Gene Expression: Transcription & Translation

Materials

Gene Expression 2D model kit:

- DNA nucleotides: 11 each of A, G, T, C
- RNA nucleotides: 6 each of A, G, U, C
- Amino acids & peptide bonds: 25 labeled and 5 blank
- tRNA : 4
- nitrogenous bases: 8 each of A, G, U, C
- ribosome – large subunit
- ribosome – small subunit

Part I. Transcription

1. Use the string to represent a nuclear envelope. Inside the nucleus, build a strand of DNA with this nucleotide sequence:

T A C C G A G A G A C T

2. The DNA strand above is the template strand. Label its 5' end and its 3' end. Write the nucleotide sequence of the complementary DNA strand above the template DNA sequence and label the 5' and 3' ends. Build the complementary DNA strand in your model.

3. Separate the double-stranded DNA in your model.
    a. What phase of transcription occurs when double-stranded DNA is separated?

    b. What kind of enzyme unwinds the double stranded DNA during transcription?

    c. How does the enzyme find the correct DNA strand and the starting point of a gene?

4. Write the sequence of RNA nucleotides complementary to the template DNA strand and label its 5' and 3' ends:

5. Build the messenger RNA molecule using the RNA nucleotides.
    a. What phase of transcription occurs when the messenger RNA molecule is built?

    b. What kind of enzyme builds the messenger RNA?

6. Move the mRNA out of the nucleus.
    a. How does mRNA exit the nucleus in a living cell?

Activity based on the kit: "From DNA to protein" catalog number 6731058, Ward's Science, www.wardsci.com
Teaching Tips & Supplemental Homework: A.O. Cheek & D. Pattison, Dept Biology & Biochemistry, Univ Houston Rev. 7/31/15

Part II. Translation

7. Use the model pieces to mimic the initial interaction of mRNA and a ribosome. Write a sentence describing how the mRNA and ribosome or ribosomal subunit(s) interact.

8. Re-write the mRNA sequence on this page, including labeling the 5' and 3' ends and underline or highlight the codons of the mRNA.

9. Write the complementary anti-codon sequences that would be found on tRNA. Use the nitrogenous base model pieces to build the complementary anti-codons on the tRNA.

10. Attach the appropriate amino acid to each tRNA using the codon chart (last page).

11. Use the model pieces to mimic the sequence of tRNA binding to the ribosome, ribosome movement along the mRNA, and synthesis of a polypeptide. You'll need to use the peptide bond model pieces.

12. How many amino acids are in the polypeptide encoded by this mRNA?

13. The amino acids are linked by peptide bonds. What catalyzes formation of these bonds?

Part III. Apply Your Knowledge of Transcription and Translation

Choose the correct answer, then list the facts you had to know to figure out the right answer. Next, explain why each wrong answer choice is incorrect.

14. How could a point mutation in DNA make a difference in a protein's function?

    A) It might exchange one stop codon for another stop codon.

    B) It might exchange one serine codon for a different serine codon.

    C) It might code for a different amino acid in the active site.

    D) It might code for a different hydrophobic amino acid.

15. The most commonly occurring mutation in people with cystic fibrosis is deletion of a single codon. This results in

    A) a base-pair substitution.

    B) a nucleotide mismatch.

    C) a polypeptide missing an amino acid.

16. Which nucleotide sequence on the template strand of DNA would code for the polypeptide sequence phe – leu – ile - val?

    A) 5' TTG-CTA-CAG-TAG 3'.

    B) 3' AAC-GAC-GUC-AUA 5'.

    C) 5' AUG-CTG-CAG-TAT 3'.

    D) 3' AAA-AAT-ATA-ACA 5'.

    E) 3' AAA-GAA-TAA-CAA 5'.

17. What amino acid sequence would be translated from the following mRNA sequence?

    5' AUG-UCU-UCG-UUA-UCC-UUG 3'

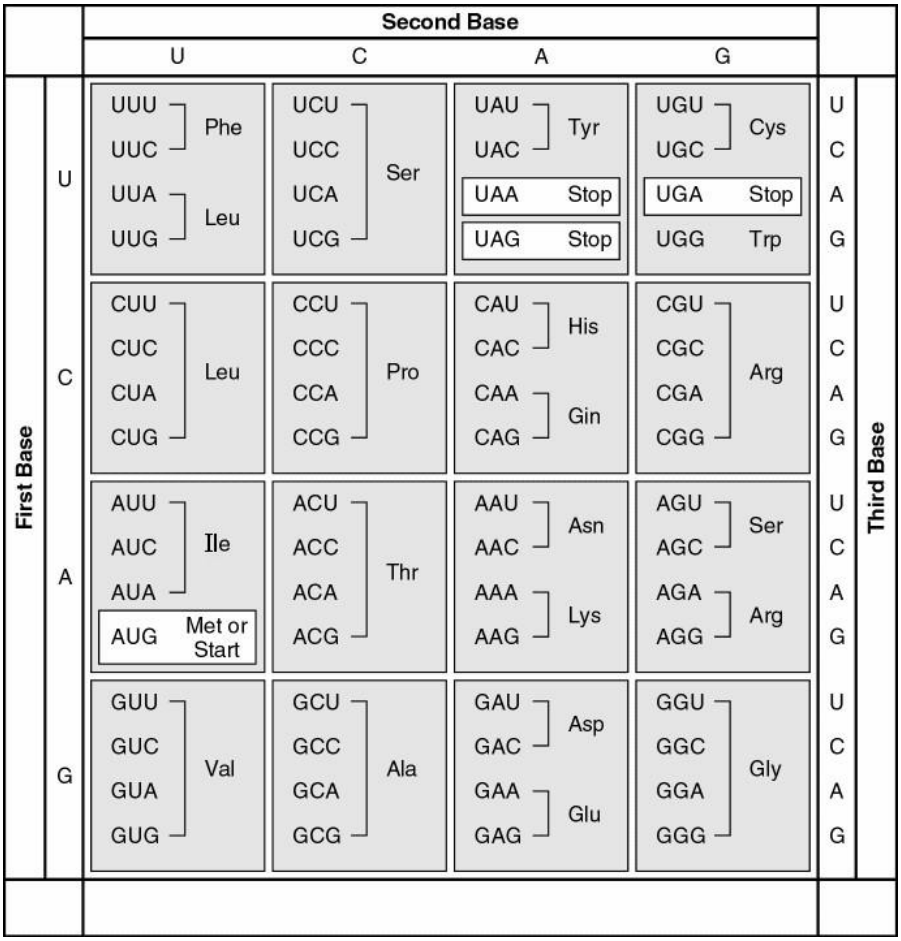
    A) met-arg-glu-arg-glu-arg

    B) met-glu-arg-arg-glu-leu

    C) met-ser-leu-ser-leu-ser

    D) met-ser-ser-leu-ser-leu

    E) met-leu-phe-arg-glu-glu



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

Supplemental Practice: Describing Transcription and Translation

Using your lecture notes and the textbook, fill in the blanks.

The process of making an mRNA molecule from DNA is called _____. When making RNA, a single strand of _____ serves as the template strand. mRNA stands for _____ RNA, which is the template for the synthesis of _____. tRNA stands for _____ RNA which is the carrier for amino acids during protein synthesis. rRNA stands for _____ RNA which makes up most of the ribosomes. The process of synthesizing a polypeptide from an mRNA template is called _____. In a eukaryotic cell, transcription occurs in the _____. The mRNA is exported through a nuclear pore to the _____ where it is translated to a polypeptide. Prokaryotes lack a membrane-bound _____ , so transcription and translation can occur _____ in the cytoplasm.

In order for transcription to occur, the DNA must be partially _____. The enzyme which does this is called _____. The other function of this enzyme is to bring in nucleotides to form the new mRNA molecule. In mRNA, the nitrogenous base _____(____) is complementary to A and C is complementary to ____. The other notable difference between RNA and DNA is that RNA contains ribose instead of _____sugar. This means that the sugar in mRNA has one more OH group than in DNA. The _____ is a _____ sequence that identifies the start of the gene to be copied. mRNA is synthesized in the _____ to _____ direction. A single gene can be transcribed _____ times by multiple RNA polymerase molecules simultaneously proceeding along the template. In bacteria, a

_____ causes the RNA polymerase to fall off the template and transcription ceases. In eukaryotes, transcription ceases after the _____. An enzyme removes the _____ from the RNA polymerase.

For translation to begin, a _____ must be assembled around the mRNA. The ribosome stabilizes coupling of _____ with _____. tRNA molecules have an _____ on one end and a specific amino acid attached to the other end. tRNA enters the ribosome and lines up its anti-codon with the complementary _____ on the mRNA. Translation begins at the _____ codon on the mRNA. Once the first tRNA, carrying _____, binds with the _____ ribosomal subunit, the _____ ribosomal subunit forms a complex around the mRNA. When the tRNA charged with the second amino acid binds to the second codon, the ribosome catalyzes formation of a _____ bond between the first and second amino acids. Once the amino acid on a tRNA has been removed, that tRNA exits the ribosome. The ribosome continues to move along the mRNA from its ___' end to its ____' end, one codon at a time. Each new amino acid is added to the growing polypeptide. An mRNA will be translated by many ribosomes at once, so a _____ mRNA molecule can be translated to make _____ copy(ies) of the polypeptide .

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Teaching Tips for Peer Mentors

The goal of this recitation is for students to describe the processes of eukaryotic transcription and translation and to apply their knowledge to predict protein structure and function.

- Have students work in groups of 2 – 3. Each group should have one kit containing all the items listed below. **Make sure students replace the packing slip and correct model parts in their kits at the end.**

- Answer all the questions yourself before you lead your first recitation session.

Materials

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Part I. Questions 1 – 6.

Questions 1 and 2. Make sure students build the complementary DNA strand and that they label the 5' and 3' ends. Emphasize the directionality of the template strand – always written and read 3' to 5'.

Question 3 is to help them describe the process of transcription.

Question 4. Make sure students apply the complementary base pairing rules, substitute U for T in the mRNA and label the 3' and 5' ends. Reiterate that the mRNA strand will be antiparallel to the template DNA strand. (You probably already know that the mRNA is parallel to the "sense" DNA strand, but you don't need to introduce this terminology.)

Question 5. This question reinforces the steps of transcription.

Question 6. Reinforce that transcription occurs inside the eukaryotic nucleus and translation occurs in the cytoplasm.

Part II. Questions 7 - 13.

Question 7. Check that students attach only the small ribosomal subunit to the mRNA.

Question 8. Check that students can identify 4 codons.

Question 9. Make sure students write out the anti-codon sequence so that they are practicing applying knowledge of the vocabulary and the complementary base pairing rules.

Question 10. Make sure students know how to read the codon chart to find the right amino acid. Check that they attach the amino acid specified by the codon on the mRNA (not by the anti-codon sequence on the tRNA!). They should load met – ala – leu and have a stop codon.

Question 11. Have them use their textbooks or go to the Study Area in www.masteringbiology.com to review the Transcription/Translation video in order to do Question 11. They should attach the tRNA

charged with met, then move the ribosome from the 5' to 3' end of the mRNA, while building peptide bonds. Make sure they use the model. Don't just explain to them from a diagram. The best way for them to learn is to figure out how to set up the model and to explain to each other.

Question 12. Make sure they realize the STOP codon will not attach an amino acid.

Question 13. Enzyme is not a sufficient answer. They need to know that the ribosome has enzymatic activity.

- After groups complete Part II, ask different groups to go to the board to answer Q 8, 9, 10, and 12.
- Pair up groups and have them take turns explaining the sequence of events during translation to each other.

Part III. Applying knowledge of transcription and translation: Questions 14 - 17.

The key part of this activity is to make sure students write an explanation of why each wrong answer choice is incorrect. Ask them to volunteer their explanations and discuss these with the entire group. This exercise will help reveal misconceptions or misunderstandings so that you can help students understand what is really happening.

Supplemental Homework:

Do not spend time on this in recitation. This is an optional review for students to do on their own time to reinforce their comprehension of the processes of transcription and translation.

Notes to Faculty

Supplies: The manipulatives kit is 2 dimensional and consists of laminated paper parts. The kit is available from Wards Scientific, www.wardsci.com, catalog number 6731058.