BIOLOGY (P530/2)

TIME 2Hours 30 Minutes

INSTRUCTIONS TO CANDIDATES

This paper consists of **six** questions.

Answer question **one** in section **A** plus any **three** others from section **B**

Candidates are advised to read the questions carefully, organize their answers and present precisely and logically.

SECTION A (40 MARKS)

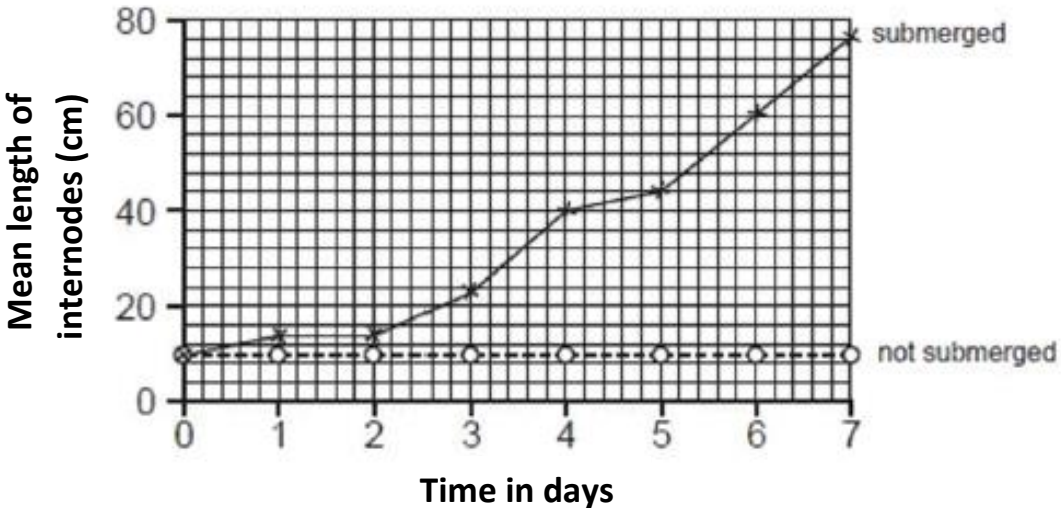
1. In an investigation to determine the effect of flooding on the growth of rice plants *Oryza sativa*, two groups of young rice plants, **A (submerged)** and **B (not submerged)** were treated as follows.

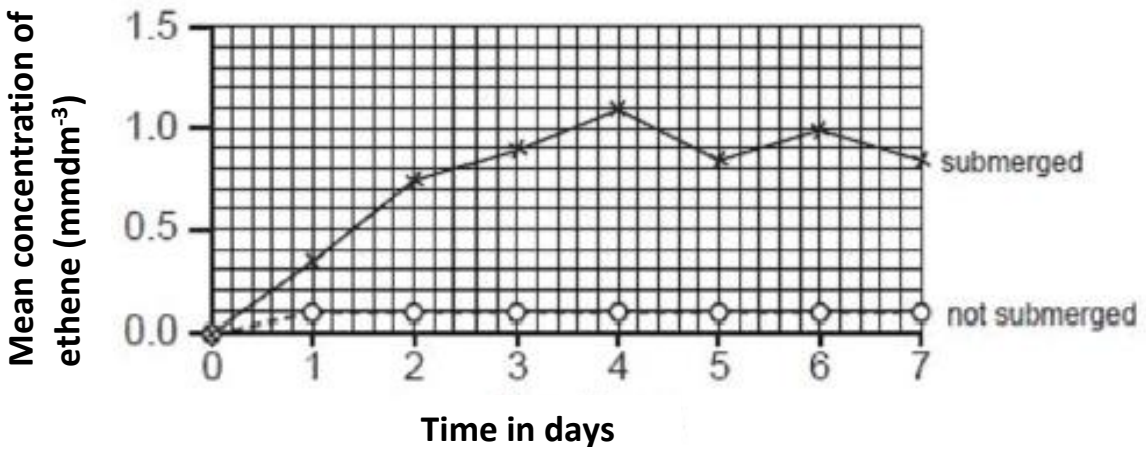
   Group **A**: Grown in a container in which the level of water was increased in 10cm steps over a period of seven days.

   Group **B**: Grown in a container in which the level of water was kept constant throughout the seven days.

   The mean length of internodes and the concentration of ethene in the rice stems of both groups of plants were measured each day.

   The results of the investigation are shown in the graphs in the figure below.





(a) Describe the effect of increasing water levels on the

(i) Length of the submerged internodes. (**6marks**)

From day 0 to day 1, mean length of internodes gradually increases;✓
From day 1 to day 2, mean length of internodes remains constant;✓
From day 1 to day 4, mean length of internodes rapidly increases; ✓
From day 4 to day 5, mean length of internodes gradually increases;✓
From day 5 to day 7, mean length of internodes rapidly increases;✓ to the highest;✓
@ 1mark

(ii) Concentration of ethene in the submerged rice stems.

(**4marks**)

From day 0 to day 2, mean concentration of ethene rapidly increases;✓
From day 2 to day 4, mean concentration of ethene gradually increases;✓to a peak;✓
From day 4 to day 7, mean concentration of ethene fluctuates rapidly;✓
@ 1mark

(b) Explain the difference in the mean concentration of ethene in the two groups of plants over the 7-days period. (**4marks**)

Mean concentration of ethene in submerged rice plants is <u>higher</u> than in non-submerged plants;✓ because in submerged plants, <u>more</u> production of ethene occurs;✓ with <u>very low</u> solubility in water;✓ thus rapidly accumulates in the tissues of stems of submerged plants;✓
@ 1mark

(c) Account for the relationship between concentration of ethene and mean length of internodes of the submerged plants. (**7marks**)

Generally, as mean concentration of ethene increases, internode length also increases;✓ because ethene stimulates anaerobic breakdown of sugars;✓to provide energy for cell division;✓and elongation of internodes;✓ and promotes development of adventitious roots;✓that absorb water and mineral salts;✓for the rapidly elongating shoots;✓
@ 1mark

(d) Of what significance is the change in mean length of internodes during submergence? (**4marks**)

Keeps the leaves always above water;✓✓allowing maximum absorption of incident sun light energy for photosynthesis;✓✓efficient gaseous exchange between plant tissues and atmosphere;✓✓/uptake of carbon dioxide for photosynthesis;✓and oxygen for aerobic respiration;✓
Exposes flowers to the agents of pollination;✓✓
@ ½ mark

(e) Other than stem elongation, explain other adaptations of rice for growth in fields flooded with water. (**9marks**)

Development of aerenchyma (air spaces) between mesophyll or cortex cells;✓✓by cell death;✓allows diffusion of oxygen from the aerial tissues into inner tissues;✓✓for aerobic respiration;✓escape of ethene;✓✓ buoyancy for exposing the shoots above water;✓✓
Highly tolerant roots to the toxic ethanol;✓✓a by-product of fermentation of sugars;✓by having high levels of alcohol dehydrogenase enzyme;✓✓ that breaks down accumulated alcohol;✓
Anaerobic respiration by the roots;✓✓to continuously generate little energy for growth;✓
@ ½ mark

(f) Explain how interaction of ethylene with Gibberellic acid and abscisic acid coordinates growth during submergence in rice. (**6marks)**

Increased stem elongation occurs;✓in presence of both ethylene and Gibberellic acid;✓because ethylene increases the sensitivity to Gibberellic acid;✓and biosynthesis of endogenous Gibberellic acid in internodes of submerged plants;✓rapidly promoting cell division and elongation in the intercalary meristem;✓an elongation zone of internodes;
Abscisic acid inhibits elongation of internodes during submergence;✓by reducing the responsiveness of Gibberellic acid;✓
Abscisic acid inhibits epidermal cell death;✓and thus adventitious root development;✓induced by ethylene;✓
Stimulation of more root development by ethylene occurs;✓in presence of Gibberellic acid;✓
@ ½ mark

SECTION B(60MARKS)

2. (a) Structurally distinguish a **chordate** from an **arthropod**. (**5marks**)

Chordate	Arthropod
Have notochord at embryo stage ✓	**No notochord**
Pharyngeal gill slits present at some stage of development ✓	**Pharyngeal gill slits absent**
Tubular/Hollow nerve cord ✓	**Solid nerve cord**
Dorsal nerve cord ✓	**Ventral nerve cord**
Closed circulatory system ✓	**Open circulatory system**
Have post-anal tail ✓	**Post-anal tail absent**
Have endoskeleton ✓	**Have exoskeleton**

Any 5 correct structural difference @ 1mark

(b) With reference to body plan of chordates, explain the meaning of the term *triploblastic coelomate*. (**7marks**)

Consists of three body layers;✓✓ectoderm;✓on the outside;✓ endoderm;✓on the inside;✓between them lies mesoderm;✓ composed of a fluid-filled space/cavity, coelom;✓lined by a thin layer of epithelial cells, peritoneum;✓separating mesoderm into somatic mesoderm;✓on the outside;✓and splanchnic mesoderm;✓ on the inside;✓connected by a mesentery;✓✓
@ 1mark

(c) Explain the main advantages of possessing

(i) Metameric segmentation. (**2marks**)

Allows <u>duplication/repetition</u> of complete organs along length of an organism;✓as each individual segment/metamere contains a number of complete organs;✓allowing for further <u>specialization</u> of the organ system;✓✓
Acc Different specialized parts of the body are separated from each other within different metameres/segments; allowing their efficient functioning;
@ ½ mark

(ii) a coelom. (**6marks**)

Isolation/separation of gut muscles and body wall muscles;✓ allow their independent functioning;✓thus much more efficient locomotion;✓and digestion occurs;✓with the latter owing to development of peristalsis/muscular movements;✓ Alimentary canal can be increased in length;✓providing greater surface area for absorption of end products of digestion;✓
Coelomic fluid acts as a hydrostatic skeleton in soft-bodied animals e.g. earthworms;✓by providing incompressible material against which muscles can act;✓

Coelom provides space in which body organs are developed and held in position by mesenteries;✓allowing them slide over each other during digestion or respiratory movements;✓
Coelomic fluid acts as a medium of exchange;✓supplying food and oxygen (metabolites);✓and removal of metabolic waste materials;✓
More differentiation of alimentary canal as an organ system occurs;✓with separate regions specialized to perform different functions;✓
Coelom provides specialized cavities e.g. pleural, pericardial and abdominal; with which fluid composition can be regulated;✓✓ Max 6marks
@ ½ mark

3. Describe the role of the following in human growth and development.
   (a) Hypothalamus. (**7marks**)

- **Act as an all-important link between nervous system and endocrine system;✓✓**
- **Controls the release of specific hormones by the anterior pituitary gland/adenohypophysis;✓✓ by secreting releasing factors;✓ and inhibiting factors;✓ from ends of the axons of the neurosecretory cells into blood/portal vessels;✓ carried to the anterior pituitary gland; for example Growth hormone releasing factor(somatocrinin) and growth hormone inhibiting factor(somatostatin) for somatotrophin (Human Growth hormone);✓ Thyrotrophin releasing factor for anterior pituitary gland to release Thyroid stimulating hormone;✓ Gonadotrophin releasing factor for anterior pituitary gland to release Follicle stimulating hormone or luteinising hormone;✓ Adrenotrophin releasing factor for adrenocorticotrphic hormone;✓ Prolactin releasing factor and prolactin inhibiting factor for prolactin;✓**
- **Involved in negative feedback;✓✓ for example, regulation of thyroxine level in blood;✓✓**

Award ½ mark for correct releasing factor/inhibiting factor tied to specific hormone

   (b) Pituitary gland. (**8marks**)

Growth hormone/somatotrophin;✓ stimulates protein synthesis;✓ by stimulating the liver to secrete somatomedins (insulin-like growth factor);✓ increased respiration of fats; promotes growth of skeleton and muscles during child hood and adolescence; increasing amino acid intake into cells;
Thyroid stimulating hormone/thyrotrophic hormone/thyrotrophin;✓ stimulates secretion of thyroxine hormone by thyroid gland;✓
Follicle stimulating hormone;✓ stimulates maturation/development of Graafian/ovarian follicles;✓ secretion of oestrogen by the ovary;✓ spermatogenesis in males;
Luteinising hormone/Interstitial cell stimulating hormone;✓ stimulates ovulation;✓ formation of corpus luteum;✓ secretion of testosterone from interstitial cells in the testes;

Prolactin;✓ stimulates milk production by mammary glands;✓
Adrenocorticotrophic hormone;✓ stimulates secretion of adrenal cortex hormones such as cortisone and aldosterone;✓
Melanocyte stimulating hormone;✓ increases skin pigmentation;✓
@ ½ mark
Award for any two correct significance of a named Adenohypophysis hormone.

(c) Thyroid gland. (**5marks**)

Secretes thyroxine hormone(T_4);✓Triiodothyronine(T_3);✓and calcitonin;✓
Thyroxine and Triiodothyronine regulate growth and development of cells especially in young mammals;✓
Increases metabolism/respiration rate;✓in times of cold;✓ producing metabolic heat;✓to replace the lost heat;✓switches on transcription;✓stimulating protein synthesis;✓stimulating brain development and growth especially of the skeleton;✓
Calcitonin decreases blood calcium ion level;✓by promoting calcium ion absorption by the bones;✓greater calcium ion loss by the kidney;✓reduced calcium ion absorption by the gut;✓
@ ½ mark ***Max 5***

4. (a) What is meant by the term **enhancement effect** in relation to photosystems? (**4marks**)

Rate of photosynthesis is greater;✓when <u>different wave lengths</u> of light used by photosystem I and II are <u>provided together</u>;✓than the sum of the rates;✓when each wave length is provided separately;✓
@ 1mark

(b) Describe the location and structure of photosystems. (**6marks**)

Occurs in the thylakoid membrane of the chloroplast grana;✓
Consists of a <u>cluster;</u>✓of photosynthetic pigment molecules, antenna complex/light harvesting complex;✓made up of a <u>primary pigment</u>, chlorophyll a;✓a reaction centre;✓<u>accessory pigments;</u>✓such as chlorophyll b, carotenoids ✓✓and <u>protein molecules</u>;✓holding pigment molecules in best positions for absorbing light energy;✓
In photosystem I/P700, chlorophyll a maximally absorbs light of wave length of 700nm;✓
In photosystem I/P680, chlorophyll a maximally absorbs light of wave length of 680nm;✓
@ ½ mark

(c) Explain the functioning of a photosystem in cyclic photophosphorylation. (**10marks**)

Light absorbed by the chlorophyll a;✓✓ of photosystem I/P700/PSI;✓✓ excites its electrons;✓✓ taken by an electron acceptor, Ferredoxin;✓✓ passed along a chain of electron carriers/cytochromes;✓✓ each at a lower energy level than the one before/downhill;✓✓ losing its energy;✓ used to add inorganic phosphate to adenosine diphosphate;✓ forming ATP;✓✓ as it falls back to the reaction centre/chlorophyll a;✓✓ via another chain of electron carries;✓✓ thus cyclic pathway;
@ ½ mark

5. (a) (i) Describe the main stages of cell signaling in the regulation of blood glucose concentration by adrenaline. (**11marks**)

In low blood glucose concentration;✓ adrenaline binds to specific receptors on the cell surface membrane;✓ forming a hormone-receptor complex;✓✓ G proteins are activated;✓✓ which in turn activate adenyl cyclase/adenylyl cyclase/adenylate cyclase enzyme;✓✓ bound to the cell surface membrane;✓ that catalyses the hydrolysis of ATP to cyclic AMP; ✓✓ an internal/intracellular messenger/second messenger;✓ within the target cell; that binds to and activates protein kinase;✓✓ initiating a phosphorylation cascade of enzymes/signal amplification;✓✓ with the last enzyme in the chain;✓ catalyzing the breakdown of glycogen to glucose;✓ that diffuses out of the target cell into blood;✓✓ increasing blood glucose concentration;✓
@ ½ mark

(ii) Suggest how the effect of adrenaline in (i) above might be of an advantage to a mammal. (**5marks**)

Much glucose is released out of the glycogen store into blood stream;✓✓ transported to skeletal muscles;✓✓ oxidized;✓✓ producing sufficient energy;✓✓ in response to stress;✓ during fighting;✓ or running way(flight);✓
@ ½ mark

(b) Briefly explain how prolonged exposure to a cold environment can lead to cold diuresis. (**4marks**)

Blood is diverted away from the skin;✓✓ loss of water through sweating is reduced;✓ more water is retained in blood;✓ release of anti-diuretic hormone from the posterior pituitary gland is inhibited; ✓ decreasing the permeability of distal convoluted tubule and collecting duct to water;✓ less water is reabsorbed back to blood;✓ much dilute/less concentrated urine is thus produced;✓

6. (a) Explain how the gene frequency of a population may be altered.
(**12marks**)

Mutation;✓Forms new alleles;✓with beneficial dominant/favourable mutant alleles selected for;✓spreading rapidly through a population;✓
Beneficial recessive mutant alleles takes a long time for it to get to homozygous state to express itself in a population by which time may already be lost;✓
Disadvantageous mutant alleles are selected against; thus completely eliminated from the population;✓
Non-random mating/sexual selection/Biased mating;✓allows only certain individuals within the population with likely inheritable characteristics to have a reproductive advantage over others;✓their alleles are passed to next generation;✓increasing the genotype frequency in the population;✓
Natural selection/selective predation;✓favours those alleles and genotypes that produce environmentally adapted phenotype;✓
increasing their frequency;✓with alleles and genotype less adapted to the environment eliminated;✓decreasing their frequency;✓
Gene flow;✓allows transfer of alleles of one subpopulation to another;✓
as a result of interbreeding between members of the two subpopulations;✓altering allele frequency in both populations;✓
causing variation;
Genetic drift;✓random change in allele frequency of a small population occurring by chance rather than by natural selection;✓owing to premature/sudden death of the sole possessor of a particular allele;✓
before reproducing; decreasing its allele frequency;✓
Genetic load;✓existence within a population of disadvantageous alleles in heterozygous condition;✓
Heterozygous genotypes have a selective advantage over homozygous ones in certain environment;✓thus heterozygotes are selected for;✓
with the less adapted homozygotes selected against;✓eliminated from the population altering the allele frequency;✓
Migration;✓individuals may leave a population to other population in the neighboring areas;✓decreasing allele frequency of the original population;✓
Individuals may also enter into a population;✓increasing allele frequency of the recipient population;✓
Size of the population;✓in a large population, number of random mating are high;✓genes which may arise by chance are quickly removed;✓
In a small population; selective breeding occurs;✓allele frequency is altered by genetic drift;✓with harmful alleles resulting in reduction of numbers;✓
***Award for any well explained cause; @ ½ mar*k;**

(b) The frequency of cystic fibrosis in the human population is approximately 1 birth in 2000. Cystic fibrosis is caused by a recessive allele. Using Hardy-Weinberg formula, determine the percentage of the population who are;

(i) Heterozygous for the dominant allele. (**5marks**)

let p represents frequency of dominant allele; ✓
q represents frequency of cystic fibrosis allele;✓
p^2 represent frequency of the dominant genotype
q^2 represent frequency of the Homozygous recessive genotype
2pq represent frequency of heterozygotes
q^2 represent the frequency of cystic fibrosis individuals;

$\Rightarrow q^2 = \frac{1}{2000}$;✓✓ = 0.0005;✓

$q = \sqrt{0.0005}$ = 0.0224;✓

From p + q = 1;✓

p = 1 – 0.0224= 0.9776;✓

Heterozygotes
2pq;✓ **= 2×0.9776×0.0224= 0.043796, 4.38%;**✓
@ ½ mark

(ii) Homozygous for the dominant allele. (**3marks)**

Homozygotes=p^2; ✓
=0.9776^2;✓
=9557, 95.6%;✓
@ 1mark

END