	Q39 C	Q40 A
Q41 C	Q42 C						

TOPIC 8

Isolating, Cloning and Sequencing DNA

You should try to answer on your own before resorting to **HELP**.

Q1

For what purpose is the polymerase chain reaction used?

A to cut DNA

B to join DNA sequences

C to produce DNA

D to clone cells

HELP

The polymerase chain reaction (PCR) is a method for amplifying a specific DNA sequences (selective amplification) in vitro.

Q2

What is not expected to be an outcome of the Human Genome Project (HGP)?

A identification of all genes present in human beings

B identification of all alleles present in human beings

C map and sequence the genetic makeup of every human being

D map and sequence all the genetic material present in the chromosomes of human beings

HELP

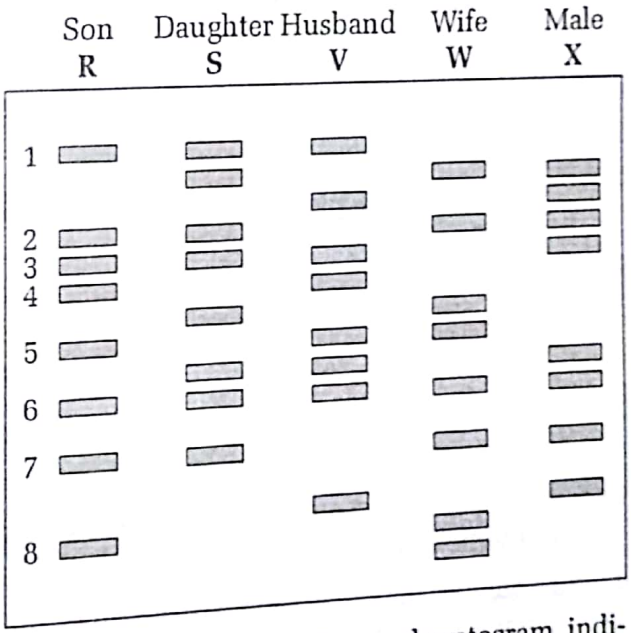
Option C is not an outcome of the HGP.

Option A, B and D are expected outcomes of HGP. Two of the expected outcomes of the Human Genome Project are:

1. To obtain a genetic linkage map of human genome. This involves the identification of thousands of genetic markers and their localization along the autosomal and sex chromosomes in human beings.
2. To obtain the DNA sequence of the entire human genome.

Q3

The diagram shows the results of electrophoresis of DNA fragments from four members of a family R, S, V, W and another male X, who claims that he is actually the father of person R.



Which bands on the electrophoretogram indicate that person V is the father of R?

A 1 and 2

B 1 and 4

C 2 and 7

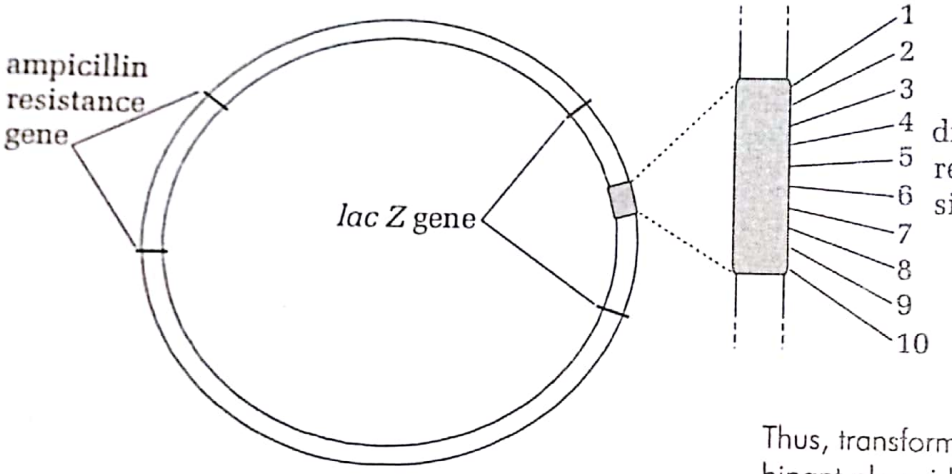
D 3 and 6

HELP

Each individual's combination is unique, having inherited one allele for each locus from each parent. Son R did not inherit band 1, band 3 and band 4 from his mother, W. Hence these 3 bands should have been contributed by male X if male X is the father. However, male X only has band 3 and is unable to contribute band 1 and band 4. Hence male X is not the father of Son R. This proves that person V is the father of Son R.

Q4

The diagram shows the plasmid pUC18. Bacteria containing this plasmid produce blue colonies when grown in the presence of *X-gal*. Bacteria containing a genetically engineered recombinant pUC18 plasmid produce white colonies.



Some of the features of this plasmid are:

1. It is small and replicates to form about 500 copies per host cell.
2. It contains restriction sites for 10 different restriction enzymes.
3. It contains a gene giving resistance to the antibiotic ampicillin.
4. It contains the *lac Z* gene which allows the metabolism of *X-gal* to produce a blue colour.

A gene of interest was inserted into one of the restriction sites to form a recombinant plasmid. Bacteria were transformed with this recombinant plasmid and identified using a selective agar medium.

Which selective growth medium would identify the bacteria containing the recombinant plasmids?

A a medium containing agar

B A medium containing ampicillin

C A medium containing ampicillin and *X-gal*

D A medium containing *X-gal*

HELP

Only transformed bacteria containing plasmids would be able to survive in a medium containing ampicillin.

Presence of the 2nd selectable marker (i.e. *lac Z* gene) enables the differentiation between a bacterial cell that has been transformed with a recombinant or a non-recombinant plasmid.

Insertion of a gene of interest into one of the restriction sites will result in the disruption of *lac Z* gene which prevents the metabolism of *X-gal* to produce a blue colour.

Thus, transformed bacteria containing recombinant plasmid will survive in a medium containing ampicillin and form white colonies on agar containing *X-gal*.

Q5

What are the advantages and limitations of the polymerase chain reaction (PCR)?

1. All lengths of DNA in the original liquid will be multiplied.
2. Large numbers of lengths of DNA are produced quickly.
3. Strict measures are needed to prevent contamination.
4. Only very small amounts of DNA are needed.

	advantages	*limitations*
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 3	1 and 4
D	2 and 4	1 and 3

HELP

The polymerase chain reaction (PCR) is a method for amplifying a specific DNA sequences in vitro. After 20 cycles, more than one million (220) copies of the target DNA (amplicons) are made.

PCR has high sensitivity and can amplify minute amount of DNA.

Q6

What uses of the information from the human genome project are generally considered to be unethical?

1. An insurance company only giving cheap rates to people with genetic predispositions to fewer diseases.
2. Genetic archaeologists identifying the earliest forms of genes to show evolutionary relationships.
3. Cytologists developing tests for only some defective genes.
4. Doctors only giving specific drugs to block the actions of faulty genes to carrier of those genes.
5. Genetic councilors giving specific lifestyle information only to people genetically predisposed to risks.
6. Parents choosing embryos for implantation only after ante-natal tests for acceptable genes.

A 1 and 3
B 1 and 6
C 2 and 5
D 3 and 4

HELP

Statement 1 is considered to be unethical as this involves the ownership and use of personal genetic information. The ownership to access of genetic information is a matter for concern e.g. should insurance agents have access to the genetic fingerprint and grants insurance policies based on clients' genetic predisposition.

Statement 6 is considered to be unethical if prenatal genetic testing results in genetic manipulation or a decision to abort based on undesirable traits disclosed by the tests

Q7

The restriction enzyme *Tai*1, cuts DNA as shown.

```
----ACGT----   →   ----ACGT        ----
----TGCA----       ----        TGCA----
```

Which of the plasmids below can be cut using restriction enzyme *Tai*1, in order to allow DNA to be inserted into the circular plasmid without loss of any part of the plasmid?

key ---- other nucleotides
The rest of the plasmid does not contain this restriction site.

A
```
----TAACGTAC----CTCAAGCT----
----AATGCATG----GAGTTCGA----
```

B
```
----TTAACGTA----CACGTGGT----
----AATTGCAT----GTGCACCA----
```

C
```
----ACGTACGT----TCCACGTA----
----TGCATGCA----AGGTGCAT----
```

D
```
----ACCTAGGT----CCACCTGA----
----TGGATCCA----GGTGGACT----
```

HELP

The plasmids below can be cut using *Tai*1 as highlighted.

A
```
----TA ACGT AC----CTCAAGCT----
----AA TGCA TG----GAGTTCGA----
```

For option B and C, there are 2 restriction sites for *Tai*1, hence if *Tai*1 is used for digestion, the sections flanked by the restriction sites will be lost.

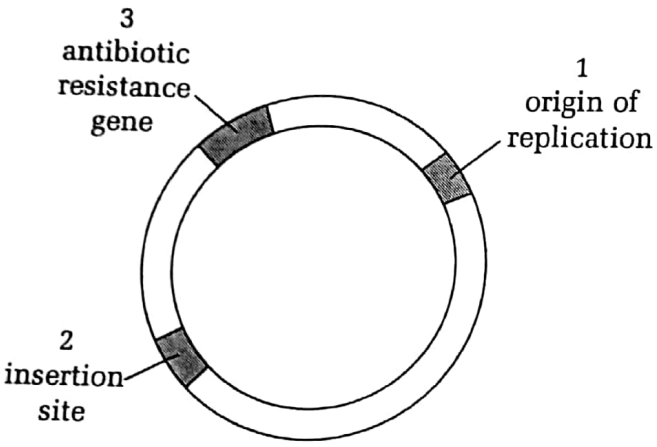
B
----TTA|ACGT|A----C|ACGT|GGT----
----AAT|TGCA|T----G|TGCA|CCA----

C
----ACGT|ACGT|----TCC|ACGT|A----
----TGCA|TGCA|----AGG|TGCA|T----

For option D, there is no restriction site for *Tai*1. Thus the DNA cannot be inserted into the plasmid.

Q8

The diagram shows some features of a plasmid.



Which row shows the role of each of the sites 1, 2 and 3?

	endonuclease target site	copying cloned gene	locating transformed cells
A	1	2	3
B	2	1	3
C	2	3	1
D	3	1	2

HELP

Site 1 is the origin of replication. Plasmid (a vector) contains an origin of replication, so that it can replicate themselves as well as the inserted gene of interest, within the host cell.

Site 2 is the insertion site, also known as the restriction site which can be targeted and cut by endonuclease for insertion of gene of interest.

Site 3 codes for antibiotic resistance gene. This allows for the selection of successfully transformed cells.

Q9

Insulin is produced by genetic engineering in several stages. Some of these stages are listed.

1. addition to DNA sequence of 'sticky ends'
2. splicing of synthesized DNA into host plasmids
3. isolation or synthesis of appropriate DNA
4. use of specific restriction endonuclease to cut host plasmid with specific 'sticky ends'

What is the correct order?

A 1 → 2 → 3 → 4

B 2 → 1 → 4 → 3

C 3 → 1 → 4 → 2

D 3 → 4 → 2 → 1

HELP

Some of the stages of production of insulin by genetic engineering are outlined as follows:

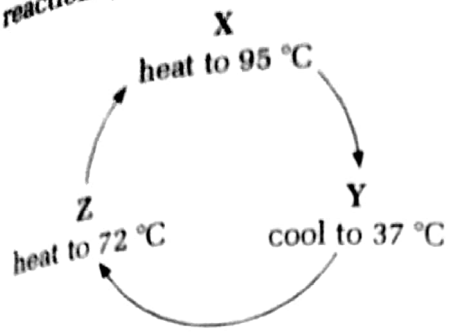
Isolation or synthesis of the insulin gene (appropriate DNA). (Stage 3)

Insertion of the insulin gene (creation of recombinant DNA molecule). Both DNA and plasmid are cut with the same restriction endonuclease. Using the same restriction endonuclease helps ensure that specific 'sticky ends' produced are complementary and can base-pair specifically. (Stage 1 and 4)

The cut plasmids and DNA fragments are then mixed *in vitro*, allowing the sticky ends to reanneal in a specific, complementary manner through the formation of hydrogen bonds between the bases. DNA ligase is then added to covalently seal the nicks between the fragments through the formation of phosphodiester bonds. (Stage 2)

Q10

The diagram shows the changes in temperature of the reaction mixture during the polymerase chain reaction (PCR).



The main events during one cycle of the reaction are listed.

1. binding of RNA primers
2. DNA synthesis
3. separation of DNA strands

Which combination correctly matches each event with the temperature in the reaction mixture?

	X	Y	Z
A	1	2	3
B	2	3	1
C	3	1	2
D	3	2	1

HELP

There are three major steps in a PCR.

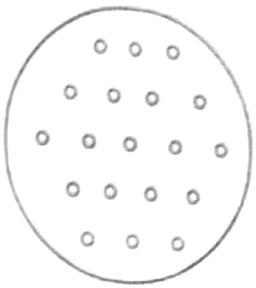
Step 1: Denaturation. The thermal cycler heats the mixture of primer and DNA fragment to about 95 °C. Hydrogen bonds holding the double-stranded DNA fragment break and the double-stranded DNA separates and dissociates into single strands.

Step 2: Annealing of primers. The solution is allowed to cool to 37 °C. As it cools, primers base pair with complementary sequences at the 3′ end of the single-stranded DNA.

Step 3: Primer extension. The thermal cycler then raises the temperature to 72 °C. Using the primer, the polymerase synthesizes the rest of the fragment resulting in new strand of DNA.

Q11

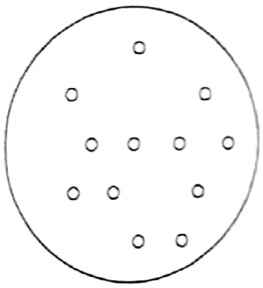
A gene coding for the production of a human gene product was inserted into a plasmid with genes coding for resistance to antibiotics ampicillin, streptomycin and tetracycline. The plasmids were used to transform *E. coli* and the bacteria grown on a nutrient medium. The resulting master plate is shown in the diagram.



Transformed cells were selected by replica plating the bacteria colonies onto media containing various antibiotics.

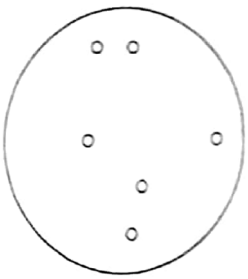
Which plate contains the colony of bacteria into which the human gene has been successfully inserted?

A



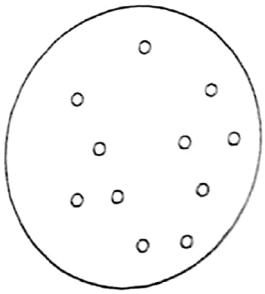
Medium with ampicillin and streptomycin

B



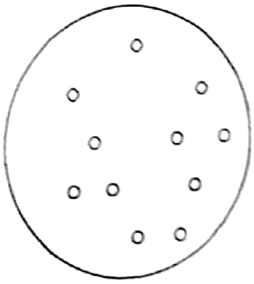
Medium with the antibiotic kanamycin

C



Medium with ampicillin, streptomycin and tetracycline

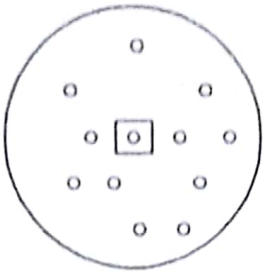
D



Medium with tetracycline

HELP

The colony of bacteria into which the human gene has been successfully inserted is highlighted as shown (option A).



Medium with ampicillin and streptomycin

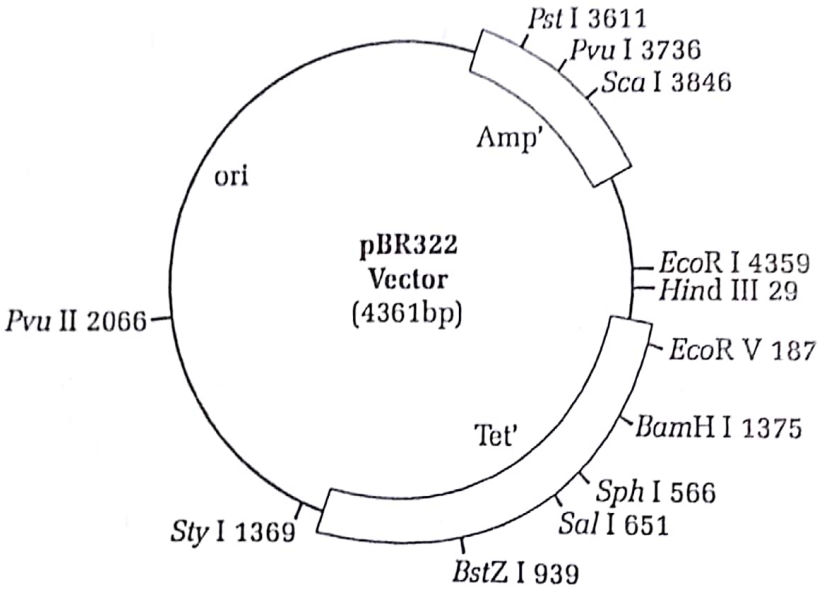
Option B: The plasmid inserted only contains genes coding for resistance to antibiotics ampicillin, streptomycin and tetracycline. Thus, even if the bacterium is transformed, it will not have resistant to kanamycin.

Option C shows colonies of transformed bacterial cells with non-recombinant plasmid. That is, all the 3 genes coding for resistance to antibiotics ampicillin, streptomycin and tetracycline are intact.

Option D has all the colonies present in medium C, indicating that the gene coding for resistance to tetracycline is intact and that the human gene has not been inserted into the gene. All colonies of bacteria present are transformed with non-recombinant plasmid.

Q12

pBR322 vector is used to clone a eukaryotic gene which has been digested by the restriction endonuclease *BamHI*.



Following transformation, bacterial cells were grown in four different media, as shown below.

I	nutrient broth plus ampicillin
II	nutrient broth plus tetracycline
III	nutrient broth plus ampicillin and tetracycline
IV	nutrient broth without antibiotics

Which of the following media would bacterial cells that contain the recombinant plasmids grow in?

A I and II

B I and III

C I and IV

D IV only

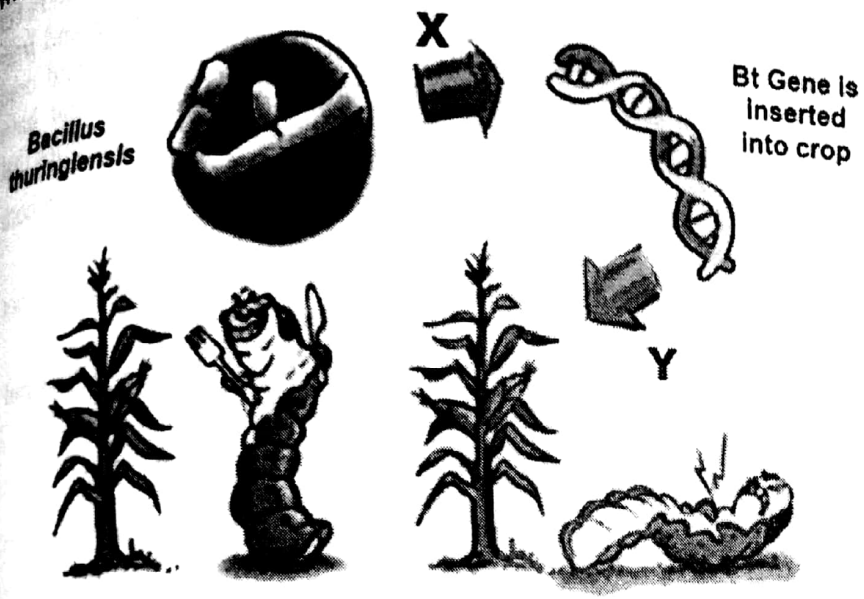
HELP

Due to insertional inactivation by the eukaryotic gene which disrupts the tetracycline resistance gene, transformed bacteria containing recombinant plasmid would not be able to survive in a medium containing tetracycline, i.e. media II and III. Thus, bacterial cells that contain the recombinant plasmids can only survive in media I and IV.

Q13

The figure below illustrates how biotechnologists can make corn become resistant to infection by European corn borer.

Which statements correctly describe X and Y?



	X	Y
A	Bt Gene is isolated from *Bacillus thuringiensis* with the help of restriction endonucleases.	Bt Gene is inserted into crop via electrophoresis.
B	Bt Gene is isolated from *Bacillus thuringiensis* with the help of restriction endonucleases.	Bt Gene is inserted into crop via electroporation.
C	Bt Gene is isolated from *Bacillus thuringiensis* with the help of restriction exonucleases.	Bt Gene is inserted into crop as a result of infection by *Agrobacterium tumefaciens.*
D	Bt Gene is isolated from *Bacillus thuringiensis* with the help of restriction exonucleases.	Bt Gene is inserted into crop as a result of infection by *Bacillus thuringiensis.*

HELP

For statement Y, Bt Gene is inserted into crop via electroporation and not electrophoresis. Gel electrophoresis is a procedure for separating a mixture of molecules through a gel in an electrical field while electroporation disturbs the phospholipid bilayer of the membrane and causes the formation of temporary aqueous pores allowing cells to uptake DNA.

For statement X, Bt Gene is isolated from Bacillus thuringiensis with the help of restriction endonucleases and not restriction exonucleases.

Q14

Plants are more readily manipulated by genetic engineering than are animal cells because

A plant genes do not contain introns.

B more vectors are available for transferring recombinant DNA into plant cells.

C a somatic plant cell can often give rise to a complete plant.

D plant cells have larger nuclei.

HELP

Option A: Plants are eukaryotes and contain introns.

Option B: There are lesser vectors available for transferring recombinant DNA into plant cells.

Option D: The size of nuclei of plant cells and animal cells are the same.

Q15

To date, genetically modified food crops have been modified to

A produce needed human nutrients.

B resist insect pest.

C deliver vaccines.

D All of the above.

HELP

Genetically modified food crops have been modified to produce needed human nutrients such as rice with increased iron and vitamins that may alleviate chronic malnutrition in Asian countries, herbicide- and insect-resistant soybeans, corn, cotton and vaccines against infectious diseases such as hepatitis B.

Q16

Which of the following characteristics is undesirable in cloning vectors used in genetic engineering?

A Control their own replication

B High copy number

C Small in size

D Vulnerable at several sites to a restriction enzyme

HELP

Option A, B and C are characteristics desirable in cloning vectors used in genetic engineering. All vectors contain an origin of replication, so that they can replicate themselves as well as the inserted gene of interest, within the host cell. The most widely used vector, bacterial plasmids, are relatively small circular molecules of double-stranded DNA that are found naturally in high numbers within certain bacteria.

Q17

A plasmid has two antibiotic resistance genes, one for ampicillin and one for tetracycline. It is treated with a restriction enzyme that cuts in the middle of the ampicillin gene. DNA fragments containing a human globin gene were cut with the same enzyme. The plasmids and fragments are mixed, treated with ligase, and used to transform bacterial cells. Clones that have taken up the recombinant DNA are the ones that

A are blue and can grow on plates with both antibiotics.

B can grow on plates with ampicillin but not with tetracycline.

C can grow on plates with tetracycline but not with ampicillin.

D Cannot grow with any antibiotics.

HELP

As the bacterial cells contain the recombinant DNA which contains the tetracycline resistance gene, the bacterial cells are able to survive on plates with tetracycline.

However, due to insertional inactivation by the human globin gene which disrupts the ampicillin resistance gene, transformed bacteria containing recombinant plasmid would not be able to survive in a medium containing ampicillin.

Q18

If the first three nucleotides in a six-nucleotide restriction site are CTG, what would the next three nucleotides most likely be?

A AGG B GTC

C CTG D CAG

HELP

Restriction sites are palindromic, that is the nucleotide sequences of each of the two DNA strands is identical when read in 5′ → 3′ direction.

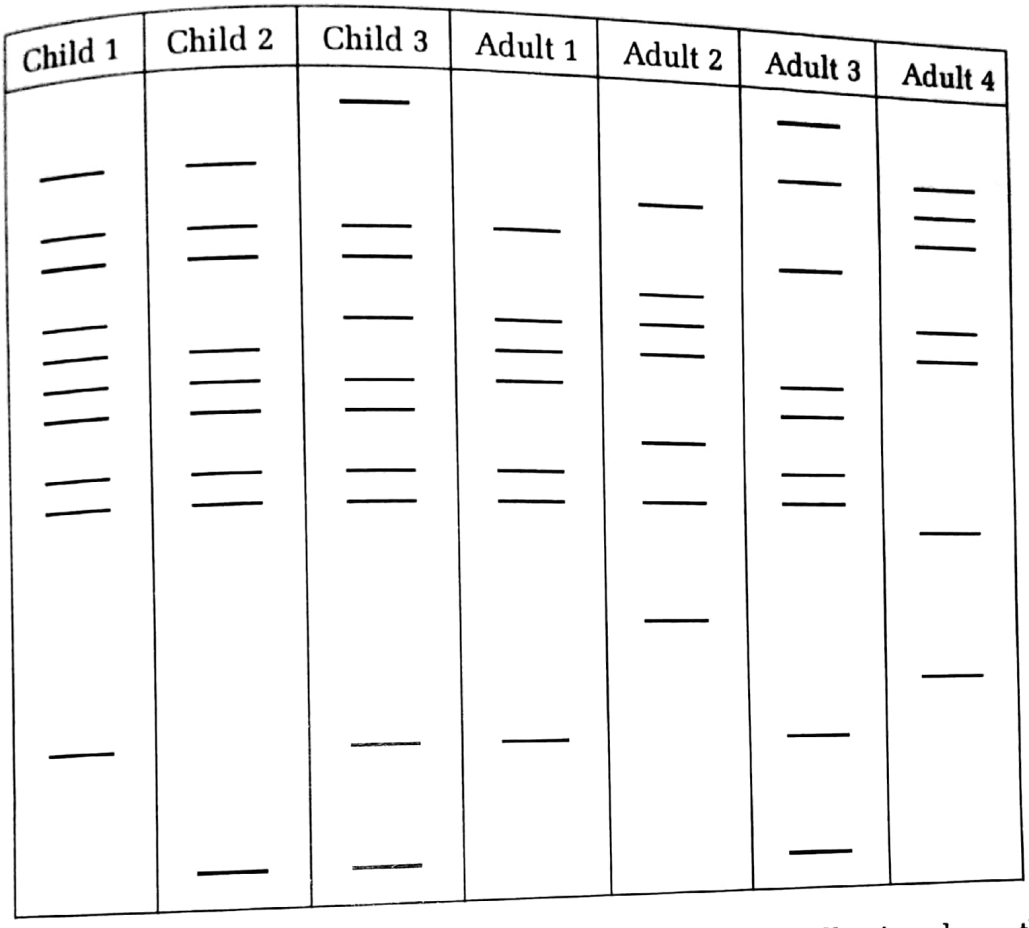
5′ - CTG CAG - 3′

3′ - GAC GTC - 5′

Q19

Nine skeletons were found in an unidentified grave. To establish the relationship between these nine individuals, small amounts of DNA were isolated from these skeletons and genetic fingerprinting was then carried out.

The chart shows some of the results obtained from the genetic fingerprinting of seven of the skeletons: three children and four adults.



All three children on the chart had the same parents. Which of the following shows the children's parents?

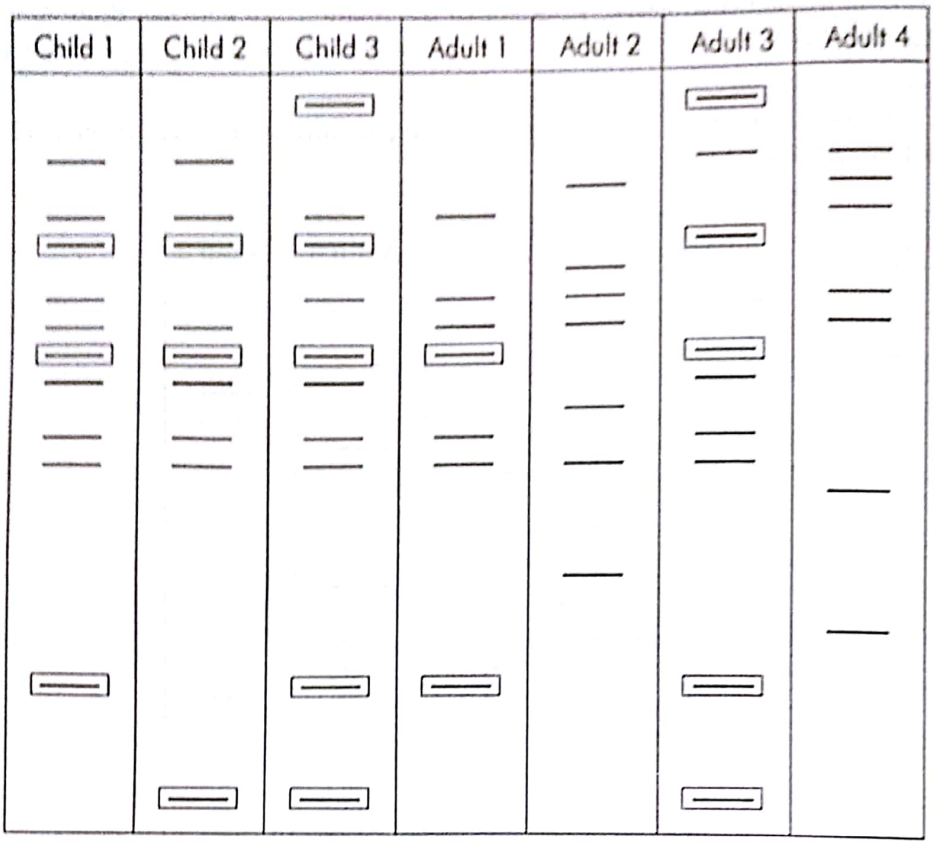
A Adult 1 and 2

B Adult 1 and 3

C Adult 2 and 4

D Adult 2 and 3

HELP



Each individual's combination is unique, having inherited one allele for each locus from each parent. Only Adult 1 and 3 are able to contribute the highlighted bands to Child 1 to 3.

Q20

At the start of the polymerase chain reaction (PCR), single stranded primers are added to the denatured DNA and the mixture cooled to 60 °C.

What explains why the denatured DNA strands anneal with primers and **not** each other?

A The primers are shorter and anneal more easily.

B The primers anneal only to the 3' end of denatured DNA.

C The primer concentration exceeds the denatured DNA concentration.

D The temperature prevents the denatured DNA from annealing together.

HELP

As the mixture cools to 60 °C, annealing of primers take place.

The denatured single strands of DNA tend to reassociate into double strands but due to the large excess of both the forward and reverse primers, primers base pair with complementary sequences at the 3' end of the single-stranded DNA and prevents the denatured DNA strands annealing with each other.

Q21

Which of the following best describes a plasmid?

A A gene within the chromosome.

B Small circular piece of DNA outside the chromosome.

C The genetic material of a bacteriophage.

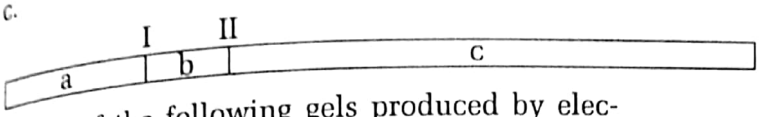
D A single, linear strand of DNA.

HELP

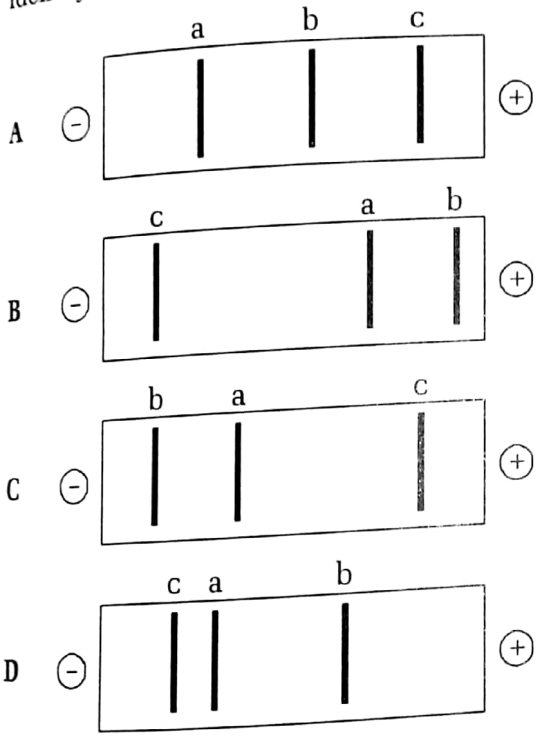
Plasmids occur naturally in bacteria, yeast, and some higher eukaryotic cells. Bacterial plasmids are relatively small circular molecules of double-stranded DNA that are found naturally within certain bacteria and separated from a bacterial cell's chromosomal DNA.

Q22

This segment of DNA has restriction sites I and II, which create restriction fragments a, b, and c.

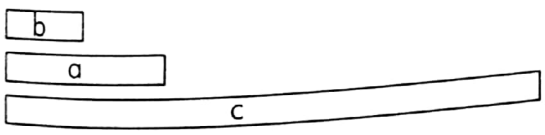


Which of the following gels produced by electrophoresis would represent the separation and identity of these fragments?



HELP

When the segment of DNA is digested, the size of the fragments will be as follows:

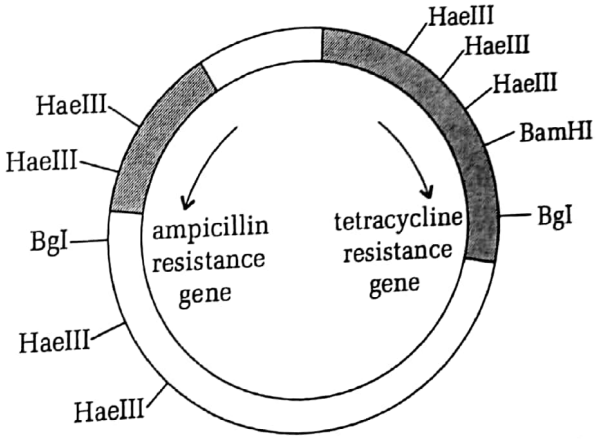


Gel electrophoresis is a procedure for separating a mixture of molecules through a gel in an electrical field. The DNA molecules, which are negatively charged, migrate toward the positive electrode, the anode. A molecule's rate of movement is determined mostly by its length; longer molecules travel more slowly through the pores in the gel, the smallest DNA fragments move faster and travel the longest distance. Thus, fragment C which is the largest fragment will be closer to the negative electrode, while fragment a and fragment b are similar in size and are closer to the positive electrode.

Q23

The gene map of a plasmid, which has been used for genetic engineering, is shown below.

It contains two antibiotic resistance genes. The positions of several restriction endonuclease binding sites are also shown below.



Which enzyme(s) would be the most suitable for the cleavage of the plasmid and the DNA containing the gene of interest?

A BamHI **B** BgI

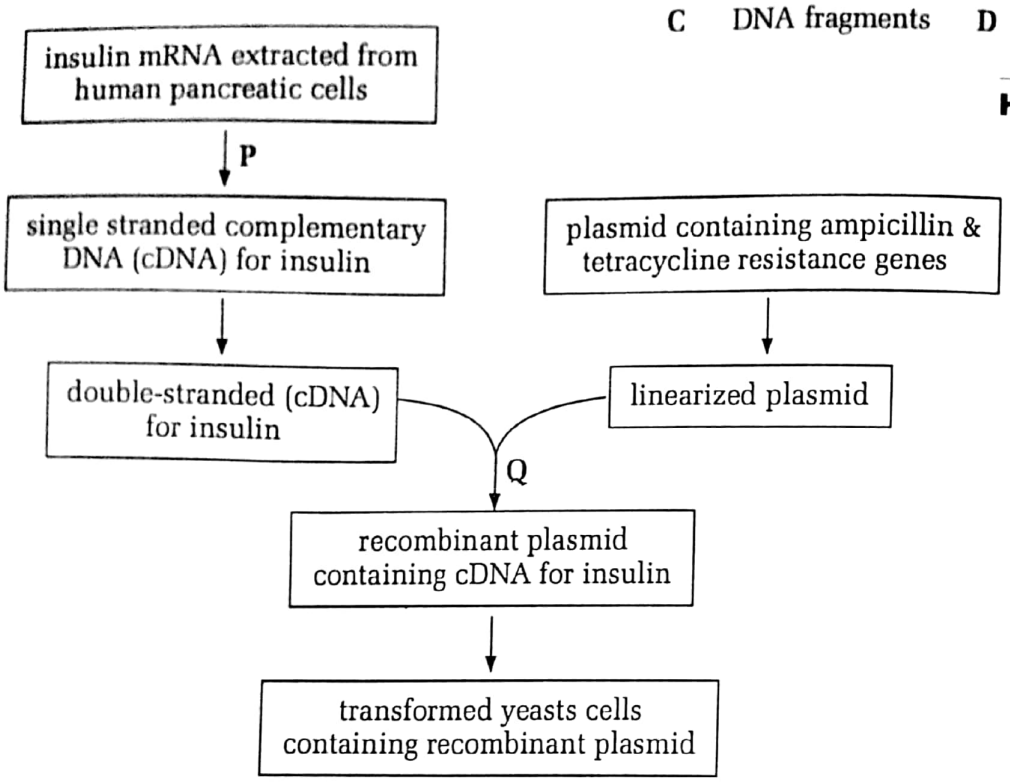
C HaeIII **D** **BamHI and HaeIII**

HELP

A suitable restriction endonuclease should cut the plasmid at only one position in order to allow the DNA containing the gene of interest to be inserted into the circular plasmid without loss of any part of the plasmid.

Q24

The following figure summarizes the formation of insulin using genetically engineered yeasts.



Which enzyme would be used at **P** and **Q**?

	P	Q
A	RNA polymerase	Restriction enzyme
B	Reverse transcriptase	Restriction enzyme
C	RNA polymerase	DNA ligase
D	Reverse transcriptase	DNA ligase

HELP

At step P, cDNA for insulin is synthesized from the insulin mRNA strand using reverse transcriptase.

At step Q, DNA ligase is added to covalently seal the nicks between the cDNA for insulin and the linearized plasmid through the formation of phosphodiester bonds to form a recombinant plasmid.

Q25

What is not necessary for PCR to occur?

A dATP **B** Primers

C DNA fragments **D** Ribonucleotides

HELP

A PCR reaction requires the following elements:

Template DNA (DNA fragments to be copied)

Oligonucleotide primers

DNA polymerase

Deoxynucleoside triphosphates (dATPs, dTTPs, dCTPs and dGTPs)

Q26

Which of the following procedures would produce RFLPs?

A incubating a mixture of single-stranded DNA from two closely related species

B incubating DNA nucleotides with DNA polymerase

C incubating DNA with restriction enzymes

D incubating RNA with DNA nucleotides and reverse transcriptase

HELP

Restriction Fragment Length Polymorphism (RFLP) analysis is a technique in which organisms may be differentiated by analysis of patterns derived from cleavage of their DNA. Differences in nucleotide sequence between alleles at a locus results in the formation of restriction fragments of different length upon digestion by the same restriction enzyme and detected by Southern blot analysis.

Q27

Bacteria containing recombinant plasmids are often identified by which process?

A examining the cells with an electron microscope

B using radioactive tracers to locate the plasmids

C exposing the bacteria to an antibiotic that kills the cells lacking the plasmid

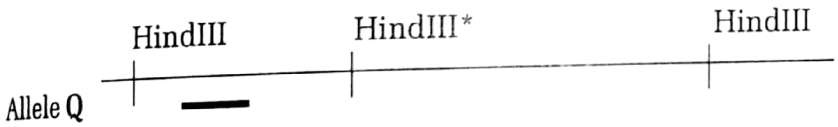
D producing antibodies specific for each bacterium containing a recombinant plasmid

HELP

Only transformed bacteria containing plasmids coding for resistances to antibiotics will be able to survive in a medium containing antibiotic. Bacteria lacking the plasmids will be destroyed by the antibiotic.

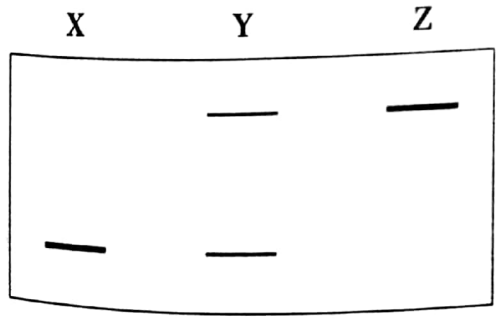
Q28

The region of the genome containing the RFLP used in this analysis is shown below.



HindIII indicates the restriction sites for this enzyme and * indicates the polymorphic site which is missing in the recessive allele q.

The black bar indicates the position of the probe used to detect the RFLP. DNA fragments from three different individuals, X, Y and Z, were subjected to restriction digestion by HindIII and separate by gel electrophoresis. The following results were obtained.



Deduce the genotype of individual Z.

A QQ

B Qq

C qq

D X^qY

HELP

Upon digestion with HindIII:

For allele Q, there is presence of 3 restriction sites, 2 restriction fragments will be formed.

For allele q, there is presence of 2 restriction sites, 1 large restriction fragment will be formed, resulting in a band that is nearest to the well.

From the analysis, there is only 1 band (nearest to the well) observed. This indicates that Individual Z carries allele q. The band is more intense as there is twice as much DNA in it, proving that Individual Z is a homozygote carrying two copies of the allele q.

Q29

How does a genomic library differ from a cDNA library?

A A genomic library contains only non-coding sequences, whereas a cDNA library contains only coding sequences.

B A genomic library varies, dependent on the cell type used to make it, whereas the content of a cDNA library does not.

C A genomic library can be made using a restriction enzyme and DNA ligase only, whereas a cDNA library requires both of these as well as reverse transcriptase and DNA polymerase.

D The genomic library contains only the genes that can be expressed in the cell.

HELP

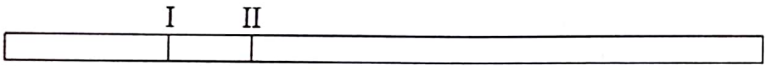
Option A and D: A genomic library contains coding and non-coding sequences.

Option B: The same genomic DNA can be obtained from all cells of the organism, thus, a genomic library does not vary and is not dependent on the cell type used to make it. Whereas each cell of an organism will give rise to a different set of mRNA depending on its stage of development, environmental conditions and functions, each cell will give rise to a differing cDNA library. The content of a cDNA library varies, dependent on the cell type used to make it.

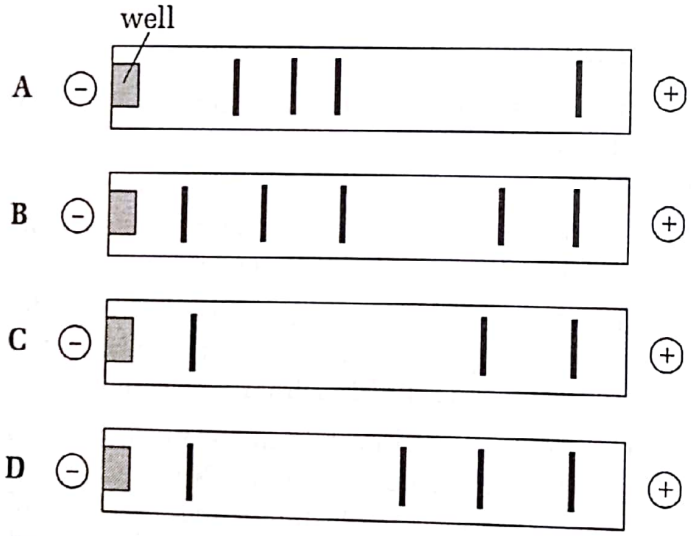
Q30

The restriction fragment shown below contains a gene whose recessive allele is lethal. The normal allele has restriction sites for restriction enzyme *pstI* at sites I and II. The recessive allele lacks restriction site I.

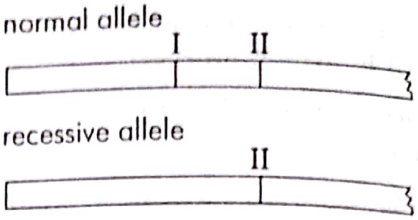
An individual who had a sister with the lethal trait is being tested to determine if he is a carrier of that lethal trait.



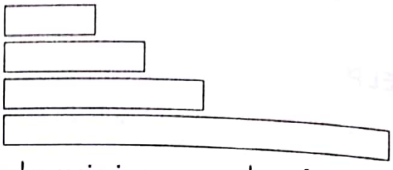
Which of the band patterns would be produced on a gel if he is a carrier?



HELP



If a individual is a carrier, he will have 1 copy of the normal allele and 1 copy of the recessive allele. When digested with restriction enzyme *pstI*, there will be 5 restriction fragments formed:



Gel electrophoresis is a procedure for separating a mixture of molecules through a gel in an electrical field. The negatively charged DNA molecules migrate toward the positive electrode at a rate inversely proportional to their length. Thus, the largest fragment will be closest to the negative electrode, while the 3 smaller fragments which are similar in length are closer to the positive electrode.

Q31

Restriction enzymes are molecular scissors used in genetic engineering to cut up DNA. In nature where are restriction enzymes found and what is their natural role?

A In viruses; to splice host cells DNA.

B In bacteria; to defend against viral invasion.

C In yeast cells, to defend against foreign DNA invasion.

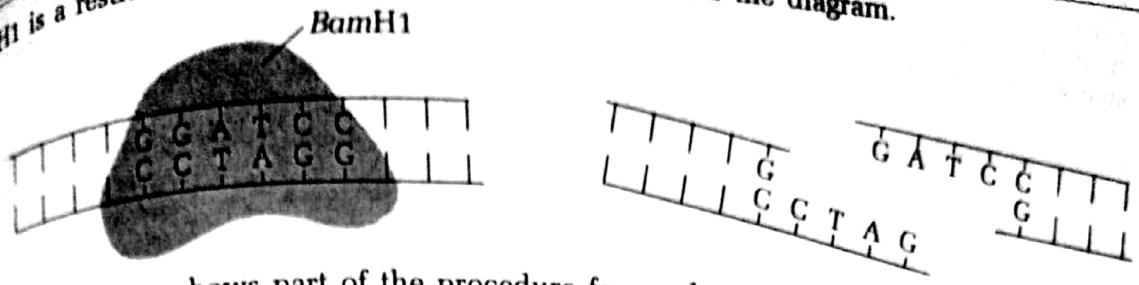
D In viruses; to defend itself against mutation.

HELP

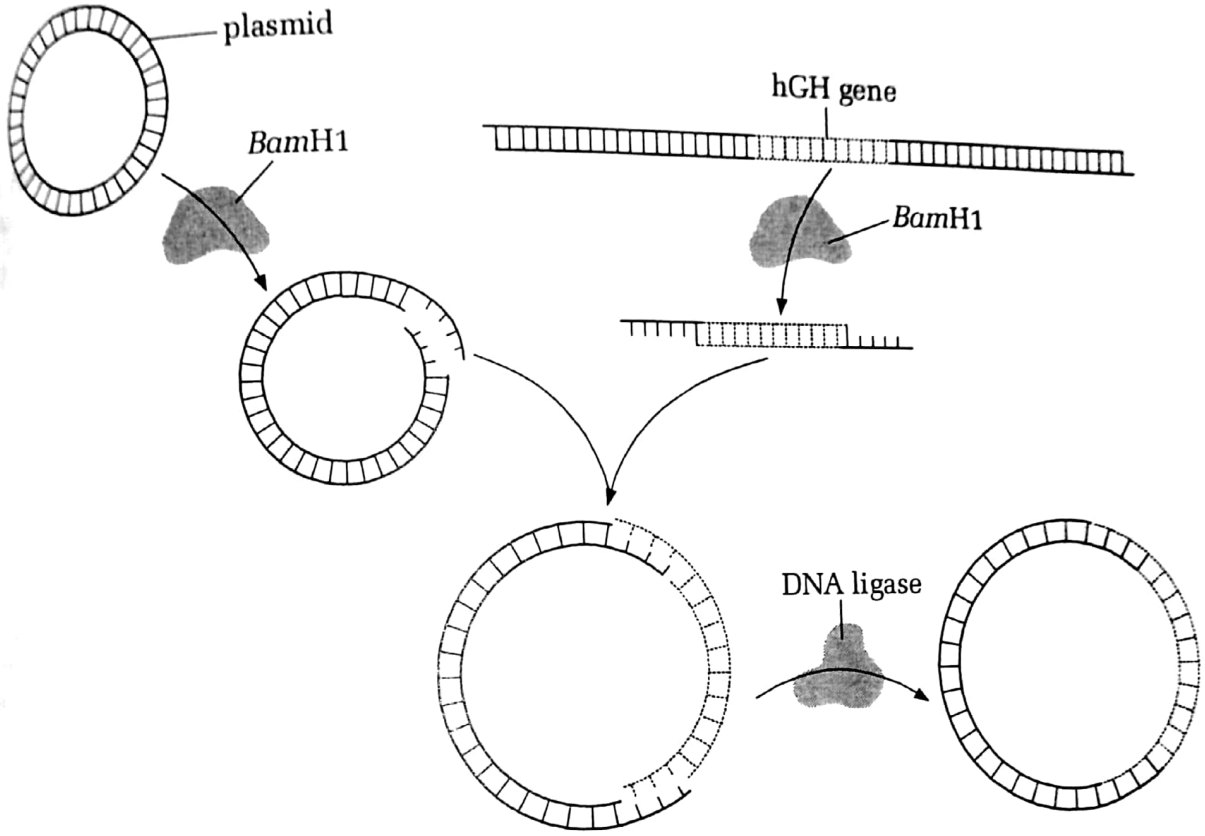
Restriction enzymes serve to protect the bacteria from attack by bacteriophages. Bacteria use their restriction enzymes to degrade the incoming viral DNA from invading bacteriophages.

Q32

BamH1 is a restriction enzyme that cuts DNA as shown in the diagram.



The diagram below shows part of the procedure for producing *E. coli* that will synthesize human growth hormone, hGH.



At the end of this process, many plasmids do not contain the hGH gene.

What could explain this?

A Different alleles of the hGH gene have different sticky ends.

B Not all of the plasmids cut by *Bam*H1 have sticky ends.

C Some of the plasmids are cut at more than one position.

D The sticky ends of some of the plasmids rejoin with each other.

HELP

Option A and B: When the hGH gene or plasmids are cut with *BamH1*, the same sticky ends will be produced. All restriction enzymes recognize and cut only at their specific restriction sites, giving the same pattern of cut each time.

Option C: As seen from the diagram, there is only one *BamH1*'s restriction site in the plasmid, thus the plasmid is only cut at one position.

Option D: The sticky ends produced are complementary and can reanneal in a specific, complementary manner through the formation of hydrogen bonds between the bases.

Q33

A student performed the following steps in a Southern blot experiment to determine the number of copies of a particular gene that has been inserted in a genetically modified organism.

(i) Transfer of DNA to nitrocellulose membrane.

(ii) Restriction digestion of genomic DNA.

(iii) Cleaved DNA separated using gel electrophoresis.

(iv) Create radioactive probe.

(v) Incubate probe and membrane.

Which is the correct sequence to the above steps?

A (ii) → (iii) → (i) → (iv) → (v)

B (ii) → (iii) → (i) → (v) → (iv)

C (iv) → (v) → (i) → (ii) → (iii)

D (v) → (iv) → (iii) → (ii) → (i)

HELP

Correct sequence to Southern blot experiment:

1. Restriction fragment separation. Genomic DNA samples to be tested are prepared and a restriction enzyme is added to produce restriction fragments.
2. Electrophoresis. The restriction fragments are then separated by electrophoresis.
3. Blotting. These restriction fragments are transferred from the gel to a sheet of nitrocellulose membrane. The single strands of DNA stick to the paper and are positioned exactly as that on the gel.
4. Hybridisation with radioactive probe. The nitrocellulose membrane is incubated with a solution containing radioactively labelled probes that is complementary to the DNA sequence of interest.

Q34

A method used to detect a particular DNA sequence within a mixture of many DNA fragments is

A DNA sequencing.

B DNA fingerprinting.

C colony hybridisation.

D Southern blotting.

HELP

A mixture of many DNA fragments will yield too many bands to be distinguished individually using gel electrophoresis. Hence Southern blotting is carried out using a specific probe to label discrete bands that contain a particular DNA sequence.

Q35

The diagram shows a section of a DNA molecule.

ATCGTAGAATTCGGCTCGAGGCATTAGAATTCCTAGGATCGAATTGGCAT
TAGCATCTTAAGCCGAGCTCCGTAATCTTAAGGATCCTAGCTTAACCGTA

This molecule was cut under ideal conditions, using two different endonucleases, *Eco*R1 and *Tac*1, which recognize different restriction sites:

*Eco*R1	GAATTC CTTAAG	*Tac*1	TCGA AGCT

What is the number of DNA fragments that can be produced?

	Number of DNA fragments
A	4
B	4
C	5
D	5

HELP

ATCGTA GAATTC GGC TCGA GGCATTA GAATTC CTAGGA TCGA ATTGGCAT
TAGCAT CTTAAG CCG AGCT CCGTAAT CTTAAG GATCCT AGCT TAACCGTA

There are 2 restriction sites respectively in the DNA molecule for the two endonucleases, *Eco*R1 and *Tac*1 (highlighted in the above diagram). Thus, *Eco*R1 and *Tac*1 are able to make a total of 4 cuts on the molecule hence giving rise to 5 DNA fragments formed.

Q36

Five stages in the production of human insulin by genetic engineering techniques are given.

1 DNA cut with restriction enzymes
2 DNA copy made using reverse transcriptase
3 messenger RNA extracted from cells
4 plasmid DNA joined to donor DNA using ligase enzymes
5 recombinant plasmid inserted into bacterial cell

Which sequence is correct?

	first ⟶ *last*
A	1 → 3 → 2 → 5 → 4
B	1 → 3 → 4 → 2 → 5
C	2 → 1 → 3 → 5 → 4
D	3 → 2 → 1 → 4 → 5

HELP

The five stages in the production of human insulin are carried out in the order 3, 2, 1, 4 and then 5.

Q37

Synthesis of human insulin by genetically manipulated bacteria involves the use of the enzyme reverse transcriptase.

What is the role of this enzyme?

A It adds 'sticky ends' to insulin genes.
B It causes complementary DNA to be formed from mRNA.
C It causes production of mRNA in the pancreas cells.
D It causes single-stranded DNA to convert to double-stranded DNA.

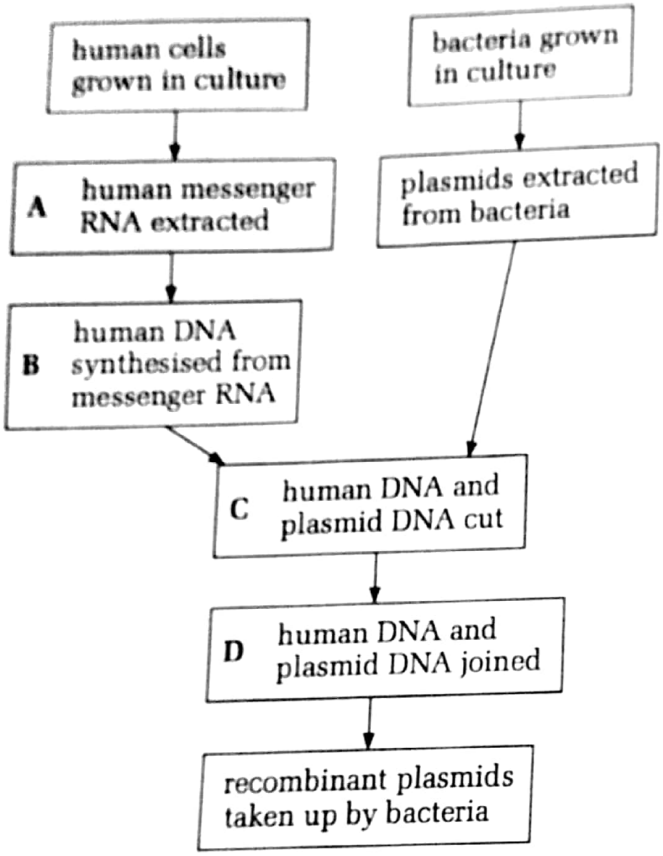
HELP

Reverse transcriptase can be used to synthesize DNA, called complementary DNA (cDNA) from the mRNA.

Q38

The flow diagram shows some of the events in the production of a human hormone by genetic engineering.

At which stage in the process is a restriction enzyme used?



HELP

Restriction enzymes are used to cut DNA between specific base sequences before the ends are joined up.

Q39

When bacteria are genetically engineered to produce human insulin, the enzymes used in the procedure are

1 ligase
2 restriction endonuclease
3 reverse transcriptase

In which order are the enzymes used?

	first → last		
A	1	3	2
B	2	3	1
C	2	1	3
D	3	2	1

HELP

Reverse transcriptase is first used to make a complementary DNA (cDNA) from an mRNA molecule. Then, restriction endonuclease is used to cut the bacterial plasmid so that sticky ends are obtained. Finally, DNA ligase is needed to join the inserted gene to the sticky ends of the plasmid vector.

Q40

In the genetic engineering of bacteria to produce insulin, what is the vector?

A a bacterium
B a gene
C an enzyme
D a plasmid

HELP

The vector is the plasmid which is removed from a bacterium and inserted with a foreign gene. The plasmid vector is then reinserted back into the host bacterium for replication.

Q41

Synthetic insulin from genetically engineered bacteria is compared with human pancreatic insulin.

Which statement and explanation about the insulin molecules is correct?

	statement	explanation
A	different	a bacterial gene is altered to resemble the human gene
B	different	altered human genes are inserted into the bacteria
C	identical	a bacterial gene is altered to resemble the human gene
D	identical	a human gene controls the synthesis of bacterial insulin

HELP

The insulin produced is identical as the synthetic gene that codes for this protein is based on the sequence of nucleotides found in human DNA that specifically codes for insulin. The bacterial genes are not altered, as the bacterial plasmid is only cut to enable the insertion of the synthetic gene.

Topic 8 Isolating, Cloning and Sequencing DNA

Q1 C	Q2 C	Q3 B	Q4 C	Q5 D	Q6 B	Q7 A	Q8 B
Q9 C	Q10 C	Q11 A	Q12 C	Q13 B	Q14 C	Q15 D	Q16 D
Q17 C	Q18 D	Q19 B	Q20 C	Q21 B	Q22 B	Q23 A	Q24 D
Q25 D	Q26 C	Q27 C	Q28 C	Q29 C	Q30 D	Q31 B	Q32 D
Q33 A	Q34 C	Q35 C	Q36 D	Q37 B	Q38 C	Q39 D	Q40 D
Q41 D							

TOPIC 9

Applications of Molecular and Cell Biology

You should try to answer on your own before resorting to **HELP**.

Q1

Stem cells are widely used in medical research.

Which property of stem cells makes them particularly useful in this research?

A They can be fused together to form a zygote.

B They can divide and eventually give rise to a whole organism.

C They can divide and be made to differentiate into various types of cell.

D They will continue to divide indefinitely.

HELP

Stem cells are capable of dividing indefinitely and producing copies of themselves. In addition, stem cells can undergo differentiation giving rise to specialized cell types.

Q2

Which of these processes could increase crop yield?

P: Inserting genes for vitamin A production into rice

Q: Inserting genes for pest resistance into cotton

R: Inserting genes for herbicide resistance into oilseed rape.

S: Inserting genes for nitrogen fixation into soya beans.

A P and Q

B Q and R

C R and S

D S and P

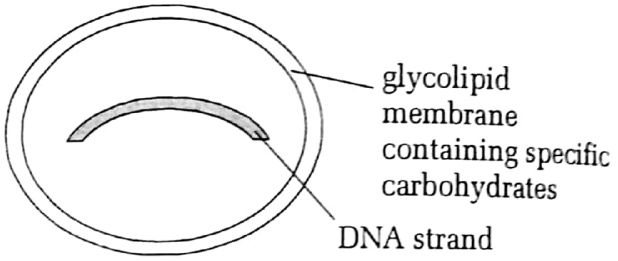
HELP

P and S are processes used to improve the quality of crop plants by improving the nutritional value of rice and soya beans.

Q3

Gene therapy is a way of treating genetic disease by introducing a piece of DNA into the cells of an affected individual. Liposomes can be used for gene therapy as they target the cells affected by a genetic disease.

The diagram shows the structure of a liposome.



What feature of a cell surface membrane allows the liposome to target cells affected by a genetic disease?

A carrier molecules

B phosphate groups

C protein channels

D receptor molecules

HELP

The liposome's glycolipid membrane containing specific carbohydrates recognizes and binds to receptor molecules on cell surface membrane of target cells. The liposome is thus able to deliver genes to specific target cells and is able to deliver DNA into the cell.

Q4

Which genetic modification could increase the yield of a crop measured as mass of crop produced per unit area per year?

A herbicide resistant plants
B delayed ripening in the fruits
C more essential amino acids in the seeds
D more vitamin A in the grain

HELP

Genetic modification of plants into herbicide resistant plants can improve crop yield. This is because herbicides are used to get rid of weeds which compete with crops for soil nutrients. Transgenic plants are not inhibited by herbicide. Thus farmers may apply a specific herbicide to control weeds population, without damaging their herbicide-tolerant crops. This leads to an increase in crop yield because of less competition from weeds.

Q5

Stem cells can be divided into four main types. Which of the four types of stem cell can differentiate into a limited range of tissues?

A adult stem cells
B embryonic stem cells
C fetal stem cells
D zygotic stem cells

HELP

Adult stem cells are tissue specific and can enter normal differentiation pathways to form only the specialized cell types of the tissue which they reside in.

Embryonic stem cells and fetal stem cells are pluripotent stem cells and have the ability to differentiate into almost any cell type to form any organ or type of cell.

Zygotic stem cells are totipotent cells, which means that it has unlimited capability to differentiate and give rise to the extra-embryonic membranes and tissues, the embryo and all post embryonic tissues and organs. The cell has the potential to give rise to any and all human cells.

Q6

Which property of embryonic stem cells makes them particularly useful in medical research?

A They can be fused together to form a zygote.
B They can divide and are pluripotent.
C They can divide and are totipotent.
D They will continue to divide indefinitely.

HELP

Embryonic stem cells are not totipotent but are multipotent cells. They have the ability to differentiate into almost any cell type to form any organ or type of cell.

Q7

A patient suffers from adenosine deaminase (ADA) deficiency, an autosomal recessive immune deficiency in which bone marrow lymphoblasts cannot replicate to generate immunocompetent lymphocytes. The treatment option that would permanently cure the patient is

A germ-line gene therapy to replace one ADA gene copy.
B germ-line gene therapy to replace both ADA gene copies.
C somatic cell gene therapy to replace both ADA gene copies in circulating lymphocytes.
D somatic cell gene therapy to replace one ADA gene copy in bone marrow lymphoblasts.

HELP

In gene therapy, only somatic cells and not germ cells are targeted for treatment.

ADA deficiency is inherited in an autosomal recessive pattern, which means two copies of the ADA gene in each cell are altered. The presence of one copy of ADA gene in bone marrow lymphoblasts will produce sufficient ADA enzymes to 'cure' the genetic disease.

Q8

Which feature of stem cells obtained from blood in the umbilical cord enables their use in the treatment of a variety of blood cancers?

A They can differentiate into bone marrow cells.

B They can differentiate into any cellular component of blood.

C They can replace blood stem cells affected by cancer.

D They are totipotent.

HELP

Umbilical cord blood stem cells are multipotent, in that they have the ability to differentiate into limited cell types to give rise to a range of specialized cells that have a specific function. Umbilical cord stem cells found in cord blood only can differentiate into any cellular component of blood eg. white blood cells (such as B lymphocytes, T lymphocytes, natural killer cells, macrophages and platelets etc.) – vital for fighting infections and safeguarding the body, red blood cells – important for transporting oxygen to cells.

Q9

Which type of gene therapy is **least** effective in transferring DNA to the nucleus?

A Adenoviruses

B DNA attached to a ligand

C Liposomes

D Retroviruses

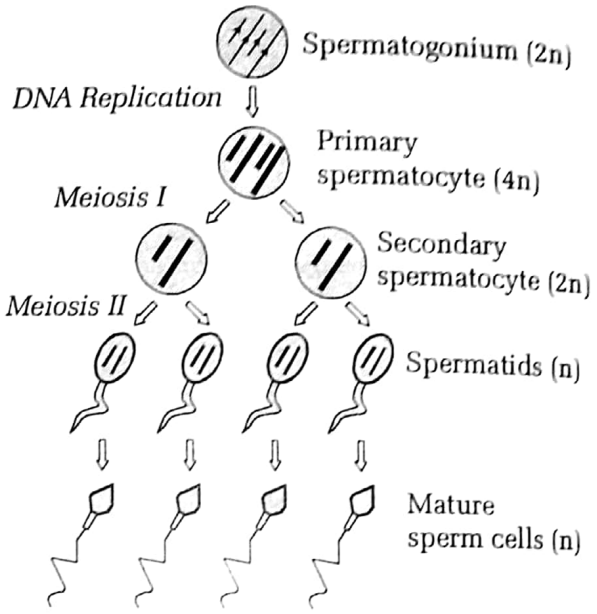
HELP

Viral delivery using adenoviruses and retroviruses are specific and ensure effectiveness. The viral vector recognizes and binds to receptor on cell and enters cells. The vector is able to deliver genes to specific target tissues and is able to deliver DNA to the nucleus.

Phospholipid bilayer of liposome mimic structure of cell surface membranes. The liposome carries the DNA in its aqueous core, fuses with the target cell's surface membrane allowing DNA to enter into cell and passes the DNA to the nucleus.

Q10

The search for pluripotent stem cells is intense. The spermatogonium is the diploid precursor of haploid sperm in the developmental pathway of mouse gametes as shown below.



Scientists were interested to find out which stages of sperm development have stem cell capacity. Two experiments were carried out using sterile host males with testes that lacked germ cells. The results are shown in the table below.

	Type of cells used	Result
Experiment 1	Secondary spermatocytes were injected	Fertility was not restored
Experiment 2	Spermatogonia were injected	Fertility was restored for the rest of the mouse's life

What property of a stem cell is missing in the secondary spermatocytes?

A Specialization

B Self-renewal

C Commitment

D A proper stem-cell niche

HELP

Stem cell niche is used to describe the microenvironment in which stem cells are found. Since fertility was restored after the injection of spermatogonia, it suggests that spermatogonium displays the general properties of stem cells such as being capable of dividing indefinitely and producing copies of themselves (self-renewal), can undergo differentiation giving rise to specialized cell types (haploid sperm).

As fertility was not restored upon injection of secondary spermatocytes, it suggest that the secondary spermatocytes do not have a stem cell niche and do not display the properties of stem cell.

Q11

What are normal functions of stem cells in a living human?

	Functions		
A	Differentiating into many kinds of cells in a 3-5 day old human embryo	Producing insulin in pancreases damaged by type 1 diabetes	Cells that can differentiate into bone cells in the skeleton
B	Differentiating into many kinds of cells in a 3-5 day old human embryo	Producing red blood cells worn out by normal wear and tear	Cells that can differentiate into cardiac muscle cells in the heart
C	Differentiating into only one kind of cell in a 3-5 day old human embryo	Producing dopamine in the brains of people with Parkinson	Cells that can differentiate into cartilage cells in the joints
D	Differentiating into only one kind of cell in a 3-5 day old human embryo	Producing differentiated cells that can be used to screen new drugs	Cells that can differentiate into nerve cells in the brain

HELP

Embryonic stem cells are described as pluripotent which means that they have the ability to develop into almost any kind of cell in the body except extra-embryonic membrane (but not the trophoblast).

Adult stem cells such as blood stem cells and muscle stem cells are undifferentiated and unspecialized cells found among differentiated cells in a tissue eg. bone marrow or organ. The primary role of adult stem cells is to maintain and repair the specific tissues where they reside.

Q12

Which genetic modifications would **not** decrease the quantity of chemicals sprayed onto crop plants by farmers?

A Fungus resistance

B Herbicide resistance

C Insect resistance

D Virus resistance

HELP

Genetic modification of plants into herbicide resistant plants can improve crop yield. This is because herbicides are used to get rid of weeds which compete with crops for soil nutrients. Transgenic plants are not inhibited by herbicide. Thus farmers may continue to apply the same quantity of specific herbicide to control weeds population, without damaging their herbicide-tolerant crops. This leads to an increase in crop yield because of less competition from weeds.

Fungus resistance, insect resistance and virus resistance plants will lead to destroy the fungus, insects or virus that is being targeted. Hence these fungus, insects or virus are unable to cause further damage to crops, farmers will have higher crop yield.

Q13

Which of the following statements is false about hematopoietic stem cells?

A Hematopoietic stem cells are able to reproduce continually.

B Hematopoietic stem cells are present in minute quantities.

C Hematopoietic stem cells can be found in the bone marrow.

D Hematopoietic stem cells can differentiate into all specialised cells.

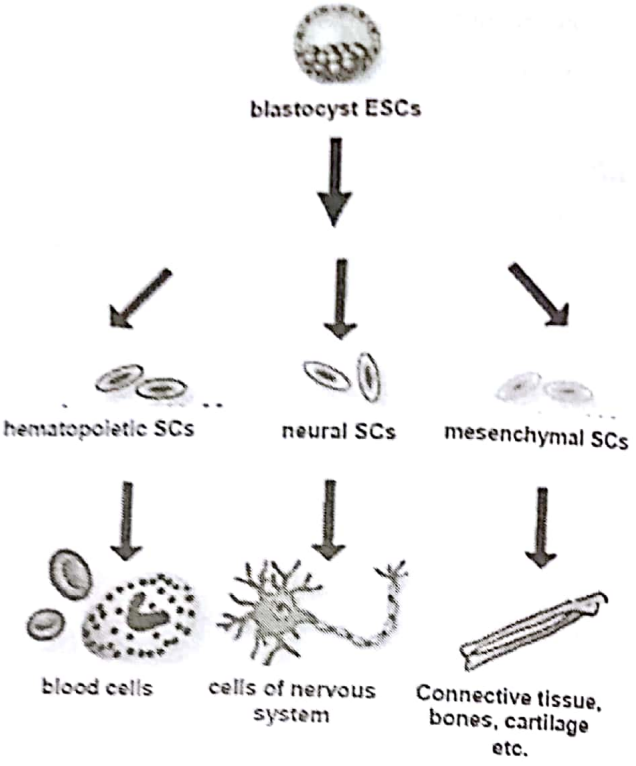
HELP

Option A: The hematopoietic stem cells will constantly divide to replace cells such as the red blood cells that are worn out in three to four months.

Option B and C: Hematopoietic stem cells are a type of adult stem cells that can only be found in the bone marrow in minute quantities. Hematopoietic stem cells can only give rise to blood cells: red blood cells and white blood cells (such as B lymphocytes, T lymphocytes, natural killer cells, macrophages and platelets etc.).

Q14

Which feature of embryonic stem cells (ESCs) is illustrated below?



A ESCs are capable of dividing indefinitely.

B ESCs are multipotent.

C ESCs are pluripotent.

D ESCs show plasticity.

HELP

Embryonic stem cells are pluripotent cells. That is, they have the ability to develop into almost any kind of cell in the body (as seen from diagram, hematopoietic SCs, neural SCs and mesenchymal SCs) except extra-embryonic membrane (but not the trophoblast).

Q15

Which of the following disorders would gene therapy be least effective?

A Cystic fibrosis

B Hungtington's disease

C Sickle cell anaemia

D Type II diabetes

HELP

Cystic fibrosis, Hungtington's disease and Sickle cell anaemia arises as a result of a genetic disorder. A genetic disorder is an illness caused by abnormalities in genes or chromosomes. They are a result of genetic disorder when there is defect in a single gene.

Type II diabetes is a type of multifactorial and polygenic (complex) disorder where manifestation of disease may be dependent on the effects of multiple genes in combination with lifestyle and environmental factors.

Gene therapy is a technique for introducing a copy of normal functional gene/allele into target cells with non-functional genes and works better when there is/are defect(s) in a single gene.

Q16

Which of the following statements are true about all stem cells?

1 Stem cells can be induced to differentiate by environmental signals.

2 Stem cells are easily isolated and propagated.

3 Stem cells are able to develop into whole organisms if implanted into the womb.

4 Stem cells make more stem cells under appropriate conditions.

A 1 and 4 B 2 and 3

C 1, 3 and 4 D 1, 2, 3 and 4

HELP

Statement 1: Stem cells can be induced to differentiate by environmental signals, giving rise to specialized cell types. E.g. hematopoietic stem cells that are found in the bone marrow can give rise to red blood cells and white blood cells.

Statement 4: Stem cells are capable of dividing indefinitely and producing copies of themselves.

Statement 2: Stem cells cannot be easily isolated.

Statement 3: Only zygotic stem cells are totipotent cells, that is, only they have the ability to differentiate into any cell type to form whole organisms.

Q17

Which of the following represents the correct plant growth regulator(s) for the formation of the corresponding plant tissue?

	Plant Growth Regulator	Formation of plant tissue
A	Auxin	Shoot
B	Auxin + Cytokinin	Callus
C	Abscisic acid	Callus
D	Cytokinin	Somatic embryo

HELP

Auxin and cytokinin is added to the nutrient agar to stimulate the cells of the explant to divide by mitosis to form a callus.

Q18

To see the range of cell types a single hematopoietic stem cell can generate, an investigator suggested the use of a modified retrovirus which carries a marker gene. The rationale behind this is

A retroviruses will inject its genome into the cell which will then move into the nucleus to be replicated.

B retroviruses will cause the genome of the stem cell to disintegrate ad synthesize its viral genetic material which will be pass on to new cells as it divides.

C retroviruses will insert its own genome into the chromosomes of the cell it infects and as the cell divides, it is possible to trace all the progeny of the cell.

D retroviruses will replace the equivalent of the marker gene in the stem cell through the process of genetic recombination thereby causing all progeny produced to carry a copy of the marker gene.

HELP

Retroviral delivery method increases the chance of incorporating DNA into host genome.

The isolated hematopoietic stem cell is infected with the retrovirus containing RNA copy of a marker gene. Once the virus has infected the target cell, the RNA copy of the marker gene is reverse transcribed (by retrovirus' own reverse transcriptase) into the normal DNA copy of the gene. The DNA is inserted into the chromosomal DNA of the hematopoietic stem cell. Whenever the stem cell divides via semi-conservative replication, the marker gene will be replicated and be present in all the progeny of the cell.

Q19

Which of the following statements regarding stem cells is ***false***?

A One potential side effect of any embryonic stem cell-based therapy is the formation of tumour.

B Stem cells are present within various organs of the adult body.

C Stem cells can develop into a whole organism when implanted into the womb.

D Stem cells can be grown and expanded indefinitely in culture under appropriate culture conditions.

HELP

Only zygotic stem cells are totipotent cells, that is, only they have the ability to differentiate into any cell type to form whole organisms.

Q20

Large quantities of useful products can be produced through genetic engineering involving

A bacteria containing recombinant plasmids.

B mammals.

C transgenic plants.

D All of the above.

HELP

Genetic engineering refers to a special set of technologies that alter the genetic makeup of animals, plants or bacteria.

Genetic engineering involving bacteria containing recombinant plasmids can be used to produced insulin.

Genetic engineering involving mammals such as cows, producing substances eg. Bovine somatotrophin (BST) can be used to improve milk yield.

Genetic engineering involving transgenic plants can be used to improve crop yield or improve quality of crop plants eg. glyphosate-resistant soy crop plants.

Q21

Which statement describes a unique feature of stem cells in adult humans?

A They can differentiate into different cell types.

B They can undergo meiosis.

C They have a complete human genome.

D They have multiple copies of active genes.

HELP

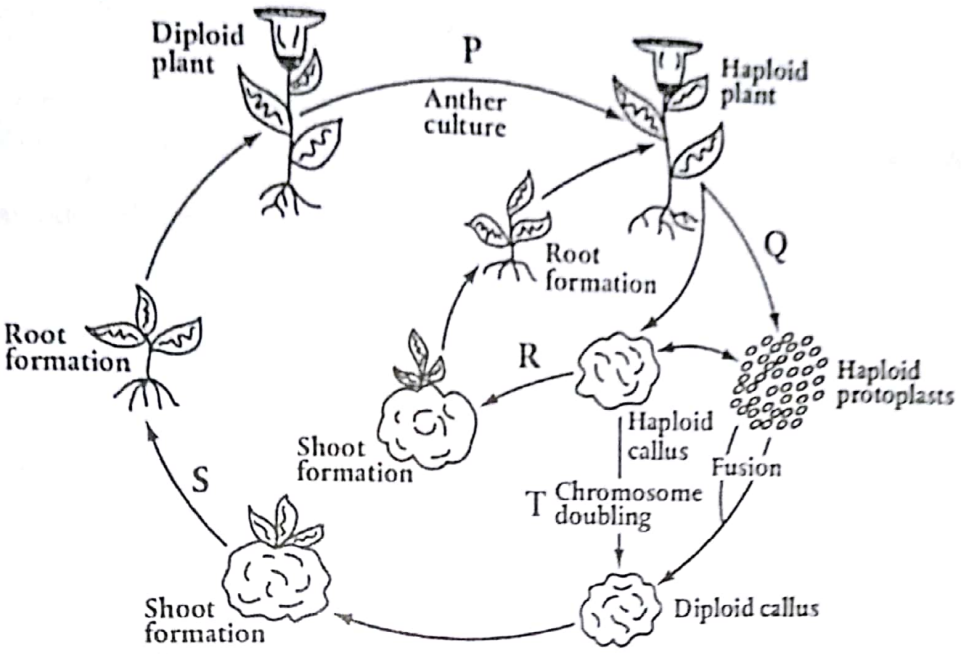
Option B: Only germ cells undergo meiosis.

Option C and D: All cells and not only stem cells have a complete human genome as well as have multiple copies of active genes.

Option A: Stem cells can undergo differentiation giving rise to different cell types.

Q22

The figure below gives some of the possible experimental manipulations in the culture of cells from *Petunia* plants.



Which of the following correctly identifies the stage for each of the events taking place in the culture of *Petunia* plant cells?

	Meiotic division	Removal of cell wall	Restoration of somatic number of chromosomes	Removal and subsequent culture of individual cells from microshoots
A	R	P	S	Q
B	P	T	T	R
C	R	R	S	P
D	P	Q	T	S

HELP

Step P: Diploid plant giving rise to anther is a result of meiosis. It is the process by which a cell nucleus divides to produce four daughter nuclei each containing half the number of chromosomes found in the original nucleus.

Step Q: Protoplast are plant cells with their cell wall removed.

Step T: A haploid callus being restore to diploid callus suggests that the somatic number of chromosomes has been restored.

Step S: With differentiation of individual cells of callus into particular tissues (shoot and roots), a plantlet is form.

Q23

Which of the following disorders would gene therapy be **most** effective?

A Cystic fibrosis

B Cancer

C Schizophrenia

D Type II diabetes

HELP

Gene therapy is a technique for introducing a copy of normal functional gene/allele into target cells with non-functional genes and works better when there is/are defect(s) in a single gene.

Cystic fibrosis arises as a result of a genetic disorder. Cystic fibrosis is a result of genetic disorder when there is defect in the cystic fibrosis transmembrane conductance regulator (CFTR) gene found on chromosome 7 coding for CFTR. Thus treatment with gene therapy will be effective.

Cancer, schizophrenia and Type II diabetes are types of multifactorial and polygenic (complex) disorder where manifestation of disease may be dependent on the effects of multiple genes in combination with lifestyle and environmental factors. Thus treatment with gene therapy will not be effective. This is because it is impossible to introduce many functional genes at the same time.

Q24

The following are advantages of transgenic plants except:

A A gene for a desirable characteristic can be identified and cloned.

B All the beneficial characteristics of an existing variety can be kept and just the desired new gene can be added.

C Sexual reproduction is necessary.

D Transgenics is much faster than conventional breeding.

HELP

Sexual reproduction will cause genetic variation. Transgenic plants are not produced by sexual reproduction. It is difficult to produce plants that breed true – homozygous for desired traits when sexual reproduction is used.

Instead, the cells of these clones divide by mitosis to maintain genetic stability. Plants produced via cloning are genetically identical and all posses the desirable features of the stock plants.

Q25

Which of the following are reasons for scientists to employ the method of plant cloning?

1 change the phenotype of an organism

2 create smaller genetic changes at a much more rapid pace

3 production of large amount of pharmaceuticals

4 selective breeding is too slow

A 1 and 2

B 1 and 3

C 1, 2 and 3

D 1, 2, 3 and 4

HELP

Statement 1 and 2: Plant cloning can be linked to genetic engineering which refers to a special set of technologies that alter the genetic makeup (phenotype) of organisms such as animals, plants or bacteria at a much rapid pace.

Statement 3 and 4: Rapid multiplication of plants allows for production of large amount of pharmaceuticals. Plants with desired traits can be multiplied rapidly than can be done using conventional breeding methods such as selective breeding, which rely on sexual reproduction.

Q26

The genetically engineered super salmon was created from Atlantic salmon stocks and are capable of growing to a large size in 14 months. Which of the following is not a benefit intended from the crop?

A Higher yield for farmers

B Minimising pollution

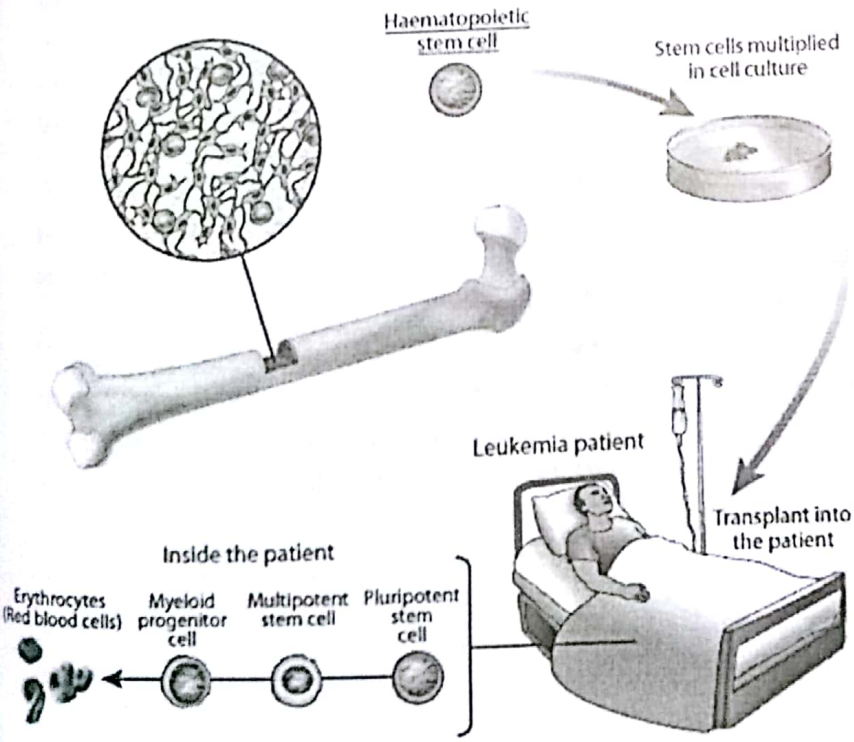
C Decreasing the food consumption of the crops in their lifetime

D Increase in supply to meet world's demand

HELP

Growth hormone is produced all year round in these genetically engineered super salmon, resulting in them growing to their maximum size 3-6× faster than their wild counterparts/ normal farmed salmon. Thus, these salmons take half the time to grow to market size. This decreases the food consumption of the crops in their lifetime as well as results in an increase in yield for the farmers. The larger salmons also results in an increase in supply to meet world's demand.

Q27



Which of the following options are characteristics of the form of treatment shown above?

1 Easy to extract in laboratory

2 Readily available

3 Difficult to control

4 Limited longevity

A 3 only

B 3 and 4

C 1 and 3

D 1, 2, 3 and 4

HELP

In gene therapy, there is problem with controlling the activity of gene expression. The concerns include the possibility that transferred genes could be 'overexpressed', producing so much of the missing protein as to be harmful. Thus ensuring correct dosage of genes to be introduced is a challenge in order for gene therapy to become effective.

The rapidly dividing nature of many somatic cells prevents gene therapy from achieving long-term benefits. The short-lived nature of gene therapy might result in patients having to be treated on a frequent basis or undergo multiple rounds of gene therapy.

Q28

Which statement best describes the characteristic of a pluripotent cell?

A Cells that can differentiate into embryonic and extra embryonic cell types.

B Cells that can differentiate into all the cells found in various tissues of the body.

C Cells that can only produce closely related family of cells.

D Cells that can produce only one cell type but have the property of self-renewal.

HELP

Option A describes a totipotent cell.

Option B describes a pluripotent cell. Pluripotent cell have the ability to differentiate into almost any cell type to form any organ or type of cell in the body.

Option C describes a multipotent cell.

Option D describes a unipotent cell.

Q29

Liposuction waste has been reported to contain 50-100 million stem cells per 250 g. When these stem cells were harvested, they could not differentiate into any other cell except for fat, bone and cartilage.

Which of the following statements best explains this?

A It is a multipotent adult stem cell which can only specialise into limited cell types.

B It is a multipotent embryonic stem cell which can specialise into almost all the cell types.

C It is a pluripotent embryonic stem cell which can specialise into almost all the cell types.

D It is a pluripotent adult stem cell which can specialise into almost all the cell types.

HELP

As the stem cells harvested could not differentiate into any other cell except for fat, bone and cartilage. This shows that the stems cells only have ability to differentiate into a limited range of cell type and is thus a multipotent cell.

Q30

A patient suffering from cystic fibrosis underwent gene therapy using a viral mediated delivery system. The treatment failed and you were asked to troubleshoot the problem.

Which of the following could not be the explanation behind the failure in the treatment?

A Failure of the expressed protein to be folded into the correct conformation.

B Integration of the target gene in the enhancer region.

C Rejection of the vector by the host immune system.

D The CFTR protein was not expressed in adequate amount.

HELP

Functional CFTR protein must be in the correct conformation and sufficient amount of CFTR proteins be embedded into cell membrane before the treatment is successful. If the conformation of the protein is incorrect or there is insufficient amount, the protein will still not be able to transport Cl^- ions, hence preventing the normal efflux of chloride ions out of the epithelial cells and CF symptoms are not alleviated.

If there is rejection of the vector by the host immune system, the normal functional CFTR allele is not released into the cytoplasm of cells and no functional CFTR protein will be synthesized.

Q31

Which of the following represents the correct plant growth regulator(s) for the formation of the corresponding plant tissue?

	Plant growth regulator	Formation of plant tissue
A	auxin	roots
B	auxin	callus
C	abscisic acid	callus
D	cytokinin	somatic embryo

HELP

High level of auxin and low level of cytokinin triggers formation of roots growth.

Q32

What are some key reasons explaining why gene therapy is not (yet) an effective treatment for genetic diseases?

I lack of knowledge of DNA sequences

II lack of efficient and safe gene delivery systems

III cost of the technology

IV some diseases involve multiple genes

V problems with appropriate gene regulation

A II only.

B I, III and IV only.

C II, IV and V only.

D All of the above.

HELP

There is a lack of efficient and safe gene delivery systems. Virus vector may regain or develop virulence and may present a variety of potential problems to the patients – toxicity, immune and inflammatory responses.

Many genetic diseases are a result of presence of many defective genes (multigene disorder). Multigene disorders would be especially difficult to treat effectively using gene therapy as it is impossible to introduce many functional genes at the same time.

The normal functional gene may be inserted within control elements which affect gene expression. In addition, there are problem with controlling the activity of gene expression such as the transferred genes could be 'overexpressed', producing so much of the missing protein as to be harmful.

Q33

What are some similarities between all cancer cells and all stem cells?

A They replicate indefinitely, lack cell-cell adhesion and are able to move from one location in the body to another.

B They lack contact inhibition, are non-differentiated and are regulated by molecular signals.

C They are able to move from one location in the body to another, are regulated by molecular signals and can be found in various parts of the body.

D They replicate indefinitely, are non-differentiated and can be found in various parts of the body.

HELP

Option A, B and C are properties of cancer cells. Only cancer cells display a lack of anchorage dependence, a lack of contact inhibition and density-dependent inhibition of cell divisions. In addition, cancer cells are able to move from one location in the body to another.

Option D is relevant to both cancer cells and stem cells. Both these cells can remain undifferentiated for a long time and are capable of dividing indefinitely and producing copies of themselves.

Q34

Gene therapy is used for the treatment of

(I) cystic fibrosis (CF) and

(II) severe combined immunodeficiency (SCID).

The difference between them is

A (I) is a transient treatment while (II) can possibly be a permanent treatment.

B (I) usually uses the *ex vivo* approach while (II) usually uses the *in vivo* approach.

C (I) usually uses adenoviruses as vectors while (II) usually uses liposomes as vectors.

D (I) treats a recessive disorder while (II) treats a dominant disorder.

HELP

Both the gene therapy for CF and SCID uses the in vivo approach.

Gene therapy for CF uses liposomes while gene therapy for SCID uses retrovirus as vectors.

Both CF and SCID are recessive disorder.

Q35

Which of the following is **not** an example of genetically modified organisms?

A Aqua Advantage Salmon that grow to adult size quickly.

B Bt corn plants that are insect-resistant.

C Golden Rice that produce high levels of beta-carotene.

D Milk-producing cows injected with bovine somatotrophin (BST).

HELP

Genetic engineering refers to a special set of technologies that alter the genetic makeup of animals, plants or bacteria, giving rise to genetically modified organisms producing proteins that are not native in the organisms.

Q36

Maize varieties are being developed in which the leaves produce proteins that are toxic to insects. The DNA coding for these toxic proteins was inserted into a maize chromosome via a bacterial plasmid. Many people are opposed to this process.

Which objection is **not** biologically valid?

A Beneficial insects may be killed if they eat genetically modified maize.

B Genes for antibiotic resistance are present in plasmids and these genes may pass to harmful bacteria.

C Hybridisation may transfer the bacterial genes from maize to weeds, giving the weed species new and harmful characteristics.

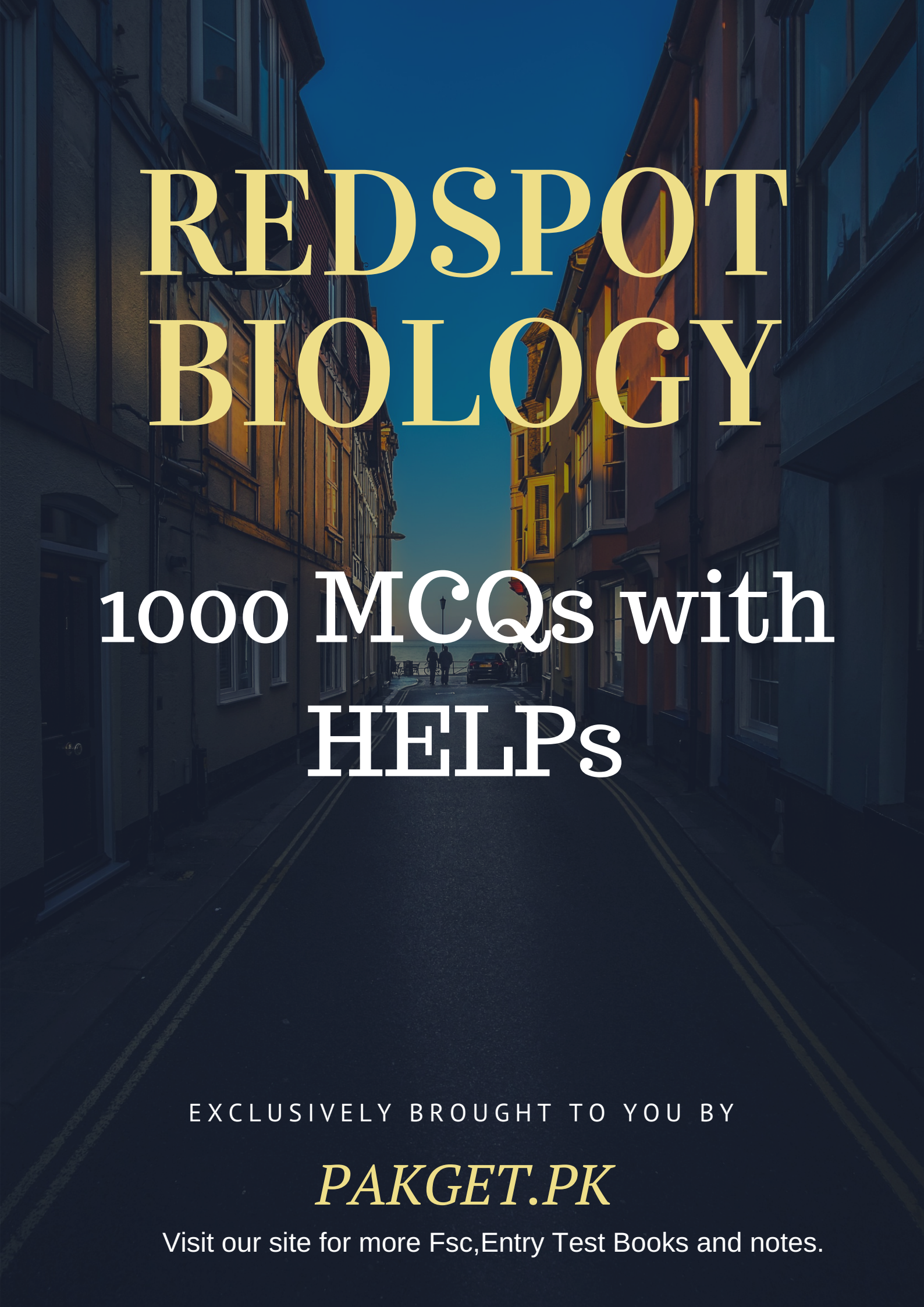
D Mutations may be caused in cattle or humans that eat the genetically modified maize.

HELP

Mutations do not occur in cattle or humans, as changes in the maize chromosome cannot be transferred by eating the maize.

Topic 9 Applications of Molecular and Cell Biology

Q1 C	Q2 B	Q3 D	Q4 A	Q5 A	Q6 B	Q7 D	Q8 B
Q9 B	Q10 D	Q11 B	Q12 B	Q13 D	Q14 C	Q15 D	Q16 A
Q17 B	Q18 C	Q19 C	Q20 D	Q21 A	Q22 D	Q23 A	Q24 C
Q25 D	Q26 B	Q27 B	Q28 B	Q29 A	Q30 B	Q31 A	Q32 C
Q33 D	Q34 A	Q35 D	Q36 D				



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