THE COPPERBELT UNIVERSITY

SCHOOL OF MATHEMATICS AND NATURAL SCIENCES

BI 110- INTRODUCTORY BIOLOGY TEST ONE DURATION: 2HRS MARKS: 100

INSTTRUCTION: ANSWER ALL QUESTIONS DATE: 13/05/2022

1.a. What is the relationship between wavelength and magnification of a microscope? (3 marks)

b. A compound microscope has the following specifications; resolution: 2, numerical aperture: 0.5, magnification of objective lenses 25X, and total magnification 500X. If the image size is 18,000 and magnification obtained after viewing the specimen is 750X, calculate the following

Wavelength of the microscope (2 marks)

Magnification of the ocular lenses (2 marks)

Size of the specimen (2 marks)

c. what are the key distinguishing features of the following microscopes;

Phase contrast microscope (3 marks)

Atomic force microscope (3 marks)

Differential interference contrast (3 marks)

d. Describe how a transmission electron microscope works. (4 marks)

e. Why is microscopy important in agriculture? (3 marks)

2.a. Write short notes on the following: lysosome, Golgi apparatus, rough endoplasmic reticulum, nucleus, mitochondrion, and ribosome. (6 marks)

b. How are prokaryotes different from eukaryotes in terms of their cell walls, interior organization, and flagella? (6 marks)

c. Explain the theory of endosymbiosis and what are the pieces of evidence that supports this theory? (3 marks)

d. Describe the role of membrane receptors and ligands? (3 marks)

e. Why are bacteria classified as prokaryotic organisms? (3 marks)

f. Robert Hooke first described cells in 1665, when he used a microscope he had built to examine a thin slice of a non-living tissue found in the bark of certain trees. A few years later, Dutch naturalist Antonie van Leeuwenhoek, who called the tiny organisms that he observed "animalcules," meaning little animals. For another century and a half, however, biologists failed to recognize the importance of cells. In 1838, botanist Matthias Schleiden made a careful study of plant tissues and developed the first statement of the cell theory.
(i)What is the cell theory? (1 mark)

(ii) Explain the postulates of the cell theory? (3 marks)

3.a. Explain why cells undergo **Go** phase. Why is important that the cell has to undergo this cycle. (3 marks)

b. At what stage do we find the spindle check point? Explain its role (4 marks).

c. Why do chromosomes condense during mitosis? (3 marks)

d. Explain how the orientation of homologous chromosomes during metaphase I of meiosis contributes to greater variation in gametes.5 marks

e. Though the stages of meiosis have the same names as the stages of mitosis, they exhibit fundamental differences. Compare and contrast the two processes to accurately state their main differences (5 marks)

f. Compare and contrast cytokinesis in plants and animal cells. (3 marks)

g. Define a karyotype (2 marks)

4.a. Draw and explain the differences between alpha and beta glucose. (3 marks)

b. Explain the two types of starch and the linkage types (3 marks)

c. what are the differences between ;**a leading and a lagging strand, Nucleoside and a nucleotide, visceral fats and subcutaneous fats** (6 marks)

d. Using molecular structures, describe how phosphodiester bonds are formed (4 marks)

e. Why is DNA negatively charged? Why does the synthesis of DNA start at 5' and end at 3'? (3 marks)

f. A strand of DNA has the sequence 5'-ATATGCGAT-3'. State its corresponding sequence of DNA (2 marks) and RNA (2 marks).

g. Explain how peptide bonds are formed. (2 marks)

BI 110 Test1 Solutions

1.a. The relationship between wavelength of light and magnification of microscope, the wavelength is inversely proportional to the magnification of microscope. The lower the wavelength the higher the resolution, the higher the magnification. The wavelength is represented as lambda.

b. resolution=0.5*wavelength

$$\frac{Resolution}{1} = \frac{0.5 * \lambda}{Numerical\ Aparture\ (NA)}$$

Hence wavelength $(\lambda) = \frac{resolution*NA}{0.5} = \frac{2*0.5}{0.5} = \frac{1}{0.5} = 2$

Total magnification=Objective lenses*Ocular lenses

Therefore **Ocular lenses**$= \frac{Total\ magnification}{Objective\ lenses} = \frac{500}{25} = 20$

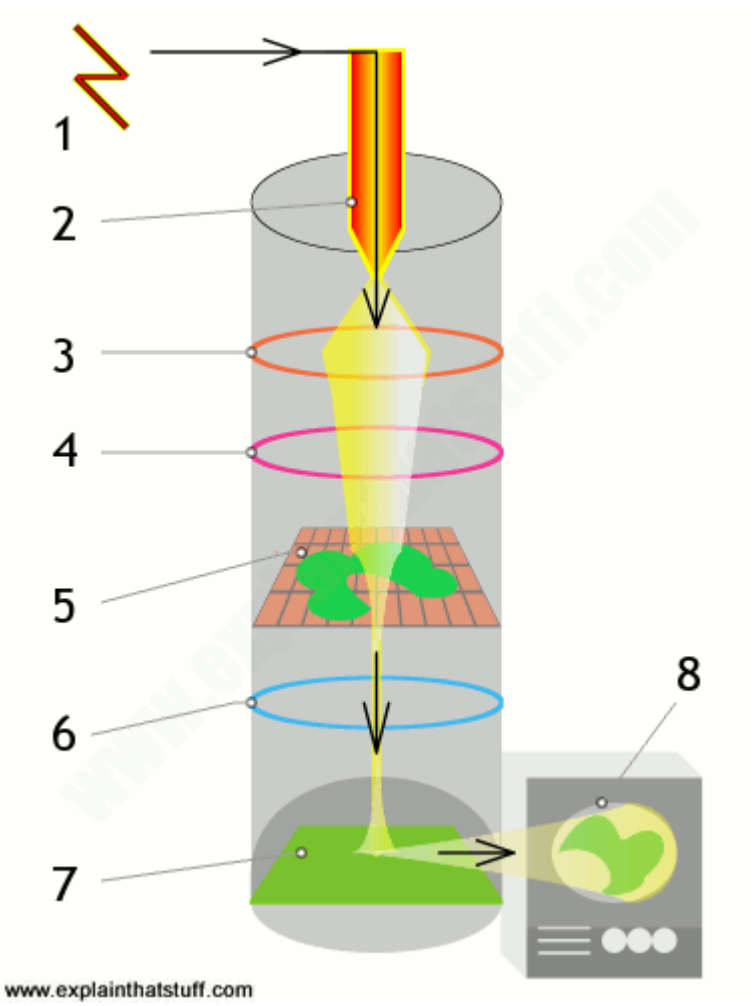
Magnification= $\frac{Image}{Specimen}$

Therefore **Specimen**$= \frac{Image}{Magnification} = \frac{18{,}000}{750} = 24$

c.

Phase contrast	Atomic force	DIC
• Views live specimen • Views unstained specimen • Uses an Annular ring/plate • Uses a phase ring/plate • Creates an image by combining different wavelengths	• Uses a diamond tip with a silicon arm • Creates images by moving back and forth on the surface of the specimen or simply by contact • Views surfaces at a molecular and atomic level	• Uses prisms to modify light coming from one source • It creates an image by combining different refractive indices and thickness of the specimen • It produces pseudo 3D images

d. **How a transmission electron microscope (TEM) works**



A **transmission electron microscope** fires a beam of electrons *through* a specimen to produce a magnified image of an object.

1. A high-voltage electricity supply powers the cathode.
2. The cathode is a heated filament, a bit like the electron gun in an old-fashioned cathode-ray tube (CRT) TV. It generates a beam of electrons that works in an analogous way to the beam of light in an optical microscope.
3. An electromagnetic coil (the first lens) concentrates the electrons into a more powerful beam.
4. Another electromagnetic coil (the second lens) focuses the beam onto a certain part of the specimen.
5. The specimen sits on a copper grid in the middle of the main microscope tube. The beam passes through the specimen and "picks up" an image of it.
6. The projector lens (the third lens) magnifies the image.
7. The image becomes visible when the electron beam hits a fluorescent screen at the base of the machine. This is analogous to the phosphor screen at the front of an old-fashioned TV .
8. The image can be viewed directly (through a viewing portal), through binoculars at the side, or on a TV monitor attached to an image intensifier (which makes weak images easier to see).

e. • Analyse the quality of your compost/ compost tea

• Analyse compaction and anaerobic conditions

• Find out about diseases before they become a problem

• Find out about changes in your soil and how effective your techniques are

2. a. Write short notes on the following: lysosome, Golgi apparatus, rough endoplasmic reticulum, nucleus, mitochondrion, and ribosome. [*6 marks*]

- ***Lysosome*:** Small, spherical, single membrane sac, found throughout the cytoplasm filled with hydrolytic enzymes. Occur in most animal cells and in few type of plant cells

  • Help in hydrolysis/digestion/break down of large molecules
  • Protect cell by destroying foreign invaders like bacteria and viruses
  • Degradation of worn out organelles
  • In dead cells perform autolysis

- ***Golgi apparatus***: synthesis/sorting/transporting/secretion of cell products

  • Modifies, sorts and packs materials synthesized in the cell
  • Delivers synthesized materials to various targets inside the cell and outside the cell
  • Produces vacuoles and secretory vesicles
  • Forms plasma membrane and lysosomes

- ***Rough endoplasmic reticulum***: is so named for the appearance of its outer surface, which is studded with protein-synthesizing particles known as ribosomes. It is a site of protein synthesis. RER synthesize secretory proteins and membrane proteins

- ***nucleus***: controls cells activities/mitosis/replication of DNA/transcription of DNA (to RNA)/directs protein synthesis

  • Control all the cell activities like metabolism,
  • Protein synthesis, growth and cell division
  • Nucleolus synthesizes ribonucleic acid (RNA) to constitute ribosomes
  • Store hereditary information in genes

- ***mitochondrion***: Mitochondria are membrane-bound cell organelles (mitochondrion, singular) that generate most of the chemical energy needed to power the cell's biochemical reactions. Chemical energy produced by the mitochondria is stored in a small molecule called adenosine triphosphate (ATP). (aerobic) respiration/generates ATP

  • Generate large quantities of energy in the form of ATP.

• Store calcium for cell signaling activities, generate heat, and mediate cell growth and death.

- ***ribosome***: produce proteins from amino acids during a process called protein synthesis or translation

b. How are prokaryotes different from eukaryotes in terms of their cell walls, interior organization, and flagella? [6 *marks*]

	prokaryotes	**eukaryotes**
cell walls	cell wall is composed of *peptidoglycan* which consists of a carbohydrate matrix (polymers of sugars)	Cell walls lack *peptidoglycan.* Plant cells-have a cell wall composed of cellulose, hemicellulose, pectin, proteins, etc. but animal cells do not have a cell wall
interior organization	There are few, if any, internal compartments, and while they contain simple structures like ribosomes, most have no membrane-bounded organelles	The interiors of eukaryotic cells contain numerous organelles**,** membrane-bounded structures that close off compartments within which multiple biochemical processes can Proceed simultaneously and independently.
flagella	Some prokaryotes have a flagellum and use it for locomotion and feeding and are able to rotate. Many prokaryotes swim using flagella and cilia.	Many multicellular and some unicellular eukaryotes today no longer possess flagella and are non-motile, but structures called **cilia** can still be found within them, cellular projections that lash back and forth.

c. Explain the theory of endosymbiosis and what are the pieces of evidence that supports this theory? [3 *marks*]

- The theory of endosymbiosis proposes that some of today's eukaryotic organelles evolved by a symbiosis in which one species of prokaryote was engulfed by and lived inside another species of prokaryote that was a precursor to eukaryotes.

THE PIECES OF EVIDENCE OF THE ENDOSYMBIOTIC THEORY ARE THAT:

- Mitochondria divide by simple fission, splitting in two just as bacterial cells do, and they apparently replicate and partition their DNA in much the same way as bacteria.

- Mitochondrial ribosomes are also similar to bacterial ribosomes in size and structure
- Both mitochondria and chloroplasts contain circular molecules of DNA similar to those in bacteria.
- The organelles like mitochondria and chloroplast are self-replicating organelles with their DNA that shares similarities with the prokaryotic genetic material and have double membrane-like prokaryotes (Both mitochondria and chloroplasts are surrounded by two membranes; the inner membrane probably evolved from the plasma membrane of the engulfed bacterium, while the outer membrane is probably derived from the plasma membrane or endoplasmic reticulum of the host cell.)
- The organelle chloroplast can perform photosynthesis and has the machinery to harvest light energy, which is also present in primitive organisms like cyanobacteria.
- The genetic material of prokaryotes and organelles like mitochondria and chloroplast is circular and encodes a few genes.

d. Describe the role of membrane receptors and ligands? [3 *marks***]**

- Membrane receptors are specialized protein molecules attached to or integrated into the cell membrane. Through interaction with specific ligands (e.g., hormones and neurotransmitters), the receptors facilitate communication between the cell and the extracellular environment. Receptors are also involved in translocation of substances (e.g., nutrients and waste products) across the membrane.

- When a ligand binds to its respective receptor, the shape and/or activity of the ligand is altered to initiate several different types of cellular responses. Such cellular responses are vital for the proliferation, migration, survival, and differentiation of cells within all multicellular organisms.

e. Why are bacteria classified as prokaryotic organisms? [3 *marks*]

Bacteria are a group of microscopic single-celled organisms that live in enormous numbers in almost every environment on Earth, from deep-sea vents to deep below Earth's surface to the digestive tracts of humans.

Bacteria lack a membrane-bound nucleus and other internal structures and are therefore ranked among the unicellular life-forms called prokaryotes.

f. (i)What is the cell theory? [1 *mark*]

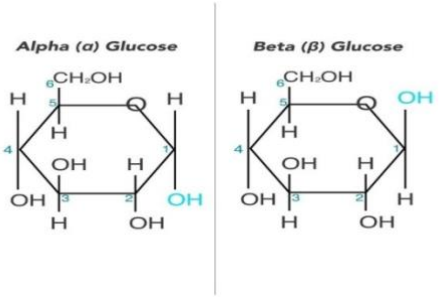
The cell theory is a scientific theory formulated in the mid-nineteenth century, a basic tenet of modern biology, first stated by Matthias Schleiden and Theodor Schwann in 1838–39, that cells are the basic units of structure and function in living organisms.

(ii) Explain the postulates of the cell theory? [3 *marks*]

1. All organisms are composed of one or more cells, and the life processes of metabolism and heredity occur within these cells.
2. Cells are the smallest living things, the basic units of organization of all organisms.
3. Cells arise only by division of a previously existing cell.

4.a. the orientation of the hydroxide at first carbon differs. Alpha glucose the OH at first prime is at the bottom, the beta glucose at first prime has the OH at the Top of H

Alpha glucose is higher in energy than beta glucose



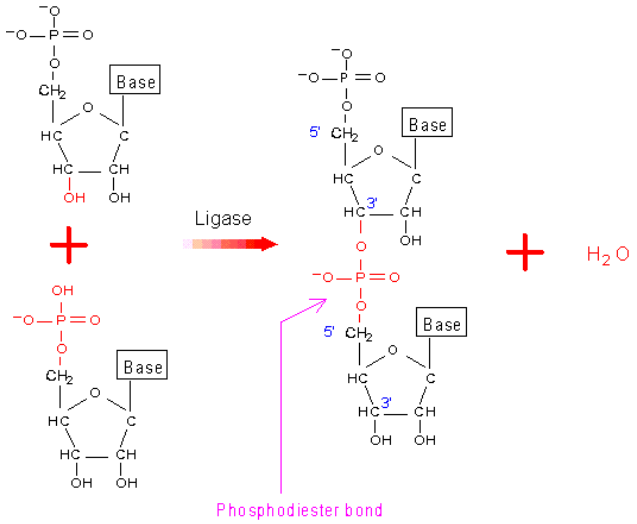
b. The two types of starch: Amylopectin is highly branched, leaving more surface area available for digestion. It's broken down quickly, which means it produces a larger rise in blood sugar (glucose) and subsequently, a large rise in insulin.
Amylose is a straight chain, which limits the amount of surface area exposed for digestion. This predominates in RS. Foods high in amylose are digested more slowly. They're less likely to spike blood glucose or insulin.
In amylose these are linked α(1-4), with the ring oxygen atoms all on the same side, whereas in amylopectin about one residue in every twenty or so is also linked α(1-6) forming branch-points.

c. .A **leading** strand is the strand which is synthesized in the 5'-3'direction while a **lagging** strand is the strand which is synthesized in the 3'-5' direction.The leading strand is synthesized continuously while a lagging strand is synthesized in fragments which are called Okazaki fragments.

A **nucleotide** is composed of three components, namely a nitrogenous base, phosphate group, and sugar. A **nucleoside** is composed of two components, namely a nitrogenous base and sugar

Subcutaneous fats are found under the skin whose primary function is insulating the animal body. Visceral fats are also known as belly fats, they are stored in the abdomen and around major organs such as the liver instestines etc, function is that it ensures some distance between organs

d. . The phosphodiester bonds are formed as the result of the *condensation reaction* between phosphate groups and hydroxyl groups of two sugar groups. For instance, the group that is being formed by the bonding of one oxygen atom and one hydrogen atom is called the hydroxyl group. Such groups are written as **-OH** or **-HO.** The "**–**" represents the carbon to which the hydroxyl group will be attached. Moreover, the molecules containing a single atom of phosphorus covalently bonded to four oxygen atoms are called phosphate groups. The other name for the phosphodiester bond is p*hosphoester bond*. See the diagram below



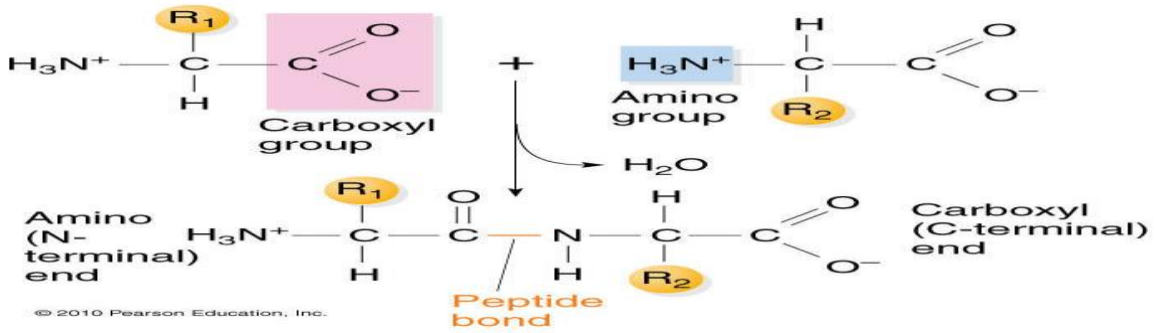
e. Because of the presence of the phosphate group in the backbone of the DNA strand. DNA is always synthesized in the 5'-to-3' direction, meaning that nucleotides are added only to the 3' end of the growing strand. As shown in Figure 2, the 5'-phosphate group of the new nucleotide binds to the 3'-OH group of the last nucleotide of the growing strand.

f. DNA: TATACGCTA

RNA: UAUACGCUA

g. A peptide bond is formed by a dehydration synthesis or reaction at a molecular level. This reaction is also known as a condensation reaction which usually occurs between amino acids. two amino acids bond together to form a peptide bond by the dehydration synthesis. During the reaction, one of the amino acids gives a carboxyl group to the reaction and loses a hydroxyl group (hydrogen and oxygen). The other amino acid loses hydrogen from the NH_2 group. The hydroxyl group is substituted by nitrogen thus forming a peptide bond. This is one of the primary reasons for peptide bonds being referred to as substituted amide linkages. Both the amino acids are covalently bonded to

each other


Carboxyl group
Amino group
H_2O
Amino (N-terminal) end
Peptide bond
Carboxyl (C-terminal) end
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