National Exams May 2018

04-Bio-A3, Cellular and Molecular Biology and Biochemistry

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a CLOSED BOOK EXAM.
   One of two calculators is permitted - any Casio or Sharp approved model.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. This exam contains a question with true and false statements. NOTE: THE MARKING SCHEME FOR THE TRUE AND FALSE QUESTION IS +0.67 FOR A CORRECT ANSWER, 0 FOR A BLANK STATEMENT, -0.67 FOR AN INCORRECT ANSWER.

6. Most questions require an answer in essay format. ***Clarity and organization of the answer are important.***

Q	Mark
1	/20
2	/20
3	/20
4	/20
5	/20
Total	/100

Marking Scheme:

Question 1: Cell structure and function (20 marks total)

a. (5 marks)
b. (5 marks)
c. (5 marks)
d. (5 marks)

Question 2: Relationship of chemical and physical structure of proteins to function including regulation of enzyme activity. (20 marks total)

a. (5 marks)
b. (15 marks total)
   i. (3marks)
   ii. (3 marks)
   iii. (9 marks)

Question 3: Development and use of recombinant proteins as therapeutic drugs, and fundamentals of therapeutic protein action. (20 marks total)

a. (8 marks)
b. (12 marks total)
   i. (3marks)
   ii. (3 marks)
   iii. (2 marks)
   iv. (2 marks)
   v. (2 marks)

Question 4: Techniques used for imaging, identification and measurement of biological materials. (20 marks total)

a. (6 marks)
b. (6 marks)
c. (8 marks)

Question 5: Recombinant DNA technology including cloning, directed mutagenesis, DNA sequencing and expression of cloned genes, site specific mutation of proteins. (20 marks total)

a. (5 marks)
b. (10 marks)
c. (5 marks)

Question 6: Cellular and Molecular Biology and Biochemistry (20 marks total)

1-30: (0.67 marks each for correct answers)
Note: THE MARKING SCHEME FOR THE TRUE AND FALSE QUESTION IS +0.67 FOR A CORRECT ANSWER, 0 FOR A BLANK STATEMENT, -0.67 FOR AN INCORRECT ANSWER.

Synopsis of Examination Paper

1. This is a question on cell structure and function.
2. This is a question on the relationship of chemical and physical structure of proteins to function including regulation of enzyme activity.
3. This is a question on the development and use of recombinant proteins as therapeutic drugs, and fundamentals of therapeutic protein action.
4. This is a question on techniques used for imaging, identification and measurement of biological materials.
5. This is a question on recombinant DNA technology including cloning, directed mutagenesis, DNA sequencing and expression of cloned genes, site specific mutation of proteins.
6. This is a question on cellular and molecular biology and biochemistry.

Question 1: Cell structure and function (20 marks total)

a) **(5 marks)** Explain in your own words the importance of lipid membranes in living organisms. Use complete sentences.

b) **(5 marks)** Provide evidence to suggest which elements (4) are the most abundant in living cells? Good evidence would include the molecular composition of major chemical constituents of a cell. Justify your answer.

c) **(5 marks)** There are many ways material can enter the cell. For small molecules, it is possible for them to cross the membrane simply by diffusion, which can be described by the equation below. In your own words explain the different terms and variables in the equation below, and the driving principle behind passive diffusion.

$$\frac{dm}{dt} = -kA(C_i - C_o)[=]kg/s$$

d) **(5 marks)** Sketch the difference between *facilitated* diffusion and active transport of molecules across a phospholipid bilayer.

Question 2: Relationship of chemical and physical structure of proteins to function including regulation of enzyme activity. (20 marks total)

a) **(5 marks)** Explain in your own words the importance of the tertiary structure of proteins in creating a catalytic domain in an enzyme. Use complete sentences.

b) **(15 marks)** The rate of a simple enzyme reaction is given by the Michaelis-Menten equation. If the maximum reaction rate (V_{max}) for the enzyme is 100 umoles/sec and the Michaelis-Menten constant (K_M) is 1 mM, estimate the reaction rate at:

i) **(3 marks)** 0.8 mM

ii) **(3 marks)** 1.2 mM

iii) **(9 marks)** Justify your answer by plotting a graph of reaction rate vs substrate concentration and labeling key features (including V_{max} and K_M)

Question 3: Development and use of recombinant proteins as therapeutic drugs, and fundamentals of therapeutic protein action (20 marks total)

Recombinant proteins can be made in a variety of cells from *Escherichia coli* cells (*E. coli*) to Chinese Hamster Ovary (CHO) cells.

a) **(8 marks)** What are the major differences between these two types of cells? Answer in complete sentences.

b) **(12 marks)** Recombinant antibodies figure prominently as therapeutic drugs. Answer in complete sentences.

i. **(3 marks)** What is an antibody?

ii. **(3 marks)** What is the primary function of an antibody?

iii. **(2 marks)** What can be a secondary function of an antibody?

iv. **(2 marks)** What post-translational modification in a cell can aid in the efficacy of the molecule as a therapeutic?

v. **(2 marks)** What happens during the aforementioned post-translation modification?

Question 4: Techniques used for imaging, identification and measurement of biological materials. (20 Marks Total)

a) (6 marks) In your own words, describe confocal microscopy and what it can be used for?

b) (6 marks) In your own words, describe electron microscopy and what it can be used for?

c) (8 marks) What is meant by cell viability? Would you use either of the microscopy methods in a) or b) to assess the viability of cells? Explain?

Question 5: Recombinant DNA technology including cloning, directed mutagenesis, DNA sequencing and expression of cloned genes, site specific mutation of proteins. (20 marks total)

An important technique in cloning genes is the polymerase chain reaction (PCR).

a) (5 marks) What materials are required to perform a PCR?

b) (10 marks) A PCR is run for 24 cycles to amplify a single strand of DNA in a sample. At the end of the 24 cycles, it was found that multiple products resulted from the amplification. Is this possible? Explain.

c) (5 marks) If the initial copy number of your template DNA was 10, how many strands of DNA would you expect to have after 10 PCR cycles? Explain any and all assumptions.

Question 6: Cellular and Molecular Biology and Biochemistry (20 marks total)

NOTE: THE MARKING SCHEME FOR TRUE AND FALSE QUESTIONS IS +0.67 FOR CORRECT ANSWER, 0 FOR BLANK STATEMENT, -0.67 FOR INCORRECT ANSWER.

1. Pyrimidine nitrogenous bases in nucleotides that make up deoxyribonucleic acid include guanine and adenine.	
2. Nucleotides of ribonucleic acid contain hydroxyl groups (-OH) at the 2 and 3 carbon of their sugar moiety.	
3. RNA is less stable compared to DNA because of the number of hydroxyl groups (-OH) groups present on the sugar moiety of its nucleotides.	
4. Okazaki fragments are short strands of DNA that are made in a discontinuous fashion during DNA replication	
5. Okazaki fragments occur on what is known as the lagging strand.	
6. DNA polymerase is a molecule involved in DNA replication.	
7. RNA polymerase is a molecule involved in translation.	
8. In Eukaryotes, there are at least three different types of RNA polymerase.	
9. An operon is a sequence of genes in Prokaryotes that are transcribed together into a single mRNA.	
10. An operator site, which is different from an operon, is a sequence of DNA where either a repressor protein or an activator protein can bind.	

11. The Pribnow box and the TATA box are elements of promoter sequences in Prokaryotes and Eukaryotes respectively.	
12. A Shine-Dalgarno sequence serves as a ribosomal binding site and is generally upstream from the start codon	
13. Although both prokaryotic and eukaryotic ribosomes consist of two subunits; eukaryotic ribosomes have four different types of rRNA, whereas prokaryotic ribosomes have three different types of rRNA.	
14. Ribosome subunits and rRNA are characterized by how they separate under centrifugal force.	
15. Of the three major types of RNA, transfer RNA, also known as tRNA, is typically composed of the smallest number of nucleotides.	
16. Cells that thrive under aerobic conditions produce significantly more ATP through the electron transport chain than during glycolysis.	
17. Enzymes increase the activation energy required for chemical reactions to proceed.	
18. Kinases are enzymes that rearrange the position of atoms such that the molecular formula stays the same even though the resulting molecule is different.	
19. Ribosomes are composed of two DNA subunits.	
20. Proteins can be made up of multiple polypeptide chains.	

21. Methionine in a polypetide chain can form a disulfide bond with another methionine in a polypeptide chain.	
22. More hydrogen bonds form between adenine and thymine than between guanine and cytosine in molecules of DNA.	
23. Restriction enzymes are enzymes that can cut DNA in locations with a particular nucleotide sequence.	
24. Apoptosis is a "programmed" cell death i.e. the cell takes cues from the environment that lead to a cascade of events ultimately resulting in the controlled destruction of the cell.	
25. Introns are segments of DNA that code for a gene.	
26. Prokaryotes are characterized by having their genomic material surrounded by a nuclear membrane distinct from the cytoplasmic membrane.	
27. There are different nucleotides for prokaryotic and eukaryotic organism.	
28. Some organelles found in eukaryotes are on the same order of size as prokaryotic organisms.	
29. Viruses cannot be seen using a light microscope.	
30. Codons are composed of a sequence of three nucleotides in the coding strand of DNA (as opposed to the template strand) or in messenger RNA	