Biotechnology in Agriculture

Introduction: Farmers around the world work hard to produce safe, nutritious food to feed both the immediate and global community while stewarding the land, air and water around them. The world's population of eaters continues to grow while the number of farms and available land decreases so it is important that farmers can grow more while minimizing their land use and environmental impact.

Overview: Read through the key terms and supplemental resources to explore some of the tools that farmers and scientists use to efficiently produce safe, nutritious food. Explore the genetic material of a delicious food item through an at-home lab activity. Societal relevance and career connections will also be investigated.

Key Terms:

Agriculture is the cultivation of land and breeding of animals and plants to provide food, fibre, medicinal materials and other products to sustain and enhance life

Sustainable development involves using systems and practices that meet the needs of the present without compromising the ability of future generations to meet their own needs. We typically consider sustainability in terms of three pillars: Environmental, Economic and Social. A sustainable system balances the ecosystem conservation, financial viability and the needs of a healthy community.

Sustainable Agriculture satisfies human needs for food, clothing and other resources while improving environmental quality, using resources efficiently, reducing waste, being economically viable and improving the quality of life for farmers and communities.

Biotechnology combines knowledge of life and living organisms with modern technology to create new systems, devices, materials, food, etc. that could improve human life and help preserve the environment. Most biotechnologies are associated with agriculture and medicine.

GMO (genetically modified organism). The genetics of virtually all plant-based food we eat today have been modified over time, so the term "GMO" could technically apply to all of them. When people talk about GMOs, they are often referring to **genetic engineering**.

Examples of Biotechnology's Uses in Agriculture:

- Drought, cold and pest resistant plants
- Reproductive technologies
- Environmental cleanup
- Improved vaccines
- Transgenic animals
- Improved nutrition
- Reduce food waste
- Genetically Modified Organisms

Supplemental Resources:

Visit this link to watch a short video on plant breeding and GMOs.
https://www.youtube.com/watch?v=L2LORw1rCpY

Visit this link to learn more about farming and the environment:
https://aitc-canada.ca/en-ca/learn-about-agriculture/category/farming-the-environment

Visit this link to learn more about Plant Biotechnologies in Agriculture
https://aitc-canada.ca/en-ca/learn-about-agriculture/category/plant-biotechnology

Visit this link to learn more about the history and uses of genetically modified organisms:
SnapAg: GMOs

Strawberry DNA Extraction

Purpose: Many biotechnologies are applied to the DNA of plants. With GMOs, the sequence of a plant's DNA is altered in order to modify or induce a trait. In this activity you will collect and observe the DNA from Strawberries.

Materials:

- 90mL Water
- 10mL Dish Soap
- 1.25mL Salt
- 1 Strawberry (frozen works well)
- 5mL Rubbing Alcohol chilled in the freezer for at least an hour
- 2 Small glass containers
- Stir Stick
- Zip Top Baggie
- Strainer
- Eye dropper or Bamboo skewer

Procedure:

1. Combine water, dish soap and salt in a small glass container (a bowl or measuring cup would work as well). Mix well.

2. Place a strawberry and the dish soap mixture in the plastic baggie. Removing as much air as possible, carefully seal the bag. Rinse the glass container, you will use this again.

3. Manually 'mash' the strawberry with your fingers through the plastic baggie for about 5 minutes or until no large pieces remain.

4. Set the strainer on the glass container. Taking care, pour the strawberry mixture through the strainer to separate the liquid and solid portions. Gently press the solids caught in the strainer to remove as much liquid as possible. Discard the solids.

5. Transfer the liquid to the second glass container (a transparent measuring cup or small drinking glass would work well). Add 5mL of chilled Isopropyl Alcohol (rubbing alcohol).

6. View the glass container at eyelevel. Make note of your observations.

7. Using the eye dropper or bamboo skewer, remove the white "film". It is safe to handle if you want to feel it.

8. Thoroughly wash and dry all the reusable equipment. Properly dispose of the consumable materials.

Discussion Points:

- Why did we mash the Strawberries?
- Why did we use dish soap?
- What does lysis mean?
- Why did we use salt?
- Why did we use alcohol?
- Why was the alcohol chilled?
- What did you see when you observed the test tube at eye level?

Solutions:

Why did we mash the strawberries? To break up the cellulose in the plant cell walls in order to allow the detergent solution to come in contact with the lipid cell membrane. Dish Soap detergents break up lipids- this is why soap works on dirty dishes. It breaks up the cell membranes to allow the DNA to escape from the nucleus.

Lysis = Cutting. Lysing a cell means cutting it open. We used dish soap to lyse or cut open the cells. The DNA was able to leave the lysed cell but wasn't immediately visible because it is tightly packed and very, very small.

Salt neutralizes the negatively charged phosphate group on the DNA backbone so the DNA molecules can come together instead of repelling each other (makes DNA less soluble in water).

Alcohol was used to make the DNA visible. We could see DNA with the naked eye by collecting cells, breaking them open and condensing the DNA from all the cells together. Think of the long thin DNA molecules as thin white threads- if they were stretched across the room they would be hard to see but piled all together on the floor they would be visible. Alcohol made the DNA 'pile together on the floor' (precipitate) or come out of the solution into a mass large enough to see. Chilling the alcohol before mixing it into the cell solution improved it's ability to cause the DNA to precipitate.

If you viewed the glass container at eye level, you should have initially viewed a transparent pink liquid. Adding the chilled alcohol likely caused a cloudy or murky region to form in the center of the liquid. You may have caused the cloudy region to increase by gently stirring with the bamboo skewer. Finally, you make have been able to pick up the cloudy mass with the skewer. This mass contains the nucleic acids and DNA from the strawberry.

Relevance of DNA Isolation:

Isolation of DNA is often the first step before many research, forensic or clinical analysis such as:

- DNA profiling
- Cloning
- Disease Diagnoses
- DNA sequencing
- GMO in agriculture or pharmaceuticals
- Environmental testing, biodefense

Biotechnology is applied in a variety of exciting career areas:

Biological Technician- Work with biologists to conduct tests, record observations, and research information in relation to the environment. Carry out experiments to support research. Set up, operate, and maintain laboratory equipment

Agricultural Technician- Conduct research and perform tests on samples of plants and animals. Determine the yield for a new seed variety by planting and monitoring seeds in a test plot. Perform experiments to determine how to stop the spread of a plant virus. Maintain agricultural facilities and equipment.

Forensic DNA Analyst- Identify, isolate, and even copy small amounts of DNA from biological evidence. Compare DNA strands to those from a known source to determine whether there is a probability of a match. Can place criminals at a crime scene or identify victims.

Plant Scientist- Study crops and develop ways to improve their quality and quantity. Improve yield. Control pests and weeds more safely and effectively. Conserve soil and water. Find ways to help feed our growing population.

Clinical Research Associate- Assist in the design, preparation, planning, implementation and review of clinical trials. Ensure it adheres to regulatory and ethical standards.

Animal Scientist- Conduct research and experiments to breed, care for, and develop domestic farm animals. Explores and performs research on animal genetics and crossbred animals; advises farmers on animal care.