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## DNA Bracelets

by

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### Objectives:

- 1) Using plastic beads, construct a representation of "standard" sequence of amino acids based upon a provided DNA sequence.
- 2) Demonstrate the resulting effects of silent, point, and frameshift mutations in the original DNA strand on the RNA and amino acids.

### Activities:

- 1) General Directions: You will need to form a group of 5 students. Remove the staple from this packet and assign one page to each student. All students will need to refer to this beginning page for the amino acid/bead conversion chart. Each student will use their assigned DNA sequence, make any required changes, and write the corresponding mRNA sequence. Use the codon chart in your text to translate the mRNA sequence into an amino acid sequence. Next consult the amino acid/bead conversion chart on this page to determine which bead colors are coding for these amino acids. Construct a bead bracelet corresponding to your amino acid sequence. Answer the questions on your sheet. Compare bracelets with the others in your group and then answer the questions below. You may keep your bracelets as a special biology memento!

#### *Amino acid/ bead conversions*

<b>arginine</b> = orange	<b>cystine</b> = brown	<b>glutamine</b> = green
<b>histadine</b> = black	<b>leucine</b> = red	<b>methionine</b> = yellow
<b>proline</b> = purple	<b>serine</b> = white	<b>threonine</b> = blue
<b>valine</b> = pink		

### Summary Exercise:

- 1) Which type of mutation caused the greatest change in the final protein? Explain.

- 2) Which types of mutation caused the least change in the final protein? Explain.
  
- 3) Why don't all mutations change the final protein?

## **Page 2: Standard DNA sequence**

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will construct an amino acid chain using the "standard" DNA sequence as directed by your teacher. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. When finished, show the beads to your teacher before moving on to the questions.

**DNA Sequence**                    TAC   GAA   AGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**mRNA Sequence:**

**Amino acids:**

**Bead colors:**

### **Interpretation:**

- 1) What is special about the first codon?
- 2) Why does the sequence of colors repeat?
  
- 3) Does the same color bead always correspond to the same DNA sequence? Give at least 2 examples from this lesson.
  
- 4) What feature of the genetic code is demonstrated by your answer to question 3?

### Page 3: Same-sense (Silent) Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make a same-sense or silent mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. When finished, show the beads to your teacher before moving on to the questions.

To mutate this DNA sequence, change the second A in GAA (below) to a T. Then transcribe and translate this new sequence and answer the questions.

**DNA Sequence:** TAC GAA AGA TGA GAG AGT TGC GAC AGG TGT

**DNA Sequence #2:**

**mRNA sequence:**

**Amino acids:**

**Bead colors:**

**Interpretation:**

- 1) What changes in the RNA sequence were caused by the changes in the DNA?
- 2) What changes in amino acids were caused by the changes in the DNA?
- 4) Explain why this type of mutation is referred to as a silent mutation.

## Page 4: Insertion Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make an insertion or addition mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. If you end up with a codon that only has 1 or 2 amino acids, assume that translation will stop and no amino acid will be added there. When finished, show the beads to your teacher before moving on to the questions.

To mutate this sequence, add one base to the gene by adding a G between the TGC and GAC DNA triplets.

**DNA Sequence:** TAC GAA AGA TGA GAG AGT TGC^GAC AGG TGT

**DNA Sequence #3:**

**mRNA Sequence:**

**Amino acids:**

**Bead colors:**

**Interpretation:**

- 1) What changes in the RNA sequence were caused by the changes in the DNA?
- 2) What changes in amino acids were caused by the changes in the DNA?
- 3) What happens to the amino acid chain if the frame shift results in an RNA codon of UAA, UAG, or UGA?
  - 1) How will the changes in amino acids affect the protein that is expressed by this gene?
  - 4) Explain why this type of mutation is referred to as a frame shift mutation.

## Page 5: Deletion Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make a deletion mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. If you end up with a codon that only has 1 or 2 amino acids, assume that translation will stop and no amino acid will be added there. When finished, show the beads to your teacher before moving on to the questions.

Delete one base from the gene by dropping the second G in the GAG DNA triplet.

**DNA Sequence**                    TAC   GAA   AGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**DNA Sequence #4:**

**mRNA Sequence:**

**Amino acids:**

**Bead colors:**

**Interpretation:**

- 1) What changes in the RNA sequence were caused by the changes in the DNA?
  
- 2) What changes in amino acids were caused by the changes in the DNA?
  
- 3) What happens to the amino acid chain if the frame shift results in an RNA codon of UAA, UAG, or UGA?
  
- 3) How will the changes in amino acids affect the protein that is expressed by this gene?
  
- 4) Explain why this type of mutation is referred to as a frame shift mutation.

## Page 6: Missense Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make a point mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet.

To mutate this sequence, change the first A in the third codon to a G.

**DNA Sequence**                    TAC   GAA   AGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**DNA Sequence #5:**

**mRNA Sequence:**

**Amino acids:**

**Bead colors:**

**Interpretation:**

- 1) What was the effect of this DNA change on the final bracelet?
- 2) If you had changed the second A of the third codon instead of the first, would you have gotten the same results? Explain.
- 3) Why is this mutation called a “point” mutation”?
- 4) What other mutation done by one of your group members could also be considered a “point” mutation? Explain.

## **DNA Bracelets**

### **Teachers Key**

**Objectives:**

- 1) Using plastic beads, construct a representation of "standard" sequence of amino acids based upon a provided DNA sequence.
- 2) Demonstrate the resulting effects of silent, point, and frameshift mutations in the original DNA strand on the RNA and amino acids.

## Activities:

- 4) General Directions: You will need to form a group of 5 students. Remove the staple from this packet and assign one page to each student. All students will need to refer to this beginning page for the amino acid/bead conversion chart. Each student will use their assigned DNA sequence, make any required changes, and write the corresponding mRNA sequence. Use the codon chart in your text to translate the mRNA sequence into an amino acid sequence. Next consult the amino acid/bead conversion chart on this page to determine which bead colors are coding for these amino acids. Construct a bead bracelet corresponding to your amino acid sequence. Answer the questions on your sheet. Compare bracelets with the others in your group and then answer the questions below. You may keep your bracelets as a special biology memento!

### *Amino acid/ bead conversions*

<b>arginine</b> = orange	<b>cystine</b> = brown	<b>glutamine</b> = green
<b>histadine</b> = black	<b>leucine</b> = red	<b>methionine</b> = yellow
<b>proline</b> = purple	<b>serine</b> = white	<b>threonine</b> = blue
<b>valine</b> = pink		

## Final Interpretations

- 1) Which type of mutation caused the greatest change in the final protein? Explain.

*Deletion. Because it altered the sequence earlier in the translation.*

- 5) Which types of mutation caused the least change in the final protein? Explain.

*Silent mutation. The sequence was changed but it did not change the amino acid.*

- 6) Why don't all mutations change the final protein?

*Some mutations may change the original DNA sequence but due to the degeneracy of the genetic code, do not change the amino acid in the final protein.*

## **Page 2: Standard DNA sequence**

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will construct an amino acid chain using the "standard" DNA sequence as directed by your teacher. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. When finished, show the beads to your teacher before moving on to the questions.

**DNA Sequence**                      TAC   GAA   AGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**mRNA Sequence:**                      AUG   CUU   UCU   ACU   CUC   UCA   ACG   CUG   UCC   ACA

**Amino acids:**                      *met   leu   ser   thr   leu   ser   thr   leu   ser   thr*

**Bead colors:**                      *Y   R   W   Blu   R   W   Blu   R   W   Blu*

**Interpretation:**

5) What is special about the first codon?

*It an initiation codon.*

6) Why does the sequence of colors repeat?

*Because different DNA sequences can code the same amino acid*

7) Does the same color bead always correspond to the same DNA sequence? Give at least 2 examples from this lesson.

*No, different sequences can code for the same color. The DNA sequences GAA and CAC both code for leucine, red; AGA and AGG both code for serine, white.*

8) What feature of the genetic code is demonstrated by your answer to question 3?

*The genetic code is degenerate in that the code is redundancy in amino acid coding for. There are 64 codes for 20 amino acids.*

### Page 3: Same-sense (Silent) Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make a same-sense or silent mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. When finished, show the beads to your teacher before moving on to the questions.

To mutate this DNA sequence, change the second A in GAA (below) to a T. Then transcribe and translate this new sequence and answer the questions.

**DNA Sequence:** TAC GAA AGA TGA GAG AGT TGC GAC AGG TGT

**DNA Sequence #2:** TAC GAT AGA TGA GAG AGT TGC GAC AGG TGT

**mRNA sequence:** AUG CUA UCU ACU CUC UCA ACG CUG UCC ACA

**Amino acids:** met leu ser thr leu ser thr leu ser thr

**Bead colors:** Y R W Blu R W Blu R W Blu

#### **Interpretation:**

1) What changes in the RNA sequence were caused by the changes in the DNA?

*Adenine appeared in place of uracil in the transcription.*

2) What changes in amino acids were caused by the changes in the DNA?

*There was no change in the amino acid.*

3) Explain why this type of mutation is referred to as a silent mutation.

*The mutation is not manifested in the coded amino acid sequence.*

## Page 4: Insertion Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make an insertion or addition mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. If you end up with a codon that only has 1 or 2 amino acids, assume that translation will stop and no amino acid will be added there. When finished, show the beads to your teacher before moving on to the questions.

To mutate this sequence, add one base to the gene by adding a G between the TGC and GAC DNA triplets.

**DNA Sequence:** TAC GAA AGA TGA GAG AGT TGC<sup>^</sup>GAC AGG TGT

**DNA Sequence #3:** TAC GAA AGA TGA GAG AGT TGC GGA CAG CAC T

**mRNA Sequence:** AUG GAT UCU ACU CUC UCA ACG CUG UCC ACA A

**Amino acids:** met leu ser thr leu ser thr pro val his

**Bead colors:** Y R W Blu R W Blu Pur Pnk Blk

### Interpretation:

1) What changes in the RNA sequence were caused by the changes in the DNA?

*The RNA was severely changed. The insertion shifted the order of the sequence.*

2) What changes in amino acids were caused by the changes in the DNA?

*The coded amino acids were changed significantly.*

3) What happens to the amino acid chain if the frame shift results in an RNA codon of UAA, UAG, or UGA?

*These are termination codons. Translation will stop prematurely.*

4) How will the changes in amino acids affect the protein that is expressed by this gene?

*A different protein that may not have any function would be produced.*

9) Explain why this type of mutation is referred to as a frame shift mutation.

*The sequence order was shifted by the number of nucleotides that were inserted.*

## Page 5: Deletion Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make a deletion mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet. If you end up with a codon that only has 1 or 2 amino acids, assume that translation will stop and no amino acid will be added there. When finished, show the beads to your teacher before moving on to the questions.

Delete one base from the gene by dropping the second G in the GAG DNA triplet.

**DNA Sequence**                    TAC   GAA   AGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**DNA Sequence #4:**        *TACGAA   AGA   TGA   GAA   GTT   GCG   ACA   GGT   GT*

**mRNA Sequence:**        *AUG   GAT   UCU   ACU   CUU   CAA   CGC   UGU   CCA   X*

**Amino acids:**            *met   leu   ser   thr   leu   gln   arg   cys   pro   X*

**Bead colors:**            *Y       R       W    Blu    R       G       O    Brn   Pur   X*

**Interpretation:**

1) What changes in the RNA sequence were caused by the changes in the DNA?

*When the DNA sequence was changed, the RNA reading frame was shifted.*

2) What changes in amino acids were caused by the changes in the DNA?

*Different amino acid were coded after the deletion shifted the sequence.*

3) What happens to the amino acid chain if the frame shift results in an RNA codon of UAA, UAG, or UGA?

*These are termination codons. Translation will stop prematurely.*

3) How will the changes in amino acids affect the protein that is expressed by this gene?

*A different, shortened protein will be produced that may not be functional.*

4) Explain why this type of mutation is referred to as a frame shift mutation.

*The number of nucleotides that were deleted shifted the RNA reading frame.*

## Page 6: Missense Mutations

Name:

Directions: Using the beads and the color chart on the first page of this packet, you will make a point mutation of the standard DNA and then construct an amino acid chain. Be certain to show the RNA sequence you use to determine the final amino acid chain. Record the names of the amino acids and then construct the bracelet.

To mutate this sequence, change the first A in the third codon to a G.

**DNA Sequence**                    TAC   GAA   AGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**DNA Sequence #5:**    TAC   GAA   GGA   TGA   GAG   AGT   TGC   GAC   AGG   TGT

**mRNA Sequence:**            *AUG CUU CCU ACU CUC UCA ACG CUG UCC ACA*

**Amino acids:**                *met leu pro thr leu ser thr leu ser thr*

**Bead colors:**                *Y        R    Pur   Blu    R    W    Blu    R    W    Blu*

### Interpretation:

5) What was the effect of this DNA change on the final bracelet?

*A different amino acid was translated and there was a color change in the bracelet.*

6) If you had changed the second A of the third codon instead of the first, would you have gotten the same results? Explain.

*No. Changing the second A to G yields a DNA of AGG which transcribes RNA of UCC. UCC translates serine, which would result in a silent mutation. The original amino acid sequence would be restored.*

7) Why is this mutation called a “point” mutation”?

*There was a change in only a single nucleotide.*

8) What other mutation done by one of your group members could also be considered a “point” mutation? Explain.

*The same sense mutation.*

## Page 7: Exercise Packet Materials:

One student exercise packet should be prepared for each group of 5 students.

Materials for the student packets include:

- Plastic sandwich bags (to hold kit contents).
- 5 - 8 inch long sisal, jute or any decorative cord that plastic beads may be stung on.
- Plastic colored beads in the following colors and numbers:
  - ✓ A minimum of 5 yellow beads.
  - ✓ A minimum of 13 red beads.
  - ✓ A minimum of 3 purple beads.
  - ✓ A minimum of 12 blue beads.
  - ✓ A minimum of 11 white beads.
  - ✓ A minimum of 1 pink bead.
  - ✓ A minimum of 1 brown bead.
  - ✓ A minimum of 1 black bead.
  - ✓ A minimum of 1 orange bead.

Note: Additional beads may be included at the instructor's discretion.