



Strathmore University

Institute of Mathematical
Sciences

Master of Science in Biomathematics

April 2020

BMA 8204: Introduction to Computational and Structural Biology

Date: 7th September 2020

Duration: 4 Hours

Answer **Question 1** and any other two questions

Question 1 [30 marks]

- a) State the *central dogma* of information flow in biology. [5 marks]
- b) Describe the DNA structure, pointing out the importance of the Nitrogenous bases C, G, A, & T. What are the bases in the corresponding RNA structure? [7 marks]
- c) Describe the translation process from mRNA to protein. [3 marks]
- d) Illustrate, by aid of a diagram, what happens in the transcription of HIV in a human cell, bringing out clearly the roles of reverse transcriptase and mRNA. [15 marks]

Question 2 [15 marks]

- a) In genetic sequencing,
 - i. Define the term *Phylogeny* [3 marks]
 - ii. Mention two types of data that can be used in building phylogenetic trees. [2 marks]
- b) Determine a “distance” between the following two genetic sequences
ACGTTAGCT
ACCTAAG -T
Mention other methods for calculating the distance. [10 marks]

Question Three [15 marks]

A per unit of time mutation occurs with intensity or rate μ . The number of events that can take place is an integer number. Let $P_n(t)$ denote the probability that exactly n mutations occurred during the time t :

$$P_n(t) = P(X(t) = n).$$

The probability that exactly one mutation happens during time interval $[t, t+\delta t]$ is $\mu\delta t$. Ignoring the possibility of having more than one mutation during the time interval the probability of no mutation in $[t, t+\delta t]$ is then $1 - \mu\delta t$. In other words, we are assuming that, at time $t + \delta t$, the number of mutations either remains unchanged or increases by one. More formally

$$P_0(t + \delta t) = (1 - \mu\delta t)P_0(t).$$

Hence show that

$$P_0'(t) = -\mu P_0(t) \quad (3 \text{ marks})$$

and thus

$$P_0(t) = e^{-\mu t}. \quad (5 \text{ marks})$$

Similarly show that

$$P_1'(t) = -\mu P_1(t) + \mu P_0(t)$$

Hence derive expression for $P_1(t)$. **(7 marks)**

Question Four [15 marks]

a. In relation to phylogenetics define the following terms:

i. A tree of life; **(1 mark)**

ii. Genetic distance between individuals; and **(1 mark)**

iii. Mention two methods that could be used to build trees. **(2 marks)**

d. Consider the following distance matrix for a genetic tree:

	A	B	C	D	E
A	0		10		16
B	7			10	
C		8	0		8
D	12		5		
E		14		5	0

i. Fill the empty rectangles of the distance matrix. **(5 marks)**

ii. Construct an undirected tree that fits the matrix. **(6 marks)**