The Copperbelt University
School Of Mathematics And Natural Sciences

BI 110 Test one (60 marks) **03/04/2023**

Answer All Questions **Duration 2hrs**

1. Multiple choice (10 marks), Negative one (-1) for a wrong answer, Zero for I don't know, 1 mark for each correct answer.

i) Which of the following would be most appropriate method to observe and measure the size of ribosomes in a eukaryotic cell?
A) a hand lens (magnifying glass) B) standard light microscopy C) scanning electron microscopy D) transmission electron microscopy E) I don't know

ii) You disrupt all hydrogen bonds in a protein. What level of structure will be preserved?
A) primary structure B) secondary structure C) tertiary structure D) quaternary structure E) I don't know

iii) If one strand of a DNA molecule has the sequence of bases 5′-ATTGCA-3′, the mRNA synthesized following the template will be _____.
A) 5′-TAACGT-3′ B) 5′-TGCAAT-3′ C) 3′-UAACGU-5′ D) 5′-UGCAAU-3′ E) I don't know

iv) A cell with a predominance of smooth endoplasmic reticulum is specialized in.....
A) transporting carbohydrates to neighbouring cells B) import and export large quantities of protein C) actively secrete large quantities of protein D) synthesize large quantities of lipids E) I don't know

v) Motor proteins provide for molecular motion in cells by interacting with what types of cellular structures?
A) membrane proteins of the inner nuclear envelope B) free ribosomes and ribosomes attached to the ER C) components of the cytoskeleton D) cellulose fibers in the cell wall E) I don't know

vi) The molecular formula for glucose is $C_6H_{12}O_6$. What would be the molecular formula for a polymer made by linking ten glucose molecules together by dehydration reactions?
A) $C_{60}H_{120}O_{60}$ B) $C_{60}H_{102}O_{51}$ C) $C_{60}H_{100}O_{50}$ D) $C_{60}H_{111}O_{51}$ E) I don't know

vii) If a cell at metaphase of mitosis contains 20 sister chromatids, how many chromosomes will be present in a G1 cell?
A) 5 B) 10 C) 20 D) 40 E) I don't know

viii) Mendel continued some of his experiments into the F2 or F3 generation in order to __
A) obtain a larger number of offspring on which to base statistics
B) observe whether or not a recessive trait would reappear
C) observe whether or not the dominant trait would reappear
D) distinguish which alleles were segregating E) I don't know

ix) Mendel's observation of the segregation of alleles in gamete formation has its basis in which of the following phases of cell division?
A) prophase I of meiosis B) anaphase II of meiosis C) metaphase II of meiosis
D) anaphase I of meiosis E) I don't know

$(C_6H_{12}O_6)_{10}$ $(H_2O)_9$ $C_{60}H_{120}O_{60}$ $H_{18}O_9$

x) 23) Black fur in mice (*B*) is dominant to brown fur (*b*). Short tails (*T*) are dominant to long tails (*t*). What fraction of the progeny of crosses *BbTt* × *BBtt* will be expected to have black fur and long tails?

A) 1/16 B) 3/8 C) 1/2 D) 9/16 E) I don't know

2.a. Compare and contrast the imaging capabilities and applications of the differential interference microscope and scanning tunnelling microscope. (6 marks)

b. How do the three postulates of the cell theory help us understand the fundamental properties and behaviours of living organisms? (2 marks)

c. State the structural differences between a gram positive and gram negative bacteria. (2 marks)

3.a. List and recognize four major components of an amino acid, and explain how amino acids may be grouped according to the physical and chemical properties of the side chains. (4,4 marks)

b. Identify an alpha glycosidic linkage and describe how it is formed. (3 marks)

c. What role does complementary base pairing play in the functions of nucleic acids? (3 marks)

d. What is the relationship between DNA and RNA, and how do they differ in terms of their structure and function? (6 marks)

4. a. Differentiate between chromatin and chromatid. (2 marks)

b. How is a G1 arrest different from G0 in the cell cycle? (2 marks)

c. Write the phases of the cell cycle against each of the events.

i. The disintegration of the nuclear membrane.
ii. The appearance of the nucleolus.
iii. Division of centromere.
iv. Replication of DNA (4 marks)

d. Telophase is the reverse of prophase. Elucidate the statement (4 marks)

e. You have an individual who is totally heterozygous for 2 genes that are not linked (i.e., not on the same chromosome). One gene is for ear size (**AA** and **Aa** being big ears whereas **aa** is for small ears) and the other gene is for buggy eyes (**BB** and **Bb** for buggy eyes whereas **bb** represents normal eyes). If you test cross this individual, what are the resulting genotypes and phenotypes? (8 marks)

AA and Aa (BB Bb)

Aa Bb

END OF EXAM

basic, acidic, polar, non-polar hydrophobic hydrophilic

BI 110 marking key 2023

Question 1

1 i) D

2 ii) A

3 iii) C

4 iv) D

5 v) C

6 vii) B

7 viii) B

8 ix) D

9 x) C

10 D

Question 2

2. a. Compare and contrast the imaging capabilities and application of the differential interference microscope and scanning tunnelling microscope? **(6 marks)**

Similarity

- Both the DIC and STM microscopes use a probe-sample interaction to generate an image **[2]**

Differences (Any of the two answers)

- The DIC microscope provides both amplitude and phase information about the sample and allows for the visualization of fine surface details; while the STM uses a sharp metallic tip to scan the surface of the sample and detect the tunnelling current between the tip and the surface;
- The DIC microscope has a lower resolution; compared to the STM microscope that is capable of creating high-resolution images with atomic-level detail;
- The DIC microscope is commonly used in biology, materials science, and geology to study transparent or low-contrast samples; while the STM microscope is used in materials science and physics to study the surface properties of conductive materials

and investigate atomic-level phenomena such as quantum tunnelling; (Accept any of the two) [4]

b. How do the three postulates of the cell theory help us understand the fundamental properties and behaviours of living organisms? (2 marks)

- The cell theory is a critical framework that helps us understand the basic properties and behaviours of living organisms;
- it provides a foundation for studying the structure and function of cells;
- Explaining the diversity of life;
- understanding the continuity of life;
- and advancing medical research; (Accept any of the two) [2]

c. State the structural differences between a gram positive and gram negative bacteria. (2 marks)

Gram-positive bacteria have a thick peptidoglycan layer outside the cell membrane; in contrast, gram-negative bacteria have a thinner peptidoglycan layer sandwiched between two membranes (an outer membrane and an inner membrane) with a periplasmic space in between;

Gram positive bacteria have teichoic acids embedded in their peptidoglycan layer, which provide additional support to the cell wall; while gram negative bacteria contains lipopolysaccharides (LPS), which can cause an immune response in humans; (Accept any of the two)

Question 3

3. (a) The four major components of an amino acid are:

1. Amino group (-NH2)
2. Carboxyl group (-COOH)
3. Hydrogen atom (H)
4. Side chain or R-group

Amino acids can be grouped according to the physical and chemical properties of their side chains. This classification is based on the characteristics of the R-group, which can be polar, nonpolar, Ionizable (acidic), Aromatic (basic), or special function.

1. Nonpolar amino acids, such as leucine, often have R groups that contain —CH2 or —CH3.

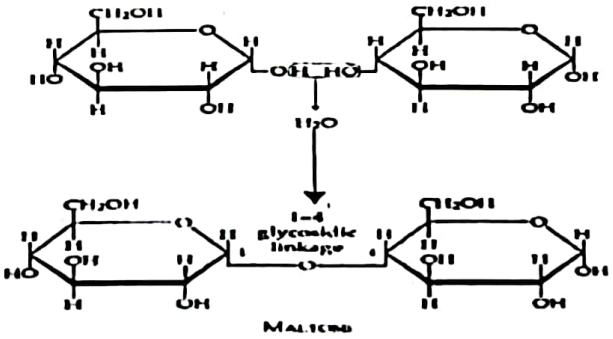
2. Polar uncharged amino acids, such as threonine, have R groups that contain oxygen (or only —H).

3. Ionizable amino acids, such as glutamic acid, have R groups that contain acids or bases.

4. Aromatic amino acids, such as phenylalanine, have R groups that contain an organic (carbon) ring with alternating single and double bonds.

5. Special-function amino acids have unique individual properties; methionine often is the first amino acid in a chain of amino acids, proline causes kinks in chains, and cysteine links chains together.

3(b) The formation of an alpha glycosidic linkage occurs through a condensation reaction between two monosaccharides, in which a molecule of water is removed. Alpha glycosidic linkages are commonly found in many polysaccharides, including glycogen, starch, and maltose.



3(c) Complementary base pairing plays a crucial role in the functions of nucleic acids, which are the building blocks of genetic information in living organisms. In both DNA and RNA, complementary base pairing enables the storage and transmission of genetic information, and also plays a role in various cellular processes such as replication, transcription, and translation.

In DNA, the double helix structure is formed by the complementary base pairing of nucleotide bases, in which adenine (A) pairs with thymine (T) through two hydrogen bonds, and cytosine (C) pairs with guanine (G) through three hydrogen bonds. This base pairing is specific, meaning that A only pairs with T, and C only pairs with G. This specificity ensures that the genetic information stored in DNA is accurately replicated and transmitted during cell division, and also enables the accurate sequencing of DNA.

In RNA, base pairing also plays a key role in the regulation of gene expression and in the formation of the ribosome during translation. RNA molecules can form base pairs with other RNA molecules, as well as with single-stranded DNA. For example, RNA strand through

base pairing, resulting in a messenger RNA (mRNA) molecule that carries the genetic information from the DNA to the ribosome. In addition, the ribosome itself is made up of RNA molecules that base pair with each other to form a complex, three-dimensional structure that enables protein synthesis.

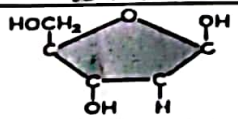
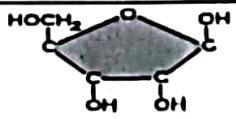
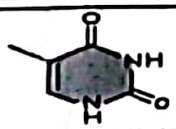
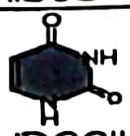
Overall, the complementary base pairing of nucleotide bases in nucleic acids is essential for the accurate storage and transmission of genetic information, and also plays a key role in a wide range of cellular processes that are essential for life and avoids formation of mutated cells.

3(d) DNA and RNA are closely related. DNA contains the genetic information necessary for encoding proteins, although it does not produce proteins directly. RNA carries the information from the DNA and transforms that information to produce proteins that perform most cellular functions.

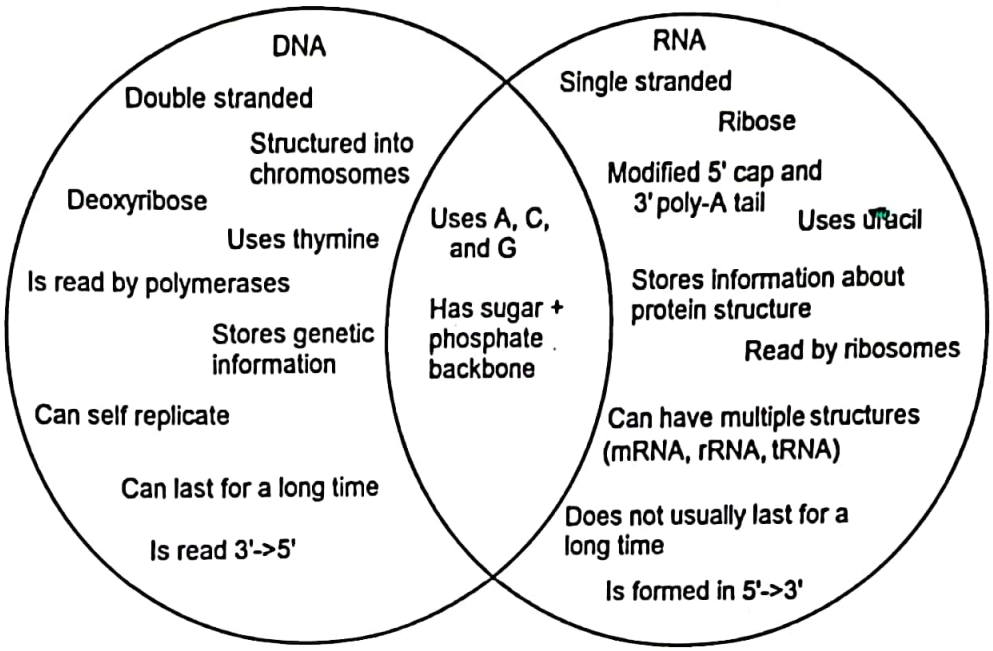
Functional Difference: DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) are very similar molecules that serve very different functions. DNA is responsible for long term storage of genetic information. It resides in the nucleus of eukaryotic cells. RNA, on the other hand, is responsible for several important processes including transporting the genetic information found in DNA to other sites in the cell where it can be used to make proteins. It is found in the cytoplasm of a cell.

Structural Difference: DNA and RNA are made up of nucleotides. These tiny subunits are made of a sugar, nitrogenous base, and phosphate group. The differences start to show up when we take a closer look at their structures. The most obvious difference is that DNA is a **double-stranded** molecule, while RNA is **single-stranded**. DNA is also much longer than RNA. While both DNA and RNA have sugar molecules in their subunits, those sugars are slightly different. DNA uses **deoxyribose**, but RNA uses **ribose**, which has an extra **hydroxyl** group (OH), tacked on.

DNA and RNA also have nearly identical nitrogenous bases. Both have the bases adenine, cytosine, and guanine. However, DNA uses a fourth base called **thymine**. RNA's fourth base is **uracil**.

	DNA	RNA
SUGAR	 DEOXYRIBOSE	 RIBOSE
BASE	 THYMINE	 URACIL

Other differences between DNA and RNA



Question 4

a. **Differentiate between chromatin and chromatid.** [2]

CHROMATIN	CHROMATID
It is the diffused, deep staining hereditary material.	It is longitudinally split half of a chromosome, light staining hereditary material.
It is metabolically inert.	It is metabolically active

It's the indistinguishable mass of DNA molecules	They are part of chromosome attached to it with a centromere.
It's the material that makes up chromosomes	They are the two parts of a chromosome that are joined together during cell division.

b. **How is a G1 arrest different from G0 in the cell cycle?** [2]

G1 arrest is sort of the body's way of saying "something is wrong, you shall not pass" to a cell. There is a checkpoint in G1 where the cell is looking to see if there is anything wrong, hence removing any cells that are potentially cancerous.

G0 on the other hand is more of a natural resting phase for the cell where it is no longer dividing or preparing to divide. Some cells go into this stage naturally and although they continue to function they are no longer growing and dividing (such as heart cells). The cells are sometimes called 'quiescent' because they will never re-enter G1 from the resting period, whereas other cells in G0 may.

c. Write the phases of the cell cycle against each of the events.

i. The disintegration of the nuclear membrane
PROPHASE [1]

ii. The appearance of the nucleolus.
TELOPHASE [1]

iii. Division of centromere.
ANAPHASE [1]

iv. Replication of DNA.
S-PHASE [1]

d. Telophase is the reverse of prophase. Elucidate the statement [4]

Prophase events are reversed during the telophase stage. During the **prophase stage**, condensation of chromosomes takes place and also the centrosomes move to opposite sides of the nucleus, forming spindle fibers. The nuclear envelope disappears completely and the nucleolus gradually breaks down at the end of the prophase or in the late prophase.

On the other hand, as the **telophase stage** begins, the spindle dissolves (is absorbed in the cytoplasm) and the chromosomes become decondense and lose even more of their individuality after reaching their respective poles. Finally, a nuclear membrane develops around each set of chromosomes which separates the nuclear deoxyribonucleic acid (DNA) from the cytoplasm. Additionally, the nucleolus, Golgi complex, and ER reappear during telophase. Thus, it can be inferred that the events taking place during the telophase stage are the reverse of the events occurring in the prophase stage. **Hence, telophase is the reverse of prophase.**

e. You have an individual who is totally heterozygous for 2 genes that are not linked (i.e., not on the same chromosome). One gene is for ear size (**AA** and **Aa** being big ears whereas **aa** is for small ears) and the other gene is for buggy eyes (**BB** and **Bb** for buggy eyes whereas **bb** represents normal eyes). If you **test cross** this individual, what are the resulting genotypes and phenotypes?

AaBb X aabb

	ab	ab	ab	Ab
AB	AaBb	AaBb	AaBb	AaBb
Ab	Aabb	Aabb	Aabb	Aabb
Ab	aaBb	aaBb	aaBb	aaBb
ab	aabb	aabb	aabb	Aabb

[5]

Thus you get the following

Percentages	Genotypes	Phenotypes
25%	AaBb	Big ears, Buggy eyes
25%	Aabb	Big ears, Normal eyes
25%	aaBb	Small ears, Buggy eyes
25%	aabb	Small ears, Normal eyes

[3]