

UNIT VI - PLANT TECHNOLOGIES

Lesson 4: Emerging Applications of Plant Biotechnology

Competency/Objective: Identify emerging applications of biotechnology in plants.

Study Questions

1. **What are biofuels?**
2. **What are biopolymers?**
3. **What are some traits that producers desire in plants?**

References

1. *Biotechnology: Applications in Agriculture (Student Reference)*. University of Missouri-Columbia: Instructional Materials Laboratory, 1998, Unit VI.
2. Activity Sheet
 - a) AS 4.1: Designer Plants--The Agricultural Products of the Future

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TEACHING PROCEDURES

A. Review

Plants have been cultivated for centuries to provide food for both humans and animals. An increasing number of plants are now grown for industrial and medical uses as well. As discussed in Lesson 3, plants can be genetically modified to improve their usefulness for these purposes. Just as George Washington Carver discovered more than a hundred uses for peanuts, so are today's scientists discovering new uses for plants, especially modified plants. Some emerging applications of plant biotechnology will be examined in this lesson.

B. Motivation

Pass out one soybean-derived crayon, labeled "A," and one traditional crayon, labeled "B," to three or four students. Ask these students to evaluate the two crayons and determine which one is better. List their comments on the board. Ask students if any of them know any young children who play with crayons. Have they ever seen them chew on or simply eat a crayon? Tell the class that one of the crayons is safe to eat. Increase student interest by telling the class that one of the two crayons earned four college students more than \$100,000 and prompted many offers of high-paying jobs. Explain that the four college students won a contest sponsored by the United Soybean Board by developing soybean-based crayons. Talk about how a problem relevant to one of those college students (his younger brother eating crayons) sparked a new use for a traditional crop plant.

Pass around a piece of soybean "marble" and explain that a fifth-grader discovered this product. She was trying to come up with a project for her school science fair. She mixed glue and newspaper in a blender and then heated it in the microwave. The mixture formed a hard, granite-like block that could be worked like wood. The formula has been changed slightly, with the glue being replaced by a product made from soy flour, and her discovery is now being marketed as a building material.

Point out that the genetic engineering of plants provides researchers the opportunity to modify a plant so that it is better suited for a particular application. Therefore, more plant-derived products like these will probably be developed, and existing products will likely be enhanced.

C. Assignment

D. Supervised Study

E. Discussion

1. Show a sample of biodiesel to the class and ask students how it is made. Ask students to list other plant-derived fuels.

What are biofuels?

- a) Biofuels are combustible substances derived from organic sources. Nearly all biofuels are derived from plants.
- b) Several types of biofuels exist.
 - 1) Alcohol-based fuels
 - (a) These fuels are made by fermenting plant materials.
 - (b) An example is gasohol, a fuel that is 10 percent alcohol and 90 percent gasoline.

- (c) Researchers are searching for plants that they can modify to produce ethanol more economically.
 - 2) Plant oil-based fuels, or biodiesels
 - (a) These fuels are made from seeds with a high oil content.
 - (b) Most are the result of the addition of methanol to the plant oil and the removal of a sticky substance called glycerin.
 - (c) Soybean and rapeseed oils are most commonly used.
 - (d) Scientists are looking for ways to engineer plants to produce a larger quantity of oil and to require less extensive processing.
 - 3) Biogas fuels
 - (a) Methane gas is derived from the anaerobic (oxygen-free) digestion of plant materials and/or animal waste by microorganisms.
 - (b) Researchers are examining the possibility of developing plants that would produce crop residue that is more useful for methane production.
- 2. Ask a student to look up the definition of a polymer (a natural or synthetic substance that is formed by joining many simple molecules to form large molecules) and read it to the class. Then ask the students to speculate about the definition of a biopolymer.

What are biopolymers?

- a) Biopolymers are complex chemical compounds produced by living things; biopolymers from genetically engineered plants may be useful in a variety of industries.
 - b) Biotechnology is being applied to develop five different types of biopolymers.
 - 1) Carbohydrates - Researchers are working on the development of a modified corn starch that does not break down when heated in the microwave and genetically engineered potato plants with leaves that have a high sugar content.
 - 2) Fatty acids - Scientists are working on modifying corn and canola oils to contain a high level of either saturated or unsaturated fatty acids depending on which is needed for a given application.
 - 3) Pharmaceutical proteins - These biopolymers are used for human health products.
 - 4) Industrial enzymes - Scientists are trying to modify plants to provide enzymes at a low price for purposes such as fermentation for brewing, processing and bleaching paper, and a feed additive to aid in digestion in livestock.
 - 5) Bioplastics - Scientists are attempting to develop plants with tissues that contain a higher level of the chemical components of plastic.
- 3. Ask students to use their imaginations and list the characteristics (other than increased yield) that they think would be valuable plant traits. Some of the traits listed are more than likely being researched as possible crop enhancements. Have students complete AS 4.1. Divide the class into groups of three or four students. Assign two or three sectors of the agricultural industry (based on the FFA proficiency award areas) to each group. Have students use any available resources, including textbooks, magazines, and the Internet. Encourage the group members to pick different questions to research and then compile all of the answers. The answers that the students come up with should be rational, but encourage them to use their imaginations as well as their resources.

What are some traits that producers desire in plants?

- a) Environmentally tolerant plants
 - 1) Drought-tolerant plants
 - 2) Frost-tolerant plants
 - 3) Salt-tolerant plants
 - b) Forestry products
 - 1) Stronger wood
 - 2) Fire-resistant wood

- 3) Trees that grow more quickly
- c) Food products with an improved taste
 - 1) Sweet corn and peas that stay sweet longer
 - 2) Naturally decaffeinated coffee
- d) Fiber crops such as naturally colored and fade-resistant cotton

F. Other Activities

- 1. Have students search the Internet looking for emerging applications of plant biotechnology.
- 2. Have students compete in the Missouri Department of Agriculture New Product Contest using products created with biotechnology.

G. Conclusion

Biofuels, biopolymers, and specialized plants with traits desired by producers are three major emerging applications of plant biotechnology. As information about the vast quantity of genes available from microbes, animals, and plants increases, more and more specialty crop plants will be developed. Most of these crops will comprise only a fraction of plant agriculture, and demand will determine which crops are grown.

H. Answers to the Activity Sheet

AS 4.1

Answers will vary.

I. Answers to the Evaluation

- 1. c
- 2. d
- 3. e
- 4. b
- 5. a
- 6. a
- 7. d
- 8. Stronger wood, fire-resistant wood, and trees that grow more quickly
- 9. Drought-tolerant plants, frost-tolerant plants, or salt-tolerant plants

EVALUATION

Match the examples of biopolymers with their descriptions.

- | | | |
|----------|--|----------------------------|
| 1. _____ | These biopolymers are used in the bleaching of paper and as additives to animal feeds. | a. Carbohydrates |
| 2. _____ | This type of biopolymer is found in modified oils from corn or canola. | b. Pharmaceutical proteins |
| 3. _____ | Scientists are attempting to change the chemical components of plants to contain higher levels of substances used for these biopolymers. | c. Industrial enzymes |
| 4. _____ | These biopolymers are used for human health products. | d. Fatty acids |
| 5. _____ | This group of biopolymers consists of products like a modified corn starch that does not break down when heated in the microwave. | e. Bioplastics |

Circle the letter that corresponds to the best answer.

6. Which of the following is not a type of biofuel for which genetically modified plants are being developed?
- a. Petroleum-based fuel
 - b. Alcohol-based fuel
 - c. Plant oil-based fuel
 - d. Biogas fuel
7. Biopolymers are:
- a. Complex carbon compounds that are byproducts of many types of plant biotechnology research.
 - b. Combustible substances derived from plants or animals.
 - c. Inorganic chemicals that cause plants to mutate.
 - d. Complex chemical compounds from genetically engineered plants that are useful in many industries.

Complete the following short answer questions.

8. What are three products that the forestry industry would like biotechnology researchers to develop?
9. What are three types of environmentally tolerant plants that scientists are researching?

Designer Plants--The Agricultural Products of the Future

Objective: Describe products of plant biotechnology that could be a part of the future of agriculture.

Answer the following questions to describe a possible plant product produced through biotechnology that might be used in one of the sectors of agriculture assigned to you by your instructor. You will need to use resources like textbooks, magazines and the Internet along with your imagination to complete this assignment.

1. Which sector of agriculture were you assigned?

2. What are the problems or limitations in raising plants used in this sector? (Include anything that costs money or time to control or overcome.)

3. What traits are currently being researched that may help improve the plants used in this agricultural sector?

4. What traits could be added to a plant that would not affect its main use but would improve its secondary uses or byproducts?

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