Name _____ Date _____ Period _____

MODELING TRANSCRIPTION & TRANSLATION

PURPOSE:

In this investigation, you will model the processes of transcription and translation. Transcription occurs when DNA is converted into messenger RNA in the nucleus of a cell. The mRNA then exits the nucleus through the pores in the nuclear envelope and goes to a ribosome. Translation occurs when the mRNA is converted into a polypeptide sequence on a ribosome. This protein is what ultimately gives an organism or cell its phenotype. By completing this activity, you will see how Chargaff's rules and the genetic code chart contribute to the production of a protein in a cell.

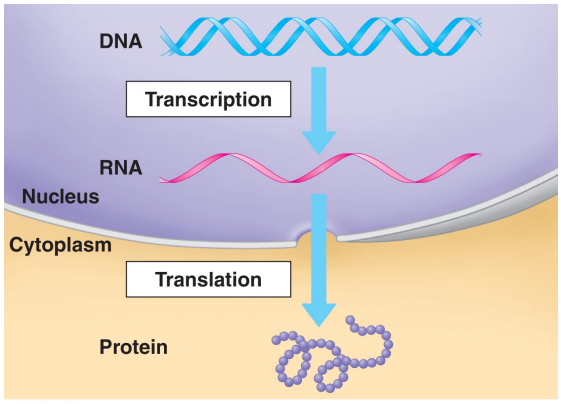
HYPOTHESIS:

If a gene is located on a strand of DNA, then a protein _____ be built by following Chargaff's rules and by using the genetic code chart.

WORD BANK FOR HYPOTHESES: can / cannot

MATERIALS:

- 3 segments of DNA: TGCTCAGTC, GTAAAATATC, and GGCATCCGG
- 1 paper cut-out model of RNA Polymerase
- 6 paper cut-out models of amino acids: TYR, MET, PRO, ISO, PHE, ASP
- 1 paper cut-out model of Stop Sign
- 7 paper cut-out models of tRNA: GGC, AAA, UAU, UAC, AUG, CUG, ACU
- 7 paper cut-out models of mRNA "U"
- 7 paper cut-out models of mRNA "A"
- 7 paper cut-out models of mRNA "G"
- 7 paper cut-out models of mRNA "C"
- 2 paper cut-out models of 5' END
- 2 paper cut-out models of 3' END
- large diagram of a ribosome
- genetic code chart
- tape



PROCEDURE:

1. Line up the three segments of the DNA molecule **upside-down** from left to right as follows:

   3'-G-G-C-C-T-A-C-G-G-C-T-A-T-A-A-A-A-T-G-C-T-G-A-C-T-C-G-T-5'

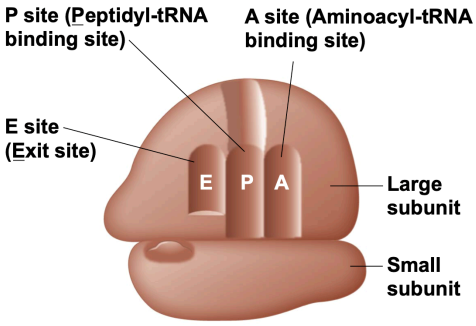
   Using two small pieces of tape, label the left side with the **3' END** cut-out and the right side with the **5' END** cut-out.

2. Write the complementary mRNA base sequence in the space below. Include the 5' and 3' ends in your sequence.

   _____

3. **MODELING TRANSCRIPTION** – Use your RNA Polymerase cut-out to add the complementary mRNA bases, one at a time, beneath the top strand. Pay attention to Chargaff's Rules as you add the bases. Attach a long piece of tape over the grey area beneath the mRNA bases to hold them together. Finally, using two small pieces of tape, label the left side with the **5' END** cut-out and the right side with the **3' END** cut-out. For simplicity, only the "template" strand is created and used. The "non-template" strand will be ignored. **Take a photo of the DNA and mRNA strands.**

4. **MODELING TRANSLATION** – Remove the DNA sequence and set it back in the bag. You will no longer use the DNA sequence. Take out the large picture of the ribosome and place it on your table. Starting from the right side of your ribosome, slide the mRNA to the left (beginning with the 5' end) until the start codon (AUG) is centered on the small ribosomal subunit. The three sections of the ribosome, from left to right, are the "E" site, the "P" site, and the "A" site. The start codon should be located just beneath the "P" site.



5. Determine which amino acid will bind to AUG by using the genetic code chart. Then determine which tRNA molecule will bind to AUG. HINT: You will need to find a tRNA whose anti-codon is complementary to AUG. Attach the amino acid to the top of the tRNA molecule. Then bring the tRNA to the ribosome and place it above the AUG in the "P" site. You should be able to see evidence of a lock-and-key fit. **Take a photo of the ribosome.**

6. The next codon on the mRNA molecule is CCG. Determine which amino acid will bind to CCG by using the genetic code chart. Then determine which tRNA molecule will bind to CCG. HINT: You will need to find a tRNA whose anti-codon is complementary to CCG. Attach the amino acid to the top of the tRNA molecule. Then bring the tRNA to the ribosome and place it above the CCG in the "A" site. You should be able to see evidence of a lock-and-key fit.

7. Remove the amino acid from the tRNA in the "P" site and place it above the amino acid on the tRNA in the "A" site. Secure it from the back using tape.

8. Slide everything in the ribosome three bases to the left. The empty tRNA molecule will slide into the "E" site, where it will exit the ribosome.

9. Repeat steps 6-8 for the AUA and UUU codons. **Take a photo of the ribosome as soon as you add the tRNA and amino acid for UUU in the "A" site, but before you transfer the amino acids onto it.**

10. Remove the amino acids from the tRNA in the "P" site and place them above the amino acid on tRNA in the "A" site. Secure them from the back using tape. **Take a photo of the ribosome.**

11. Slide everything in the ribosome three bases to the left. Remove the empty tRNA molecule through the "E" site. Show the discarded tRNA molecule off to the side. **Take a photo of the ribosome, including the discarded tRNA.**

12. Repeat steps 6-8 for the remainder of the codons. When you get to the stop codon, attach the stop sign to the tRNA. The tRNA with the stop sign will bind to the codon in the "A" site. **Take a photo of the ribosome.**

13. Separate the ribosome, the mRNA sequence, the amino acid sequence, and the tRNA with the stop sign. Note that there will be unused mRNA bases downstream from the stop codon. **Take a photo of all of these components.**

RESULTS:

There should be seven data tables for this lab:

- Data Table #1: Photo of Transcription
- Data Table #2: Photo of Translation – Initiation Step
- Data Table #3: Photo of Translation – Codon Recognition Step
- Data Table #4: Photo of Translation – Peptide Bond Formation Step
- Data Table #5: Photo of Translation – Translocation Step
- Data Table #6: Photo of Translation – Termination Step
- Data Table #7: Photo of Translation – Final Product

The names of the data tables correspond to the photos that you took during the lab in the order that you took them.

DISCUSSION:

1. How were Chargaff's rules used to create the strand of mRNA during transcription? Describe the evidence shown in Data Table #1.

2. What is the role of the mRNA during translation? How does it convey a "message" from the nucleus to the ribosome?

3. What is the role of the tRNA during translation? In your answer, discuss the structure-function relationship of the codon and the anti-codon. Cite evidence from Data Tables #4, #5, and #6 to support your answer.

4. What is the role of the start codon during translation? Cite evidence from Data Table #2 to support your answer.

5. What is the role of the stop codon during translation? Cite evidence from Data Tables #6 and #7 to support your answer.

POST-LAB QUESTIONS:

1. Assume a point mutation is added on the second codon. The CCG codon is mutated to ACG. Hypothesize what amino acid will be placed instead of proline. Then predict the anti-codon of the tRNA that will bring the different amino acid.

2. Assume a frame-shift mutation occurs and a U is inserted between the two C's in the second codon:

   Original Sequence: AUG – CCG – AUA – UUU – UAC – GAC – UGA – GCA
   Mutated Sequence: AUG – C**U**C – GAU – AUU – UUA – CGA – CUG – AGC – A

   Predict the entire sequence of amino acids that will be produced on the ribosome.

3. Assume a point mutation converts a normal codon into an early stop codon. Predict whether the amino acid sequence will become shorter or longer. Will the protein be fully functional? Explain your reasoning.

QUESTIONS TO HELP YOU WITH YOUR LAB REPORT:

1. Was your hypothesis correct? Explain using CLAIM → EVIDENCE → REASONING.

2. Identify 1 or 2 sources of error for this lab. Explain your answer(s).

3. Identify 1 or 2 ways to improve this lab. Explain your answer(s).

4. What conclusion(s) can you draw regarding the process of transcription?

5. What conclusion(s) can you draw regarding the process of translation?