Topic: Gene Mutations WS

Summary: Students will learn about frame shift mutations and base substitution mutations.

Goals & Objectives: Students will be able to demonstrate how mutations change the amino acid sequence. Students will be able to explain the difference between mutations.

Standards: CA Biology 4c. Students know mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.

Time Length: 40 minutes

Prerequisite Knowledge: Students know the rules for DNA / RNA base pairing. Students know what are protein synthesis, purines, pyrimidines, and how to use a codon table.

Materials:

- Handouts and pencils

Procedures:
1. Review with the class about point mutations and the differences between frame shift and base substitution.
2. Students work on the handout by themselves.

Accommodations: Students with an IEP can take the handout home if they need extra time, and/or do questions 1 - 3 and questions 11 - 24.

Evaluation:
Each line with and underline is worth one point for a total of 25 points. Students should have circled the mutated DNA or amino acid to help speed up grading.
Gene Mutations Worksheet

There are two types of mutations, small-scale gene mutations and large-scale chromosomal mutations. You will do gene (point) mutations in this handout. Since mRNA is read in threes (codons), an addition or deletion of a base changes the reading frame of the sequence.

FRAMESHIFT MUTATIONS

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

Insertion Example THE BOY CUT HIS SLI PAN DAT ETH EHO TDO

Insert a base

Deletion Example THE BOY CUT HIS LIP AND ATE THE HOT DOG

Delete a base

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

The insertion shifts the reading frame to the right. The deletion frame shifts the reading frame to the left. Insert a letter C for the two insertion questions and for the deletion questions, delete the H or one base letter.

Write each codon per line.

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

Insertion THE BOY ____ ____ ____ ____ ____ ____ ____ ____

Deletion THE BOY CUT ____ ____ ____ ____ ____ ____ ____ ____

Now use real DNA code and translate it into the correct amino acids. Decide where in the original DNA code to cause a mutation on the rest of the questions. Please use the codon table on the last page to find the corresponding amino acids.

Write each codon per line and circle the mutated DNA base where the mutation took place.

Original DNA TAC GGA CGA TCT CAG GAG CCT ATA ATC

Insertion DNA ____ ____ ____ ____ ____ ____ ____ ____

Mutated mRNA ____ ____ ____ ____ ____ ____ ____ ____

Mutated Amino Acids ____ ____ ____ ____ ____ ____ ____ ____

Original Amino Acid Met Pro Ala Arg Val Leu Gly Tyr STOP

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Write each codon per line and circle the mutated DNA base where the mutation took place.

Original DNA: TAC    GGA   CGA  TCT   CAG   GAG   CCT    ATA   ATC
Deletion DNA: _____ _____  _____ _____ _____ _____  _____ _____ _____
Mutated mRNA:   _____ _____  _____ _____ _____ _____  _____ _____ _____
Mutated Amino Acids: _____ _____  _____ _____ _____ _____  _____ _____ _____

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

Usually a frame shift mutation results in the synthesis of a nonfunctional protein. Why do you think your mutated proteins might not be functional?
______________________________________________________________________
______________________________________________________________________

BASE SUBSTITUTION MUTATIONS
For simplicity, change only one base for all the following base substitution mutations.

A different type of gene mutation is called base substitution. It is the simplest type of mutation where a nucleotide pair is replaced with a different nucleotide pair.

Base Substitution: GAC → GGC

One type of base substitution is called transversion mutation. Transversion mutation happens when one purine (A, G) is swapped with a pyrimidine (C, T).

Purine → Pyrimidine: GAC → TAC
Pyrimidine → Purine: GAC → GAG

Use the DNA code below to demonstrate a purine → pyrimidine transversion mutation. All you have to do is change one DNA base.

Write each codon per line and circle the mutated amino acid.

Original DNA: TAC CAT GCA GAT CTG GCC CAG TTC ATC
Transversion DNA: _____ _____  _____ _____ _____ _____  _____ _____ _____
Mutated mRNA: _____ _____  _____ _____ _____ _____  _____ _____ _____
Mutated Amino Acid: _____ _____  _____ _____ _____ _____  _____ _____ _____

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

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The opposite of transversion mutations is *transition mutations*. A transition mutation happens when one purine is swapped with the other purine or pyrimidine with pyrimidine.

<table>
<thead>
<tr>
<th>Original Mutation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purine → Purine</td>
<td>GAC → AAC</td>
</tr>
<tr>
<td>Pyrimidine → Pyrimidine</td>
<td>GAC → GAT</td>
</tr>
</tbody>
</table>

Use the DNA code below to demonstrate a purine → purine transition mutation. All you have to do is change one DNA base.

**Write each codon per line and circle the mutated amino acid.**

<table>
<thead>
<tr>
<th>Original DNA</th>
<th>TAC GTC GCT CAA CGG GAC CTG ACC ACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition DNA</td>
<td>_______ _______ _______ _______ _______</td>
</tr>
<tr>
<td>Mutated mRNA</td>
<td>_______ _______ _______ _______ _______</td>
</tr>
<tr>
<td>Mutated Amino Acid</td>
<td>_______ _______ _______ _______ _______</td>
</tr>
</tbody>
</table>

Original Amino Acid  Met  Gln  Arg  Val  Ala  Leu  Asp  Trp  STOP

A third type of base substitution is called *silent mutation*. Silent mutation happens when one base in a codon is changed but both code for the same amino acid.

<table>
<thead>
<tr>
<th>Original DNA</th>
<th>TAC CAT TCT CGG TGT AAA AGG GCG ATT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silent DNA</td>
<td>_______ _______ _______ _______ _______</td>
</tr>
<tr>
<td>Mutated mRNA</td>
<td>_______ _______ _______ _______ _______</td>
</tr>
<tr>
<td>Mutated Amino Acid</td>
<td>_______ _______ _______ _______ _______</td>
</tr>
</tbody>
</table>

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

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A base mutation that creates a new stop codon in place of an amino acid is called a \textit{nonsense mutation}.

\begin{align*}
\text{DNA} & \quad \text{TGT} \rightarrow \text{TGA} \\
\text{Amino Acid} & \quad \text{Cys} \rightarrow \text{STOP}
\end{align*}

Use the DNA code below to demonstrate a nonsense mutation. All you have to do is change one DNA base to create a new stop codon.

\textbf{Write each codon per line and circle the mutated amino acid.}

\begin{align*}
\text{Original DNA} & \quad \text{TAC} \quad \text{GGT} \quad \text{AAT} \quad \text{CAA} \quad \text{ATA} \quad \text{GAA} \quad \text{CCT} \quad \text{GAG} \quad \text{ACT} \\
\text{Nonsense DNA} & \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \\
\text{Mutated mRNA} & \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \\
\text{Mutated Amino Acid} & \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____} \quad \underline{____}
\end{align*}

\text{Original Amino Acid} \quad \text{Met} \quad \text{Pro} \quad \text{Leu} \quad \text{Val} \quad \text{Tyr} \quad \text{Leu} \quad \text{Gly} \quad \text{Leu} \quad \text{STOP}

Please explain the difference between a frame shift mutation and a base substitution mutation.

\begin{center}
\textbf{Codon Table}
\end{center}

\begin{center}
\begin{tabular}{c|c|c|c|c|c|c|c}
\hline
  & Phe & Ser & Tyr & Cys & U & C & A \\
\hline
U & Phe & Ser & Tyr & Cys & UC & CA & AG \\
\hline
C & Leu & Pro & His & Arg & UC & CA & AG \\
\hline
A & Ile & Thr & Asn & Ser & UC & CA & AG \\
\hline
G & Val & Ala & Asp & Gly & UC & CA & AG \\
\hline
\end{tabular}
\end{center}

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Gene Mutations Worksheet Key

There are two types of mutations, small-scale gene mutations and large-scale chromosomal mutations. You will do gene (point) mutations in this handout. Since mRNA is read in threes (codons), an addition or deletion of a base changes the reading frame of the sequence.

**FRAMESHIFT MUTATIONS**

**DNA Sentence** THE BOY CUT HIS LIP AND ATE THE HOT DOG

**Insertion Example** THE BOY CUT HIS SLI PAN DAT ETH EHO TDO

**Deletion Example** THE BOY CUT HIS LIP AND ATE THE HOT DOG

The *insertion* shifts the reading frame to the right. The *deletion* frame shifts the reading frame to the left. Complete the following lines for frame shift mutations.

**Write each codon per line.**

<table>
<thead>
<tr>
<th>DNA Sentence</th>
<th>THE BOY CUT HIS LIP AND ATE THE HOT DOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion</td>
<td>THE BOY CUT HIS SLI PAN DAT ETH EHO TDO</td>
</tr>
<tr>
<td>Deletion</td>
<td>THE BOY CUT HIS LIP AND ATE THE HOT DOG</td>
</tr>
</tbody>
</table>

**Comment [S1]:** Insert base C

**Comment [S2]:** Delete base H

Now use real DNA code and translate it into the correct amino acids. Decide where in the original DNA code to cause a mutation on the rest of the questions. Please use the codon table on the last page to find the corresponding amino acids.

**Write each codon per line and circle the mutated DNA base where the mutation took place.**

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

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Insertion DNA

Mutated mRNA

Mutated Amino Acids

Original Amino Acid

Write each codon per line and circle the mutated DNA base where the mutation took place.

Deletion DNA

Mutated mRNA

Mutated Amino Acids

Original Amino Acid

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

BASE SUBSTITUTION MUTATIONS

A different type of gene mutation is called base substitution. It is the simplest type of mutation where a nucleotide pair is replaced with a different nucleotide pair.

Base Substitution

One type of base substitution is called transversion mutation. Transversion mutation happens when one purine (A, G) is swapped with a pyrimidine (C, T).

Purine → Pyrimidine

Pyrimidine → Purine

Use the DNA code below to demonstrate a purine → pyrimidine transversion mutation. All you have to do is change one DNA base.

Write each codon per line and circle the mutated amino acid.

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The opposite of transversion mutations is *transition mutations*. A transition mutation happens when one purine is swapped with the other purine or pyrimidine with pyrimidine.

Purine → Purine  
GAC → AAC

Pyrimidine → Pyrimidine  
GAC → GAT

Use the DNA code below to demonstrate a purine → purine transition mutation. All you have to do is change one DNA base.

**Write each codon per line and circle the mutated amino acid.**

<table>
<thead>
<tr>
<th>Original DNA</th>
<th>TAC</th>
<th>GTC</th>
<th>GCT</th>
<th>CAA</th>
<th>CGG</th>
<th>GAC</th>
<th>CTG</th>
<th>ACC</th>
<th>ACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition DNA</td>
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<td>Mutated mRNA</td>
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<tr>
<td>Mutated Amino Acid</td>
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<td></td>
</tr>
<tr>
<td>Original Amino Acid</td>
<td>Met</td>
<td>Gln</td>
<td>Arg</td>
<td>Val</td>
<td>Ala</td>
<td>Leu</td>
<td>Asp</td>
<td>Trp</td>
<td>STOP</td>
</tr>
</tbody>
</table>

A third type of base substitution is called *silent mutation*. Silent mutation happens when one base in a codon is changed but both code for the same amino acid.

| DNA | CTT → CTG |
| Amino Acid | Leu → Leu |

Use the DNA code below to demonstrate a silent mutation. All you have to do is change one DNA base but the amino acid stays the same.

**Write each codon per line and circle the mutated DNA base.**

<table>
<thead>
<tr>
<th>Original DNA</th>
<th>TAC</th>
<th>CAT</th>
<th>TCT</th>
<th>CGG</th>
<th>TGT</th>
<th>AAA</th>
<th>AGG</th>
<th>GCG</th>
<th>ATT</th>
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A base mutation that creates a new stop codon in place of an amino acid is called a *nonsense mutation*.

Use the DNA code below to demonstrate a nonsense mutation. All you have to do is change one DNA base to create a new stop codon.

**Write each codon per line and circle the mutated amino acid.**

**Original DNA**

TAC    GGT   AAT   CAA   ATA  GAA    CCT  GAG   ACT

**Nonsense DNA**

[Blank lines for circle]

**Mutated mRNA**

[Blank lines for circle]

**Mutated Amino Acid**

[Blank lines for circle]

**Original Amino Acid**

Met    Val   Arg   Ala   Thr   Phe   Ser   Arg   STOP

Please explain the difference between a frame shift mutation and a base substitution mutation.

______________________________________________________________________

______________________________________________________________________