1	**D**	11	**D**	21	**D**
2	**D**	12	**D**	22	**C**
3	**B**	13	**A**	23	**A**
4	**D**	14	**B**	24	**A**
5	**B**	15	**C**	25	**A**
6	**A**	16	**A**	26	**D**
7	**C**	17	**B**	27	**D**
8	**D**	18	**B**	28	**C**
9	**C**	19	**C**	29	**D**
10	**A**	20	**B**	30	**A**

STRUCTURED QUESTIONS

Question 1

(a) Describe the role of *haem* group in haemoglobin. [2]

1. Haem group in haemoglobin consists of an iron ion held in a porphyrin ring structure
2. Ref to iron ion bind with oxygen

(b) Discuss the advantages of having four subunits in haemoglobin. [3]

1. Binding of four oxygen molecules per haemoglobin results in increased oxygen carrying capacity
2. Ref to cooperative binding
3. Change in 3D conformation in one subunit results in changes in 3D conformation of the other subunits

(c) Explain how the differences in haemoglobin structure of the Greylag and Andean geese contribute to their different oxygen affinities. [4]

1. Ref. to different amino acid sequence in the for Greylag goose and Andean goose haemoglobin
2. Different R-groups interactions results in the different specific 3D conformation
3. Haem groups are more exposed to bind to oxygen in Andean goose
4. Ref to different subunit interactions and different extend of cooperativity

[Total: 9]

Question 2

(a) **(i)** Account for the trends shown by the distribution of the two types of bacteria after six months. [3]

1. Aerobic bacteria decrease with depthfrom mean number of bacteria per gram of stored soil of 12.5×10^7 to 0.9×10^7

2. Anaerobic bacteria increase with depth from mean number of bacteria per gram of stored soil of 0.6×10^7 to 8.8×10^7
3. Oxygen content of soil decreases with depth as aerobic bacteria requires oxygen for respiration
4. Less oxygen available as the final electron acceptor in ETC, decrease in ATP synthesis

(ii) Describe how aerobic bacteria are structurally adapted for cellular respiration. [2]

1. Presence of cytoplasmic membranes in aerobic bacteria. Hence, increase surface area
2. For more embedding of electron transport chain and ATP synthase to allow electron transfer / to drive oxidative phosphorylation of ADP to ATP

(b) (i) State with evidence from Fig. 6.1 which depth, A or B, were samples taken from a greater depth. [2]

1. Depth B
2. Bacteria in samples taken from depth B shows a lowered mean dehydrogenase activity with 1.5 to 2.4 au compared to 3.2 to 5.7 au in samples taken from depth A

(ii) Explain the roles of dehydrogenase in Krebs cycle of the aerobic bacteria. [2]

1. ref to substrate and ref oxidation / loss of protons and electrons
2. ref to reduction of coenzyme NAD and FAD and formation of NADH and $FADH_2$

[Total: 9]

Question 3

3 (a) State the structural features of DNA that make it a stable molecule. [2]

[Any 2]
1. complementary bases / base pairing, hold(s) strands together
2. (because of) many hydrogen bonds
3. sugar-phosphate backbone / AW, with covalent / phosphodiester, bonds

(b) Explain, in terms of mode of action of enzymes, the results of the investigation shown in Fig. 3.1. [3]

1. increasing concentration of ara-ATP (can be comparison between 0 and 5 / 20 or between 5 and 20) decreases enzyme activity, ref. to rate of DNA synthesis for enzyme activity
2. ara-ATP acting as an inhibitor
3. substrate unable to bind with active site / fewer enzyme-substrate complexes (formed)
4. further detail

for either *competitive* inhibition e.g. competes with substrate for (binding to) the active site / similar, structure / shape, as substrate or complementary shape to active site
OR
for *non-competitive inhibition* e.g. binds to site other than active site / changes shape of active site

(c) Define the term *recessive*. [1]

allele which does not have its effect in heterozygote

(d) Explain why females are less likely than males to have RGC. [2]

1. gene / allele, on X chromosome / sex linkage
2. female, needs 2 RGC alleles / homozygous recessive / can be heterozygous
3. male needs only 1 RGC allele to be affected

(e) With reference to Fig. 3.2, and using the symbols **R** for the dominant allele and **r** for the recessive allele, state the genotypes of the individuals **1** and **6**. [2]

1 X^RX^r

6 X^rY

[Total: 10]

Question 4

(a) Explain what is meant by recombinant plasmid DNA. [2]

1a. DNA from two sources: bacteria plasmid, and
1b. (eukaryotic) foreign gene of interest
2. Where they are ligated together

(b) Outline the roles of the enzymes used in the formation of the recombinant plasmid DNA. [2]

1. Restriction enzymes / endonucleases
2. Cleavage of phosphodiester bonds of the DNA
3. DNA ligase
4. Catalyses the formation of phosphodiester bond

(c) One of the foreign genes inserted into the plasmid, codes for resistance to a particular antibiotic.
Explain why it is important to include a gene for antibiotic resistance in the plasmid produced. [2]

1. To identify / select bacteria that have taken up the plasmid
2. After the new plasmids are incubated with bacteria, the bacteria is grown on media containing the antibiotics

3. Only those bacteria that have taken up the plasmid will be able to grow / survive on the media

(d) Explain why a farmer might choose to grow a crop that was genetically engineered to be resistant to insects, rather than spray the crop with insecticide. [2]

1. Insecticide may be harmful to humans and other living things;
2. Thus, it may kill useful insects;
3. GM crop may be cheaper to grow and manage;
4. Genetically engineered resistance may be more specific for a harmful insect;

(e) Suggest why farmer **Y** might be concerned about the possibility of his crops being fertilised by pollen from farmer **X**'s crop. [1]

1. Farmer Y may lose some of his markets if he cannot state that his crops are GM free

(f) Deduce the conclusions that can be drawn about cross-pollination and the gap between crops. [3]

1. When the crops are adjacent to each other there is cross-pollination
2. Cross-pollination can be reduced by moving crops 5 m apart
3. The difference between separating 5 m or 7 m does not influence cross pollination at the edge, only 10 m into crop

[Total: 12]

FREE RESPONSE QUESTION

Question 5

(a) Describe and explain the fluid mosaic model of membrane structure. [5]

1. A 'mosaic' / collage of proteins
2. randomly distributed
3. There are integral and peripheral proteins found in plasma membranes
4. A fluid phospholipid bilayer which is free to move about laterally
5. Due to the weak hydrophobic interactions between the hydrophobic fatty acid tails
6. Presence of cholesterol regulates membrane fluidity
7. Ref. to membranes being asymmetrical / characteristics of fluid mosaic model exist due to the composition of the components of the membrane: proteins and lipids
8. Ref. to membranes being amphipathic / consisting of phospholipids will a hydrophilic phosphate head and hydrophobic hydrocarbon tails

(b) Outline the roles and functions of membranes within cells and at the surface of cells. [8]

Within cells:

1. Organelles can be bound by membranes
2. Maintenance of characteristic differences between the contents of each organelle and the cytosol
3. These local environments allow for incompatible processes to occur simultaneously / compartmentalisation of specific reactions

4. The presence of membranes also helps to increase surface area
5. Allow for the embedding of enzymes and proteins that mediate many cellular reactions

At the surface of cells:

6. Definition of cell's boundaries: The cell membrane keeps the interior of the cell physically separated from the surrounding environment
7. Organisation & localisation of function
8. Membranes are selectively permeable and allows for desirable substances to be kept within and undesirable substances kept out of the cell
9. The phospholipid bilayer acts as a hydrophobic barrier and it is impermeable to polar molecules and ions across it
10. Regulation of cell's content / regulate the transport of substances into and out of the cell and its organelles, via transport proteins
11. Cell-to-cell recognition via glycoproteins

(c) Explain how meiosis and random fertilisation can lead to variation. [7]

1a. crossing over during prophase I
1b. occurs between non-sister chromatids of homologous chromosomes
1c. at the chiasmata
1d. results in breakage and formation of new linkage groups / new combination of alleles / recombinant gametes

2a. independent assortment of chromosomes during metaphase I
2b. where pairs of homologous chromosomes align randomly along the metaphase plate
2c. results in different chromosome combinations in the gametes
2d. number of possible combinations is 2^n

3a. random fusion of gametes during fertilisation
3b. since each gamete carries different combinations of genes
3c. this adds to genetic variation of a zygote formed

Question 6

(a) Outline the role of organelles in protein synthesis. [5]

Organelles (O)	Role (R)
O1.Nucleus	F1a. nucleoplasm contains genes / genetic information F1b. codes for synthesis mRNA / polypeptide chains / proteins
O2.Ribosomes	F2. where they undergo translation / protein synthesis on bound / free ribosomes
O3.Rough endoplasmic reticulum	F3a. parts of the newly-synthesized polypeptide in the rER lumen may undergo post-translational folding F3b. The rER then packages proteins into transport vesicle / buds off from the rER
O4.Golgi apparatus	F4a. Transport vesicles then fuse with the *cis* face of the Golgi apparatus F4b. chemical modification / glycosylation / phosphorylation F4c. trimming of polypeptides take place in F4d. eventually leading to the packaging of the mature protein into F4e. secretory vesicles which eventually bud off from the *trans* face of Golgi apparatus

(b) Describe how the information on DNA is used to synthesise mRNA. [7]

1. Ref. to (information is) exist as a sequence of bases / nucleotides

Initiation
2a. Transcription factors (e.g TFIID) mediate the process
2b. RNA polymerase binds to the promoter (forming a transcription initiation complex)
3a. RNA polymerase unwinds the DNA double helix
3b. and breaks hydrogen bonds between the DNA strands / separates the DNA strands
4a. A transcription bubble is formed
4b. in which one DNA strand acts as a template

Elongation
5a. Free ribonucleotides are aligned along the DNA template strand
5b. via complementary base-pairing, i.e. A-U, T-A, G-C, C-G
6a. RNA polymerase catalyses the formation of phosphodiester bond between ribonucleotides

6b. Single-stranded, growing RNA is elongated in the 5' to 3' direction

Termination

7. RNA polymerase transcribes a terminator sequence which acts as a signal for transcription termination
8. RNA transcript is released
9. RNA polymerase dissociates from DNA

(c) Explain with named examples, how embryological and molecular homologies support Darwin's theory of evolution. [8]

1. Homology is defined as similarity in characteristics resulting from a shared ancestry, which reflects evolutionary relationship

Embryological homology:

Named example: Homology in early embryonic development in vertebrates

2. At some time during development, all vertebrates bear striking anatomical similarities such as having a post anal tail and exhibiting paired pharyngeal (throat) pouches

3. These develops into homologous structure with different functions: e.g. pharyngeal pouches develop into gill slits in fishes & parts of ears & throat in humans

4. The more closely related organisms are, the longer the embryological development remains similar

5. This indicates that the vertebrates have shared ancestry / share a common ancestor

6. But the development of embryo is modified in the descendants due to natural selection and change of allele frequencies

Molecular homology:

7. When an ancestral species gives rise to two or more descendants, these descendants will exhibit high overall similarity in their DNA / primary amino acid sequence

8. However, as the descendants evolve independently, they will accumulate more and more differences in their DNA / primary amino acid sequence

9. Indicating descent with modification

Named example: molecular sequence homology

10a. Chimpanzees and human exhibit few differences in their DNA (97.6% similarity) compared to human and other primates

10b. The greater the degree of homology / similarity in the DNA sequences of between two species, the more closely related the two species are considered to be