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Mutations Activity

Introduction: DNA is genetic material made of nucleotides. Last unit we saw how proteins were created through transcription (DNA→mRNA) and translation (mRNA→linked amino acids). However, in this unit we want to see how those processes can "go wrong" and create mutations. In this activity you will investigate a *gene mutation* in which there is a change in one nucleotide. This can be a *point mutation* called a substitution, where a base pair is "swapped" with the incorrect base. Or it can be an insertion or deletion: which will cause a *frameshift mutation.* You will see how these changes affect the way the message is transcribed to RNA and translated to protein. Explore the effects of gene mutations.

Concepts: By the end of this lab you should
-be refreshed on transcription and translation
-understand how a point mutation can alter a gene
-understand the different types of point mutations

Background:DNA is an example of a complex biological polymer called a nucleic acid, which is made up of small subunits called nucleotides. There are four possible nitrogen bases in DNA—adenine (A), guanine (G), cytosine (C), and thymine (T). The nitrogen bases will preferentially bond with only one other nitrogenous base–adenine with thynine and guanine with cytosine. The bonded nitrogen bases are called a *base pair*. This DNA is used to complete protein synthesis.

During protein synthesis at the ribosome, mRNA sequences are read and translated into amino acids. Another area of the tRNA transports a specific amino acid. The amino acids are linked together into chains by enzymes to form proteins.

Depending on the DNA sequence The 20 amino acids are brought to the ribosomes by transfer RNA (tRNA). An infinite variety of proteins can be formed from the 20 amino acids, which can occur in any number and in any order.

These amino acids are specified by codons (or three nucleotides in a row on mRNA). If the mRNA is copied incorrectly during transcription a mutation will occur. A *gene mutation* is a change in a single base pair of a gene. Point mutations, or *single nucleotide polymorphisms* (SNPs), involve only one nitrogen base change of the three nitrogen bases in a codon. Perform this activity and witness the change a single gene mutation in the DNA can have on a resulting protein.

Pre-lab Questions

1. This lab shows the effect of point mutations, which will cause a gene mutation (only effects one gene). What is the difference between this and a chromosomal mutation?

2. Describe each of the mutations:
   a. Substitution

   b. Insertion

   c. Deletion

3. Write the correct type of mutation that occurred in creating the mRNA strand for each of the following examples. Original DNA: ATCCGCTTACG
   a. UUGGCGAAUCG: _____
   b. UATGGCGAAUCG: _____
   c. UGGCGAAUCG: _____

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4. An insertion and deletion will cause a "frameshift." Explain what this means. Is this more or less likely to cause a noticeable mutation than a substitution?

5. Refresh your knowledge on how to use the universal codon chart below

	U	C	A	G
U	UUU = phe UUC = phe UUA = leu UUG = leu	UCU = ser UCC = ser UCA = ser UCG = ser	UAU = tyr UAC = tyr UAA = stop UAG = stop	UGU = cys UGC = cys UGA = stop UGG = trp
C	CUU = leu CUC = leu CUA = leu CUG = leu	CCU = pro CCC = pro CCA = pro CCG = pro	CAU = his CAC = his CAA = gln CAG = gln	CGU = arg CGC = arg CGA = arg CGG = arg
A	AUU = ile AUC = ile AUA = ile AUG = met	ACU = thr ACC = thr ACA = thr ACG = thr	AAU = asn AAC = asn AAA = lys AAG = lys	AGU = ser AGC = ser AGA = arg AGG = arg
G	GUU = val GUC = val GUA = val GUG = val	GCU = ala GCC = ala GCA = ala GCG = ala	GAU = asp GAC = asp GAA = glu GAG = glu	GGU = gly GGC = gly GGA = gly GGG = gly

AUG codes for:

CCG codes for:

GAU codes for:

UAA codes for

Procedures:

1. Using the DNA strand on the "Mutation Consequences Worksheet" transcribe the DNA into mRNA.
2. Using the Universal Codon Chart found in the pre-lab translate the mRNA into its corresponding amino acid sequence.
3. Obtain a six pieces of paper labeled 1 through 6 from your teacher. Place them face down on your table.
4. The first nucleotide that will be mutated is the 4th nucleotide in the strand of DNA.
5. Each student will pick a slip of paper and complete the worksheet for the specific mutation they drew, by following the instructions below.
6. No student in a group may use the same number.

Number Drawn	**Corresponding Action**
1	Substitute specified nucleotide with an A
2	Substitute specified nucleotide with a C
3	Substitute specified nucleotide with a G
4	Substitute specified nucleotide with a T
5	Delete the nucleotide
6	Insert a nucleotide immediately after the specified nucleotide. Toss the die again until you roll 1–4 to determine which nucleotide will be inserted.

7. Write the complete DNA sequence with one mutation in nucleotide 4.
8. Complete the mRNA sequence from the mutated DNA.
9. Translate the amino acid sequence from the mRNA.
10. Circle any differences from the original protein produced.
11. Repeat this activity again having the mutation occur at nucleotide 6. Each group member must use a new mutation.
12. Answer the questions.

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Data

Trial 1

(mutate the 4th nucleotide). Make sure each group member is doing a different mutation

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Nucleotide	T	A	C	G	T	G	T	T	A	G	T	C	T	A	A	G	A	A	A	C	T

- The 5′ end is located at nucleotide 1 and the 3′ end is located at nucleotide 21.

mRNA																					
Amino Acid Sequence																					

Number rolled_____

Mutated DNA Sequence																					
mRNA from mutated DNA																					
Amino Acid sequence																					

Trial 2

(mutate the 6th nucleotide). Make sure you are doing a different mutation than trial one. Each group member is doing a different mutation

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Nucleotide	T	A	C	G	T	G	T	T	A	G	T	C	T	A	A	G	A	A	A	C	T

- The 5′ end is located at nucleotide 1 and the 3′ end is located at nucleotide 21.

mRNA																					
Amino Acid Sequence																					

Number rolled_____

Mutated DNA Sequence																					
mRNA from mutated DNA																					
Amino Acid sequence																					

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Questions:

1. What is the significance of choosing a number at random to determine how to mutate the DNA?

2. Did your mutation in trial 1 cause a change in the amino acid sequence produced? How about during trial 2? Explain why or why not.

3. Compare your own outcome in trial 1, to your own outcome in trial 2. What do you notice?

4. Compare the outcomes in trial 1 with your group. Did anyone produce the same exact protein?

5. Is it possible to have a mutation in nucleotide 4 that would produce the same amino acid?

6. Could any mutations have occurred in nucleotide 6 that would produce the same amino acid as was produced from the original DNA sequence?