

Name: _____

2006 7.012 Problem Set 3

Due before 5 PM on FRIDAY, October 13, 2006.

Turn answers in to the box outside of 68-120.

PLEASE WRITE YOUR ANSWERS ON THIS PRINTOUT.

1. Which reaction is catalyzed by each of the enzymes listed below? Answer by stating which specific type of bond is affected (e.g. "covalent" is not specific enough), and whether each enzyme catalyzes the formation or the breaking of that type of bond.

(a) helicase

(b) DNA polymerase

(c) DNA ligase

(d) RNA polymerase

(e) ribosome

2. A portion of the DNA sequence and the corresponding predicted amino acid of a protein-encoding gene is given below.

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5 '   ggg act cgg tgc tgt gat tgt cgg gct gct cct   3 '  
3 '   ccc tga gcc acg aca cta aca gcc cga cga gga   5 '
```

ala thr ile thr pro

You decide to make a DNA primer that would hybridize to the mRNA produced from this gene. What would the sequence of the primer be? Limit your answer to the 15 nucleotides that would hybridize in the boxed region. Give the sequence of the primer that would hybridize to the mRNA and label the primer's 5' and 3' ends.

3. The picture shown below is a sequence alignment of an entire gene's DNA sequence and the entire sequence of the mRNA produced from that gene. The top line is the DNA and the bottom line is the mRNA. Each nucleotide in the gene is numbered. Vertical dashes indicate nucleotides that are identical in both sequences. Dots indicate nucleotides in the DNA sequence that are not found in the mRNA sequence.

@ represents a 5'-G-cap.

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- (a) At what nucleotide position in the gene does transcription begin?
- (b) At what nucleotide position in the gene does transcription end?
- (c) At what nucleotide position in the gene does translation begin?
- (d) At what nucleotide position in the gene does translation end?
- (e) How many introns does the gene have?
- (f) For each intron, give the nucleotide positions of its beginning **and** its end.
- (g) How many exons does the gene have?
- (h) How many amino acids long would the protein be that is encoded by this gene?
- (i) At what nucleotide positions does the 5' untranslated region begin **and** end?
- (j) At what nucleotide positions does the 3' untranslated region begin **and** end?

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4. The following sequence is a wild-type bacterial gene that encodes a short protein. The sequence given is from the point where transcription starts (called “+1”) to the point where transcription ends.

5' -ACTTCGATATGTCTAAAATAT**T**CGATCGATCTGTGGGGCCTAGCTAGCTAACCAGAGACGCTACCG-3'
3' -TGAAGCTATACAGATTTTAT**A**GCTAGCTAGACACCCCGGATCGATCGATTGGTCTCTGCGATGGC-5'

(a) Which strand (the upper or the lower) is used as the template in transcription?

(b) Write out the entire sequence of the RNA transcribed from this wild-type gene. Make sure to label the 5' and 3' ends of your molecule.

(c) Write out the amino acid sequence of any protein that is encoded by this wild-type gene. Make sure to label the N and C termini of your molecule.

The following sequence is a mutant version of the above gene that is present in a mutant bacterial strain. The nature of the mutation is that **the base-pair bolded above in the wild-type sequence has been deleted**. The sequence given is from the point where transcription starts to the point where transcription ends.

5' -ACTTCGATATGTCTAAAATACGATCGATCTGTGGGGCCTAGCTAGCTAACCAGAGACGCTACCG-3'
3' -TGAAGCTATACAGATTTTATGCTAGCTAGACACCCCGGATCGATCGATTGGTCTCTGCGATGGC-5'

(d) Which strand (the upper or the lower) is used as the template in transcription?

(e) Write out the amino acid sequence of any protein that is encoded by this mutated gene. Make sure to label the N and C termini of your molecule.

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The following sequence is a wild-type gene that encodes a tRNA-ser molecule that recognizes the codon 5'-UCG-3' on all mRNAs in the bacterial cell. The sequence given is from the point where transcription starts (called "+1") to the point where transcription ends.

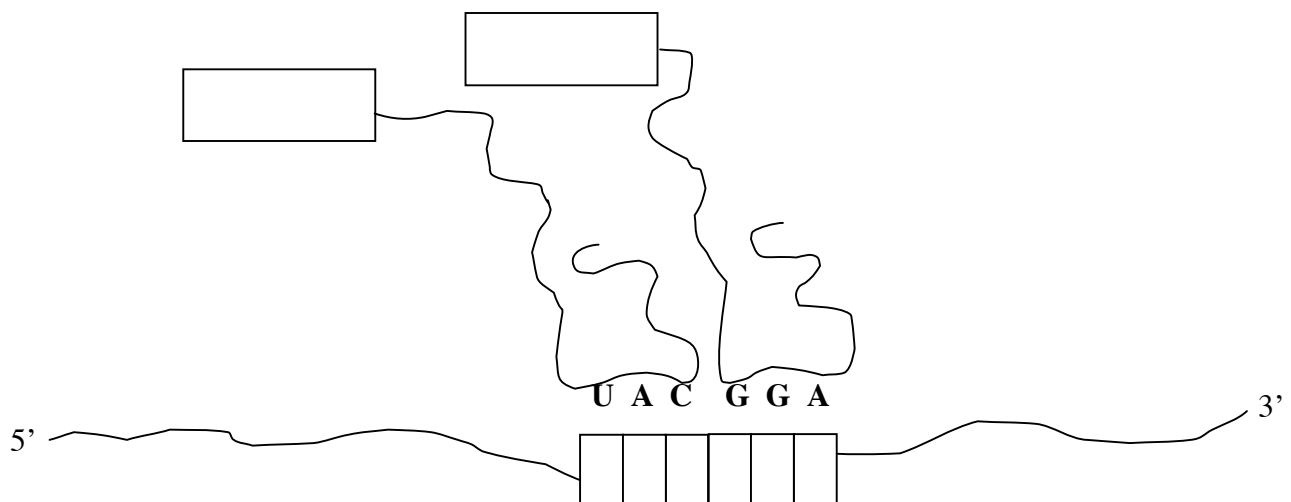
5' -CCGTTGCTCAGATCTGGATATCGTCCATCCTGCATGCACTTGCTCATGCTGATACGCGCAACGGT-3'
3' -GGCAACGAGTCTAGACCTATAGCAGGTAGGACGTACGTGAACGAGTACGACTATGCGCGTTGCCA-5'

(f) Which strand (the upper or the lower) is used as the template in transcription?
(Remember that tRNAs are DIRECTLY transcribed from tRNA-encoding genes. There is no mRNA intermediate in the production of a tRNA molecule from a tRNA gene!)

(g) Write out the amino acid sequence of any protein that is encoded by this wild-type gene. Make sure to label the N and C termini of your molecule.

(h) Put a box around the double-stranded DNA portion of the wild-type tRNA gene that encodes the anticodon portion of the tRNA. (Do this in the drawing of the sequence that we provided for you at the top of the page.)

5. Below is a diagram of two tRNAs and an mRNA in the active site of the ribosome during translation of the mRNA into protein. Three nucleotides from the sequence of each tRNA are shown for you.



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- (a) In the diagram above, label the 5' and 3' ends of each tRNA.
- (b) In the diagram above, fill in the box attached to one end of each tRNA with the name of the amino acid that would be attached there.
- (c) In the diagram above, fill in the boxes in the mRNA with the 6 nucleotides that would be present there.
- (d) Which tRNA is about to transfer its attached amino acid over to the other tRNA and exit the active site: the tRNA on the left or the tRNA on the right?
- (e) After the tRNA you mentioned in part (d) leaves, what will the sequence (so far) of the newly made protein be? Be sure to label the N and C termini of the growing polypeptide chain.

6. Tryptophan is one of the 20 amino acids used by all organisms to make their proteins. Bacteria can synthesize tryptophan from scratch, or they can directly use any tryptophan that is available to them from the environment. The genes that encode enzymes that synthesize tryptophan are transcriptionally regulated in a logical way that minimizes energy expenditure.

- (a) Should these tryptophan synthesis genes be expressed when tryptophan:
... is present in the environment? ... is absent from the environment?
- (b) A mutant bacterium has no activity for one of these tryptophan synthesis enzymes. Does this result prove that there is a mutation in the gene encoding this enzyme?
- (c) One method of gene regulation is to control whether or not a gene is transcribed and translated. Another method is to control activity of a protein by whether or not it is phosphorylated. Which of these two methods of regulation allows for a faster response to changing cellular conditions?
- (d) Which of these two methods of regulation requires less energy to express an active gene product?