Protein Synthesis Worksheet
Living Environment

Name _____
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This activity was modified from an original posting by Kim Foglia.

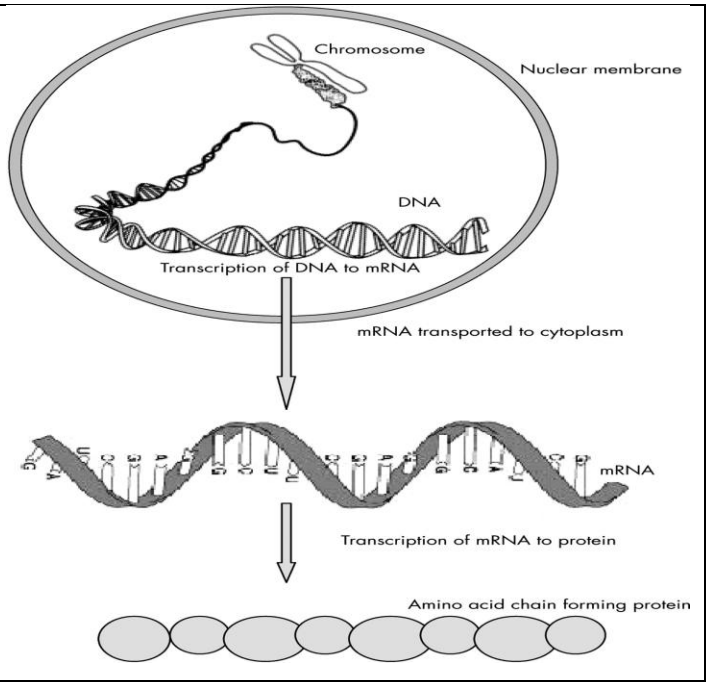
DNA is the molecule that stores the genetic information in your cells. That information is coded in the four **bases** of DNA: C (cytosine), G (guanine), A (adenine), and T (thymine). The DNA directs the functions of the cell on a daily basis and will also be used to pass on the genetic information to the next generation. Because of its critical role in all the functions of the cell, DNA is kept protected in the nucleus of your cells.

DNA is organized in sections called **genes**. Genes code for **proteins**, and it is proteins that do all the work in the cell. They function as **structural proteins** — serving as the building blocks of cells and bodies. And they function as **enzymes** — directing all the chemical reactions in living organisms. Proteins also function as **antibodies** which are produced by certain white blood cells to destroy antigens.

Proteins are made in the **cytoplasm** by **ribosomes**. So the information from DNA must be transmitted from the nucleus to the cytoplasm. Since DNA is too large to move from through the nuclear membrane, it must undergo the process of transcription. **Transcription** uses a DNA strand as a template to produce a strand of RNA. Each gene on the DNA is read and codes directly for a **messenger RNA** (**mRNA**) molecules. The mRNA is made by matching its complementary bases — C, G, A, and **U** (**uracil**) — to the DNA bases. It is important to note that the base T (thymine) is replaced by the base U (uracil) in RNA. The mRNA molecule then leaves the nucleus and carries the code for making the protein from the DNA gene to the ribosome in the cytoplasm.

The ribosome reads the sequence of bases on the mRNA in sets of three — the triplet **codons**. Another type of RNA — **transfer RNA** (**tRNA**) — brings the protein building blocks — **amino acids** — to the ribosome as they are needed. The ribosome bonds the amino acids together to build the protein coded for by the gene back in the nucleus. This process of assembling the protein on the ribosomes is called translation. This analogy makes sense, because we have now changed from the language of nitrogenous bases to that of amino acids in making the protein.

Image source:
http://pmj.bmj.com/content/83/986/731/F1.large.jpg



Assessment

1. List three functions of proteins in living things.

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Use the universal codon chart on the next page, the introductory reading, as well as your knowledge of biology to complete the following questions.

Universal Genetic Code Chart

Messenger RNA Codons and Amino Acids for Which They Code

First base	Second base: U	Second base: C	Second base: A	Second base: G	Third base
U	UUU, UUC: PHE UUA, UUG: LEU	UCU, UCC, UCA, UCG: SER	UAU, UAC: TYR UAA, UAG: STOP	UGU, UGC: CYS UGA: STOP UGG: TRP	U C A G
C	CUU, CUC, CUA, CUG: LEU	CCU, CCC, CCA, CCG: PRO	CAU, CAC: HIS CAA, CAG: GLN	CGU, CGC, CGA, CGG: ARG	U C A G
A	AUU, AUC, AUA: ILE AUG: MET or START	ACU, ACC, ACA, ACG: THR	AAU, AAC: ASN AAA, AAG: LYS	AGU, AGC: SER AGA, AGG: ARG	U C A G
G	GUU, GUC, GUA, GUG: VAL	GCU, GCC, GCA, GCG: ALA	GAU, GAC: ASP GAA, GAG: GLU	GGU, GGC, GGA, GGG: GLY	U C A G

Use the DNA sequence below to determine the associated mRNA sequence and protein fragment it codes for.

1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
T	A	C	A	G	C	C	A	C	T	G	A	G	C	T	C	C	C	G	A	G	C	T	C	C	G	A	A	C	T

2. Neatly record the sequence of the **mRNA transcribed** from this DNA strand.

1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

3. Divide the **mRNA** sequence into its triplet **codons** and rewrite them in order below as 3-base groups (triplet codon).

4. Record the **amino acid** sequence that this mRNA coded for. You can use the 3 letter amino acid abbreviation found in the universal genetic code chart.

MUTATIONS

Sometimes when DNA is copied errors occur. We call these **mutations**. Sometimes mutations cause only minor changes to a gene and therefore make only minor changes in the protein produced from that gene. These types of mutations may cause only minor effects to the way an organism looks or functions — the **phenotype** of the organism. But sometimes mutations can cause great changes to the gene and therefore greatly alter the protein that is made from that gene. This is because a mutation can produce a change in the amino acid sequence making up a protein. Different amino acids have different charges. The way these charges interact influence the way the protein folds, producing its shape. Remember from our study of the lock and key concept that the shape of a protein determines its function by the way it fits with other molecules. These changes may have great effects on the organism, since the protein will not be able to perform its normal function. This may lead to the inheritance of a genetic disease.

One mutation is called a **point mutation** where only one base in the gene is copied incorrectly during **DNA replication**.

Use the DNA sequence below assess the change a point mutation could produce on the associated mRNA sequence and protein fragment it codes for.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
T	A	C	A	G	C	C	A	C	T	G	A	G	C	T	C	C	C	G	A	G	C	T	C	C	G	A	A	C	T

5. Below, rewrite the original **DNA** sequence (from above), but simulating a **point mutation** at the 13th base. It was accidentally changed during DNA replication from a **G** to an **A**.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

6. Divide the **mRNA** sequence into its triplet **codons** and rewrite them in order below as 3-base groups (triplet codon) in the first row below. Then translate your mRNA triplet codons from this row into the sequence of amino acids composing the protein in the bottom row. You can use the 3 letter amino acid abbreviation found in the universal genetic code chart.

7. Did this change in the DNA sequence cause any significant change to the amino acid sequence and therefore the protein produced? Support your answer.

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Now we will simulate the effect of a point mutation having a less dramatic effect. Use the DNA sequence below assess the change a point mutation could produce on the associated mRNA sequence and protein fragment it codes for.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
T	A	C	A	G	C	C	A	C	T	G	A	G	C	T	C	C	C	G	A	G	C	T	C	C	G	A	A	C	T

8. Below, rewrite the original **DNA** sequence (from above), but let's simulate a **point mutation** at the 9th base. It was accidentally changed during replication from a **C** to a **T**.

9. Divide the **mRNA** sequence into its triplet **codons** and rewrite them in order below as 3-base groups (triplet codon) in the first row below. Then translate your mRNA triplet codons from this row into the sequence of amino acids composing the protein as in the previous example.

10. Did this change in the DNA sequence cause any significant change to the amino acid sequence and therefore the protein produced? Support your answer.

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11. Why do cells have to produce RNA from DNA? _____

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12. Where does protein synthesis occur in a cell? _____

13. Define the following terms in reference to our study of genetics.

replication _____

transcription _____

translation _____

14. Explain in your own words the meaning of the following quotation.
"DNA gets all the glory, but proteins do all the work!"

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15. The translation of proteins from mRNA is often compared to the translation of a foreign language. Explain this analogy.

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16. Explain how a change in one nitrogenous base produces a change in the function of a protein.

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