BIOTECHNOLOGY

Genetic improvement method: mutagenesis

Focus questions	How are breeding techniques being used in agriculture to solve problems? How might mutations in DNA lead to both natural variation and beneficial traits in agricultural crops?
Vocabulary	Gene mutation, point mutation, mutagenesis, codon, transcription, translation, amino acid sequence, induced mutagenesis, ionizing radiation, protein synthesis

Mutagenesis is the process of creating changes (mutations) in an organism's DNA using chemicals, radiation, or other methods. This process is applied often randomly, which can lead to new traits. Breeders select beneficial mutations over time. **Induced mutagenesis,** using radiation or chemicals to create random genetic changes, has generated desirable traits like new colors, disease resistance, or better yields not found in nature, with over 3,000 mutant varieties released globally. For example, some wheat varieties used today were developed through radiation-induced mutagenesis to improve yield and resilience.

Mutagenesis has some advantages including:

- A low cost for farmers or horticulturalists, as research institutions often develop and release new varieties.
- Farmers pay standard seed costs since mutagenesis is not patent-restricted like GMOs or CRISPR, but the benefit of improved traits (e.g., shorter growing period) can increase revenue.
- Farmers may adopt such varieties when publicly released that are well-adapted to their local conditions.

Materials

Per student or pair of students:

- Student handout with DNA sequences
- Codon chart (genetic code table)
- Colored pencils or highlighters (3–4 colors)
- Access to computers/tablets for research

Procedure

1. Begin with a strand of DNA.

   Original double-stranded DNA

   ```
   AGT CCA GTA TGC CCT GAT
   TCA GGT CAT ACG GGA CTA
   ```

2. It becomes mutated through a site-directed mutagenesis from irradiation with ionizing radiation found in nature. Only one codon is changed.

   Mutated double-stranded DNA

   ```
   AGT CCA GTA CAG CCT GAT
   TCA GGT CAT GTC GGA CTA
   ```

3. Transcribe both the original and mutated *top* DNA strands into mRNA.

4. Use the provided codon chart to translate both of your mRNA strands into an amino acid sequence.

5. What is different about your two sequences? Will the protein that they code for be the same? Why or why not? What ramifications could this have for the organism? Could it be positive or will it always be negative since it is a mutation?

Extension

1. Research a common plant/food that has been developed by mutagenesis from the list below.

   Food crops
   - Rice
   - Wheat
   - Barley
   - Grapefruit
   - Peanuts and beans
   - Soybeans
   - Vegetables
   - Bananas and pears

   Ornamental plants
   (also developed through mutagenesis)
   - Chrysanthemums, roses, carnations
   - Dahlias, alstroemeria, azaleas

2. Develop a short presentation including 1–2 specific examples and document: crop/plant name, trait gained, benefit to humans, images, and specific details. Create a collective list of mutagenesis-derived foods.

Reflection

1. What was the most challenging part of this activity for you?

2. What was the most interesting thing you learned?

3. How does this activity change your understanding of where our food comes from?

Rubric for self-assessment

Skill	Yes	No	Unsure
I can explain what happens during transcription (DNA → RNA).			
I can explain what happens during translation (RNA → protein).			
I can use a codon chart to determine which amino acids are coded by mRNA.			
I understand how a change in DNA can change the protein that is made.			
I can explain how mutations can lead to new traits in organisms.			
I can give examples of foods developed through mutagenesis.			
I understand the difference between natural and induced mutagenesis.			