I. Multiple Choice Questions (24 points)

(1) The combination of histone proteins with DNA gives rise to what structure?
A) cohesins
B) telomeres
C) centromeres
D) nuclear scaffold
E) nucleosomes

(2) Histones are _____ that are usually associated with _____.
A) acidic proteins; DNA
B) acidic proteins; RNA
C) basic proteins; DNA
D) basic proteins; RNA
E) coenzymes derived from histidine; enzymes

(3) Which of the following types of DNA repair is often coupled with transcription?
A) photoreactivation
B) base excision repair
C) replication
D) nucleotide excision repair
E) all of the above

(4) Which base or bases is/are methylated to identify the original template strand of replicated DNA?
A) A
B) C
C) G
D) A and G
E) C and G

(5) What is a common trigger for the bacterial SOS response?
A) thymine starvation
B) DNA cross-linking agents such as mitomycin C
C) ultraviolet radiation
D) mutation of DNA replication genes
E) all of the above

(6) What role does integration host factor (IHF) play in site-specific recombination during phage λ lysogeny?
A) binds host DNA forcing a DNA bend
B) supercoils phage DNA
C) cleaves host and phage DNA at specific sites to create sticky ends
D) ligates host and phage DNA once recombination occurs
E) all of the above

(7) The *E. coli* core polymerase is missing the ____ subunit and binds to DNA with _____ specificity than the holoenzyme.
A) σ; less
B) σ; greater
C) α; less
D) α; greater
E) none of the above

(8) As RNA polymerase moves along the DNA, it creates a single stranded region of about 18 base pairs that is called a _____.
A) transcription bubble
B) transcription single-stranded region
C) transcription droplet
D) transcription vesicle

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E) transcription bead

(9) Rifampicin is known to inhibit RNA synthesis in *E. coli*. Once the first ten nucleotides have been incorporated, rifampicin does not inhibit RNA synthesis. Which of the following best explains how rifampicin functions?
A) rifampicin binds only to the core enzyme when bound to DNA but can bind to the holoenzyme when not bound to DNA
B) rifampicin can bind to RNA polymerase when the polymerase is not bound to DNA but cannot bind when the polymerase is bound to DNA
C) rifampicin only inhibits when the α subunit is bound to the core enzyme
D) rifampicin is able to bind to the nucleotide binding site at any time
E) none of the above

(10) The *E. coli* promoter region contains a -10 consensus sequence of _____ on the sense strand.
A) GAGAGA
B) CTCTCT
C) GAGGAG
D) GACGTC
E) TATAAT

(11) In eukaryotic cells, RNA polymerase ____ transcribes most of the ribosomal RNA, RNA polymerase ____ transcribes the major structural genes and RNA polymerase ____ transcribes tRNAs.
A) I; II; III
B) I; III; II
C) II; I; III
D) II; III; I
E) III; II; I

(12) The carboxyl-terminal domain (CTD) of RNA polymerase II is involved in
A) binding to promoter regions of DNA.
B) formation of the transcription bubble.
C) coordinating post-transcriptional processing events.
D) recognition of the termination signal.
E) None of the above.

II. Short Answer Questions (26 points)

1.What is the difference in function between the DNA-binding domain and the activation domain of transcription factors? (3 points)

2. What is the function of a mediator in regulating transcription? (3 points)

3. Please describe the significance and functions of the σ subunit? (3 points)

4. Explain the difference between constitutive and regulated expression? (3 points)

5. Give the mRNA sequence that would result from the following sense strand: (3 points)
5′-ATTCCGATTGTACGATGTCA-3′

6. The figure below shows a newly transcribed mRNA still associated with the template DNA. Draw the stem-loop structure (with the sequence) that often forms during termination. (4 points)
3′-GGTCGGGCGGATTACTCGCCCGAAAAAAAA-5′
5′-CCAGCCCGCCUAAUGAGCGGGCUUUUUUUU-3′

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7. Show the product of the following restriction digest. *Hin*dIII has a restriction site of A↓AGCTT. P- indicate the 5′ phosphate, -OH indicates the 3′ hydroxyl. (3 points)

P-TCAAGCTTCCCT**-OH**
HO-AGTTCGAACGGA**-P** + *Hin*dIII →

8. A linear DNA molecule was treated with *Bam*HI and gave two fragments with sizes of 2080 and 3600 base pairs. The same DNA was treated with *Eco*RI and gave three fragments of 1080, 2150 and 2450 base pairs. Finally, the DNA was treated with both enzymes at the same time and gave fragments of 1000, 1080, 1450 and 2150 base pairs. Provide a map of the DNA molecule clearly indicating the restriction sites. (4 points)

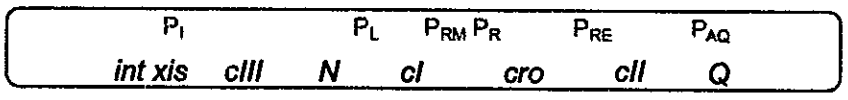
III. Explain and compare the following terms: (20 points)

(1) Catabolite activator protein (CAP) and cAMP
(2) Enhancer and silencer
(3) Histone acetyltransferase and histone deacetylase
(4) Nonsense-mediated decay and nonstop-mediated decay
(5) Group I self-splicing and pre-mRNA splicesome

IV. How does *E. coli* regulate tryptophan synthesis? (10 points)

V. Explain the mechanism of RNA interference in eukaryotic cells. (10 points)

VI. According to the following genome map of the lambda phage, answer the questions. (10 points)



(1) What are the immediate-early promoters after lambda infection? (2 points)
(2) Explain the functions of N protein. (3 points)
(3) How does the lambda phage establish its lysogenic cycle? (5 points)

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