UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE AND ENGINEERING
DEPARTMENT OF BIOLOGICAL SCIENCES

MAIN EXAMINATION PAPER 2016/2017

PROGRAMMES: B.Sc. II
B. Ed Secondary II

COURSE CODE: BIO202

TITLE OF PAPER: INTRODUCTORY MOLECULAR BIOLOGY

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

1. ANSWER QUESTION ONE (COMPULSORY) IN SECTION A AND ANY OTHER TWO QUESTIONS IN SECTION B.

2. QUESTION 1 CARRIES 50 MARKS AND EACH QUESTION IN SECTION B CARRIES 25 MARKS.

3. USE THE PROVIDED GRID FOR ANSWERS TO QUESTION 1A.

4. ILLUSTRATE YOUR ANSWERS WITH LARGE CLEARLY LABELLED DIAGRAMS WHERE APPROPRIATE

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BIO202 INTRODUCTORY MOLECULAR BIOLOGY

STUDENT ID NUMBER _____

Place an 'X' against the most appropriate answer. For instance if the answer for Question 99 is D, the answer school appear as shown below.

Question	A	B	C	D	E
99				X	

Question	A	B	C	D	E
1					
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SECTION A [Compulsory]

Question 1A (Multiple Choice, Total Marks = 20]

1. The most precise modern definition of a gene is a segment of genetic material that:
   A) codes for one polypeptide.
   B) codes for one polypeptide or RNA product.
   C) determines one phenotype.
   D) determines one trait.
   E) that codes for one protein.

2. The DNA in a bacterial (prokaryotic) chromosome is best described as:
   A) a single circular double-helical molecule.
   B) a single linear double-helical molecule.
   C) a single linear single-stranded molecule.
   D) multiple linear double-helical molecules.
   E) multiple linear single-stranded molecules.

3. Which of these statements about nucleic acids is *false*?
   A) Mitochondria and chloroplasts contain DNA.
   B) Plasmids are genes that encode plasma proteins in mammals.
   C) The chromosome of *E. coli* is a closed-circular, double-helical DNA.
   D) The DNA of viruses is usually much longer than the viral particle itself.
   E) The genome of many plant viruses is RNA.

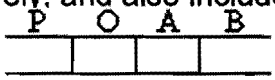
4. The DNA in a eukaryotic chromosome is best described as:
   A) a single circular double-helical molecule.
   B) a single linear double-helical molecule.
   C) a single linear single-stranded molecule.
   D) multiple linear double-helical molecules.
   E) multiple linear single-stranded molecules.

5. The fundamental repeating unit in a eukaryotic chromosome is the:
   A) centrosome.
   B) lysosome.
   C) microsome.
   D) nucleosome.
   E) polysome.

6. Which of the following statements *correctly* describes promoters in *E. coli*?
   A) A promoter may be present on either side of a gene or in the middle of it.
   B) All promoters have the same sequence that is recognized by RNA polymerase holoenzyme.
   C) Every promoter has a different sequence, with little or no resemblance to other promoters.
   D) Many promoters are similar and resemble a consensus sequence, which has the highest affinity for RNA polymerase holoenzyme.
   E) Promoters are not essential for gene transcription, but can increase its rate by two- to three-fold.

7. The operator region normally can be bound by:
A) attenuator.
B) inducer.
C) mRNA.
D) repressor.
E) suppressor tRNA.

8. The diagram below represents a hypothetical operon in the bacterium *E. coli.* The operon consists of two structural genes (A and B) that code for the enzymes A-ase and B-ase, respectively, and also includes P (promoter) and O (operator) regions as shown.



When a certain compound (X) is added to the growth medium of *E. coli,* the separate enzymes A-ase and B-ase are both synthesized at a 50-fold higher rate than in the absence of X (which has a molecular weight of about 200). Which one of the following statements is *true* of such an operon?
A) Adding X to the growth medium causes a repressor protein to be released from the O region.
B) Adding X to the growth medium causes a repressor protein to bind tightly to the O region.
C) Synthesis of the mRNA from this operon is not changed by the addition of compound X.
D) The mRNA copied from this operon will be covalently linked to a short piece of DNA at the 5′ end.
E) Two mRNA molecules are made from this operon, one from gene A the other from gene B.

9. Which of the following statements about regulation of the *lac* operon is *true*?

A) Glucose in the growth medium decreases the inducibility by lactose.
B) Glucose in the growth medium does not affect the inducibility by lactose.
C) Glucose in the growth medium increases the inducibility by lactose.
D) Its expression is regulated mainly at the level of translation.
E) The *lac* operon is fully induced whenever lactose is present.

10. A regulon is a(n):
A) group of related triplet codons.
B) network of operons with a common regulator.
C) operon that is subject to regulation.
D) protein that regulates gene expression.
E) ribosomal protein that regulates translation.

11. The tryptophan operon of *E. coli* is repressed by tryptophan added to the growth medium. The tryptophan repressor probably:
A) binds to RNA polymerase when tryptophan is present.
B) binds to the *trp* operator in the absence of tryptophan.
C) binds to the *trp* operator in the presence of tryptophan.
D) is a DNA sequence.
E) is an attenuator.

12. Which one of the following statements about eukaryotic gene regulation is *correct*?
A) Large polycistronic transcripts are common.
B) Most regulation is positive, involving activators rather than repressors.
C) Transcription and translation are mechanistically coupled.
D) Transcription does not involve promoters.
E) Transcription occurs without major changes in chromosomal organization.

13. Which one of the following statements about eukaryotic versus prokaryotic gene regulation is *not* correct?
A) Access to eukaryotic promoters is restricted by the structure of chromatin.
B) Most regulation is positive, involving activators rather than repressors.
C) Larger and more multimeric proteins are involved in regulation of eukaryotic transcription.
D) Transcription and translation are separated in both space and time.
E) Strong promoters in eukaryotes are generally fully active in the absence of regulatory proteins.

14. Which of the following is *not* true of tRNA molecules?
A) The 3′-terminal sequence is —CCA.
B) Their anticodons are complementary to the triplet codon in the mRNA.
C) They contain more than four different bases.
D) They contain several short regions of double helix.
E) With the right enzyme, any given tRNA molecule will accept any of the 20 amino acids.

15. Aminoacyl-tRNA synthetases (amino acid activating enzymes):
A) "recognize" specific tRNA molecules and specific amino acids.
B) in conjunction with another enzyme attach the amino acid to the tRNA.
C) interact directly with free ribosomes.
D) occur in multiple forms for each amino acid.
E) require GTP to activate the amino acid.

16. The enzyme that attaches an amino acid to a tRNA (aminoacyl-tRNA synthetase):
A) always recognizes only one specific tRNA.
B) attaches a specific amino acid to any available tRNA species.
C) attaches the amino acid at the 5′ end of the tRNA.
D) catalyzes formation of an ester bond.
E) splits ATP to ADP + P_i.

17. RNA polymerase:
A) binds tightly to a region of DNA thousands of base pairs away from the DNA to be transcribed.
B) can synthesize RNA chains without a primer.
C) has a subunit called λ (lambda), which acts as a proofreading ribonuclease.
D) separates DNA strands throughout a long region of DNA (up to thousands of base pairs), then copies one of them.
E) synthesizes RNA chains in the 3′ → 5′ direction.

18. Reverse transcriptase:
A) can utilize only RNA templates.
B) has a 3′ → 5′ proofreading exonuclease but not a 5′ → 3′ exonuclease.
C) is activated by AZT.
D) is encoded by retroviruses.
E) synthesizes DNA with the same fidelity as a typical DNA polymerase.

19. Compared with DNA polymerase, reverse transcriptase:
A) does not require a primer to initiate synthesis.
B) introduces no errors into genetic material because it synthesizes RNA, not DNA.
C) makes fewer errors in synthesizing a complementary polynucleotide.
D) makes more errors because it lacks the 3′ → 5′ proofreading exonuclease activity.
E) synthesizes complementary strands in the opposite direction from 3′ → 5′.

20. AZT (3′-azido-2′,3′-dideoxythymidine), used to treat HIV infection, acts in HIV-infected cells by:
A) blocking ATP production.
B) blocking deoxynucleotide synthesis.
C) inhibiting RNA polymerase II.
D) inhibiting RNA processing.
E) None of the above

Question 1B (Short Answer Questions, Total Marks = 30)

(a) Explain what introns are. [2]

(b) Explain what is meant by satellite DNA. [2]

(c) Describe two functions of DNA supercoiling. [4]

(d) Define the following:
(i) heterochromatin, [1]
(ii) euchromatin, [1]
(iii) chromatin remodelling. [1]

e) *E. coli* cells are placed in a growth medium containing lactose. Indicate how the following circumstances would affect the expression of the lactose operon
(i). A *lac* repressor mutation that prevents dissociation of *lac* repressor from the operator, [2]
(ii). A mutation that inactivates β-galactosidase, [2]
(iv). A mutation that inactivates galactoside permease, [2]
(v). A mutation that prevents binding of CRP to its binding site near the *lac* promoter. [2]

(f) Describe briefly the relationship between chromatin structure and transcription in eukaryotes. [3]

(g) Consider the following hypothetical short mRNA; what would be the sequence of the peptide produced if this were translated in an *E. coli* cell? [2]

5'-AUAGGAGGUUUGACCUAUGCCUCGUUUAUAGCC-3'

(h) The template strand of a segment of double-stranded DNA contains the sequence: (5')-TAC CTT TGA TAA GGA TAG CCC TTC ATC-(3')

(i) Write down the base sequence of the mRNA that can be transcribed from this strand. [2]

(ii) Write down the amino acid sequence that could be coded by the mRNA base sequence in (i) above, using only the first reading frame starting at the 5' end. [2]

(iii) Suppose the other (complementary) strand is used as a template for transcription. Give the amino acid sequence of the resulting peptide. [2]

The Genetic Code

1st letter	Second Letter: U	Second Letter: C	Second Letter: A	Second Letter: G	3rd letter
U	UUU Phe UUC UUA Leu UUG	UCU UCC UCA Ser UCG	UAU Tyr UAC UAA Stop UAG Stop	UGU Cys UGC UGA Stop UGG Trp	U C A G
C	CUU CUC CUA Leu CUG	CCU CCC CCA Pro CCG	CAU His CAC CAA Gln CAG	CGU CGC CGA Arg CGG	U C A G
A	AUU AUC AUA Ile AUG Met	ACU ACC ACA Thr ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG	U C A G
G	GUU GUC GUA Val GUG	GCU GCC GCA Ala GCG	GAU Asp GAC GAA Glu GAG	GGU GGC GGA Gly GGG	U C A G

SECTION B (Answer any two questions in this section)

Question 2

Explain the intricate rudiments of the Central Dogma of molecular biology, highlighting how a change in the sequence of nucleotides of a gene can affect the 3-D structure and function of a protein. [25]

Question 3

Discuss eukaryotic and prokaryotic gene expression, highlighting similarities and differences between the two. [25]

Question 4

Discuss the catabolite repression control of the *lac* operon. [25]

END OF EXAMINATION PAPER