Name _____ Date _____

TEACHER _____ LAB DAY _____ CLASS PERIOD _____

tRNA AND PROTEIN BUILDING

STANDARDS 1 - 7

LAB 21/22

RNA produced in the nucleus of a cell moves out of the nucleus to the cell's ribosomes. This RNA is a specific sequence of bases copied from the DNA which carries the chromosomal genetic message to the cytoplasm. Thus, it is called messenger RNA (mRNA). At the ribosomes, mRNA directs the building of proteins. Proteins are made up of smaller molecules called amino acids. How does a cell construct the proper amino acids into protein molecules? Formation of proteins involves another kind of RNA. Transfer RNA (tRNA) brings specific amino acids to mRNA according to the code sequence of bases found on mRNA.

In this investigation, you will

(a) use paper models to show how base shapes in mRNA match only with specific base shapes of tRNA.
(b) use paper models to show how tRNA molecules bring specific amino acid molecules to the ribosome where building of proteins occurs.
(c) learn to transcribe a DNA code to a mRNA message and translate the mRNA to the tRNA—amino acid code.
(d) study the molecular basis for gene mutations.

Materials

models of RNA nucleotides from Investigation 24 page of paper models of tRNA scissors

Procedure

Part A. Structure of tRNA

• Build a molecule of mRNA using the paper molecules from Investigation 24. Make sure you are using only RNA nucleotides. Join the RNA nucleotides to form a row of molecules in this order:

Guanine
Adenine
Cytosine
Uracil
Cytosine
Guanine

• Recall that molecules of mRNA leave the cell nucleus and move out to the cell's ribosomes. Meanwhile, transfer RNA (tRNA) is present in the cell cytoplasm. Models of tRNA were supplied to you by your teacher. Molecules of tRNA are composed of many base nucleotides. However, tRNA has a three base sequence (a triplet) that can match up with the bases of mRNA.

• Cut out the two models of tRNA. *Cut only along solid lines.* **CAUTION:** *Always be careful with scissors.*

1. (a) Name the four nucleotide bases present in tRNA. _____

(b) Do these bases differ from those found in mRNA? _____

(c) How does the tRNA molecule differ from mRNA in shape? _____

_____

• Join the tRNA molecules to the model of mRNA.

2. What base in mRNA can only join with the

(a) adenine base of tRNA? _____

(b) uracil base of tRNA? _____

(c) guanine base of tRNA? _____

3. What order of bases on mRNA will match a sequence on tRNA of

(a) UUA? (uracil, uracil, adenine) _____

(b) UCA? (uracil, cytosine, adenine) _____

(c) UGA? (uracil, guanine, adenine) _____

(d) AAA? (adenine, adenine, adenine) _____

Transfer RNA picks up amino acids in a series of chemical steps. A tRNA molecule only picks up a certain amino acid. The amino acid is attached to the tRNA at the end opposite the three bases that will attach to mRNA.

• Cut out the two remaining models of amino acids, serine and aspartic acid, from the page provided by your teacher. Join these models to their proper tRNA models. Only a specific amino acid will fit along the top of each tRNA model. Remember that each tRNA model has a three sequence base called a triplet.

4. What amino acid connects to a tRNA molecule with a triplet of

(a) AGC? _____

(b) CUG? _____

5. What molecule receives the amino acids on tRNA? _____

6. How many base molecules or nucleotides of mRNA are responsible for the coding of one amino acid? _____

Part B. Forming a Protein Molecule During Translation

When many amino acid molecules are brought to the mRNA by tRNA, the amino acids join to form a protein molecule. When tRNA molecules with their attached amino acids join to the bases of the mRNA, the formation of a protein molecule is begun. This entire process is called translation. The DNA message has been translated into a protein molecule.

7. What amino acid is attached to a tRNA molecule having a base sequence of

(a) UUU? (Read from Table 25-1.) _____

(b) GCU? _____

8. What tRNA triplet is needed to join with the following amino acids:

(a) phenylalanine? (Read from Table 25-1.)

_____

(b) valine? _____

(c) glutamic acid? _____

Depending on the type and order of amino acids, an almost endless variety of proteins can be produced. Because of the repeated matching of base sequences, the base sequence in the DNA of chromosomes codes for and controls the formation of protein molecules at ribosomes.

9. A protein molecule consists of the following amino acid sequence: leucine, glutamine, tyrosine, leucine, serine, serine. What would be the sequence of tRNA bases responsible for forming this protein? (Use Table 25-1.) _____

_____

10. A ribosome receives the following mRNA message: AAA, CGA, GAA, GUU.

(a) What will be the sequence of tRNA bases joining the mRNA molecule? _____

_____

(b) What will be the sequence of amino acids formed from this code? _____

TABLE 25-1. tRNA TRIPLET CODES OF SOME AMINO ACIDS

AMINO ACID	tRNA CODE
Serine	AGC
Proline	GGG
Leucine	AAU
Glutamic acid	CUU
Tyrosine	AUA
Arginine	GCU
Glutamine	GUU
Phenylalanine	AAA
Valine	CAA
Lysine	UUU

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As a review, you should now be able to transcribe (decode) a message in DNA base code into mRNA and then translate it into a protein molecule.

A portion of DNA on a chromosome has the sequence of bases along one strand of DNA as indicated in Table 25-2.

• Transcribe or decode this message first into mRNA code, then translate it into tRNA code and proper amino acids using Table 25-1.

TABLE 25-2. TRANSCRIBING AND TRANSLATING OF A DNA SEQUENCE

CHROMOSOME DNA CODE OF BASES	mRNA BASE CODE	tRNA BASE CODE	AMINO ACID SEQUENCE
AAT			
GGG			
ATA			
AAA			
GTT			

• Rework the cell's code language backward by completing Table 25-3.

TABLE 25-3. TRANSCRIBING AND TRANSLATING OF AN AMINO ACID SEQUENCE

AMINO ACID SEQUENCE	tRNA BASE CODE	mRNA BASE CODE	DNA BASE CODE
Proline			
Glutamic acid			
Lysine			
Serine			
Leucine			

Part C. Mutations and Base Sequence Errors

Not often are there errors in the process of forming proteins from the DNA code of instructions. An error in the process is a mutation and will result in formation of a different type of protein.

Hemoglobin is a protein in red blood cells. Hemoglobin results from the proper arrangement of almost 600 amino acids. Most humans have the correct type of hemoglobin. However, in some people the arrangement is incorrect. These people have a disease called sickle-cell anemia. Their red blood cells are sickle-shaped rather than round. As a result, the red blood cells cannot transport oxygen as well.

The following amino acid sequence represents a portion of the normal hemoglobin molecule: proline, glutamic acid, glutamic acid, lysine.

11. Translate the sequence of amino acids in normal hemoglobin into

(a) tRNA base codes. _____

_____

(b) mRNA base codes. _____

_____

(c) DNA base codes. _____

_____

In sickle-cell anemia, the sequence of amino acids is slightly different. It is proline, valine, glutamic acid, lysine.

12. Translate the sequence of amino acids in sickle-cell hemoglobin into

(a) tRNA base codes. _____

_____

(b) mRNA base codes. _____

_____

(c) DNA base codes. _____

_____

13. In terms of base nucleotides, explain the only difference between the DNA message for normal hemoglobin and the DNA message for

sickle-cell hemoglobin. _____

_____

_____

A mutation, therefore, is a difference from what we consider to be the normal sequence of bases in a molecule of DNA. The difference or error does not have to be very great. As you have just determined, a base sequence of only one triplet (three bases) can cause the formation of the wrong type of hemoglobin. A change at only one base site of the triplet can cause mutation.

14. How are mutations passed on to offspring?

_____

_____

_____

Analysis

1. What is the function of mRNA? _____

_____

2. What is the function of tRNA? _____

_____

3. How do tRNA and mRNA differ in their location within the cell? _____

_____

4. (a) Briefly describe what is meant by translation. _____

_____

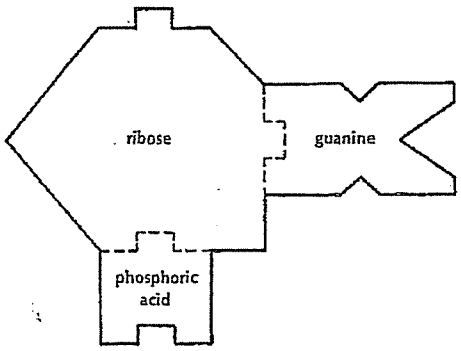
_____

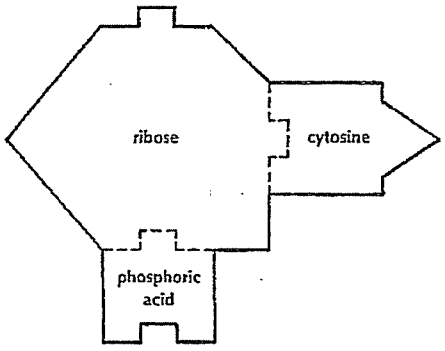
(b) What is being translated? _____

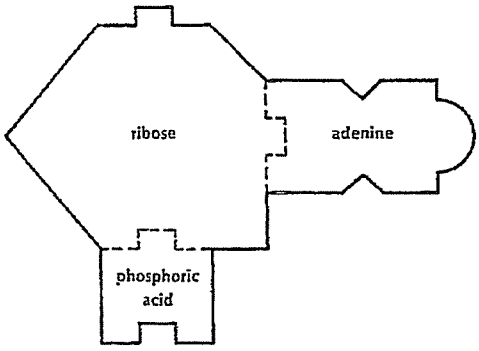
5. Complete this chart by using check marks to indicate to which molecule each characteristic applies.

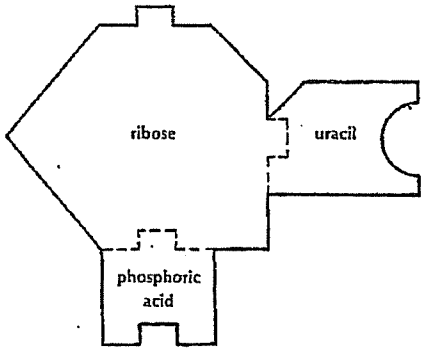
SIMILARITIES AND DIFFERENCES BETWEEN mRNA AND tRNA		
	mRNA	tRNA
deoxyribose present		
ribose present		
phosphoric acid present		
adenine present		
thymine present		
uracil present		
guanine present		
cytosine present		
contains a chemical message or code		
carries an amino acid to a ribosome		

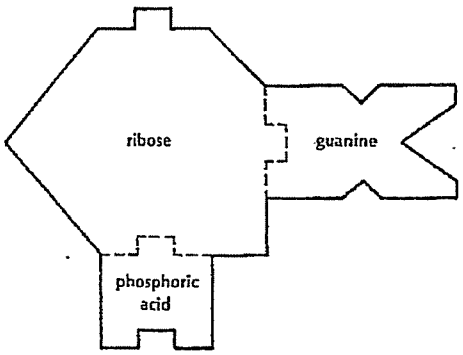
RNA NUCLEOTIDES FOR INVESTIGATION 24, "RNA AND DNA" AND INVESTIGATION 25, "tRNA AND PROTEIN BUILDING"

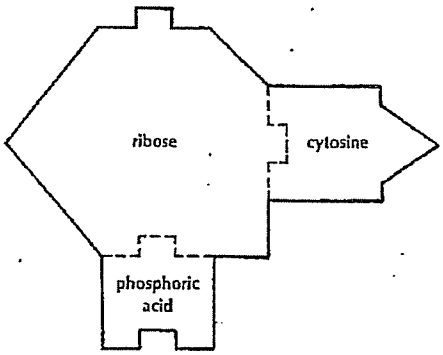












tRNA MODELS FOR INVESTIGATION 25, "tRNA AND PROTEIN BUILDING"