UNIT VI - PLANT TECHNOLOGIES

Lesson 3: Genetically Modified Plants

Competency/Objective: Describe current applications of biotechnology in plants.

Study Questions

1. **How are genetically altered plants developed?**
2. **How do herbicide-tolerant plants function?**
3. **How do insect-resistant plants function?**
4. **How do disease-resistant plants function?**
5. **What effect has biotechnology had on food quality and processing?**

References

1. *Biotechnology: Applications in Agriculture (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1998, Unit VI.
2. Activity Sheet
    a) AS 3.1: The Current State of Plant Biotechnology

UNIT VI - PLANT TECHNOLOGIES

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TEACHING PROCEDURES

A. Review

Lesson 2 discussed the procedure of plant tissue culture and its use in reproducing plants. This lesson will address producing plants that have been genetically modified. Plant breeders have always searched for healthier and more productive plants. With the development of recombinant DNA technology, plant breeders have been able to select traits from sources outside the plant species with which they are working. As the vast selection of plants, animals, and microbes is examined for potentially helpful genes, researchers will continue discovering and using new genes to increase the world's crop production and decrease the cost of production.

B. Motivation

How valuable is the development of insect- or disease-resistant plants? The global cost of the current chemical control of insects and fungal diseases is $8.7 billion. However, even with the use of these chemical controls, insects and disease cause a 12 to 13 percent reduction in crop production. The chemical insecticide and crop loss costs associated with the Colorado potato beetle and the corn rootworm are over $1 billion in the United States alone. Insect damage costs for cotton exceed $645 million. Obviously, the added costs of genetically modifying a crop to be resistant to one of these pests may be easily offset by the decrease in chemical costs and the increase in yield.

C. Assignment

D. Supervised Study

E. Discussion

1. Review with students the methods of genetically modifying animal cells. Ask students to recall the differences between animal and plant cells, especially the presence of the cell wall. Explain that the cell wall of a plant requires that a forceful method of gene insertion be used.

How are genetically altered plants developed?

a) The desired gene or genes for a trait must be found, isolated, and cloned.
b) A method of genetic transfer is selected.
    1) Bacteria or virus
        (a) The desired gene and a marker gene is inserted into the bacterium or virus, and the microorganism is placed in contact with the plant cell to be modified.
        (b) The organism infects the cell and transfers the desired gene.
    2) Gene gun
        (a) The desired gene and a marker gene are inserted into a plasmid.
        (b) The plasmid is placed on the surface of very small (1 mm in diameter), heavy metal (gold) pellets.
        (c) These pellets are shot into the plant cells with the use of a small high-pressure gun.
    3) Chemicals
        (a) The cell wall is weakened or dissolved.
        (b) The desired gene is physically placed in the cell.
        (c) The plant cell is stimulated to repair the cell wall.

c) Plant cells that incorporate the desired gene into their DNA are selected (by looking for the marker gene) and grown into mature plants through the use of tissue culture.

2. Ask students to list some commonly used herbicides. How do these chemicals kill weeds? The answer lies in the fact that an important chemical process of the plant is disrupted by the herbicide.

How do herbicide-tolerant plants function?

a) Herbicides kill plants by chemically blocking a metabolic pathway.
b) Herbicide-tolerant plants have the ability to bypass the blocked portion of the metabolic pathway; this ability comes from genes that produce certain enzymes that provide a different chemical route around the blocked portion.

3. Explain to students that plants have very little natural resistance to insects and that many insects are becoming increasingly resistant to chemical insecticides. Explain the source of resistance (*Bt*) of insect-resistant plants.

How do insect-resistant plants function?

a) *Bacillus thuringiensis (Bt)* is a soil bacterium that produces a protein that, when eaten by specific insects, dissolves the wall of the gut, causing the insect to be unable to eat and eventually to die.
b) Each *Bt* strain kills a specific type of insect.
c) The genes that cause the production of the protein in specific *Bt* strains have been isolated and transferred to several crop plants, including potatoes, corn, and cotton.

4. Point out that plant diseases are commonly caused by viruses, bacteria, and fungi. Explain how disease-resistant plants combat them.

How do disease-resistant plants function?

a) Virus-resistant plants - A small portion of the DNA from the virus is inserted into the plant DNA, giving the plant an immunity to the virus.
b) Bacteria- and fungus-resistant plants - Current research in this area centers on trying to enhance the plant's natural immune response; plants resistant to bacteria and fungi are not currently available.

5. Ask students if they have heard of or tasted a FlavrSavr™ tomato. Explain that the quality and processing of foods is being advanced by biotechnology.

What effect has biotechnology had on food quality and processing?

a) Tomato
    1) The FlavrSavr™ tomato was developed by Calgene to have a vine-ripened taste and a longer shelf life.
    2) Genes were inserted into the tomato plant that cause the production of an enzyme that slows the breakdown of pectin, which keeps the tomato from getting soft and rotting.
    3) Four other companies have gained approval for similar genetically modified tomatoes.
b) Modified canola and corn plants - These plants yield a grain that is higher in oil content and has a modified oil composition in which the level of saturated and unsaturated oil has been changed to meet different uses.
c) High-starch potatoes
    1) The potatoes are higher in starch and lower in water content.

2) When chips or french fries are made, they will absorb less oil and will therefore be lower in fat.

F. Other Activities

Plant some genetically modified Roundup Ready™ soybeans from Monsanto and some soybean seeds that are the result of a hybrid cross. When the plants reach 8 to 10 inches in height, spray the plants with Roundup. Have the students record daily observations of the effects of the Roundup on both types of plants.

G. Conclusion

The development of transgenic plants by private companies has been fueled by the potential for large profits. Producers are willing to pay companies a premium for crop seed that can lower the costs of raising a crop. The potential of genetically engineered plants is only beginning to be realized.

H. Answers to the Activity Sheet

AS 3.1

Answers will vary based on available information.

I. Answers to the Evaluation

1. a
2. b
3. d
4. a

5. *Bt* or *Bacillus thuringiensis* is a soil bacterium that produces a protein that when eaten by specific insects causes the insect's gut wall to dissolve; it eventually dies. The genes in specific *Bt* strains that cause the production of the protein have been isolated and transferred to several crop plants.

6. Students may list any one of the following: the FlavrSavr™ tomato developed to have a vine-ripened taste and a longer shelf life, modified canola and corn plants that yield a grain that is higher in oil content and has a modified oil composition, and high-starch potatoes that are higher in starch and lower in water content.

7. Students should list the following steps.

   a. The desired gene must be found, isolated, and cloned.
   b. A method of genetic transfer is selected. A bacteria or virus, a gene gun, or a chemical that dissolves or weakens the cell wall is used.
   c. Plant cells that incorporate the desired gene into their DNA are selected by looking for the marker gene and grown into mature plants through the use of tissue culture.

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EVALUATION

Circle the letter that corresponds to the best answer.

1. Which of the following is not a method of transferring DNA into a plant cell?

   a. Using two electrical probes that cause the desired DNA to be forced into the targeted plant cell
   b. Chemically weakening or dissolving the cell wall and inserting the DNA
   c. Using a gene gun that fires heavy metal pellets coated with DNA
   d. Using bacteria and viruses containing the desired gene that attack the targeted cell

2. What is the name of a piece of DNA located or placed near a targeted section of DNA that helps in the identification of the targeted section?

   a. Plasmid DNA
   b. Marker gene
   c. Targeted DNA
   d. Signal gene

3. How do herbicide-tolerant soybeans tolerate the active chemical in a herbicide?

   a. The gene added to the soybeans prevents the absorption of the chemical.
   b. The gene added to the soybeans accelerates the natural immune system of the soybean plant to ward off the toxic effect of the chemical.
   c. The gene added to the soybeans chemically reacts with the substance to neutralize it.
   d. The gene added to the soybeans produces an enzyme that provides a way around the herbicide-caused metabolic pathway block.

4. The common soil bacteria, *Bacillus thuringiensis*, has played a big role in the development of:

   a. Insect-resistant plants.
   b. Disease-resistant plants.
   c. Herbicide-tolerant plants.
   d. High-starch potatoes.

Complete the following short answer questions.

5. How do insect-resistant plants function?

6. What is one example of a biotechnology product that enhances food quality and/or processing? What aspect of the product has been changed through biotechnology?

7. What are the three steps in the development of a genetically modified plant? Briefly describe each step.

   a.

   b.

   c.

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The Current State of Plant Biotechnology

Objective: Describe the current state of plant biotechnology.

Answer the questions below. The Internet would be the best research tool, but newspapers and magazines may also be used. If additional information about plant biotechnology is found, summarize this information on the back of this activity sheet. You will be asked to share some of this information with the class.

1. List at least six companies that are involved developing products in plant biotechnology **and** one of the newest products from each company.

   a.

   b.

   c.

   d.

   e.

   f.

2. Briefly describe how one of these products was developed. (Include information on the source of the transferred gene.)

3. What genetically modified plants have been recently approved by the USDA, FDA, and EPA?

4. What do farm-related magazines have to say about the future of genetically engineered plants/crops?