CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)

NORTHERN ZONE JOINT EXAMINATIONS SYNDICATE (NZ-JES)

FORM SIX PRE-NATIONAL EXAMINATIONS 2023

BIOLOGY 1

MARKING SCHEME.

1. (a) Chloroplasts, mitochondria and bacteria have features in common
   - Double membraned
   - 70s ribosomes
   - Circular DNA
   - Enzyme system. (04 marks @ 01)

   (b) Functions of cytoplasm
   - It stores useful materials such as starch, glycogen, and lipids.
   - It stores waste materials such as nitrogenous wastes.
   - Movement of materials takes place within the cytoplasm.
   - It harbours and organises cell organelles that perform different functions such as protein synthesis in ribosomes and lipid synthesis in smooth endoplasmic reticulum. (04 marks @ 01)

   (c) The most obvious difference is the presence of direct cytoplasmic connections between cells of plants (plasmodesmata) and animals (gap junctions). These connections result in the cytoplasm being continuous between adjacent cells. (02 marks)

2. (a) classifying enzymes based on the type of reactions they catalyse.
   i) Oxidoreductases which catalyse redox reactions (biological oxidation and reduction reactions) by the transfer of hydrogen, oxygen, or electrons from one molecule to another.
   ii) Transferases which catalyse the transfer of a group from one compound to another.
   iii) Hydrolases which catalyse the splitting of a large substrate molecule into two smaller products in the presence of water (hydrolysis process).
   iv) Lyases which catalyse the removal of a chemical group by the process other than hydrolysis.
   v) Isomerases which catalyse rearrangement within a molecule, converting one isomer to another.
   vi) Ligases which catalyse the joining of two molecules by forming a new chemical bond, and it requires energy from the breaking down of ATP.

   (b) The basis of the test
      i) A non-reducing sugar (sucrose) can be hydrolysed by heating with dilute hydrochloric acid to give glucose and fructose, both of which are reducing sugars. The solution is neutralized with dilute sodium hydroxide or potassium hydroxide so as to give the reducing sugar results with the Benedict's test on heat (02 marks)
      ii) The basis of tests Biuret test is the chemical test used to detect the presence of peptide bond as a general test for detection of proteins. In the presence of dilute copper (II) sulphate ($CuSO_4$) in alkaline solution (medium), nitrogen atoms in the peptide chain form a purple complex with Copper (II) ions (Cu^{2+})
      (02 marks)

3. (a) (i) Artificial classification (*01 mark)*

   (ii) - It exploits few information about organism
   - It is less accurate
   - It is not flexible, hence difficult to accommodate new discoveries
   - It does not allow prediction of information, hence limits recent advancements in taxonomy

- It deals only with observable features and fails to consider evolutional, biochemical and genetic relationship of organisms

(Take 4 points @ 1.5 marks)

(b)(i)**Group A**- Presence of shells

(ii)**Group B**- Absence of limbs

(iii)**Group C**- Presence of wings/Ability to fly

(@01 mark)

4. Mechanism of conduction of nerve impulse along the axon

a) Polarization of the neurone's membrane

Sodium is in high concentration on the outside, whereas potassium is in high concentration on the inside. Cell membranes surround neurones, like any other cell in the body which has a membrane. When a neurone is not stimulated, just sitting with no impulse to carry or transmit, its membrane is said to be polarised. Being polarized means that the electrical charge on the outside of the membrane is positive while the electrical charge on the inside of the membrane is negative.

b) The resting potential gives the neurone a break

When the neurone is polarised, it is said to be at its resting potential. It remains in this state until when the stimulus comes along (that is, when it is stimulated). When action potential is initiated, a region of the membrane depolarises. As the result the adjacent region becomes depolarised as well.

c) Action potential

Sodium ions move inside the membrane when a stimulus reaches a resting neurone. The gated ion channels on the resting neurone's membrane open suddenly to allow the Na+ that was on the outside of the membrane to rush into the cell. While this happens, the neurone changes from being polarised to being depolarised. After more positive ions enter inside the membrane, the inside becomes positive and polarisation is removed and the threshold is reached

d) Repolarisation

Localised electrical circuits are established, causing further influx of sodium ions and so progression of the impulse. Behind the impulse, potassium ions begin to leave the axon along the concentration gradient, hence repolarisation beginning to occur due to the outward flow of K+ ions. The depolarisation speeds forward, triggering an action potential.

During repolarisation, potassium ions move outside, while sodium ions stay inside the membrane. After repolarisation, the inside of the cell becomes flooded with Na+; the gated ion channels on the inside of the membrane open to allow K+ to move to the outside of the membrane. With K+ moving to the outside, the membrane's repolarisation restores electrical balance, although it is the opposite of the initial polarised membrane that had Na+ gates close. Otherwise, the membrane could not repolarize. Then Na+ ions are actively forced out of the axoplasm in the process called sodium pump. However, since K+ ions are also involved in this process, the process is best called cation pump.

(10 marks @ 02.5)

5. Nervous and hormonal control of the gastric juice secretion

The nervous or cephalic phase.

This is the initial stage which is initiated by sight, thought, taste, or smell of food, which later triggers a reflex in which nerve impulses relayed from the brain cause gastric glands to release their secretions.

Generally, the nervous signals that trigger this phase emanate from cerebral cortex appetite centres and are transmitted to the stomach through the vagus nerve. This in turn causes the secretions of histamine and increases hydrochloric acid and gastrin secretion in the stomach. (03 mark)

Gastric phase.

It occurs once the food is chewed and has arrived in the stomach. The partially digested food substances such as proteins in the stomach stimulate the endocrine cells in the stomach walls to secrete gastrin from gastric glands which increase the secretion of the gastric juice.

Normally, peptides buffer the stomach acidity; therefore, as they leave the stomach acidity increases and as pH gets below 2, negative feedback is triggered to inhibit the parietal and gastrin cells. This process winds up the gastric phase as the need for pepsin and HCl declines. Furthermore, when fat-containing food enters the stomach, the hormone called enterogastrone or gastric inhibitory peptide is released from the wall of the stomach. This hormone decreases the flow of gastric juice and reduces movement of the muscles of the stomach (churning motions) or gastric peristalsis. (04 mark)

Intestinal phase.

This phase occurs when chyme arrives in the first region of the small intestine called duodenum and triggers gastric activity and nervous reflexes. Food material in the duodenum stimulates both the alkaline and enzyme rich components of pancreatic juice.

The alkaline component of pancreatic juice is secreted in response to the presence of acid in the duodenum. The acidified chyme in the duodenum triggers the secretion of secretin and cholecystokinin (CCK) or pancreozymin (PZ) from the duodenal walls.

Secretin causes the production of bile and mineral salts from gall bladder and pancreas respectively.

CCK stimulates the secretion of enzymes from pancreas and contraction of gall bladder to release bile. Moreover, secretin and CCK suppress gastric secretion and motility in which a decline in gastrin secretion and contraction of pyloric sphincter will limit admission of more chyme into the duodenum. This gives the duodenum ample time to work on the chyme it has received before receiving more.

The enteroendocrine cells also secrete gastric-inhibitory peptide, also called gastrointestinal inhibitory peptide (GIP) which inhibits the secretion of gastric acid in the stomach.

Also, GIP stimulates insulin secretion in preparation for processing nutrients that are about to be absorbed by the small intestine. Trypsin in the duodenum inhibits the release of enzymes via the inhibition of CCK. This is a feedback control mechanism

which limits the quantity of enzymes in the small intestine and may have a protective function (04 mark)

6. (a) Changes in the flower after fertilization
   - Zygote undergo rapidly mitotic division forming multicellular embryo. The embryo then differentiates into young shoot called plumule, young root called radical and simple seed leaves called cotyledons.
   - The endosperm nucleus undergoes mitotic division to give rise to mass of endosperm tissue.
   - Integuments of ovules form tough protective layer called seed coat or Testa.
   - The micropyle remains as a small pore in the Testa through which oxygen and water enter during germination of seed.
   - During embryo development nucellus disintegrate to provide nutrients for supporting initial growth.

   (Any 5 points @ 01 mark =05 marks)

   b) Five advantages of reproduction by seeds

   - The seed contain the food for the developing embryo either in dicot or monocot
   - Seed protect the embryo
   - Seed can remain dormant and survive adverse conditions.
   - The seed is physiologically sensitive to favourable condition and sometimes must undergo after ripening so that it will not germinate immediately.
   - The plant is independent of water for sexual reproduction and therefore better adapted for land environment. (5 points @ 01 mark =05 marks)

7. (a) Importance of phosphorylation of glucose during initial stage of glycolysis are;
   i. It makes glucose accessible to enzymes.
   ii. It prevents glucose from escaping because glucose-6-phosphate does not fit in the plasma membrane.
   iii. ATP provides activation energy required to activate glucose to start glycolysis.
   iv. Increases the reactivity of the oxygen in the resulting phosphate ester.

   (04 marks @ 01)

(b) Explain the adaptations to oxygen uptake for divers.

- They use oxygen more efficiently, that is, they fill their lungs and exchange 90% of their air in each breath. Thus, before a dive is taken, they take a deep breath to accumulate oxygen in their lungs.
- They have a high blood volume with plenty of haemoglobin and myoglobin. This allows long oxygen retention time.
- They have a high tolerance to lactic acid and carbon dioxide, that is, their muscles can work anaerobically while holding their breath.
- They can tolerate tremendous atmospheric pressure at great depths. Their lungs and ribs are collapsible; air spaces are minimised; and nitrogen absorption is limited.
- Diving mammals slow their heart rate, stop their breathing, and shunt blood flow from their extremities to the brain, heart, and muscles when starting a dive.
- Seals can hold their breath for about two hours. They rely on internal oxygen stores when they are down there.
- Myoglobin of the seals and dolphins is more concentrated than that of humans, almost ten times, this gives them a chance of storing oxygen for a long time when under water. (06 marks @ 01 any six points)

8. Chromosome analysis

a. i. In the early interphase.

The DNA content of the cell is 2. this is the form of the DNA of this cell. (01 mark)

Mitosis.

Metaphase:

DNA content = 4. this is due to the fact that the DNA replication has taken place prior to mitosis. (01 mark)

late telophase:

The DNA content is 2. This is caused by the separation of chromatids during anaphase, therefore the newly formed cells (daughter cell) which goes into the interphase have the DNA content 2 each. (01 mark)

Meiosis I.

Zygotene:

The DNA contents is 4, this is due to the replication of the DNA prior to meiosis. (01 mark)

meiosis 2.

Late telophase:

DNA content = 1. This is explained by the fact that the DNA content was halved from 4 to 2 during anaphase I and again it was halved from 2 to 1 during anaphase II as chromatids separated. (01 mark)

ii. Late telophase I:

DNA content would be 2. this is due to the reduction from 4 to 2 during anaphase I as the homologous pairs separates and move apart. (01 mark)

Prophase II: the DNA content= 2. this is due to the fact that there is no DNA replication in interphase following meiosis I. (01 mark)

b. meiosis and variation.

- **Production and fusion of haploid gametes** ($00^1/_2$ mark)

Variety of offspring is increased by mixing the genotype of one parent with that of the other. This is achieved by using formation of gametes. ($00^1/_2$ mark)

During gamete formation meiosis, halves the number of chromosomes in daughter cells so that each gamete must contain half the number of chromosomes of the adult if the chromosome. ($00^1/_2$ mark)

Meiosis is thus instrumental in permitting variety in organisms, and giving them the potential to evolve. ($00^1/_2$ mark)

- **The creation of genetic variety by the random distribution of chromosomes during metaphase I.** (00½ mark)

When the pairs of homologous chromosomes arrange themselves on the equator of the spindle during metaphase I of meiosis, they do so randomly. (00½ mark)

Although each one of the pair determines the same general features, they differ in the detail of these features. (00½ mark)

The random distribution and consequent independent assortment of these chromosomes produces new genetic combinations. (00½ mark)

- **The creation of genetic variety by crossing over between homologous chromosomes** (00½ mark)

During prophase I of meiosis, equivalent portions of homologous chromosomes may be exchanged. (00½ mark)

In this way new genetic combinations are produced and linked genes separated. (00½ mark)

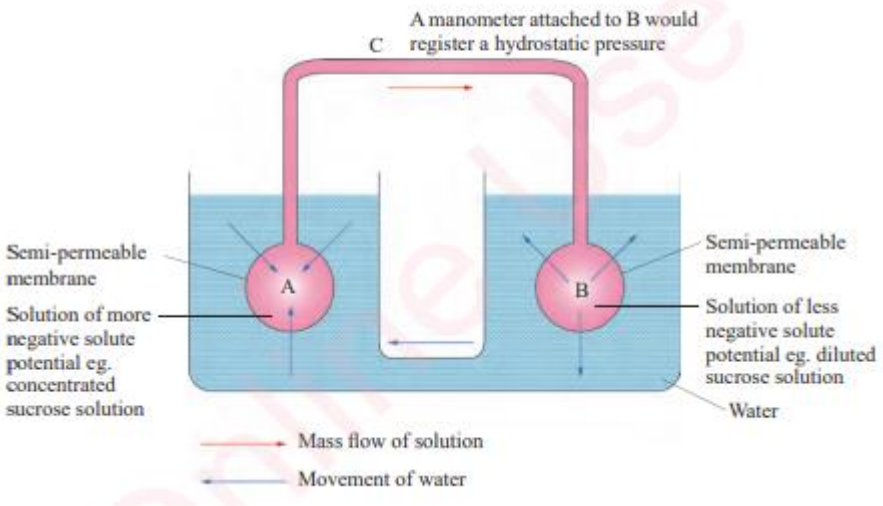
The variety which meiosis brings about is essential to the process of evolution so ensures that species constantly change and adapt when these conditions alter. (00½ mark)

9. (a) Münch prepared a model with two containers A and B each of which contained a sugar solution. The solution in container A was more concentrated than that in container B. Each container had a semi-permeable membrane. (02 marks)

The two containers were connected by a tube. After being placed in water, the two solutions initially took up the water by osmosis. However, the tendency of water uptake was higher in container A than it was in container B. As the water entered in container A, the hydrostatic pressure built up in the closed system

A-C-B tube, which in turn forced water out of container B. (02 marks)

Consequently, the mass flow of solution occurred through tube C along the generated pressure gradient; due to osmotic uptake of water, the osmotic gradient also was built from container A to container B. Since the water continued to dilute the contents of container A and solutes accumulated at container B, then the system came into equilibrium. (02 marks)



(04 marks)

(b) This model can be used to explain the flow of sugar molecules from the leaves to the roots. Container A can represent the leaves, which are the source of sugars manufactured during photosynthesis process. Water then leaks out continuously in the mesophyll cells in the leaves making the solute potential (Ψs) of the leaf cells more negative. This causes the water to be brought to the leaf from xylem by osmosis. The process results in raising the pressure potential (Ψp). (02 marks)

Container B can represent the sink, which is the area where sugar is used up or stored in an insoluble form. In this case, it is the root, young shoot, or fruits. (02 marks)

The hydrostatic pressure in the leaves increases and the pressure gradient is created between the leaves (source) and the roots (sink) resulting in the mass flow of solute along the gradient. In plants, solutes are constantly being used up at the sink (B) and produced at the source (A), and therefore, the equilibrium state is not reached. (02marks)

10. Explain the main events of the citric acid cycle indicating the formation of ATP, carbon dioxide, reduced NAD and FAD.

i) Reaction 1: Condensation

Citrate is formed by joining acetyl-CoA to oxaloacetate. This condensation reaction is irreversible, committing the 2-carbon acetyl group to the Krebs cycle. (02 marks)

ii) Reactions 2 and 3: Isomerization

The hydroxyl (—OH) group of citrate must be repositioned. This rearrangement is done in two steps: First, a water molecule is removed from one carbon; then water is added to a different carbon. As a result, an —H group and an —OH group change positions. The product is an isomer of citrate called isocitrate. This rearrangement facilitates the subsequent reactions. (02 marks)

iii) Reaction 4: The First Oxidation

Isocitrate undergoes an oxidative decarboxylation reaction. First, isocitrate is oxidized, yielding a pair of electrons that reduce a molecule of NAD+ to NADH. Then the oxidized intermediate is decarboxylated; the central carboxyl group splits off to form CO2, yielding a 5-carbon molecule called α-ketoglutarate. (02 marks)

iv) Reaction 5: The Second Oxidation

Next, α-ketoglutarate is decarboxylated by a multienzyme complex similar to pyruvates dehydrogenase. The succinyl group left after the removal of CO2 joins to coenzyme A, forming succinyl-CoA. In the process, two electrons are extracted, and they reduce another molecule of NAD+ to NADH. (02 marks)

v) Reaction 6: Substrate-Level Phosphorylation

The linkage between the 4-carbon succinyl group and CoA is a high-energy bond. this bond is cleaved, and the energy released drives the phosphorylation of guanosine diphosphate (GDP), forming guanosine triphosphate (GTP). GTP can transfer a phosphate to ADP, converting it into ATP. The 4-carbon molecule that remains is called succinate. (02 marks)

vi) Reaction 7: The Third Oxidation

Next, succinate is oxidized to fumarate by an enzyme located in the inner mitochondrial membrane. The free-energy change in this reaction is not large enough to reduce NAD+. Instead, FAD is the electron acceptor forming FADH2. (02 marks)

vii) Reactions 8 and 9: Regeneration of Oxaloacetate

In the final two reactions of the cycle, a water molecule is added to fumarate, forming malate. Malate is then oxidized, yielding a 4-carbon molecule of oxaloacetate and two electrons that reduce a molecule of NAD+ to NADH. (02 marks)

Oxaloacetate, the molecule that began the cycle, is now free to combine with another 2-carbon acetyl group from acetyl-CoA and begin the cycle again. (01 marks)