

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BEng (HONS) BIOMEDICAL ENGINEERING and
BEng (HONS) MEDICAL ENGINEERING

SEMESTER ONE EXAMINATIONS 2022/23

MOLECULAR PRINCIPLES OF BIOMEDICAL
ENGINEERING

MODULE NO: BME4002

Date: Monday 9th January 2023

Time: 14:00 – 16:00

INSTRUCTIONS TO CANDIDATES:

Candidates are advised that the examiners attach importance to legibility of writing and clarity of expression. **YOU ARE STRONGLY ADVISED TO PLAN YOUR ANSWERS**

There are **THREE** sections.

Answer **ALL** questions from Section A and Section B.

Answer **ONE** question from Section C.

Write all answers in your answer booklet.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Calculators are permitted, but all working must be shown.

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SECTION A: Answer ALL questions in this section; 1 mark per question, 30 marks in total.

1. Unlike DNA, RNA contains:
 - a. Adenine.
 - b. Uracil.
 - c. Phosphate groups.
 - d. Thymine.

2. What is produced during translation?
 - a. tRNA.
 - b. mRNA.
 - c. Polypeptides.
 - d. None of the above.

3. The covalent bonds that contribute towards holding the tertiary structure of a protein together are called:
 - a. Disulphide bonds.
 - b. Phosphodiester bonds.
 - c. Glycosidic bonds.
 - d. Ester bonds.

4. Point mutations:
 - a. Can have no effect on the resulting protein structure.
 - b. Can have a minor effect on the resulting protein structure.
 - c. Can have a major effect on the resulting protein structure.
 - d. All of the above are true.

5. Amino acids contain carbon, hydrogen, oxygen, and what other main element?
 - a. Nitrogen.
 - b. Phosphorous.
 - c. Iron.
 - d. Magnesium.

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6. If a double stranded DNA molecule is found to be composed of 30% cytosine, how much guanine would be expected?

- a. 20%.
- b. 30%.
- c. 50%.
- d. 70%.

7. When NaCl is dissolved in water, the NaCl is the _____ and the resulting liquid is the _____.

- a. Solvent; solution.
- b. Solute; solvent.
- c. Solute; solution.
- d. Solvent; solute.

8. Which of the following is a function of the mitochondria?

- a. Detoxification of poisons.
- b. Production of ATP.
- c. rRNA synthesis.
- d. Protein folding.

9. If 2 moles of NaCl is dissolved in 500 mL of water, what is the concentration of the resulting solution?

- a. 0.004 M.
- b. 0.5 M.
- c. 2 M.
- d. 4 M.

10. Which of the following is correct?

- a. $M_r = \text{mass} \times \text{moles}$
- b. $\text{Moles} = M_r \div \text{mass}$
- c. $\text{Moles} = \text{mass} \times M_r$
- d. $\text{Moles} = \text{mass} \div M_r$

11. Which of the following are found in prokaryotic AND eukaryotic cells?

- a. Ribosomes.
- b. Chloroplasts.
- c. Smooth endoplasmic reticulum.
- d. Nucleus.

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12. The fatty acids in a phospholipid molecule attach to:
- Inositol.
 - Glycerol.
 - Phosphate.
 - Glucose.
13. Which of the following is not an example of a cell signalling cellular "response"?
- Change in gene expression.
 - Activation of enzymes.
 - Hormone binding to a cell-surface receptor.
 - Secretion of proteins.
14. In RNA, _____ codon(s) translate to _____ amino acid(s)
- 1; 1.
 - 3; 1.
 - 1; 3.
 - 1; 20.
15. How many chromosomes does a human cell have when it is not undergoing cell division?
- 22.
 - 23.
 - 44.
 - 46.
16. Which of the following temperatures (in °C) would be appropriate to be used as the 1st, 2nd and 3rd temperatures respectively of a PCR cycle?
- 55, 95, and 72.
 - 55, 72, and 95.
 - 72, 95 and 55.
 - 95, 55, and 72.
17. Which of the following is not an important factor in membrane fluidity?
- The proportion of unsaturated fats.
 - The proportion of saturated fats.
 - The presence of albumin.
 - The presence of cholesterol.

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18. Which of the following is not a fibrous protein?
- Collagen.
 - Keratin.
 - Elastin.
 - Porin.
19. The bond between two nucleotides in a single strand of DNA is an example of a/an_____:
- Covalent bond.
 - Ionic bond.
 - Hydrogen bond.
 - Peptide bond.
20. Which of the following is not a type of chromosomal aberration?
- Inversion.
 - Duplication.
 - Isolation.
 - Translocation.
21. Which of the following mutation types results in a protein being prematurely truncated during translation?
- Silent.
 - Synonymous.
 - Nonsense.
 - Missense.
22. Amino acids are joined together into a protein chain by which of the following?
- Ribosomes.
 - DNA polymerase.
 - Hydrogen bonds.
 - Messenger RNA.
23. Which of the following statements about enzymes is NOT true?
- Enzymes act as catalysts.
 - Enzymes can provide a microenvironment in which reactions take place.
 - Enzymes are unchanged by the chemical reaction in which they are involved.
 - Enzymes are unspecific and can therefore generally recognise multiple substrates.

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24. Which of the following are not applications of PCR?

- a. Cloning.
- b. Protein quantification.
- c. Gene expression studies.
- d. Mutagenesis.

25. For the following DNA template strand, which of the options below corresponds to the mRNA that would be formed following transcription, written 5' to 3'?

Template strand: 3'-G G A C T G A T T-5'

- a. 5'-C C T G A C T A A-3'
- b. 5'-C C U G A C U A A-3'
- c. 5'-G G A C T G A T T-3'
- d. 5'-G G A C U G A U U-3'

26. How many different codons are possible?

- a. 3.
- b. 20.
- c. 64.
- d. An infinite number.

27. The absence of double bonds makes a fatty acid:

- a. Saturated.
- b. Hydrogenated.
- c. Oxygenated.
- d. Unsaturated.

28. Energy is released when:

- a. A phosphate group is added to a molecule of ATP.
- b. A phosphate group is released from a molecule of ATP.
- c. A phosphate group is either added or released from a molecule of ATP.
- d. A nitrate group is released from a molecule of ATP.

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29. Which of the following statements about water molecules is true?

- a. The molecule is completely uncharged.
- b. The molecule is slightly charged.
- c. The molecule is ionic.
- d. The molecule has a lattice structure.

30. The cytosol:

- a. Has a pH less than 6.
- b. Is predominantly made of water.
- c. Has a thin consistency.
- d. Is found in between cells.

[Total for Section A: 30 marks]

SECTION B: Answer ALL questions in this section; 5 marks per question, 40 marks in total.

1. Describe, with examples, the different types of DNA mutation.

[5 marks]

2. A patient presents herself at a genetic counselling clinic saying that her and her partner want to have a baby, but she is concerned that any child she has may have the autosomal recessive condition spinal muscular atrophy. She herself is a carrier for the mutation which causes the disease, and previous tests have shown that her partner is also a carrier for the same mutation. With the use of a Punnett square calculate the percentage likelihood of their baby being affected by the disease. Finally, comment on whether or not the child is more likely to have the disease if it is a biological male rather than female.

[5 marks]

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3. Design the PCR primers (15 bases in length) which would be required to copy the target region (red) of the sequence below (Figure 1). What would be the size (in base pairs) of the resulting product?

5' TGCCGATCGCGCTAAAGCTCGTAAGCTCGCTAGATCGCTCTAAAAGCTCGCTATGCTCGAAAT 3'
Figure 1: DNA sequence for Question 3

[5 marks]

4. Describe, with the help of illustrations, the chemical composition and structure of double-stranded DNA.

[5 marks]

5. You are working as a technician in a medical laboratory.

- a) Describe how you would make 600 mL of a 0.4 M solution of NaCl.
(Molar Mass Na = 23; Molar Mass Cl = 35).

[3 marks]

- b) How would you dilute the solution described in part (a) to make 0.2 L of a 100 mM solution?

[2 marks]

[Total 5 marks]

6. Explain what is meant by the terms “recessively” and “dominantly” inherited traits.

[5 marks]

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7. Name the 5 structures labelled A-E in the diagram of a eukaryotic cell shown below in diagram 7A and state the principal function of each of the structures.

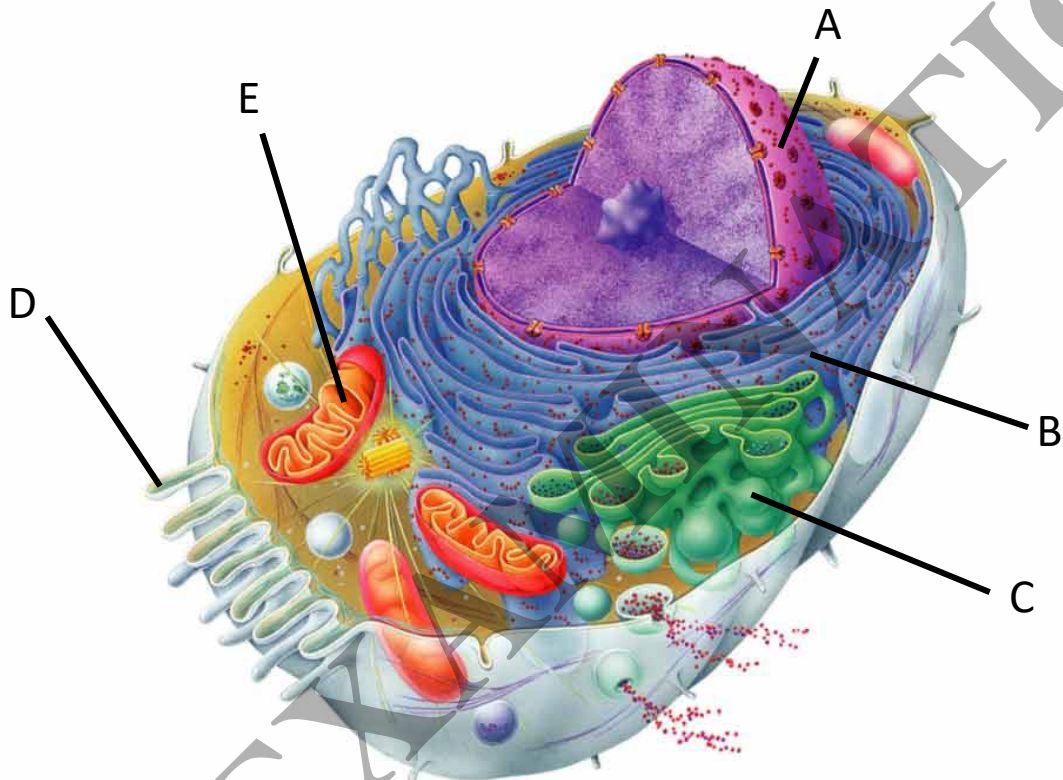


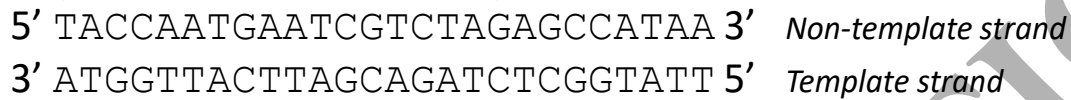
Diagram 7A

[5 marks]

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Position 1

Position 18



- a) Assuming transcription begins at position 1, what sequence of mRNA would be produced during transcription? [1 mark]
- b) Using the information supplied in Table 1 (see below), what amino acid sequence would be produced from your mRNA sequence in part (a) during translation? [2 marks]
- c) What would happen if the DNA base in the **template strand** at position 18 was mutated from C to G?

[1 mark]

[2 marks]

[2 marks]

[Total 5 marks]

Table 1: The Genetic Code

		Second letter								
		U		C		A		G		
First letter	U	UUU	} Phe	UCU	} Ser	UAU	} Tyr	UGU	} Cys	U
		UUC		UCC		UAC		UGC		C
		UUA		UCA		UAA		UGA		A
		UUG	UCG	UAG	UGG	G				
	C	CUU	} Leu	CCU	} Pro	CAU	} His	CGU	} Arg	U
		CUC		CCC		CAC		CGC		C
		CUA		CCA		CAA		CGA		A
		CUG	CCG	CAG	CGG	G				
	A	AUU	} Ile	ACU	} Thr	AAU	} Asn	AGU	} Ser	U
		AUC		ACC		AAC		AGC		C
		AUA		ACA		AAA		AGA		A
		AUG	ACG	AAG	AGG	G				
	G	GUU	} Val	GCU	} Ala	GAU	} Asp	GGU	} Gly	U
		GUC		GCC		GAC		GGC		C
		GUA		GCA		GAA		GGA		A
		GUG	GCG	GAG	GGG	G				
										Third letter

[Total for Section B: 40 marks]
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SECTION C: Answer ONE question only; 30 marks.

1. Explain the processes by which a cell uses the information contained within DNA to synthesise proteins. You should include an explanation of the genetic code in your answer.

[30 marks]

OR

2. Write an essay on the polymerase chain reaction, with reference to the purpose, mechanism and reagents involved.

[30 marks]

OR

3. Write an essay on proteins. In your answer you should include an account of how proteins fold and describe some of their functions.

[30 marks]

[Total for Section C: 30 marks]

END OF PAPER