



## Biotechnology

Suggested Time: 1.5 Hours

### **What's important in this lesson:**

Understanding that biotechnology has been used by humans for a long time but with the advent of new techniques the possibilities are endless.

### **Complete these steps:**

1. Get a copy of the Student Handout: Biotechnology and work through it at your own pace. You'll need a copy of a textbook for help in places. Check your answers with your teacher where needed.
2. Try the Assessment: Biotechnology. Make sure you have about 10-15 minutes to complete the test and give this to your teacher.
3. Complete the Reflection activity.

### **Hand-in the following to your teacher:**

1. Student Handout
2. Assessment and Evaluation activity.
3. Reflection activity.

### **Questions for the teacher:**



## Biotechnology

### Technology and Food Production

Biotechnology refers to various techniques that use living organisms to make products. It includes a variety of methods that can alter the genetic makeup of an organism.

**Instructions:** Highlight information in the following sections that help to explain how selective breeding, grafting and cloning are done along with an example of each. Answer the questions that follow.

### Selective Breeding:

This is one of the oldest methods of altering an organisms' genetic makeup. It is done by breeding individuals which have desired traits together to produce offspring with similar traits. We have used these methods to produce plants and animals species that would be healthier and more productive since early times. (eg. Holstein cattle for large amounts of milk production, border collies for herding). In plants crossbreeding involves taking the pollen from one plant and using it to fertilize the eggs of another plant. All the seeds are planted and any plants showing the desired traits are selected and bred again.



Fig 1: Belgian Blue cattle have a mutation in the myostatin gene. They produce grossly over exaggerated muscles which are good for producing large amounts of meat but tend to cause birthing problems since the calves are so large.



Fig. 2: A featherless chicken has been recently bred for farming in hot climates. Can you think of any advantages?



**Cloning:**

Cloning has always occurred in nature. It is a natural process and the majority of organisms on the planet produce exact duplicates of themselves by Asexual Reproduction (ex. binary fission, budding and other techniques such as cuttings). Many plants (ex. carrots, strawberries, potatoes) are easily produced by cloning while others such as grasses cannot be produced this way. The secret seems to lie in the genetic material of the plant.

Techniques for cloning include: cuttings, layering, using roots and tissue culture to name but a few. In cloning plants for food, cuttings are taken from a plant with a desired trait, rooted and grown into an identical copy of the parent plant.

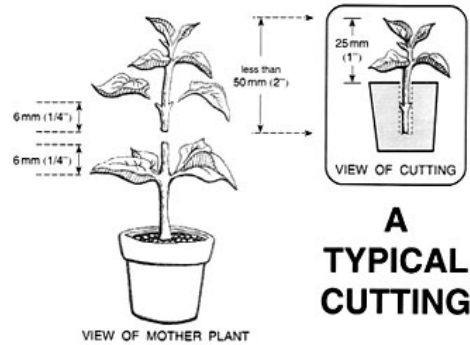


Fig. 3 One method of preparing plant cuttings

Grafting is another technique that is used quite a bit. For example a cutting from a seedless-grape vine can be grafted onto other grapevines, thus seedless grapes will continue to be produced. Grafting is often used with fruit trees since some produce good roots but poor fruits while others are the opposite. Branches from trees that produce good fruit are grafted or attached to the trees that have the good roots. These trees can now produce the good quality fruits but also survive winter.

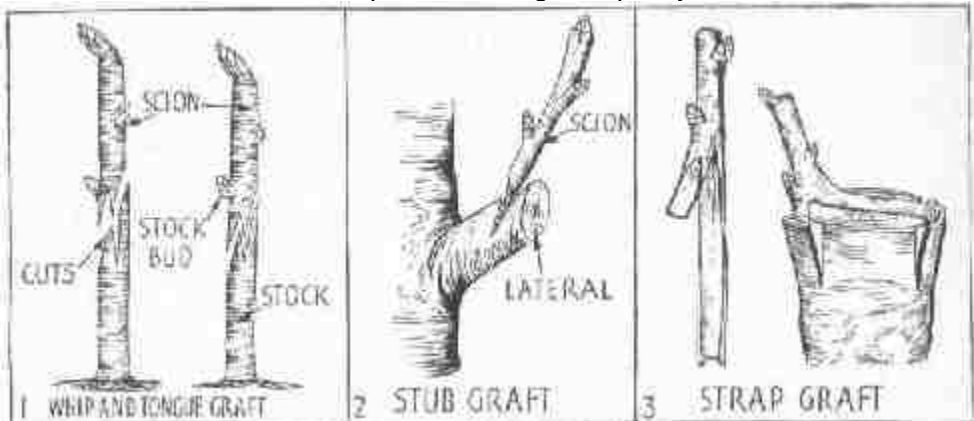


Fig. 4: A selection of grafting techniques

A lot of research is being done on the cloning of animals. The biggest breakthrough happened in 1997 when Dr. Ian Wilmut in Scotland, cloned a sheep called Dolly using the genetic material from an adult body cell and transferring it into an egg cell from which the nucleus was removed. The young embryo was then placed into a third sheep. When she was born, Dolly did not resemble her birth mother, instead she had characteristics of the sheep from which the nucleus was removed.

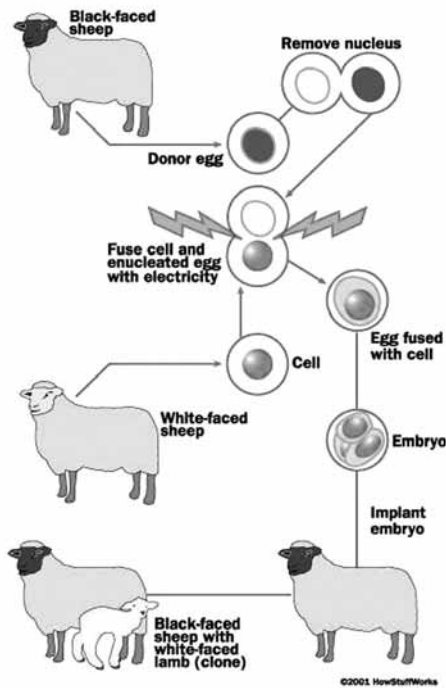


Figure 5: Steps used in cloning Dolly

1) Explain why cloning is considered Asexual Reproduction.

2) Complete the following table

<b>Traditional Method</b>	<b>Describe</b>	<b>Example</b>
selective breeding		
cloning		
grafting		



- 2) Imagine that farmers were able to easily clone any animal in their herd or flock. What might be the benefits for food production? Would there be any disadvantages?

### Genetic Engineering

Crops can now be bred using genetic engineering. The resulting products are called genetically modified (GM) foods. Genetic engineering involves transferring genes from the DNA of one organism to another. Using these techniques Canadian scientists have developed wheat and rye that can grow in cold conditions. Corn, soybeans and potatoes have been genetically modified to resist pests. Plants may also be modified so that their quality and food value is improved along with being resistant to certain herbicides. One of the biggest success stories in Canada is Canola or Rapeseed which was modified by selective breeding to improve the oil colour and flavour and genetically engineered so that it can now resist disease and drought.

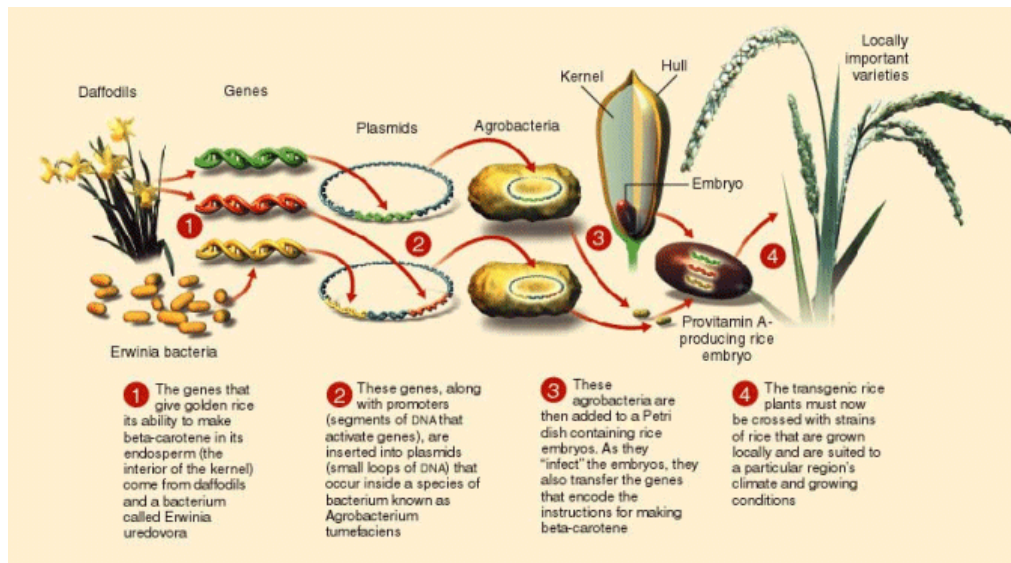


Fig. 6: The technique used to develop Golden Rice that is high in Vitamin A.

The same methods used on plants can also be employed on animals. In fact Atlantic salmon have been genetically modified with the "antifreeze" gene that produces a protein to prevent the fishes' blood from freezing. Hormones have also been used to increase the production of farm animal products. For example Bovine Growth Hormone is injected into cows to produce more milk.

### **Biotechnology in Humans**

All living organisms including humans are subject to genetic diseases or disorders caused by defects in the DNA. Such a defect may be caused by a mutation or by the fact that some of the DNA may be missing (due to mistakes that occur during cell division) To find these defects in humans genetic screening is performed. One way this is accomplished is by doing a karyotype (a picture of a cell's chromosomes).

# Student Handout: Unit 2 Lesson 3



Gene therapy is a technique which may be used to replace defective genes with healthy ones. To do this a working gene is inserted into a virus that will be used to attack the patient's cells that has the defective gene in them. The virus will then insert the working gene into the patient's cells thus giving the cell the correct information to correct the disorder.

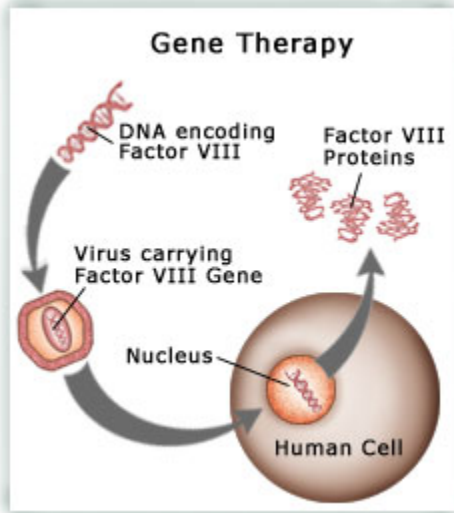


Fig. 7 Gene therapy for treating Hemophilia, a genetic disease in which people have bleeding and bruising.

Sometimes it is not possible to replace the faulty or missing gene. An alternative is to engineer bacteria that can produce the product of the specific gene. For example it is not possible to use gene therapy to insert the insulin gene into pancreas cells. But bacteria have been engineered that can produce human insulin protein quickly and inexpensively.

Transgenic animals are animals that have been given human genes in the fertilized eggs. The animals will grow up usually producing the protein in its milk which can then be purified (ex. The DNA for Human protein C is used to treat blood clots has been inserted into pigs). Other advantages to this technique are that the animal does not have to be killed to obtain the protein and this gene will continue to be passed on to further offspring.

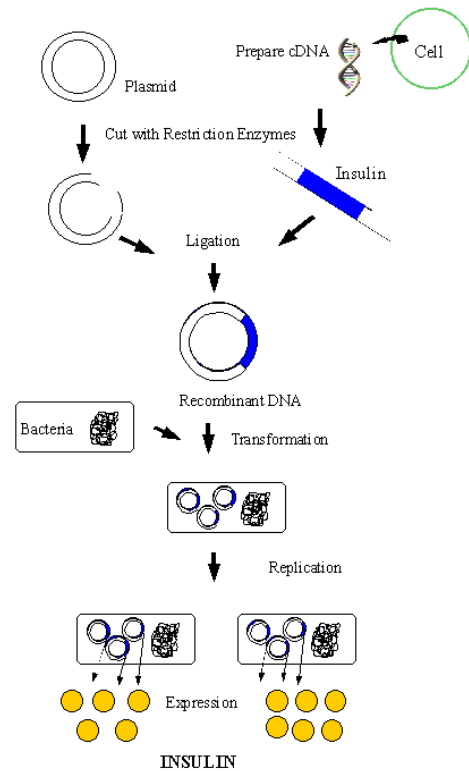


Figure 8: Cloning of Insulin

## Student Handout: Unit 2 Lesson 3



### Pros and Cons of using Genetically Modified Food

Pros	Cons
Man has been doing selective breeding since agriculture began. Genetic engineering is really no different	Genetic engineering involves the moving of some genes that nature could never do. This will pose unexpected consequences
Genetic engineering often uses bacteria or other organism. Having the genes that make them dangerous removed or disabled prevents them from causing sickness.	Genetic engineering makes use of disease causing organisms such as viruses and bacteria as vectors that carry the gene to be transferred. These organisms could spread into the environment with unpredictable and dangerous consequences.
All procedures are subject to strict monitoring. The risk is therefore minimal. New varieties are tested for toxicity more than any crop plants have been in the past	Genetic engineering is potentially dangerous and consequences could be irreversible. Also the consequences could take years to show up.
Enhances biodiversity by allowing weeds to continue growing for longer thus providing nutrition for animals. Also the reduced use of insecticides increases insect diversity.	The total herbicides and insecticides used with tolerant crops kill all weeds and insects thus reducing biodiversity in the field.
Helps solve the problem of world hunger by creating varieties, which will make more efficient use of scarce land. Crops can be engineered with increased nutrient value.	World hunger will not be solved using this technology. It is a problem of inequitable distribution of wealth. A balanced diet is really all that is needed.
More profit for the farmer and lower prices for the consumer.	The farmer cannot save seed from year to year and therefore has more expenses. No benefit to the consumer.
Genetic engineering allows for the creation of plants that can produce vaccines and pharmaceuticals.	Genetic engineering is already used to produce pharmaceuticals in microbes under much safer conditions. It should not be taken into the environment where there is a risk.

4) What is genetic engineering?

5) Why is genetic engineering so important for food production?

## Student Handout: Unit 2 Lesson 3



6) How did Canadian scientists modify Canola to make it more pleasing to the consumer?

7) What are some of the advantages of genetically modified foods?

8) What are some of the disadvantages of genetically modified foods?



## Assessment and Evaluation: Unit 2 Lesson 3



### Modified True/False

*Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.*

- \_\_\_ 1) When plants such as strawberries send out runners, they reproduce without sex cells (gametes)
- \_\_\_ 2) If a sheep were cloned, you would expect the offspring to be the same sex.
- \_\_\_ 3) Genetically modified foods have been around for a thousand years.

### Multiple Choice

*Identify the letter of the choice that best completes the statement or answers the question.*

- 4) Selective breeding is
- breeding two organisms that you have chosen from two different species.
  - choosing which organisms will be allowed to reproduce.
  - the process by which animals select their mates.
  - the process by which plants select their mates.
- 5) Which of the following methods can be used to reproduce plants?
- genetic engineering
  - grafting
  - cutting
  - all of the above
- 6) Which of the following technologies can not be used to help humans with medical problems.
- Transgenic organisms such as pigs
  - Gene therapy
  - Engineering bacteria
  - Selective breeding

### Short Answers

- 7) Why might a gardener want to graft a piece of vine from one grape species to the stem of another species?
- 8) Explain two advantages of using biotechnology in crop production.
- 9) Explain one possible disadvantage of using biotechnology in crop production.

## Reflection Activity: Unit 2 Lesson 3



Write three paragraphs to answer the following:

Do you think you have the right to know what substances are in the food you eat, or how your food is produced?

Would you buy milk produced by genetic engineering? Why or why not?

Would you pay more for milk that was not produced in this way?