RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION

CANDIDATE NAME										
CENTRE NUMBER	S					CLASS		INDEX NUMBER		

BIOLOGY **9744/03**

Paper 3 Long Structured and Free-response Questions **14 Sep 2018**

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions in the spaces provided on the Question Paper.

Section B
Answer any **one** question in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

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

For Examiner's Use	
Section A	
1	**/ 25**
2	**/ 25**
Section B	**/ 25**
Total	**/ 75**

This document consists of **19** printed pages and **1** blank page.

Section A

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

1 Plant tissue culture is a technique to produce an entire plant using undifferentiated meristem cells. A cluster of meristem cells can be extracted and stimulated with growth hormones to differentiate to form different types of cells that give rise to an entire plant.

(a) Suggest why meristem cells from any part of a plant can be used to produce the entire plant in plant tissue culture. [2]

1. **The meristem cell contains all the DNA/genes/genetic material of the plant.**
2. **The meristem cell is totipotent.**

In plant tissue culture, plant hormones are added to the meristem cells to regulate growth and differentiation to form roots and shoots. These hormones include auxin and cytokinin. The experiment set up is shown in Fig. 1.1

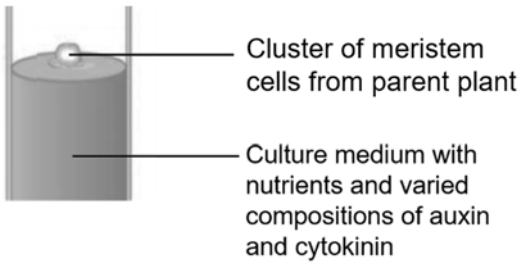
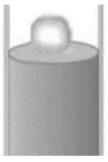
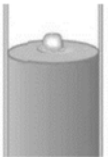


Fig. 1.1

The effects of various compositions of auxin and cytokinin on the cluster of meristem cells are summarised in Table 1.1.

Table 1.1

Concentration of auxin / mg L^{-1}	Concentration of cytokinin / mg L^{-1}	Observation
0	0	
10	0	
8	4	
6	6	
4	8	
0	10	

(b) With reference to Table 1.1, state three conclusions on the effect of auxin and cytokinin on plant growth and differentiation. [3]

1. **Both auxin and cytokinin are required for cell division / plant formation.**
2. **Equal concentration of auxin and cytokinin leads to growth/cell division but no differentiation.**
3. **High auxin concentration and low cytokinin concentration leads to cells differentiating to root.**
4. **Low auxin concentration and high cytokinin concentration leads to cell differentiating to shoot.**

The plant hormone auxin plays a key role in growth and differentiation in plants by altering the expression of selected genes. Genes that are activated or repressed by the presence of auxin are known as auxin-responsive genes (ARGs).

ARG expression is controlled by two transcription factors, auxin response factor and auxin repressor. Binding of auxin response factor to ARE recruits the auxin repressor. Fig. 1.2 shows how auxin controls the expression of an ARG.

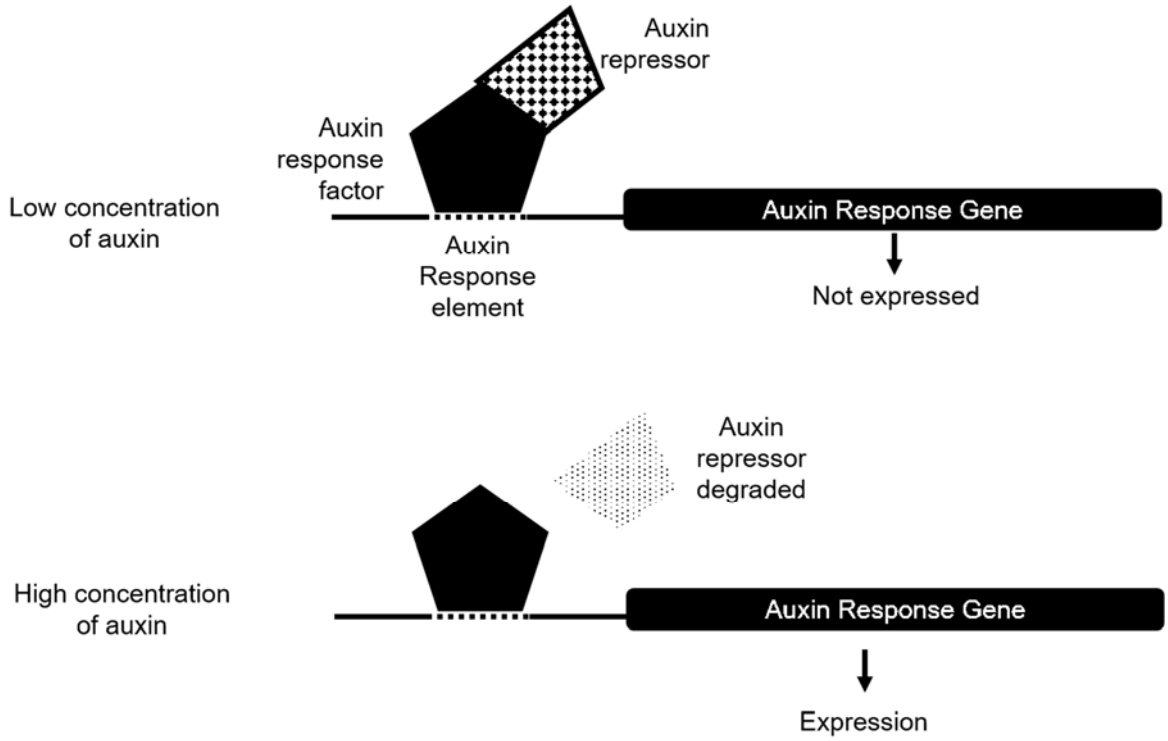


Fig. 1.2

(c) Explain why auxin repressor interacts specifically with auxin response factor. [2]

1. **Auxin repressor and auxin response factor interact at binding sites,**
2. **that are complementary shape,**
3. **and contains amino acid residues,**
4. **that can form (compatible) R group interactions.**

(d) With reference to Fig. 1.2, state the level at which the gene expression of the following proteins are controlled. [2]

(i) Protein product of ARG

Transcriptional control

(ii) Auxin repressor

Post-translational control

(e) Describe the role of an enzyme involved in each level of control stated in **(d)**. [4]

1. **RNA polymerase,**
2. **binds to promoter of auxin response gene**
3. **to initiate transcription.**

4. **Proteasome,**
5. **recognise ubiquitin-tagged auxin repressor,**
6. **hydrolyses auxin repressor**
   or
7. **Enzyme transferring ubiquitin to auxin repressor,**
8. **tag auxin repressor for degradation**
9. **by proteasome.**

For many years, bacteria have been genetically manipulated to produce therapeutic proteins for human diseases.

In recent years, plant molecular farming, the practice of using plants to produce human therapeutic proteins, has gained the attention of many pharmaceutical companies. Plants are modified by introducing human gene sequences into their genomes, which serve as templates for protein synthesis.

(f) Describe how protein synthesis in bacteria cells differ from plant cells. [3]

Feature	Bacteria	Plant cell
Order of transcription and translation	Transcription and translation occur simultaneously	Translation begins only after transcription is completed
Post transcriptional modification	No post transcriptional modification	Modified by adding 5' capping, RNA splicing, 3' polyadenylation
Post-translational modification	No post translational modification	Modified by glycosylation, phosphorylation, cleavage etc.
Ribosomes involved	70S ribosomes	80S ribosomes
Location	Transcription and translation in cytoplasm	Transcription in nucleus, Translation in cytoplasm/rough endoplasmic reticulum

Plant molecular farming produces therapeutic proteins such as clotting factor XIII.

Individuals suffering from haemophilia A cannot produce functional clotting factor XIII due to a point mutation. They suffer from severe bleeding and need injections of clotting factor XIII throughout their life.

(g) Describe how a point mutation can lead to the production of clotting factor XIII with reduced function. [3]

1. **Base-pair substitution in clotting factor XIII gene**
2. **resulting to missense mutation,**
3. **change in corresponding mRNA codon,**
4. **change in corresponding amino acid,**
5. **with different (R group) properties.**
6. **Resulting polypeptide chain will not fold properly,**
7. **changing its three-dimensional structure/shape.**

Or

8. **Base-pair insertion/deletion at the end of the clotting factor XIII gene**
9. **resulting in frameshift,**
10. **change in small number of terminal mRNA sequence,**
11. **change in corresponding amino acid at the end of the polypeptide chain,**
12. **with different (R group) properties.**
13. **Resulting polypeptide chain will not fold properly,**
14. **hanging its three-dimensional structure/shape.**

A study investigates the presence of plant-derived blood clotting factor XIII after injection into a patient suffering from haemophilia A. Blood plasma is extracted from the patient and the proteins in the sample are separated by a technique known as sodium dodecyl sulfate - polyacrylamide gel electrophoresis (SDS-PAGE).

In SDS-PAGE, proteins are first treated with the chemical SDS before they are inserted into wells in a polyacrylamide gel for gel electrophoresis. The proteins are then separated on the basis of size, using the same principle as agarose gel electrophoresis. SDS-PAGE is illustrated in Fig. 1.3.

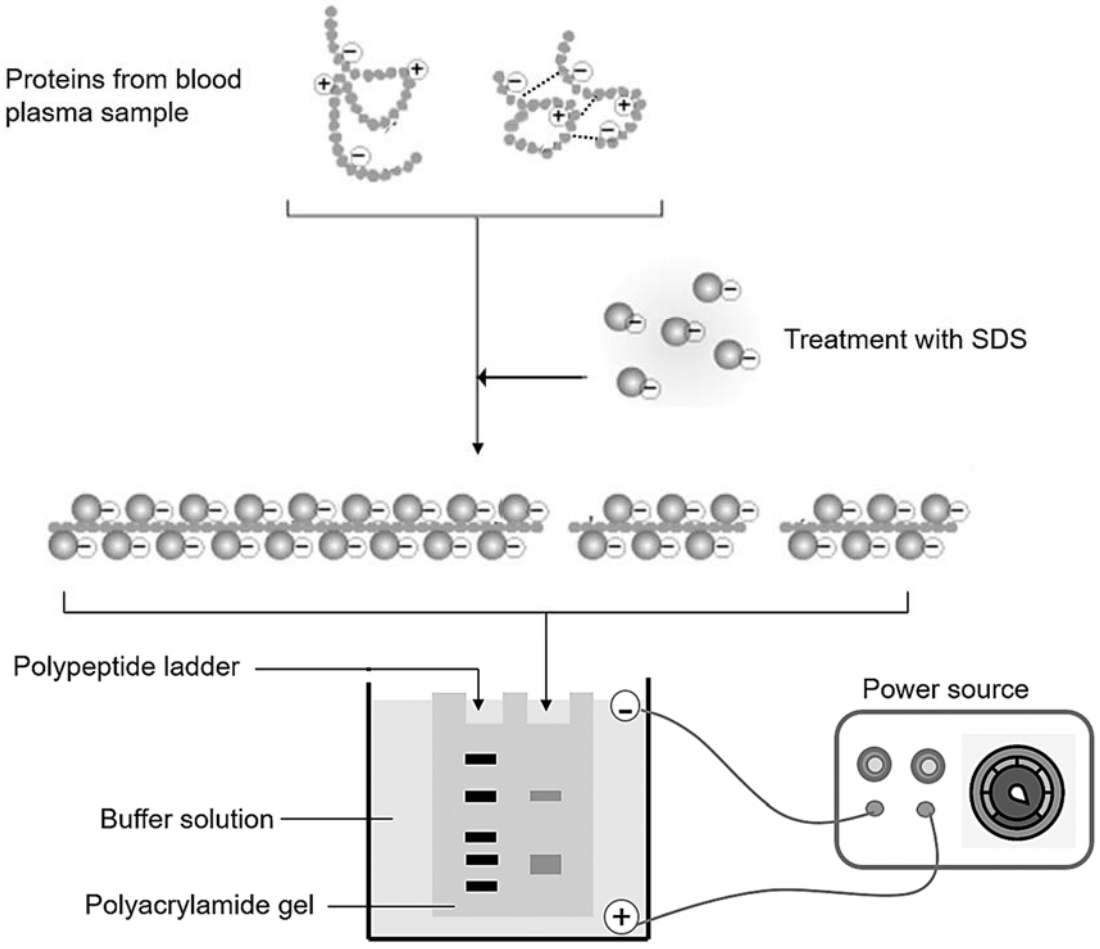


Fig. 1.3

(h) With reference to Fig. 1.3,

(i) describe the effect of SDS treatment on proteins from the blood plasma, and [2]

1. **SDS coat/bind to proteins,**
2. **break R group interactions**

causes proteins to

3. **unfold**
4. **form linear polypeptides.**
5. **separate (quaternary protein) into subunits.**
6. **be negatively charged.**

(ii) describe how polyacrylamide gel electrophoresis is used to separate and determine the length of SDS-treated proteins. [4]

1. **Proteins loaded into wells at the negative electrode,**
2. **when a direct current is applied/electric field set up,**
3. **causes polypeptide to migrate towards positive electrode.**
4. **Shorter polypeptide migrate through the pores of the polyacrylamide gel faster than longer polypeptides.**
5. **Less resistance for the shorter polypeptides to move through the pores of the gel,**
6. **found nearer to the positive electrode.**
7. **Polypeptide ladder used to calibrate size of polypeptide,**
8. **positions protein compared with polypeptide ladder.**

[Total: 25]

2 Rising global temperatures are causing an increase in the frequency and severity of extreme climatic events like heat waves.

A study on heat waves in India tracked the mean summer temperatures from 1960 to 2009 and attributed the temperature changes to greenhouse gas emissions. Scientists warned that if greenhouse gas emissions continue to rise at the current rates, there may be severe impact on crop yield and livestock that can lead to population mortality.

Fig. 2.1 shows the result of this study.

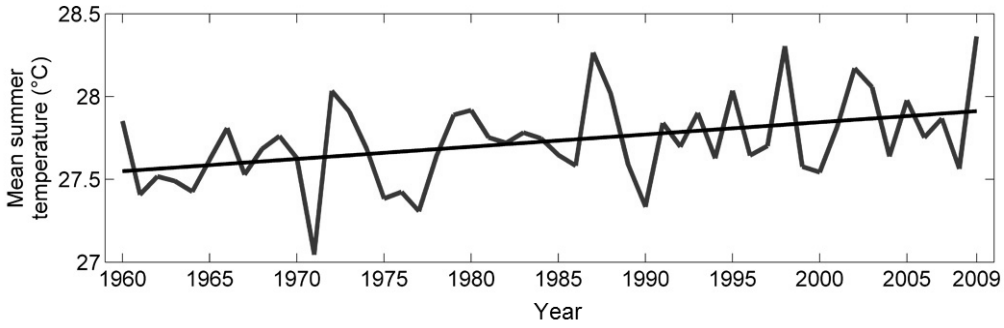


Fig. 2.1

Source: Mora et. al., 2017

(a) With reference to Fig. 2.1, describe the change in summer temperatures since 1960 and explain how this may be attributed to greenhouse gas emissions. [3]

1. **Mean summer temperatures increase from 27.6°C to 27.9°C from 1960 to 2009.**

2. **This is due to increased CO_2**
3. **and methane discharge,**
4. **that reabsorbs infrared radiation,**
5. **causing retention of solar heat in (Earth's) atmosphere.**

To better understand the impact of heat waves on population mortality, a concurrent study on crop yield was conducted during the same time period. Table 2.1 summarises the yield of wheat and maize plants.

Table 2.1

crop	mass of harvest / million tonnes		change in yield / %
	1960	2009	
Wheat	**98.00**	127.40	+ 30
Maize	78.20	**82.11**	+ 5

(b) **(i)** Complete Table 2.1. [2]

(ii) Explain the change in wheat yield from 1960 to 2009. [2]

1. **Increase in crop yield,**
2. **due to higher CO_2 concentration,**
3. **and higher temperature,**
4. **thus increased carbon fixation / rate of photosynthesis**
5. **resulting in greater plant mass.**

(iii) Scientists attributed the lesser increase in maize yield to decreased viability of maize seeds. Explain why this may be true. [2]

1. **Accelerated growth in maize**
2. **results in lesser time for seed growth / maturation.**
3. **Most seeds do not develop into mature plants for harvest.**

(c) State why such increases in crop yields will not sustain with further increase in temperatures. [2]

Further increase in temperature may cause

1. **denaturation of enzymes halts metabolic activities.**
2. **droughts that limit water supply.**
3. **floods that drown crops.**
4. **more weeds that competes with crops.**
5. **more pests that destroys crops.**

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Buffaloes play a major role in sustaining India's agriculture. In another study on heat waves, scientists used buffalo T lymphocytes to investigate the effect of heat stress on livestock's vulnerability to diseases.

The expression of HSP60, a heat-shock protein, is upregulated in response to heat stress. Fig. 2.2 shows the role of HSP60 in PKC signaling. PKC signaling is triggered by the CXCR4 receptor.

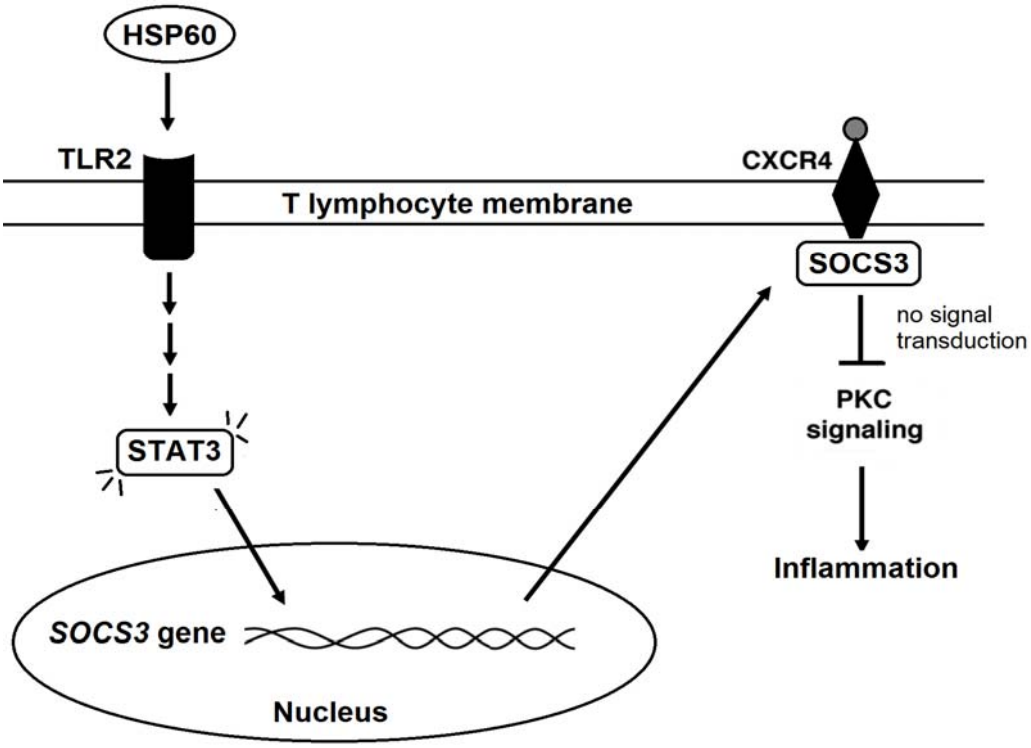

Fig. 2.2

(d) (i) Inflammation is part of the innate immune response.

Describe what is meant by innate immune response. [2]

1. **Innate immunity is genetically determined.**
2. **It provides broad defences against infection and is**
3. **the first line of defence / activated almost immediately.**
4. **It responds the same way for every antigen encounter / not specific to any pathogen.**

(ii) With reference to Fig. 2.2, describe how heat stress results in decreased inflammation in buffaloes. [5]

1. **Heat stress increases concentration of HSP60,**
2. **causing increase frequency of (HSP-TLR2) signalling.**

3. **HSP60 binds to TLR2,**
4. **activating TLR2,**
5. **resulting in activation of STAT3 (relay proteins).**
6. **(activated) STAT3 enters the nucleus**
7. **and act as a transcription factor / initiate transcription**
8. **of *SOCS3* gene,**
9. **resulting in synthesis of SOCS3 protein.**
10. **SOCS3 binds to CXCR4,**
11. **preventing trigger of the PKC signalling pathway.**

(iii) Suggest how decreased inflammation increases buffaloes' vulnerability to diseases. [2]

1. **Reduced immune cells at site of infection.**
2. **Increases opportunity for pathogens to proliferate in buffalo.**

Further investigation of HSP60 protein reveals molecular homology across various species of buffaloes.

Fig. 2.3 shows the DNA sequences of the same segment of *HSP60* gene in various buffalo species. Shaded regions indicates similarity with the common ancestor.

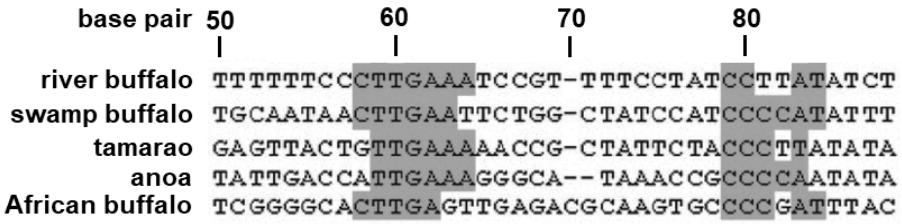

Fig. 2.3

(e) Explain how the molecular data in Fig. 2.3 supports Darwin's theory of evolution. [4]

1. **Identical nucleotide at base pair 59 / 60 / 61 / 62 / 79 / 80 for all species**
2. **Consequences of descent from a common ancestor**
3. **as buffaloes more suited to the environment reproduce to pass on favorable alleles to offspring.**

4. **Nucleotide variation at base pair 58 / 63 / 64 / 81 / 82 / 84**
5. **Consequence of (descend with) modification**
6. **Different environment favours different phenotypes**
7. **giving rise to variation (in reaction to heat stress).**

(f) State which species of buffalo is most closely related to the common ancestor. [1]

Swamp buffalo.

[Total: 25]

Section B

Answer **one** question in this section.

Write your answers on the line paper provided at the end of this Question Paper.

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

Your answers must be in continuous prose, where appropriate.

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

3 **(a)** Describe the polymerisation of different types of biomolecules in a plant and explain how these biomolecules allow plant growth and survival. [15]

Formation

1. **starch**
2. **formed from α-glucose**
3. **when hydroxyl groups from two glucose molecules react**
4. **to form α(1-4) glycosidic bonds**
5. **and α(1-6) glycosidic bonds**
6. **forming amylose**
7. **and amylopectin**
8. **through condensation reactions**

9. **cellulose**
10. **formed from β-glucose**
11. **every other β-glucose is inverted**
12. **forming β(1-4) glycosidic bonds**

13. **Proteins**
14. **formed from amino acids**
15. **when carboxyl group of one amino acid**
16. **reacts with the amino group of another**
17. **to form a peptide bond (through a condensation reaction)**

18. **DNA**
19. **and RNA**
20. **formed from nucleotides / nucleoside triphosphates**
21. **when 3'-OH group of one nucleotide**
22. **reacts with the 5' phosphate group of an incoming nucleotide**

23. to form a phosphoester bond (through a condensation reaction)

Growth and Survival

Starch

24. Storage of energy

25. to provide substrate for aerobic respiration

Cellulose

26. Structural support

27. Help the plant to gain light (for photosynthesis)

28. Withstand osmotic pressure

Proteins

29. Enzymes

30. To carry out metabolic processes

31. Transcription factors

32. for regulation of gene expression

33. carrier/channel/transport proteins

34. for membrane transport / chemiosmosis

35. hormones / receptors

36. for cell signalling

37. cytoskeleton

DNA / RNA

38. contain gene sequence

39. tRNA / rRNA synthesis

40. allow protein synthesis

(b) All living organisms (autotrophs and heterotrophs) require energy to survive. Outline the processes in which they obtain energy and explain the advantage of each process to the organism. [10]

Photosynthesis

1. **Plants harness light energy**
2. **using photosynthetic pigments**
3. **to produce ATP and NADPH**
4. **for activation**
5. **and reduction**
6. **of carbon (in Calvin Cycle)**
7. **to synthesise glucose.**

Advantage

8. **Utilises energy source that is readily available**
9. **Ability to utilise inorganic source of carbon**

Aerobic Respiration

10. **plants and animals release chemical energy**
11. **through a series of redox reactions / oxidative breakdown of**
12. **respiratory substrates**
13. **catalysed by enzymes**
14. **produce ATP**
15. **by substrate level phosphorylation**
16. **and chemiosmosis**

Advantage

17. **Convert (chemical) energy to readily usable forms in living cells**
18. **Relatively large amount of ATP synthesised (compared to anaerobic respiration)**

Anaerobic Respiration

19. **undergo alcoholic fermentation**
20. **in yeast and plants**
21. **lactate fermentation**
22. **in mammals**
23. **regenerate NAD^+**
24. **for glycolysis to proceed**

Advantage

25. **Can produce ATP in absence of oxygen**

[Total: 25]

4 **(a)** Cancer is a disease associated with abnormal cell division with the potential to invade other parts of the body. Outline how genetic and environmental factors cause cancer and explain why it is challenging to cure cancer. [15]

Genetic factors

1. **Gain in function mutation**
2. **of proto-oncogenes**
3. **resulting in hyperactive / degradation-resistant / excessive protein**
4. **causing overstimulation of cell cycle**

5. **Loss of function mutation**
6. **Of tumour suppressor genes**
7. **result in non-functional or no protein**
8. **leading to loss of normal restraints on cell cycle**
9.

Environmental factors

10. **Exposure to ultraviolet light**
11. **Thymine-thymine dimersation**
12. **causes base-pair mutation**

13. **Ionising radiation / X-ray**
14. **causes double-strand break**
15. **leading to chromosomal mutation**

16. **Carcinogenic chemicals**
17. **causes intercalation of DNA**
18. **cause base-pair mutation**

19. **Viruses**
20. **introduces oncogenes / disrupts tumour suppressor genes**
21. **leading to compromised immune system**

Challenging to cure cancer

22. **Multiple gene mutations / metabolic processes, difficult to rectify**
23. **Ability to divide indefinitely / obtain nutrients for growth, difficult to restrain growth / spread**
24. **Located at sites that are difficult for drug access**
25. **Difficult to differentiate between normal and cancer cells, difficult to target**
26. **Located in vital tissues / organs, cannot be removed without compromising body function**
27. **Difficult to fully eradicate, possibility of relapse**
28. **Symptoms only detectable at late stages, widespread of cancer cells is challenging to remove**

(b) Discuss the role of constituent biomolecules of the cell surface membrane in the movement of substances across the membrane. Explain the need for a variety of transport mechanisms. [10]

1. **Phospholipids**

2. **Non polar / hydrophobic hydrocarbon tails**
3. **acts as a barrier**
4. **to large / polar substances**

5. **Transient gaps between phospholipid molecules**
6. **allows for passage of small substances**

7. **forms vesicles**
8. **containing substance of large size / quantity**
9. **Channel / carrier proteins**

10. **offers hydrophilic pathways**
11. **to transport specific substances**
12. **that are small and charged / polar**

13. **Receptor proteins and**
14. **Coat proteins**
15. **allows for specificity**
16. **in transport of substances of large size/ quantity**

17. **Cholesterol**

18. **fits between phospholipid molecules**
19. **Restrict movement**
20. **of small substances**

A variety of transport mechanisms needed to cater to transport of substances

21. **with different shape / charge / size / polarity**
22. **down or against concentration gradient**
23. **using a variety of energy source (such a ATP, light and free energy)**
24. **coupled to other metabolic process (like oxidative phosphorylation)**
25. **AVP**

[Total: 25]