Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Period: \_\_\_\_\_

**Gene Mutations Activity**

**Background:** There are two types of mutations, small-scale gene mutations and large-scale chromosomal mutations. In this activity you will be learning about gene (point) mutations. There are two basic types of gene mutations, base substitution and frameshift (insertions and deletions). In frameshift mutations, an insertion or deletion of a base changes the reading frame of the sequence since mRNA is read in groups of three nitrogen bases (codons). This causes several amino acids to be affected unless the deletion or insertion is a group of three. There are very few examples of frameshift mutation diseases in organisms because they are usually fatal to the organism because the proteins do not function. In substitution mutations, a simple base substitution does not change the reading frame because one nitrogen base is simply substituted with a different nitrogen base, so only one amino acid is affected unless there are several base substitutions.

**Part 1: *Frameshift Mutations***

Example 1: Insertion Frameshift

DNA Sequence Sentence: THE BOY CUT HIS LIP AND ATE THE HOT DOG

 **↘**

Affect of Insertion: THE BOY CUT HIS **S**LI PAN DAT ETH EHO TDO

 **↑**

 **Insert a nitrogen base**

Example 2: Deletion Frameshift

 **Delete a nitrogen base**

 **↓**

DNA Sequence Sentence: THE BOY CUT HIS LIP AN**D** ATE THE HOT DOG

 **↙**

Affect of Deletion: THE BOY CUT HIS LIP ANA TET HEH OTD OG

The insertion shifts the reading frame to the right. The deletion shifts the reading frame to the left.

Complete the following lines for frameshift mutations. Write each codon per line:

DNA Sequence: THE BOY CUT HIS LIP AND ATE THE HOT DOG

Insertion: THE BOY \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_

**↑**

**Insert a nitrogen base (insert an additional Y)**

Deletion: THE BOY CUT \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_

**↑**

**Delete a nitrogen base (delete the I in HIS)**

**Part II:** Now use a real DNA sequence and transcribe and translate it into the correct amino acids. Please use the mRNA codon chart below to find the corresponding amino acids.



In the original DNA code put the **insertion frameshift mutation** in the **FOURTH CODON by inserting a G after the C in TCT**. Write each codon per line and **circle** the mutated nitrogen base where the mutation took place and the amino acid.

Original DNA: TAC GGA CGA TCT CAG GAG CCT ATA ATC

Insertion Mutation \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated mRNA \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated Amino Acids \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Original Amino Acid Sequence: Met Pro Ala Arg Val Leu Gly Try STOP

In the original DNA code put the **deletion frameshift mutation** in the **THIRD CODON by deleting the C of CGA**. Please use the mRNA codon chart provided to find the corresponding amino acids. Write each codon per line and **circle** the mutated nitrogen bases where the mutation took place and the amino acid.

Original DNA: TAC GGA CGA TCT CAG GAG CCT ATA ATC

Deletion Mutation \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated mRNA \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated Amino Acids \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Original Amino Acid Sequence: Met Pro Ala Arg Val Leu Gly Try STOP

**Part III: *Base Substitution Mutations***

A different type of gene mutation is called a base substitution mutation. It is the simplest type of mutation where a nucleotide pair is replaced with a different nucleotide pair. There are three types of base substitution mutations: missense, silent, and nonsense.

Example 1: ***Missense Point Mutation***

A missense mutation occurs when one nitrogen base is substituted for another nitrogen base causing a different amino acid than previously to occur in the protein sequence.

Purine → Pyrimidine **G**AC → **T**AC Purine → Purine **G**AC → **A**AC

Pyrimidine → Purine GA**C** → GA**G** Pyrimidine → Pyrimidine GA**C** → GA**T**

Use the DNA code below to demonstrate purine → pyrimidine**missense point mutation**. All you have to do is change the DNA base in the **SECOND CODON from CAT to GAT.** Write each codon per line and **circle** the mutated nitrogen base and amino acid.

Original DNA: TAC CAT GCA GAT CTG GCC CAG TTC ATC

Missense Mutation \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated mRNA \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated Amino Acids \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Original Amino Acid Sequence: Met Val Arg Leu Asp A Arg Val Lys STOP

Example 2: ***Silent Point Mutation***

A *silent mutation* happens when one base in a codon is changed but both code for the same amino acid.

DNA Codon: CT**T** → CT**C**

mRNA codon: GAA →GAG

Amino Acid: Glutamic Acid → Glutamic Acid

Use the DNA code below to demonstrate a **silent mutation**. All you have to do is change one DNA base in the **THIRD CODON from TCT to TCC.** Write each codon per line and **circle** the mutated nitrogen base and amino acid.

Original DNA: TAC CAT TCT CGG TGT AAA AGG GCG ATT

Silent Mutation \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated mRNA \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated Amino Acids \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Original Amino Acid Sequence: Met Val Arg Ala Thr Phe Ser Arg STOP

Example 3: ***Nonsense Point Mutation***

A base mutation that creates a new stop codon in place of an amino acid causing a premature stopping of translation is called a *nonsense mutation*.

DNA codon: AT**A** → AT**T**

mRNA codon: UA**U** → UA**A**

Amino Acid: Tyrosine → STOP

Use the DNA code below to demonstrate a nonsense mutation. All you have to do is change one DNA base to create a new amino acid sequence with a premature stop codon in the **FIFTH CODON by changing ATA to ATT**. Write each codon per line and **circle** the mutated nitrogen base and amino acid.

Original DNA: TAC GGT AAT CAA ATA GAA CCT GAG ACT

Nonsense Mutation \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated mRNA \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Mutated Amino Acids \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

Original Amino Acid Sequence: Met Pro Leu Val Tyr Leu Gly Leu STOP

**Analysis Questions:**

1. How many amino acids were affected in the point mutations?

2. How many amino acids were affected in the frameshift mutation?

3. Explain the difference between a frameshift mutation and a substitution mutation.

4. Which type of mutation, a frameshift or a substitution mutation, has more effect on the organism? Why?

5. Usually a frameshift mutation results in the synthesis of a nonfunctional protein. Why do you think mutated proteins might not be functional?

6. Which type of substitution mutation would be insignificant to the organism? Why?

7. Which type of substitution mutation would have the greatest affect on the organism? Why?

8. Which type of mutation would most likely cause major changes to physical structures of the organism?