Student Name: _____ Student NUMBER:_____

BCH/BIO 3170
Molecular Biology – 1st Midterm
Oct. 02, 2012
Dr. Odette Laneuville

Section 1: Multiple Choice Questions (2 pts each):	
#1 to #15	/30 pts
Section 2: Short Essay Questions (5 pts each):	
#1 to #8	/40 pts
Section 3: Long Essay Questions (10 pts each):	
#1 to #3 PICK 2 out of the 3	/20 pts
Total:	**/90**

Instructions:
WRITE YOUR NAME and STUDENT NUMBER on TOP of EVERY page of the Questionnaire.

Absolutely no books, hand outs, recordings, electronics including calculators or notes are allowed.

Write your answers to the multiple choice questions on the bubble sheet.

Write your answers to essay questions, both short and long, directly on the Questionnaire.

At the end of the examination period you must return the bubble sheet and the Questionnaire.

Section 1: Multiple Choice Questions (2 pts each):
#1 to #15

#1 Which of the following statement is NOT a characteristic of prokaryote genomes. Select the best answer. ANSWER A
A. Coding DNA represents approximately 10% of the entire genome.
B. The length of sequences located between genes is very short.
C. Repetitive sequences are not frequently found.
D. The average size of prokaryotic genes is smaller than eukaryotic genes.
E. No intronic sequences are found.

#2 Identify the best definition for "lateral gene transfer" in prokaryotes.
ANSWER E.
A. DNA sequence unique to a species.
B. DNA sequence originating from plasmids only and integrated into the prokaryote genome.
C. DNA sequence originating from the same prokaryote and transferred to a different location in the genome.
D. DNA sequence always duplicated before transferred to the prokaryotic genome.
E. DNA sequence originating from the genome of a prokaryote and integrated into the genome of a different prokaryote.

#3. Select the answer corresponding to the definition of a Holliday junction. ANSWER B
A. a DNA sequence located between genes in the genome of most prokaryotes.
B. a mobile junction between four strands of DNA.
C. a DNA sequence flanking RNA transposons.
D. a DNA sequence used in the process of non-homologous recombination.
E. a highly conserved structure found in DNA prokaryotes and not in eukaryote DNA.

#4. Which of the following is not a biological consequence resulting from the process recombination: ANSWER E
A. integration of specific DNA elements into the genome of a host.
B. generation of new genes.
C. DNA repair.
D. generation of new allele combinations during meiosis.
E. none of the above

#5. Identify the enzyme with endonuclease activity. ANSWER A and B
A. UvrC
B. UvrB
C. UvrA
D. RecD
E. None of the above

#6. Identify the statement that is WRONG concerning recombination that takes place during meiosis. ANSWER: A

A. The process begins with the action of an endonuclease that cuts one of the DNA strand on one chromosome.
B. The process requires a group of proteins including RecA, UvrA and UvrB.
C. When the Holliday junction has created an open structure, two hexamers of UvrB bind.
D. UvrB uses the energy released from the hydrolysis of ATP to ensure branch migration.
E. None of the above.

#7 During the reaction of base excision to repair damaged DNA, the gap created by the enzyme AP endonuclease is filled by which DNA polymerase? ANSWER: C

A. DNA pol II
B. DNA pol III
C. DNA pol I
D. primase
E. RNA pol

#8 Which enzymes are involved in the mismatch repair system? Select the best answer. ANSWER: A

A. DNA pol III
B. AP endonuclease
C. DNA pol I
D. DNA glycase
E. UvrB

#9. Identify ALL the enzymes capable of catalyzing the formation of phosphodiester bonds between two nucleotides. Select the BEST answer. ANSWER D

A. DNA ligase
B. Primase
C. DNA polymerase III
D. A, B and C are correct
E. A and C are correct

#10. Select the correct answer. Replication of DNA on the lagging strand occurs: ANSWER B

A. Continuously from 5' to 3'
B. Discontinously from 5' to 3'
C. Continuously from 3' to 5'
D. Discontinously from 3' to 5'
E. due to the repair activity of DNA polymerase

#11. Identify the DNA sequence that is not recognized by sigma factor during the step of initiation of transcription. ANSWER: A
A. the transcription start site
B. the TATA box
C. TTGACA
D. A and C
E. A and B

#12. Select the correct answer. During the reaction of DNA synthesis catalyzed by the enzyme DNA pol, the energy released from the hydrolysis of the activated nucleotide (NTP) into NMP is used: ANSWER: E
A. for the formation of the phosphodiester bonds.
B. for the binding of the free nucleotides to DNA pol.
C. to ensure the correct the matching between the added nucleotide on the RNA chain and the corresponding nucleotide on the DNA matrix strand.
D. To undo the DNA-RNA hybrid as the transcription fork advances.
E. For the movement of DNA polymerase on the DNA.

#13. Which DNA polymerase of E. coli lacks the exonuclease 5' to 3' activity? Select the best answer. ANSWER: C
A. DNA pol I
B. DNA pol I and DNA pol II
C. DNA pol II and DNA pol III
D. DNA pol I and DNA pol III
E. DNA pol I, II and III.

#14. Identify the TRUE statement concerning the state of transcription of the lactose operon when bacteria are growing in a media without lactose and rich in glucose. ANSWER B
A. The repressor is not bound to the operator and CAP protein is bound to the CAP site.
B. The repressor is bound to the operator and CAP protein is not bound to the CAP site.
C. The repressor is not bound to the operator and CAP protein is not bound to the CAP site.
D. The repressor is bound to the operator and CAP protein is bound to the CAP site.
E. RNA pol is transcribing the lactose operon.

#15. How does cAMP influence the expression of the lactose operon? ANSWER: C
A. binds directly to RNA pol and increases transcription.
B. reduces the affinity of the repressor for DNA.
C. binds to CAP and the cAMP-CAP complex increases the affinity of RNA pol for the promoter.
D. increases the transport of glucose in the bacteria.
E. None of the above.

Section 2: Short Essay Questions (5 pts each): LIMIT YOUR ANSWER TO THE SPACE PROVIDED ON THIS SIDE OF THE PAGE.

#1 List 5 structural characteristics of the B form of the DNA double helix. (5pts)
ANSWER: 5 from the list below. 1 pt for each.

1. 2 chains of complementary polynucleotides complementary and turning around the same axis in the right orientation.
2. The 2 chain run in opposite directions: one is oriented 5' towards 3' and the other 3' towards 5'.
3. The bases are located inside the helix while sugars are located outside of the helix and the net charge of the helix is negative.
4. The plans formed by the bases are practicly perpendicular to the axis of the helix.
5. The 2 chains are maintained by hydrogens bonds formed between 2 bases located in the same plan. The force of the H bonds is additive and contribute to the stability of the double helix.
6. Hydrophobic interactions and van der Waals forces stabilize the helicoidal structure.
7. The distance between the phosphorous atom located at the exterior of the helix and the axis of the helix is 1nm. The width of the double helix is equal to 2 nm.
8. A pyrimidine from one chain is always paired with a purine of the other chain creating the uniformity of the helix.
9. The helix makes one complete turn every 10 nucleotides. The distance between 2 adjacent bases on the same chain is equal to 0.34 nm. A complete turn of the helix measures 3.4 nm.
10. The nitrogen atoms linked to the C4 of the cytosine and to the C6 of the adenine are taking the amino (NH2) forminstead of the imino (NH) form. Similarly, the oxygen atoms linked to the C6 of the guanine and to the C4 of the thymine are taking keto (C=O) form instead of the enol (C-OH) form. Those configurations impose restrictions to the base pairing: A-T and C-G (rule established by Chargaaf).
11. Since A from one chain is only pairing with T and C only pairs with G, the sequence of the nucleotides are fixed and knowing the sequence of a chain, one can deduct the sequence of the other chain.

#2. Define the term "multipartite genome" with reference to prokaryotes. (5 pts) Your answer should be one sentence only.

ANSWER: multipartite genomes are genomes divided into 2 or more DNA molecules.

Section 2: Short Essay Questions (5 pts each):
LIMIT YOUR ANSWER TO THE SPACE PROVIDED ON THIS SIDE OF THE PAGE

#3. Associate the following proteins with each function listed below: (5pts)

Proteins: **MutS**
MutL
MutH

Function:
A. Was found only in prokaryotes: MutH
B. Bind specifically to mismatched nucleotides: MutS
C. Triggers the degradation of the DNA strand with a Nick until the mismatch is reached: MutL
D. Forms a dimer with MutL: MutS
E. Has ATPase activity: MutS

#4 Name the repair mechanism used to replace a 5-methylcytosine that was deaminated in genomic DNA. (5 pts) Your answer should be 1 short sentence only.

ANSWER: Base excision.

Section 2: Short Essay Questions (5 pts each):
LIMIT YOUR ANSWER TO THE SPACE PROVIDED ON THIS SIDE OF THE PAGE

#5. How does the enzyme RNA polymerase find promoter sequences (~60 bp) efficiently in the genome of prokaryotes (~4 x 10^6 bp). (5 pts)

ANSWER: sigma factor (1 pt) reduces the affinity of RNA pol for sequences that are not promoters (2 pts) and increases the affinity of RNA pol for DNA sequences that are promoters (2 pts).

#6. Briefly explain the role of the protein Rho in the reaction of transcription. (5 pts)

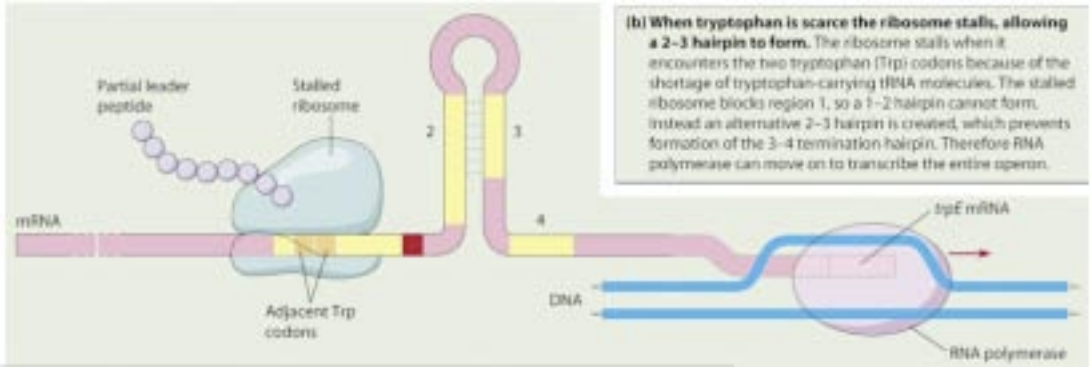
ANSWER: Rho binds to the 5'end of the RNA chain (1 pt) and travels towards the 3' end of the RNA (1 pt). A hairpin structure is formed (1 pt) in the RNA in the transcription bubble and this will stall the DNA pol (1 pt). Rho breaks the DNA-RNA hybrid (1 pt).

Section 2: Short Essay Questions (5 pts each):
LIMIT YOUR ANSWER TO THE SPACE PROVIDED ON THIS SIDE OF THE PAGE
#7 What is the role of CAP (catabolic activator protein) in the regulation of expression of the lactose operon? (5 pts)

ANSWER: CAP binds to the CAP site (1 pt) (located between the *i gene* and operator site) and increases the affinity of RNA pol (2 pts) for the promoter (2 pts) of the lactose operon.

#8 During the regulation of expression of the tryptophan operon, the absence of the amino acid tryptophan in the milieu will impact the mechanism of attenuation. Illustrate with a diagram the regions of RNA transcribed from the control region and that are important for the mechanism of attenuation. Your diagram must also include the structure this RNA will adapt under low tryptophan concentrations. (5 pts)

ANSWER: region 2 will hybridize with region 3 (1 pt) because the ribosome is stalled on region 1 (1 pt) on the RNA where 2 consecutive trp codons (1 pt) are located. As a result, the DNA polymerase will continue the transcription of the trp operon into the structural genes (1 pt). Diagram 1 pt.



Student Name: _____ Student NUMBER:_____

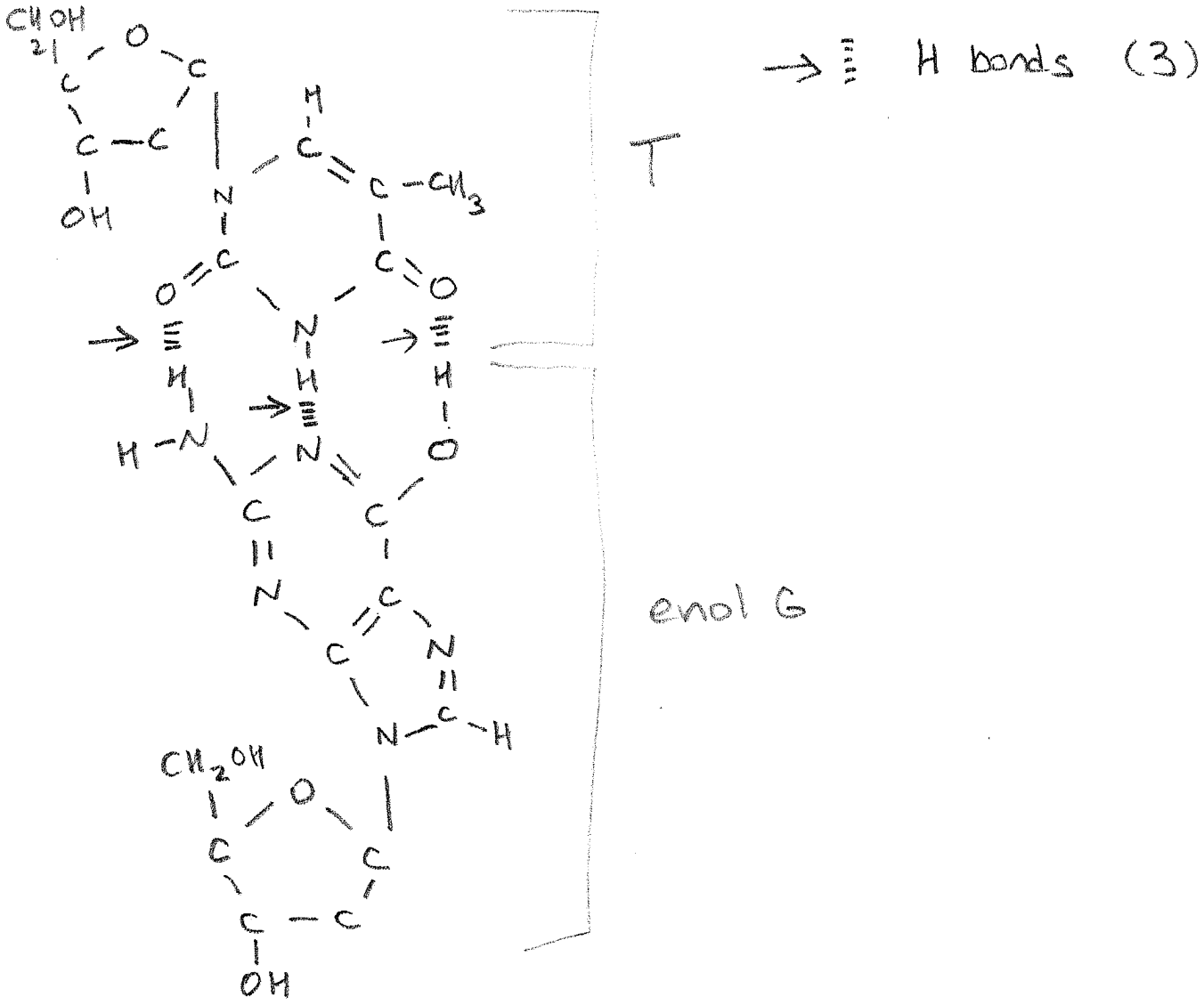
Section 3: Long Essay Questions (10 pts each): PICK 2 out of the 3

LIMIT YOUR ANSWER TO THIS SIDE OF THE PAGE

#1 Draw the chemical structure of the enol form of the nucleotide G (guanine) and the nucleotide it would pair with if found in the DNA double helix. Indicate on your diagram, the location of the hydrogen bonds formed between the two nucleotides. (10 pts)

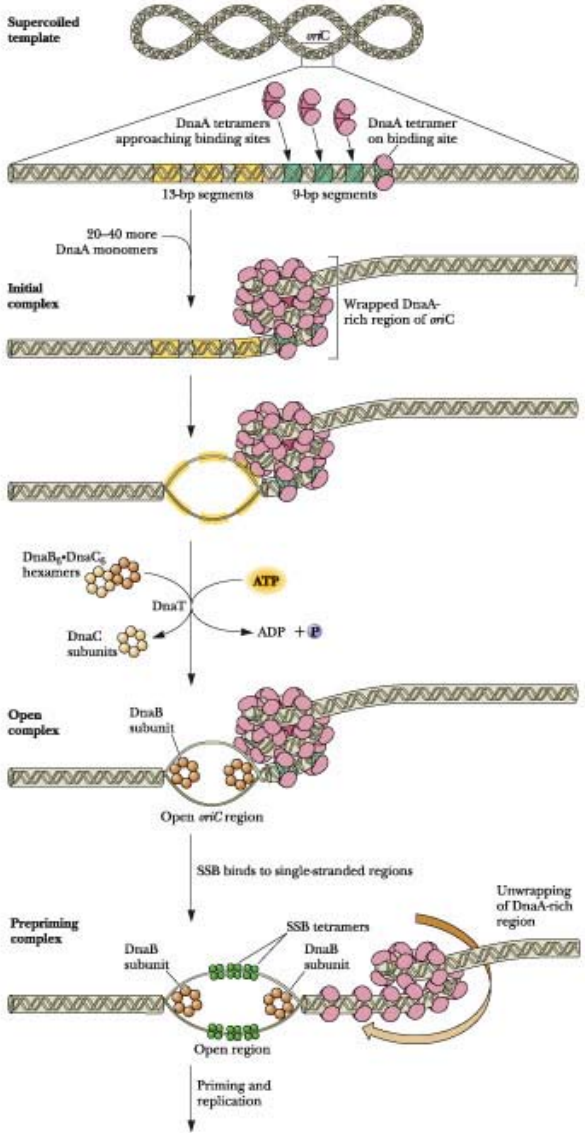
Your answer MUST include all atoms for each nucleotide: H, N, C and O. The sugar and base components must be included.

ANSWER:
sugar = 1pt.
H bonds = 1.5 pts (0.5 pt each)
Enol G = 3.5 pts (take 0.5 pt off for each mistake but no more than 3.5 pts)
T = 3 pts (take 0.5 pt off for each mistake but no more than 3 pts)
Location of the glycosidic bond between the sugar and the base = 1 pt.



Section 3: Long Essay Questions (10 pts each): PICK 2 out of the 3
LIMIT YOUR ANSWER TO THIS SIDE OF THE PAGE

#2 Draw the replication fork. Your diagram must include the 4 different proteins (and their names) playing a role at the step of initiation in prokaryote. List the names of the 4 proteins, DNA sequences or other proteins they bind to and briefly explain their role during the step of initiation. (10 pts)
ANSWER: Diagram 4.5 pts
dnaA (0.5 pt): binds to the 9-nts sequence at the OriC site (0.5 pt). Role: melts DNA double helix (0.5 pt).
dnaB (0.5 pt): binds to the two replication forks as an hexamer (0.5 pt). Role: has helicase activity (0.5 pt).
dnaC (0.5 pt): form an hexamer and binds to dnaB (0.5 pt). Role: inhibitor of dnaB when not bound to DNA replication fork (0.5 pt).
SSB: bind to single stranded DNA (0.5 pt) in the replication bubble and prevent the degradation of DNA or the formation of hybridization structures (0.5 pt).



Section 3: Long Essay Questions (10 pts each): PICK 2 out of the 3
LIMIT YOUR ANSWER TO THIS SIDE OF THE PAGE

#3 Explain how the repressor of the tryptophan operon regulate the expression of the structural genes included in the tryptophan operon. Your answer must include a diagram of ALL the structural and regulatory sequences forming the tryptophan operon, the binding site of the repressor, how the binding is regulated and the consequences of the binding of the repressor (or not) on the expression of the structural genes of the tryptophan operon. (10 pts)

ANSWER:

- **Trp is high:**
  1. trp will bind to the repressor (1 pt) and the complex repressor-trp has a high affinity for operator (1 pt). The binding of the complex repressor-trp to the operator will prevent the RNA pol to bind the promoter and transcribe the structural genes (1 pt).
- **2. Trp acts as a co-repressor (1 pt).**

- **Trp is low:**
  1. repressor is inactive; not bound to the operator (1 pt).
  2. operator is free and RNA pol binds to the promoter and will transcribe the structural genes of the trp operon (1 pt).

  Diagram: names of regulatory elements (2 pts) and order (2pts)