PAPER 1

Qn No.	Correct Answer	Qn No.	Correct Answer	Qn No.	Correct Answer
1	**B**	11	**A**	21	**D**
2	**B**	12	**C**	22	**A**
3	**B**	13	**D**	23	**C**
4	**A**	14	**D**	24	**A**
5	**C**	15	**A**	25	**D**
6	**D**	16	**D**	26	**B**
7	**B**	17	**A**	27	**D**
8	**B**	18	**B**	28	**A**
9	**D**	19	**A**	29	**C**
10	**A**	20	**A**	30	**C**

PAPER 2

QUESTION 1

(a) (i) Name and state the function of organelles A and B [2]

A: Mitochondria, site of cellular respiration to generate ATP

B: Nucleus, to store genetic material / DNA.

(ii) Explain why there is an abundance of organelle C in the plasma cell. [2]

1. There is an abundance of structure C which is studded with ribosomes.
2. As ribosome is the site of polypeptide synthesis
3. and the ER lumen is the site of protein folding
4. Both are necessary to make large quantity of proteins

(b) Explain how the structure of the cell membrane relates to its role in maintaining the internal environment of the plasma cell. [3]

1. Structure D is composed of a phospholipid bilayer, with hydrophilic phosphate head and hydrophobic hydrocarbon tails
2. The hydrophobic hydrocarbon tails creates a hydrophobic core
3. The cell membrane is selectively permeable, allowing desirable substances to be kept within and undesirable substances kept out of the cell
4. It defines the boundary of the cell, keeping the interior of the cell physically separated from the surrounding environment
5. The membrane is fluid, which allows both phospholipids and proteins to move about laterally
6. This allows cell membrane to form pseudopodia to engulf foreign particles

7. Proteins are randomly distributed in the phospholipid bilayer
8. Carrier and channel proteins help to regulate the transport of substrate into and out of the cells

9. Cholesterol is commonly found wedged between phospholipids in cell membrane
10. and regulates membrane fluidity

(c) Describe how macrophages engulf and digest cellular debris. [3]

1. Macrophage engulfs the cellular debris through endocytosis / phagocytosis
2. The plasma membrane of macrophage ,invaginates / extends outwards to enclose, the debris to form vesicles
3. The vesicles pinch off the cytoplasm
4. And may fuse with lysosome which contains hydrolytic enzymes to digest the cellular debris

[Total: 10 marks]

QUESTION 2

(a) Describe how light is harvested at structures A and B. [3]

1. Accessory pigments embedded in the thylakoid membrane forms the antenna complex of photosystems
2. Range of pigments allow for a range of wavelengths to be absorbed
3. Photons or light energy is absorbed by these pigment molecules
4. Electrons in the pigment molecules are excited / moves to higher energy level
5. These energy is passed from one pigment to another via resonance energy transfer
6. Resonance energy is captured by the excitation of an electron of special chlorophyll a in the reaction center

(b) Explain the effect that the herbicide binding to this protein will have on photosynthesis. [2]

1. Triazine prevents non-cyclic photophosphorylation
2. Resulting in no electrons available to form reduced NADP
3. As ATP is produced by cyclic photophosphorylation, ATP is still produced
4. Resulting in no / less , ATP and no reduced NADP available for Calvin cycle / light independent reaction / conversion of GP to TP

(c) (i) Using Fig 2.2, describe and explain the effects an increase in oxygen concentration will have on photosynthesis [3]

1. An increase in oxygen concentration reduces the rate of photosynthesis / increases the rate of photorespiration

2. This is less Rubisco is available for CO_2 / more oxygen competing with CO_2 for Rubisco; / more O_2 binding to Rubisco/ O_2 outcompetes CO_2 for Rubisco

3. This results in less CO_2 , fixation for Calvin cycle, / excess CO_2 given off

4. There is less, glycerate 3-phosphate / GP / TP , produced and less RuBP being, regenerated / formed

(c)(ii) Suggest why the process outlined in Fig 2.2 is known as photorespiration. [2]

1. The process uses oxygen and, excretes / produces , carbon dioxide

2. Light energy / non-cyclic photophosphorylation / light dependent reaction / products of the light dependent reaction / ATP and NADPH, is required for this process to occur

3. The same photosynthetic enzyme / Rubisco is used and allows the Calvin cycle to continue

(d) Suggest why these plants do not show photorespiration. [1]

1. oxygen's 3D conformation is not complementary to PEP carboxylase, thus oxygen is not a substrate for / cannot bind to / will not compete for PEP carboxylase

2. PEP carboxylase , is only specific to carbon dioxide

[Total: 10 marks]

QUESTION 3

(a) Outline what is meant by "*descent with modification by natural selection*". [3]

1. Descent with modification: present-day *species arose from a succession of ancestors*
2. Accumulation of diverse modifications, adaptations over millions of years
3. Shared ancestry
4. Natural selection is the mechanism that brings about descent with modification
5. Natural environment "selects" for certain traits to be propagated

(b) (i) Explain why variation is important in selection. [3]

1. Inherited allelic variation exist in the individuals present in the populations
2. Natural selection occurs where different habitats each exerts its own specific/ different selection pressure
3. Thus different habitats select for favourable phenotypes
4. resulting in differential survival and reproductive abilities of individuals in the population on the island/ increase chances of survival till reproductive age
5. Individuals that are selected for pass on alleles to their offspring

(ii) Sketch a graph on the axes below to show the distribution in size of seahorses as a result of disruptive selection.
[1]

1. two peaks
2. dip in middle connected

(iii) Explain how disruptive selection has been maintained in this species of seahorse. [3]

1. mates selected by size
2. few intermediates mate
3. habitat for intermediate size no longer available / difference in predation
4. intermediates selected against / extremes selected for
5. alleles for extreme phenotypes (more likely to be) passed on
6. increase in allele frequencies for extreme phenotypes

[Total: 10 marks]

QUESTION 4

(a) (i) Explain the significance of forming more stem cells. [2]

1. To preserve a population of undifferentiated cells
2. By mitotic division / allowing long-term self-renewal

(ii) Suggest how a cell differentiates to form a specialised cell. [2]

1. signals that switch on / off certain genes
2. Thus, different proteins are produced in order to change the cell

(b) Suggest two ethical concerns on the use of embryonic stem cells. [2]

1. Blastocyst must be destroyed when the cells are removed
2. Issue on egg donation

(c) (i) Explain how uncontrolled cell division can result in cancer. [3]

1. Accumulation of mutations in cancer-critical genes
2. Rate of cell division exceeds rate of cell death
3. Normal cell cycle checkpoints become dysfunctional
4. (a) Angiogenesis, the formation of blood vessel
   (b) Metastasis, the development of secondary malignant growths at a distance from a primary site of cancer

(ii) State one other causative factor that can increase the chances of cancerous growth. [1]

1. UV rays
2. Radiation
3. Genetic disposition
4. Age

[Total: 10 marks]

QUESTION 5

(a) Describe the properties of plasmids that allow them to be used as DNA cloning vectors. [6]

1. Plasmids exist as circular double-stranded DNA which can exist independently in bacteria
2. Plasmids contain an origin of replication which allows it to replicate independently
3. so that

4. Selectable markers are present in plasmids
5. Such markers confer some well-defined traits on the host organism that can be selected for
6. e.g.antibiotic resistance of the transformed bacteria / synthesis of the enzyme β-galactosidase by the transformed bacteria

7. Such traits differentiate / distinguish transformed cells from non-transformed / untransformed cells;

(b) Explain how eukaryotic genes are cloned using *E. coli* cells to produce eukaryotic proteins to avoid the problems associated with introns. [8]

1. Eukaryotic DNA contains introns, while prokaryotic cells do not have introns
2. Hence, prokaryotic cells such as *E.coli,* does not have the RNA splicing machinery to remove the introns
3. To circumvent the problems associated with introns, cDNA can be used as the gene of interest instead
4. cDNA can be synthesized via reverse transcription by using the mRNA of the eukaryotic gene as a template

5. Use restriction enzyme to cut restriction sites flanking the cDNA of the eukaryotic gene of interest to obtain restriction fragments of sticky ends
6. Use the same restriction enzyme cut the plasmid at the multiple cloning site of the plasmid with sticky end
7. The sticky ends generated in both the cDNA gene of interest and the plasmid allows for complementary base pairs to anneal via hydrogen bonding
8. The cDNA should be placed under the control of the a strong promoter, such as lac promoter to induce production of the eukaryotic protein

9. Restriction fragment ligates with the plasmid with the help of ligase via the phosphodiester bonds, forming a recombinant plasmid
10. Recombinant plasmid is then transformed into the *E.coli* host cell via heat shock/electroporation;

11. Selection of *E.coli* with recombinant plasmids carrying selectable markers, e.g ampicillin and isolate them;
12. Culture the selected *E.coli* with the recombinant plasmids in liquid medium;
13. Lactose is then added to induce transcription of the lac operon, to induce production of the eukaryotic protein in interest;

(c) Outline how insulin can be produced by genetic engineering technique. [6]

1. Synthesis of human insulin in bacteria, *Escherichia coli*

2. Based on known amino acid sequences of the A and B chains, trinucleotides representing all the codons are synthesised and joined together in the order dictated by the amino acid sequences
3. Two artificial genes are constructed, i.e. one carrying the artificial gene for the A chain and the other carrying the artificial gene for the B chain
4. Each artificial gene is placed under the control of ① the strong *lac* promoter; and ② a part of the β-galactosidase structural genes
5. Both recombinant plasmids containing the two artificial genes are transformed separately into *E. coli*

6. *E. coli* cells are grown in the presence of lactose to switch on transcription from the *lac* promoter
7. The two artificial genes are expressed independently as fusion proteins, consisting of the first few amino acids of β-galactosidase, followed by the A or B polypeptide
8. a. Each gene was designed such that its insulin and β-galactosidase segments were separated by a methionine residue
   b. so that the insulin polypeptides could be cleaved from the β-galactosidase segments by treatment with cyanogen bromide
9. The purified A and B chains were mixed, reduced and reoxidized to form the disulfide bonds present in native insulin

QUESTION 6

(a) Describe the structure of an amino acid and the formation of a peptide bond. [6]

1. All amino acids have an α-carbon covalently bonded to
2. A hydrogen atom
3. A carboxyl group / (-COOH)
4. an amine group / ($-NH_2$), and
5. a variable R-group that is unique to each amino acid

6. Each amino acid becomes joined to another amino acid via a condensation reaction
7. with the elimination of a molecule of water
8. The peptide bond –C-N-
9. is formed between carboxyl group of one amino acid
10. to the amine group of its neighbour
11. Peptide bond formation takes place in the ribosome/ribosomal large subunit
12. with the help of peptidyl transferase

(b) Describe how the information on DNA is used to synthesise polypeptides in eukaryotes. [8]

1. General transcription factors are recruited at the promoter
2. to mediate the binding of the RNA polymerase to the promoter
3. forming the transcription initiation complex

4. DNA double helix unwinds
5. separating the 2 strands to form a transcription bubble

6. One of the two unwound/exposed DNA strands acts as a template
7. for complementary base pairing for the assembly of incoming ribonucleotides
8. The template strand is read in the 3’ to 5’ direction
9. to facilitate the synthesis of mRNA
10. in the 5’ to 3’ direction
11. In which the formation of phosphodiester bond is catalysed by RNA polymerase

12. RNA polymerase transcribes a terminator sequence on the DNA
13. which triggers the release of the RNA chain
14. and dissociation of the RNA polymerase
15. Addition of 5’ methylguanosine cap to the pre-mRNA
16. Addition of poly(A) tail to the pre-mRNA
17. Introns are removed from the pre-mRNA by spliceosomes
18. while exons are ligated together to form a mature mRNA

19. 5’ methylguanosine cap of the mRNA is recognised by the small ribosomal subunit
20. which binds to the mRNA in search for the start codon AUG
21. Start codon on the mRNA binds with initiator tRNA through complementary base pairing

22. Followed by the binding of the large ribosomal subunit
23. forming a translation initiation complex
24. Initiator tRNA is situated in the P site of the ribosome
25. while A site is ready for next aminoacyl-tRNA

26. Codon of the mRNA allows for complementary base pairing with the anticodon of the aminoacyl-tRNA
27. Peptide bond is formed
28. between initial methionine at P site and second amino acid at A site
29. catalyzed by peptidyl transferase

30. Growing peptidyl-tRNA in the A site is translocated to the P site
31. when ribosome shifts along the mRNA by one codon in the 5' to 3' direction

32. Termination occurs when ribosome reaches a stop codon
33. Release factor binds directly to the stop codon in the A site
34. with the addition of water molecule
35. Bond between polypeptide and tRNA at the P site is hydrolysed, resulting the formation of a polypeptide

(c) Describe the causes of genetic variation in a population. [6]

1. During prophase I of meiosis, crossing-over takes place between non-sister chromatids
2. resulting in recombination of segments of non-sister chromatids between homologous chromosomes
3. This leads to the formation of new combinations of alleles in gametes

4. At metaphase I, independent assortment of homologous chromosomes
5. The orientation of the bivalents with respect to the poles is random
6. Hence a 50% chance that a daughter cell gets a paternal chromosome or a maternal chromosome

7. Random fusion / fertilisation of gametes during sexual reproduction
8. carrying different combinations of chromosomes adds to genetic variation of the zygote formed

9. Mutations
10. occurs to generate new alleles