Hands-On Two
Transcription - Translation

Problem 1 [Multiple Choice]

1) Nucleotides and nucleic acid polymers have a polarity with respect to their structure. Which of the following would be attached to the 5' carbon of the ribose of the first nucleotide in a polymer?

A) A hydroxyl group
B) Another nucleotide
C) A nitrogenous base
D) A phosphate group

2) How do the monomers found in DNA differ from the monomers found in RNA? Choose all that apply.

a) DNA incorporates four different nitrogenous bases; RNA incorporates three different nitrogenous bases.

b) Thymine is found in DNA but not RNA.

c) There is a 3' hydroxyl on the RNA monomer, but not on the DNA monomer.

d) There is a 2' hydroxyl on the RNA monomer, but not on the DNA monomer.

A) a, c B) c, d C) a, b D) b, d

3) How many different functional groups are attached to the alpha carbon of an amino acid?

A) 5 B) 4 C) 1 D) 3 E) 2

4) If the following sequence were a complete mRNA, which codon would be recognized as the stop codon?

5' – UAAUGCUGACUAGUUAAGCCCGAGCGAA – 3'

A) UAA B) UGA C) UAG

Problem 2

a) Complete the following table. Assume that

- the reading is from left to right
- the columns represent transcriptional and translational alignments

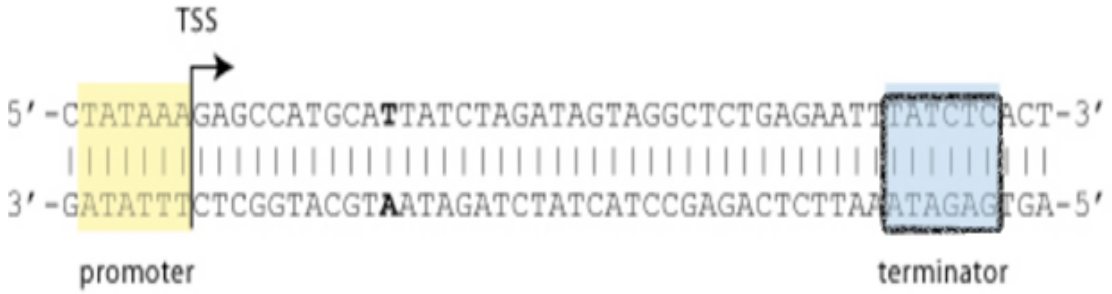
C												DNA double helix
						C	C	A				
	U	A				G						mRNA transcribed
									G	C	G	Appropriate tRNA anticodon

	Met (M)			Amino acids incorporated into protein

b) Label 5' and 3' ends of DNA and RNA, as well as the amino and carboxyl ends of proteins. [*Introduction to Genetic Analysis* by Griffiths et al., 2005]

Problem 3

The following double-stranded DNA sequence is part of a hypothetical yeast genome which happens to contain a very small gene. Transcription starts



at the Transcription Start Site (TSS), proceeds in the direction of the arrow and stops at the end of the Transcription Terminator (the boxed region).

a) Which strand of DNA shown, the top or the bottom, is the template strand?

b) What is the sequence of the mRNA produced from this gene? Label the 5' and 3' ends.

c) What is the sequence of the protein produced from the mRNA in (b)? Label the N and C termini.

d) If a mutation (an insertion) were found where a T/A (top/bottom) base pair were added immediately after the T/A base pair shown in bold, what would be the sequence of the mRNA? What would be the sequence of the protein?

Problem 4

The following double-stranded bacterial (E. coli) DNA sequence codes for a hypothetical protein. Both strands are shown; the top strand reads 5' to 3' left to right, while the bottom strand reads 5' to 3' right to left. The nucleotides are numbered 1 to 100. NOTE: Transcription begins with and includes the underlined C/G (top strand/bottom strand) base pair in position 9, and the RNA polymerase proceeds from left to right along the DNA.

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    1                   20                  40
5'-GTGTCCGTCTAATATTGTGAGATGTTATATCCCGCCGTCAACACCATCAA-3'
   ---------+---------+---------+---------+---------+
3'-CACAGGCAGATTATAACACTCTACAATATAGGGCGGCAGTTGTGGTAGTT-5'

              60                  80                  100
5'-ACAGGATAATCGCCTGCTGGGGCAAAGGCGGTGAAGGTAAAGGTGTTGCC-3'
   ---------+---------+---------+---------+---------+
3'-TGTCCTATTAGCGGACGACCCCGTTTCCGCCACTTCCATTTCCACAACGG-5'
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a) Which strand is used as a template for transcription, the top or the bottom?

b) Where would the promoter be relative to the start of transcription?

c) What are the first 15 nucleotides of the resulting mRNA? Indicate the 5' and 3' ends.

d) What are the first 5 amino acids translated from the resulting mRNA? Indicate the amino and carboxyl termini of the protein.

e) Do the underlined nucleotides TAA encode a stop codon for the protein? Explain your answer.

Consider the situations in parts (f-h) independently.

f) A mutation occurs which results in the insertion of an extra G/C (top strand/bottom strand) base-pair immediately after base pair 11 (A/T shown in bold). What effect will this insertion mutation have on the mRNA transcript and on the resulting protein?

g) A different mutation results in the substitution of the T/A base pair at position 30 (shown in bold and underlined) with a G/C base pair. How would this mutation affect the sequence of the protein that is produced?

h) A different mutation occurs which results in the substitution of the C/G base pair at position 42 (shown in bold italics) to a T/A base pair. How would this mutation affect the sequence of the protein that is produced?

Problem 5

A mutation is found in a tRNA-encoding gene. The wild type allele produces a tRNA that recognizes the codon GAA, and is charged with the amino acid glutamic acid (Glu). The mutant tRNA is still charged with Glu, but the anticodon is mutated such that it recognizes the codon

UAA. What effect will this have on translation in these cells? How will the proteins produced be different? [Adapted from *Fundamentals of Biology* by E. Lander et al., 2012]