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DNA Mutation Consequences

Introduction

DNA is genetic material made of nucleotides. How does a change in one nucleotide affect the way the message is transcribed to RNA and translated to protein? Explore the effects of point mutations.

Concepts

- Point mutations
- Transcription and translation

Background

DNA is an example of a complex biological polymer called a nucleic acid, which is made up of small subunits called nucleotides. The components of the DNA nucleotide are deoxyribose (a simple sugar), a phosphate group, and a nitrogen base. There are four possible nitrogen bases in DNA—adenine (A), guanine (G), cytosine (C), and thymine (T). In DNA, the nucleotides pair using hydrogen bonds to form a double strand. Because these two strands are twisted, it is referred to as a double helix. 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*.

How is information from nuclear DNA brought to the ribosomes for protein synthesis? The answer is simple—by a single strand of RNA called messenger RNA (mRNA). RNA is composed of a single strand rather than a double strand as in DNA. RNA contains a sugar called ribose, a phosphate group, and four nitrogen bases. Rather than thymine (T), RNA contains uracil (U). Messenger RNA molecules that are complementary to specific gene sequences in DNA are made in the nucleus by a process called *transcription*. The genetic information from DNA is transcribed into a single strand RNA "message" to be sent from the nucleus to the ribosomes for 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. 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. Table 1 illustrates the 64 possible codons and the amino acid they code for The anticodon region on the tRNA contains a sequence of nitrogen bases. The nitrogen bases of the tRNA bond to a series of three nitrogen bases on the mRNA called a *codon*.

Table 1. Universal Codon Chart (mRNA to tRNA + amino acid)

	U	C	A	G
U	UUU phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine
	UUC phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine
	UUA Leucine	UCA Serine	UAA Stop	UGA Stop
	UUG Leucine	UCG Serine	UAG Stop	UGG Tryptophan
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine
	AUG Methionine	ACG Threonine	AAG Lysine	AGG Arginine
G	GUU Valine	GCU Alanine	GAU Apartic Acid	GGU Glycine
	GUC Valine	GCC Alanine	GAC Aspartic Acid	GGC Glycine
	GUA Valine	GCA Alanine	GAA Glumatic Acid	GGA Glycine
	GUG Valine	GCG Alanine	GAG Glumatic Acid	GGG Glycine

Mutations are changes in a DNA sequence. A *point 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 point mutation in the DNA can have on a resulting protein. Dice will be used to determine the random change that will occur in the specified mutation location.

Materials

DNA Mutation Consequences Worksheet
Dice
Universal codon chart

Safety Precautions

This classroom activity is considered nonhazardous. Follow all normal classroom safety guidelines.

Procedure

1. Transcribe the DNA on the DNA Mutation Consequences Worksheet into mRNA.
2. Using the Universal Codon Chart translate the mRNA into its corresponding amino acid sequence.
3. Obtain a six sided dice. The first nucleotide that will be mutated is number 4. Roll the die and follow the instructions below.

Number Rolled	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.

4. Write the complete DNA sequence with one mutation in nucleotide 4.
5. Complete the mRNA sequence from the mutated DNA.
6. Translate the amino acid sequence from the mRNA.
7. Circle any differences from the original protein produced.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard C: Life Science, structure and function in living systems
Content Standard F: Science in Personal and Social Perspectives, personal health
Content Standards: Grades 9–12
Content Standard C: Life Science, the cell, molecular basis of heredity
Content Standard F: Science in Personal and Social Perspectives, personal and community health

Name: _____

DNA Mutation Consequences Worksheet

	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																					

1. Did this mutation cause a change in the Amino Acid sequence produced? Explain why or why not.

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

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