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General Biology 2
Quarter 3: Week 1 - Module 1
Genetic Engineering

STEM - General Biology 2
Grade 12 Quarter 3: Week 1 - Module 1: Genetic Engineering
First Edition, 2021

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General Biology 2

Quarter 1: Week 1 - Module 1:

Genetic Engineering

Target

The central Dogma of molecular biology explains the flow of genetic information and the molecular mechanism in understanding how genotype translate to phenotype, it became apparent then that changing an organismal trait is possible by altering its genetic make-up known as genetic engineering.

You have learned already from your grade 8 Biological science about the Central Dogma of Molecular Biology which covers the lesson on nucleic acid and its types- DNA and RNA and their structures and the flow of genetic information from genes to proteins through the process of DNA replication, transcription, translation in order to make an enormous variations of proteins. You have learned also about heredity and variation wherein traits are being inherited by the off springs from their parents and that desirable and undesirable traits of an off springs including diseases can be inherited from their parents. But the possibility to enhance a good trait will be possible now through the process of genetic engineering.

This module will make you understand more about genetic engineering including the processes and techniques used and the different applications of genetic engineering.

After going through this lesson, you are expected to:

1. Outline the processes involved in genetic engineering (STEM_BIO11/12-IIIa-b-6)
2. Discuss the applications of recombinant DNA. (STEM_BIO11/12-IIIa-b-7)

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Genetic Engineering

Many people are unaware that humans have been practicing genetic engineering since the ancient times. Selective breeding or classical breeding in agricultural crops and livestock has actually altered the genetic make-up of these organisms over the centuries in such a way that they no longer resemble their non-domesticated relatives. This practice has been common long before genes were discovered.

Jumpstart

Do the activity below to know about desirable and enhanced traits and traits modification in both plants and animals.

Good luck!

Activity 1: Am I Good Enough?

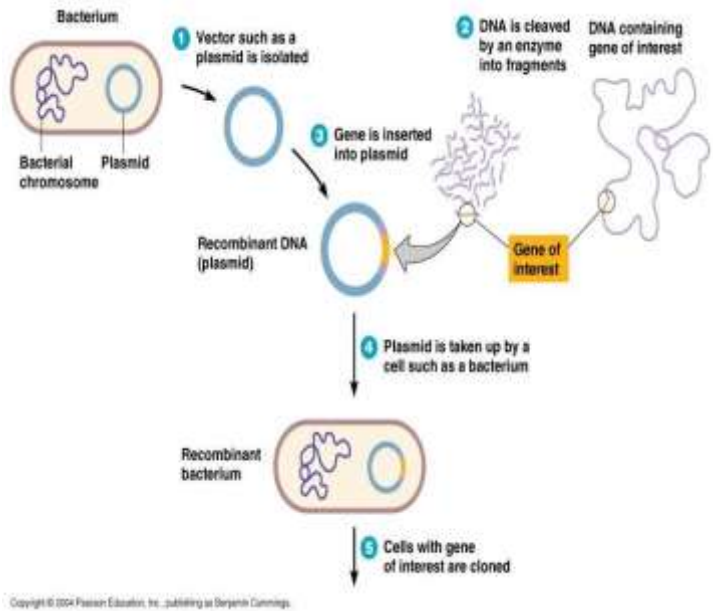
Directions: Below are example of plants and animals that are common and available in our locality. Identify at least one desirable or enhanced trait that each of them has. The first one will be given as an example

Example of plants/animals	Desirable or enhanced trait
1. Grapes	Seedless fruit
2. Guapple	Large size Guava
3. Corn	Seeds
4. Rice	Milled white
5. Coconut	round and elongate fruit of white
6. Banana	tropical fruit
7. Bittermelon	bitter
8. Cow	thick-skulled
9.Chicken	rounded body
10. Pig	stocky body

Discover

Genetic engineering involves the use of molecular techniques to modify the traits of a target organism. The modification of traits may involve; 1. Introduction of new traits into an organism as to enhancement of present traits by increasing the expression of the desired gene or by disrupting the inhibition of the desired genes' expression.

Genetic engineering includes *classical breeding* which is considered as the traditional way of genetic engineering which practices the mating of organisms with desirable qualities and *Recombinant DNA technology (rDNA),* a modern technique of genetic engineering. Recombinant DNA technology is the joining together of **DNA** molecules from two different species. The recombined **DNA** molecule is inserted into a host organism to produce new genetic combinations that are of value to science, medicine, agriculture, and industry

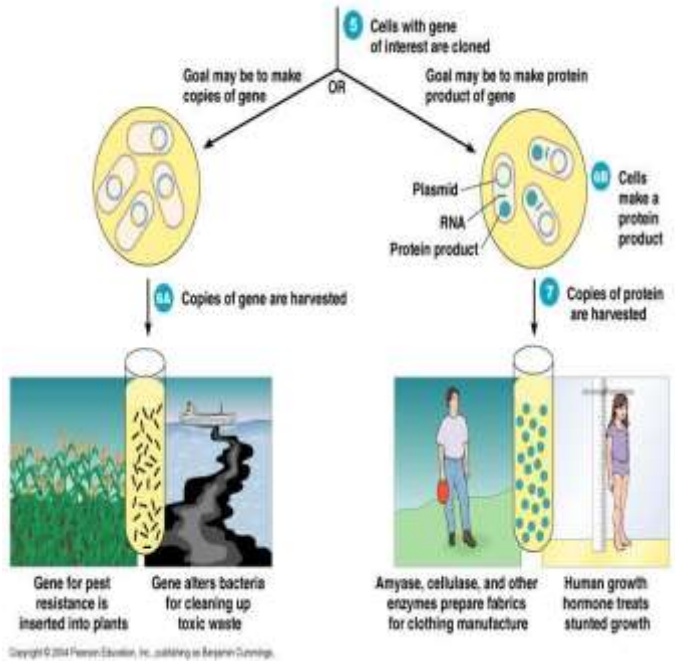


The general outline of recombinant DNA are as follows;

I. **Cutting** or cleavage of DNA by restriction enzymes (REs) as shown on steps 2 on the diagram. Restriction enzymes are called 'molecular scissors' cutting the DNA at specific target sequences leaving a single-stranded overhang at the site of the cleavage (step 2). These overhangs of the donor DNA (gene of interest) will be paired with other overhangs (vector DNA).

II. **Selection** of an appropriate vector or vehicle which would propagate the recombinant DNA (shown on step 1). The most commonly used as vectors are plasmids (circular DNA molecules that originated from bacteria, viruses and yeast cells). Plasmids are not part of the main cellular genome, but they carry genes that provide the host cell with useful properties such as drug resistance, mating ability, and toxins production. They are small enough to be conveniently manipulated experimentally and furthermore, they will carry extra DNA that is spliced to them.

III. **Ligation** (join together) of the gene of interest (eg. from animal) with the vector (cut bacterial plasmid) as shown on step 3 of the above diagram. The resulting molecule is called recombinant DNA. It is recombinant in the sense that it is composed of DNA from two different sources.



IV. **Transfer** of the recombinant plasmid into a host cell (that would carry out replication to make huge copies of the recombined plasmid). In the above diagram as shown in steps 4, the host cell is a bacterium known also as recombinant bacterium which will undergo cloning or replication of recombinant DNA

V. **Selection process** to screen which cells actually contain the gene of interest. The next step after cloning, therefore, is to find and isolate that clone among other members of the library. If the library encompasses the whole genome of an organism, then somewhere within that library will be the desired clone.

VI. **Sequencing of the gene** to find out the primary structure of the protein. Once a segment of DNA has been cloned, its nucleotide sequence can be determined. The nucleotide sequence is the most fundamental level of knowledge of a gene or genome. It is the blueprint that contains the instructions for building an organism, and no understanding of genetic function or evolution could be complete without obtaining this information.

After the process of recombinant DNA, these plasmids or gene copies will now be introduced to its host organisms to confer upon them the desired trait. A gene for pest resistance for example, as shown from the image above, may be isolated, cloned and inserted into plant cell. Alternatively, bacterial cells may express the inserted gene in order to produce protein products. Some important human proteins like hormones and enzymes are produced by this technique.

These are some ways in which these plasmids may be introduced into host organisms;

1. *Biolistic***.** In this technique, a "gene gun" is used to fire DNA-coated pellets on plant tissues. Cells that survive the 'bombardment', and are able to take up the expression plasmid coated pellets and acquire the ability to express the designed protein.

2. *Plasmid insertion by Heat Shock Treatment.* Heat Shock Treatment is a process used to transfer plasmid DNA into bacteria. The target cells are pre-treated before the procedure to increase the pore sizes of their plasma membranes. This pretreatment (usually with CaCl2) is said to make the cells "competent" for accepting the plasmid DNA. After the cells are made competent, they are incubated with the desired plasmid at about 4°C for about 30min. The plasmids concentrate near the cells during this time. Afterwards, a "Heat Shock" is done on the plasmid-cell solution by incubating it at 42°C for 1 minute then back to 4°C for 2 minutes. The rapid

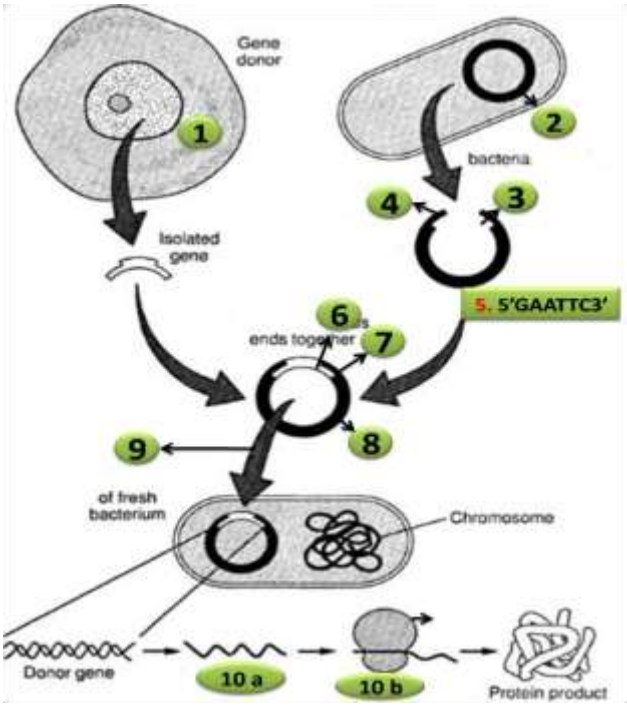
rise and drop of temperature is believed to increase and decrease the pore sizes in the membrane. The plasmid DNA near the membrane surface are taken into the cells by this process. The cells that took up the plasmids acquire new traits and are said to be “transformed”.

3. *Electroporation*. This technique follows a similar methodology as Heat Shock Treatment, but, the expansion of the membrane pores is done through an electric “shock”. This method is commonly used for insertion of genes into mammalian cells.

Explore

Recombinant DNA technology has been widely used not only in agriculture but in making human proteins also. In your next activity, you are going to enrich further your knowledge on the process of recombinant DNA technology. Have fun while learning!

Enrichment Activity 1: This activity will assess your understanding on the steps of recombinant DNA technology. Choose the best answer from the four options. See the image/diagram for your reference.



1. Based from the rDNA technology diagram, what does it mean by the labelled number 1?

(A.) Isolation of gene of interest

B. Transformation

C. Identification of donor gene

D. Selection of donor gene

2. It is double-stranded, self-replicating, circular DNA molecule present in bacteria which is widely used as a gene cloning vector. The structure is labelled 2 in the diagram.

A. Cosmid (B.) Plasmid

C. Phagemid D. Genome

Source: https://iopscience.iop.org/book/978-0-7503-1299-8/chapter/bk978-0-7503-1299-8ch3#:~:text=Introduction

3. These enzymes are called molecular scissors which is essential in making internal cuts in a DNA molecule or vector at specific sites. (labelled 3 and 4)

A. Restriction enzymes
B. Restriction proteins
C. Polymerase
D. All of these

4. In the figure labelled 6, the DNA strand is the_____.

A. Gene of interest
B. Recombinant DNA
C. Chimeric DNA
D. None of these

5. The vector (plasmid) with foreign gene inserted is called (labelled 8)_____.

A. Gene of interest
B. Recombinant DNA
C. Chimeric DNA
D. None of these

6. In the figure 10a and 10b are processes that led to the formation of protein product encoded by the gene of interest. 10a and 10b are called_____.

A. Replication and transcription
B. Transcription and translation
C. Transcription and transformation
D. Replication and transformation

The table below shows examples of modified traits using cloned genes and their application. There are many different traits that can be introduced to organisms to change their properties.

MODIFIED TRAIT	GENE MODIFICATION	RECIPIENT ORGANISM	APPLICATION (FIELD)
Insulin Production	Insertion of Human Insulin Gene	Bacteria	(Medicine) Production of Human Insulin in Bacteria
Pest Resistance	Insertion of Bt-toxin gene	Corn / Maize	(Agriculture) Production of corn plants with increased resistance to corn boxer
Delayed Ripening	Disruption of a gene for a ripening enzyme (e.g. polygalacturonase)	Tomato plant	Agriculture) Production of plants with fruits that have delayed ripening fruits. These fruits will survive longer transport time, allowing their delivery to further locations (i.e. export deliveries)

Genetically modified organisms (GMOs) have been produced through the rDNA technology technique. Genetically modified plants are produced by integrating a gene of interest into the Ti-plasmid before inserting the plasmid into the plant cells. These now possess gene that would confer traits such as resistance to certain bacterial or fungal pests. For example, genetically engineered corn also called as 'Bt corn' expresses a gene from the soil-dwelling bacterium Bacillus thuringiensis, making

them resistant to the corn borer disease. The 'golden rice' is a transgenic variety of rice that is engineered to produce beta-carotene and prevent Vitamin-A deficiency. Rice and potato have been modified to produce harmless proteins derive from cholera to serve as a natural vaccine. Soybean has been engineered to have resistance against herbicides.

Genetic modification is not only for plants. Recombinant bacterial cells with human genes can be used in order to produce human proteins like insulin to be used by people with type I diabetes, human growth hormones which is taken to cure stunted growth, and tissue plasminogen activator which dissolves blood clots among patients who had heart attack. If larger quantities of these protein is required, an option is to insert the gene in animals. For example, transgenic pigs to produce human hemoglobin, transgenic goat for human clotting factor and other transgenic animals that is used to synthesize pharmaceutical products referred as 'pharm animal'.

For the next activity, you are going to understand deeper recombinant DNA technology and its application. You are going to make a hypothetically genetically modified organism (GMO)

Enrichment Activity 2: Designer Genes

1. Hypothetically, you are given the chance to enhance/modify a trait of certain plant/crop. These are the things that you will consider to make a genetically modified organism (GMO)

    a. Identify special trait.

    b. Identify a source organism

    c. Identify a target organism

    d. Identify the modified/ added trait

    e. What benefit/s would the recombinant organism provide to society?

2. Refer from the table below for this activity. See example below.

Special trait (gene of interest)	Source organism	Target organism	Modified trait/ added trait	Application
1.Large-sized fruit	Jackfruit/ Lanka	aratilis	Lanka-sized aratiles	Bigger size of fruits can supply greaterfood demand
2. Spicy Fruit	Chili	Tomato	Spicy Tomato	This Spicy Tomato can help us because it is 2 in 1 and you don't need to buy some spice because the tomato has spice in itself.
3. Sweet Fruit	Sugar/ Sweets	Avocado	Sweet Avocado	Sweet Fruits like this one can prevent the use of sugar or condensed milks because it has sweets in the fruit itself.
4. Seedless fruit	Seedless	Orange	Seedless Orange	Seedless fruits like this especially orange can lessen the effort to remove the seeds in the orange.
5. Large-sized fruit	Large-sized	Mango	Large-sized Mango	Bigger Fruits like this one can supply greater food demand

Deepen

At this point, you have now a clearer understanding about genetic engineering. The steps or process of recombinant DNA technology technique and its application. Recombinant DNA technology has been widely used not only in agriculture but in making human proteins also that are very useful in the field of medicine. The ability of humans to make modifications in the genome provides unlimited possibilities. The Philippines is one of the countries that was open to large-scale introduction, research and commercialization of GM crops. Today almost one million hectares has been planting Bt corn. The 'Bt talong' which was developed by the Institute of Plant Breeding at UP Los Banos, is a variant of the eggplant that is resistant to shoot and fruit borer disease. In 2015, however, the Supreme Court of the Philippines issued a ruling to ban further field testing of the Bt talong amid fear of potential problems. Nevertheless, expert academics both in the Philippines and worldwide maintain that GM crops that have been approved are safe, having underwent through lab and field testing. These also provide an alternative to the use of toxic and harmful pesticides.

The next activity is hypothetical wherein you will be acting as a biotechnologist in your locality who was able to create a genetically modified organism of a certain agricultural product that is present in your locality and was given a chance to introduce the enhanced trait of your GMO into a biotech fair in your province this coming year.

What you need:

Recyclable materials, art materials, glue, scissors

What you have to do:

1. Create a 3D model of your GMO using the available materials (recyclable) at home.
2. Write a short description of your product which contains the following;
    a. Name of your GMO (combination of the source organism and the target organism)
    b. Benefits that your GMO could provide in your locality and to the society as well.
3. Your output will be graded using the rubrics below.


GMO
STOP
IT

Rubrics for your GMO model

Criteria	Excellent (10-8)	Good (7-6)	Fair (5-4)	Poor (3-1)
Feasibility and application of the chosen GMO	The proposed trait is 90-100% possible to the target organism and the GMO is practical	The proposed trait is 70-80 % possible to the target organism and the GMO is practical	The proposed trait is 70-80 % possible to the target organism and the GMO is not so practical in the province	The proposed trait not possible to the target organism and the GMO is not so practical in the province
Creativity and Aesthetic appeal	3D model is very creative, constructed using recyclable or indigenous items.	3D model is creative, and uses recyclable or indigenous materials	3D model is slightly creative and uses recyclable or indigenous items.	3D model lacks creativity and resourcefulness
Durability	Extremely durable	Durable	Slightly durable	The model is sloppy or messy

Gauge

Directions: Read and understand each question. Choose the letter of your best answer. Use a separate sheet of paper for your answers.

1. It is a double-stranded, self-replicating, circular DNA molecule present in bacteria which is widely used as a gene cloning vector.
   A. Cosmid (B.) Plasmid C. Phagemid D. Genome

2. These enzymes are called molecular scissors which is essential in making internal cuts in a DNA molecule or vector at specific sites.
   (A.) Restriction enzymes B. Restriction proteins
   C. Polymerase D. All of these

3. What do we call the new molecule after the process of ligation wherein the vector plasmid joined with the gene of interest?
   A. Gene of interest (B.) Recombinant DNA
   C. Chimeric DNA D. All of these

4. During transfer of the recombinant plasmid into a host cell which is commonly a bacterium, the recombinant bacterium will undergo cloning. Which of the following is involve in gene cloning?

A. Replication
B. Transcription
C. Translation
D. Duplication

5. Bacterial cells as host organisms may express the gene to make protein products such as insulin and growth hormones. Which of the following processes are involved?

A. Replication and transcription
B. Transcription and translation
C. Transcription and transformation
D. Replication and transformation

6. In plant genetic engineering, which of the following acts as vector?

A. Agrobacterium tumefaciens
B. Gene of interest
C. Recipient plant cell
D. Ti-plasmid

7. Which of the following describes recombinant DNA technology?

A. Mating of organisms with desirable qualities
B. Insertion of genes into cells that makes the cells into "factories" to make products
C. Enhancing or disrupting the traits of a target organism either mating or molecular technique
D. All of the above

8. Which of the following illustrates classical breeding?

A. A farmer choose a breed of cow of greater milk production
B. The use of bacteria in order to produce human insulin
C. The insertion of cloned genes to plant cells
D. All of the above

9. Which of the following is/are example of genetic engineering?

A. A farmer choose a breed of cow for of greater milk production
B. The use of bacteria in order to produce human insulin
C. The insertion of cloned genes to plant cells
D. Cross pollination of squash flowers

10. Which of the following is an example of genetically modified plant?

A. Seedless grapes
B. Guapple (larged-sized guava)
C. Rice with beta-carotene
D. All of these

11. Being pest resistance is one of the traits that are being introduced to plants like corn and eggplant with the insertion of Bt-toxin gene to plant cell. What method is use when a gene is inserted to plants?

A. Biolistic
B. Electroporation
C. Plasmid insertion by heat shock treatment
D. All of these

12. Why recombinant DNA is very useful in improving our health condition?

A. Human insulin can be reproduced by bacteria
B. Vaccine can be reproduced by fungi or bacteria
C. Human growth hormones can be obtained from E.coli
D. All of the above

13. A biotechnologist wants to enhance the size of *duhat* fruit because research shows that it can lower blood sugar but is very expensive in the market. What could be the possible source organism which contains the gene that is responsible for the development of large fruits?

A. Lanka B. Chico C. Strawberry D. Mango

14. Mario wants a hybrid or mestizo breed of pigs to raise that's why he chooses to mate his native pig (pure breed black) to a white pig (pure breed white). What type of genetic engineering is shown in the situation?

A. Classical breeding B. Artificial selection
C. Recombinant DNA D. All of these

15. Why genetic engineering is beneficial to the society?

A. It improves crop varieties to meet the demand of increasing human population
B. production of human proteins using bacteria is a great leap in the field of medicine
C. Transgenic plants and transgenic animals play a great role in our economic
D. All of the above

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