Lab 4: DNA Replication and Protein Synthesis: Modeling Activity (15 points)

Objectives:

- To learn about the structure of DNA and base pairing
- To understand how DNA replication produces two identical copies
- To understand the two steps in proteins synthesis: transcription and translation
- To become familiar with how mutations can lead to altered proteins and what effect those mutations may have on the protein

What you need:

- Materials:
    - Four red licorice sticks/ropes
    - Two black licorice sticks/ropes
    - Toothpicks
    - Colored marshmallows
    - Paperclips
    - Masking tape or clear tape on which you can write something
    - One sheet of paper
- Video 4 study plan for reference
- Chapter Four from the text for reference
- Videos posted on Moodle

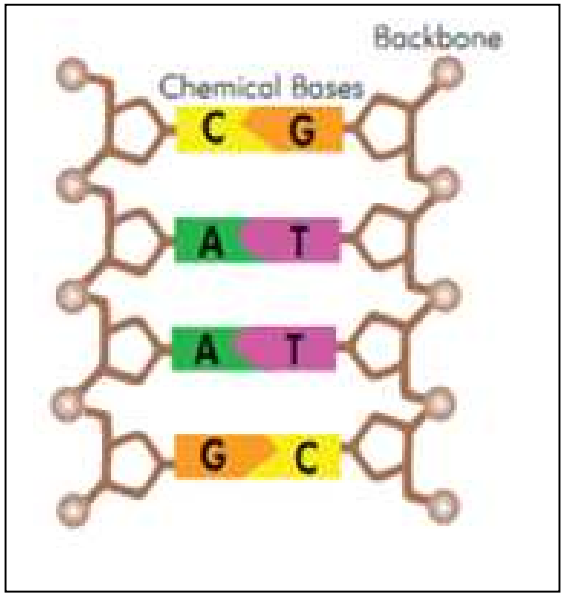
What to do:

Make a molecule of DNA

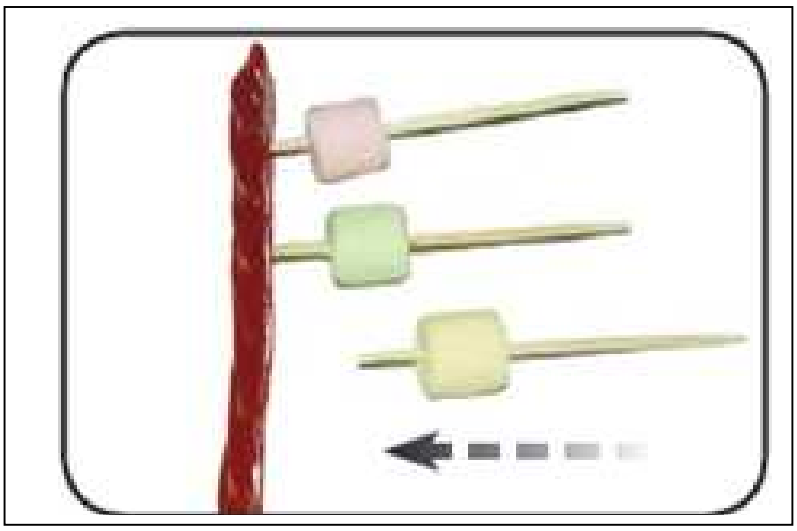
1. You will be making a strand of DNA using the licorice, toothpicks, and colored marshmallows. The directions below will help you to make the following sequence:

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

2. The sugar- phosphate backbone of the DNA will be represented by the red licorice, while the nitrogenous bases will be represented by the colored marshmallows. Use green marshmallows to represent adenine (A), pink to represent thymine (T), yellow to represent cytosine (C), and orange to represent guanine (G). Remember the things that you learned in the videos and in the textbook that adenine will base-pair with thymine and cytosine will base-pair with guanine (see next page).



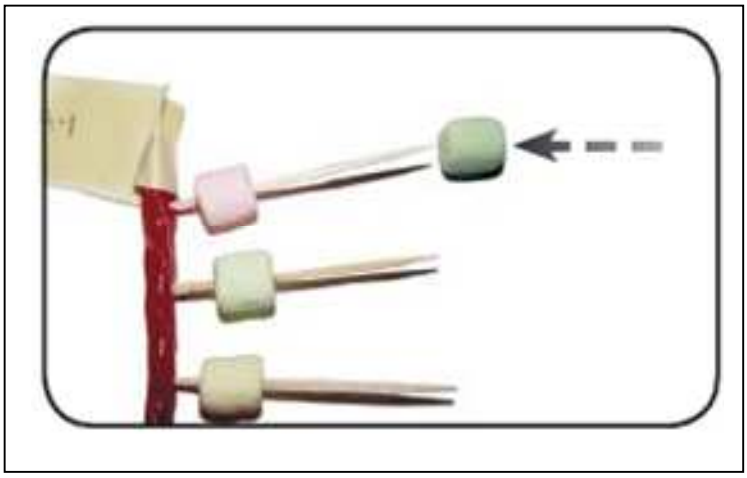
3. As you see in the picture below you will stick a toothpick through the colored marshmallows and into the red licorice stick.

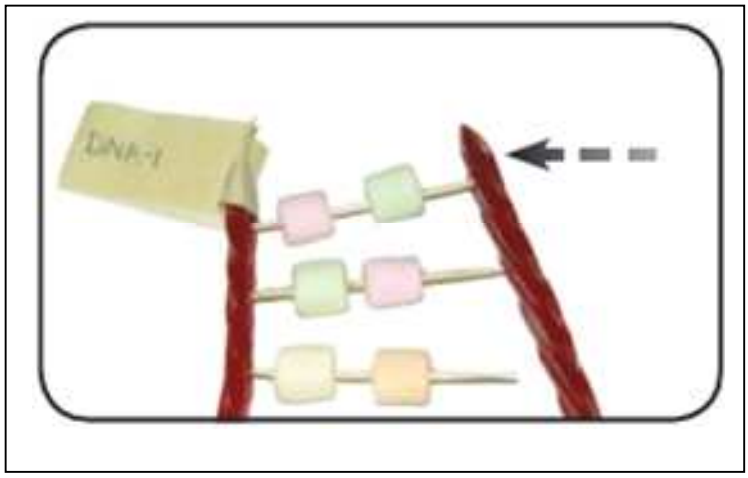


4. After you have completed the above steps you should have a piece of red licorice with marshmallows stuck in the red licorice. We will call this DNA strand #1. Label the piece of red licorice with DNA strand #1 with a small piece of paper taped to a paper clip and stick the paper clip into the end of the licorice. You should have a piece of red licorice with the following marshmallow color order:

   green – pink – orange – orange – pink – pink – yellow – yellow – orange – green – green – pink – pink – green – green

5. Make the second strand of DNA by sticking the complementary base (marshmallow) on the toothpick.





6. **In the submission form, type in the sequence of the second strand that you made (#1).**
7. Label the second piece of red licorice with DNA strand #2 with a small piece of paper taped to a paper clip and stick the paper clip into the end of the licorice. Your DNA molecule should look like a ladder at this point.
8. Twist your DNA model so that it forms the double-helix we expect to see with DNA.

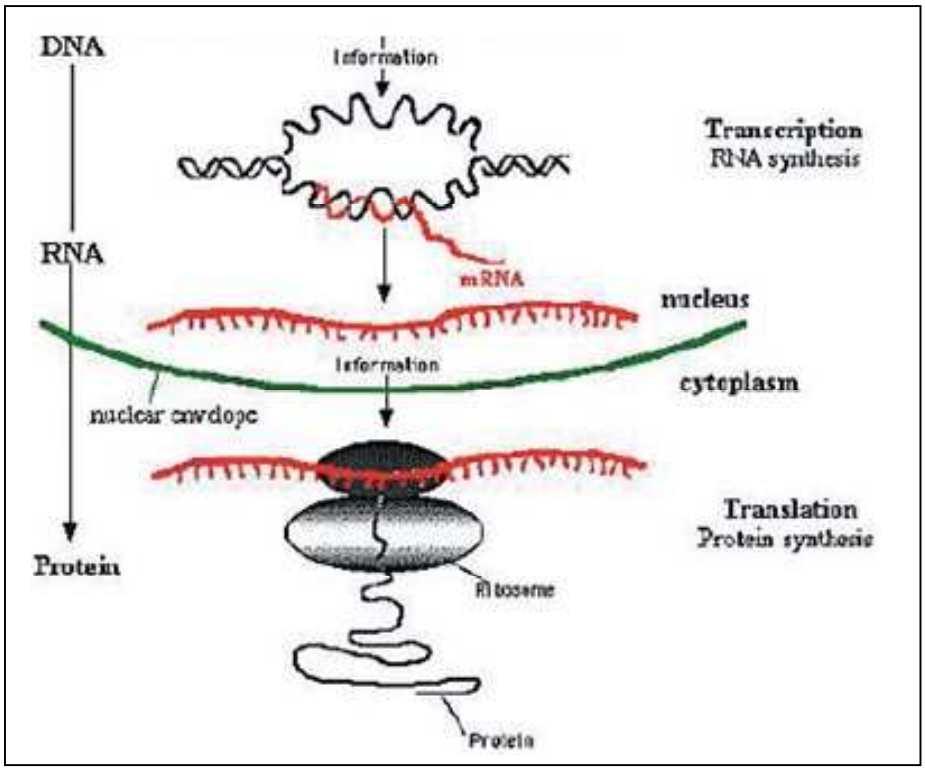
DNA Replication Modeling

9. Replication is the process that all living cells use to make identical copies of the DNA, just prior to cell division. You are going to be modeling that process in the next several steps.
10. Untwist the DNA that you twisted in step #8. The enzyme that does this inside a cell is called either DNA gyrase or Topoisomerase.
11. Using a pair of strong scissors, cut the toothpicks in between the bases of strand #1 and strand #2. **What enzyme do the scissors represent** (answer this on the submission form - #2)?

12. Now you need to repeat step #5 (you will probably need to replace the toothpicks since you cut them in two). Thus, you will be making two complementary strands of DNA – one strand complementary to Strand #1 and one strand complementary to Strand #2.
13. **When you have completed making the two complementary strands of DNA record the strands on the submission form (#3).**
14. **Also answer question #4.**

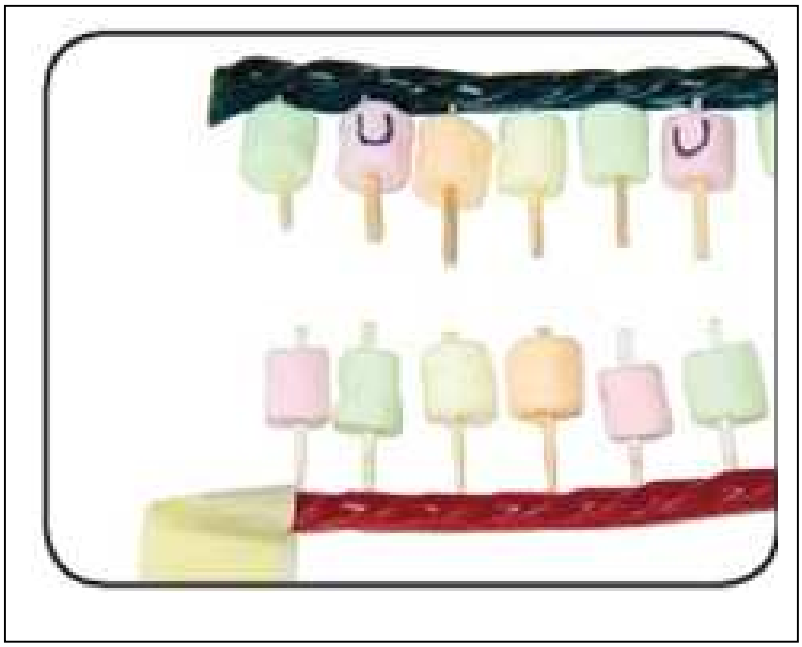
Modeling transcription:

15. Review transcription and translation in the image shown below and practice transcription and translation at http://learn.genetics.utah.edu/content/begin/dna/transcribe/



15. You will be modeling both processes in this part of the lab. Transcription is the process by which we get mRNA and translation is the process by which we get protein using the information contained within the mRNA. This step is carried out by RNA polymerase.
16. Cut Strand #1 apart so that you have two single-strands of DNA (like you did in step #11).

17. At this point, the process of transcription could yield two different mRNA molecules. For each of the two strands of DNA make the complementary strands of mRNA using the code shown below. In place of the red licorice that we used for DNA, use black licorice to represent the sugar-phosphate backbone of the RNA molecule.



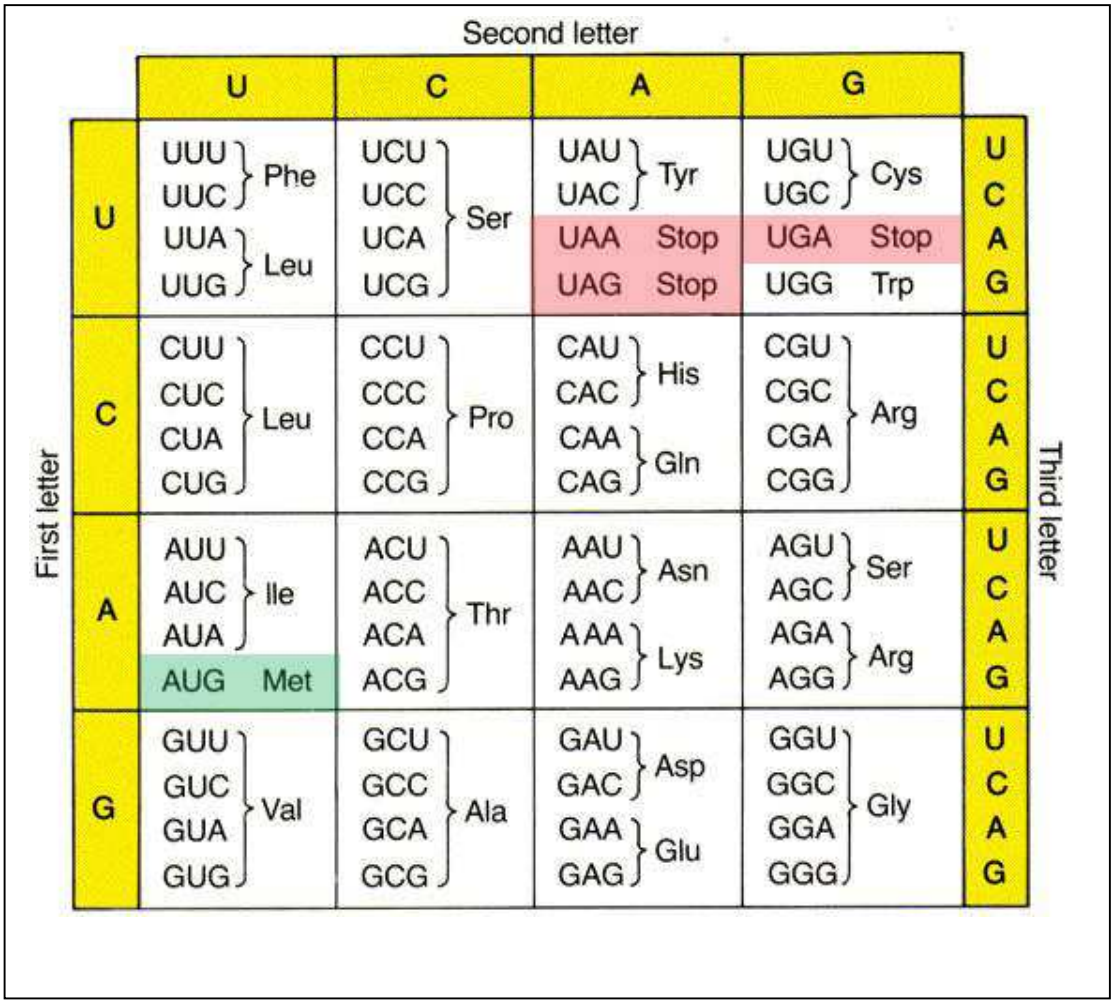
18. You will get one mRNA transcript from the original Strand #1 and one from the original strand #2 (see step #3). On the submission form type the two possible mRNA molecules that you could get from the process of transcription (#5).

19. On the submission form, list 2 ways the mRNA differs from the molecule of DNA (#6).

20. Are the two mRNA molecules identical (#7)?

Modeling translation:

21. Now we are going to translate the first codon of both strands of the mRNA. You will need to use the genetic code table shown below.
    a. Remember that it takes three bases to form a “codon” and the codons are what you see in the table below.
    b. While it is not labeled specifically in the table, the codon AUG, which codes for “met” (or methionine) is the **start codon**.
22. To read the table you can simply look for the group of three letters for each codon. However, the table is designed so that you look for the first letter on the left, the second letter across the top, and then the third letter along the right.
    a. Thus, is you were looking for the amino acid coded for by the codon “CAA” you would look for the “C” along the left side. The “C” is in the second box from the top.
    b. The second letter is an “A”, which is the third box from the left. The intersection between the first base and the second base goes to a box where there are four codons – CAU, CAC, CAA, and CAG.
    c. The third letter, which is an “A” is the third codon down in that box. That codon codes for “gln” (glutamine).



23. **Which strand will you be translating and why (#8 and #9)? Record your answers on the submission form.**

24. **What enzyme is going to be translating the mRNA and forming the covalent bonds between the amino acids (#10)?**

25. **What is the name of the RNA molecule that will be bringing the amino acids to the enzyme mentioned in the above question (#11)?**

26. Starting with the strand that has the start codon tape a circle of paper to each codon (group of three bases).

27. Using the genetic code table on the previous page identify each of the amino acids that correspond to the codons of your mRNA strand. Write the three letter abbreviation on the paper circles. **On the submission form type in each of the codons (three bases per box) and then below each codon type in the three-letter abbreviation for the corresponding amino acid.**

Mutations

28. Sometimes the enzyme DNA polymerase makes a mistake and the wrong base is added to the growing strand of DNA during the process of replication. Other times a mutagen causes a change in one or more of the bases. If this occurs it is a mutation. **Fill out the tables shown in the submission form to see the result of mutations.** Use the codon table provided earlier in this activity to determine the amino acid sequence for the gene sequence below.
29. There is a rare occasion when things really get messed up during DNA replication and the DNA polymerase either adds a base or removes a base. We call these frameshift mutations. You will explore these on the submission form in questions #36 and #37.