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DEPARTMENT OF EDUCATION
SCHOOLS DIVISION OF NEGROS ORIENTAL
REGION VII

Kagawasan Ave., Daro, Dumaguete City, Negros Oriental



RECOMBINANT DNA

for General Biology 2 Grade 11

Quarter 3 / Week 1



SELF-LEARNING KIT

NegOr_Q3_GenBio2_SLKWeek1_v2

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FOREWORD

The Department of Education through the Bureau of Curriculum Development and Curriculum Standards Development Division has crafted the Most Essential Learning Competencies (MELCs) for teachers to address the needs and demands of the learners brought about by the pandemic.

This self-learning kit (SLK) will help the learners to have full understanding on the important applications of recombinant DNA. Learners will be able to outline the processes involved in genetic engineering and appreciate the important applications of recombinant DNA.

The writer ensures that the lessons are substantial, simple, and interactive so that Filipino learners will learn meaningfully.

OBJECTIVES

At the end of the lesson, learners shall be able to:

K: discuss the applications of recombinant DNA;

S: outline the processes involved in genetic engineering; and

A: appreciate the importance of recombinant DNA by listing its applications in daily life.

LEARNING COMPETENCIES

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



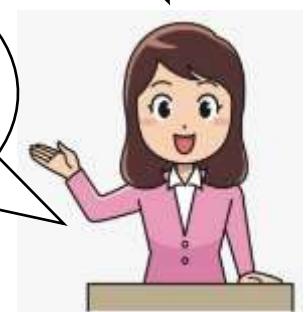
Ma'am, why is it that the tomatoes do not have the same size?

Good question, Cardo!
The reason for that is the so-called recombinant DNA.



But what is recombinant DNA?

Another good question, Cardo!
Well, that will be our lesson for today.



I. WHAT HAPPENED

PRE-TEST

Directions: Identify the word(s) described in each item by filling in the correct letters. Write your answers in your notebook.

1. It produces genetically engineered organisms.

R_CO_B_N_NT DNA

2. Genetically modified crops

A_R_C_LT_R_L APPLICATIONS

3. Production of antibiotics, hormones, and vaccines

M_D_C_L AP_LIC_T_ON

4. It is a molecule which contains all information necessary to build and maintain an organism.

D_O_YR_B_N_CL_IC A_C_D

5. Production of chemical compounds of commercial importance

_ND_STRI_L A_PL_C_TI_N

6. It is a process using recombinant DNA technology to alter the genetic makeup of an organism.

G_N_T_C ENG_N_ER_NG

7. It is the basic unit of heredity.

G_N_S

8. It produces copies of genes or segments of DNA.

G_N_C_O_N_NG

9. An individual that supplies living tissue to be used in another body.

D_N_R_RG_N_S_

10. A DNA nucleotide used as a vehicle to artificially carry foreign gene/materials.

V_CT_R G_N_M_

II. WHAT I NEED TO KNOW

DISCUSSION

A Brief History of Recombinant DNA

The use of recombinant (r)DNA technology to produce genetically engineered organisms started in the early 1970s with the pioneering transfer of genes between bacteria of the same *Escherichia coli* (*E. coli*) species. Following these successful pilot experiments, in 1978 Cohen and colleagues progressed to transfer an insulin synthesis gene into a plasmid of *E. coli*, with that producing the first genetically modified organism (GMO). By 1982, this protocol received full approval from national drug regulatory authorities, notably the US Food and Drug Administration, thereby enabling the economically viable mass production of human insulin, a hormone that regulates blood sugar levels and is made naturally by beta cells in the pancreas. This facilitated the widespread commercial availability of insulin at a price affordable to patients with the metabolic disorders' types 1 and 2 diabetes mellitus, who either fail to produce or to metabolize sufficient insulin.

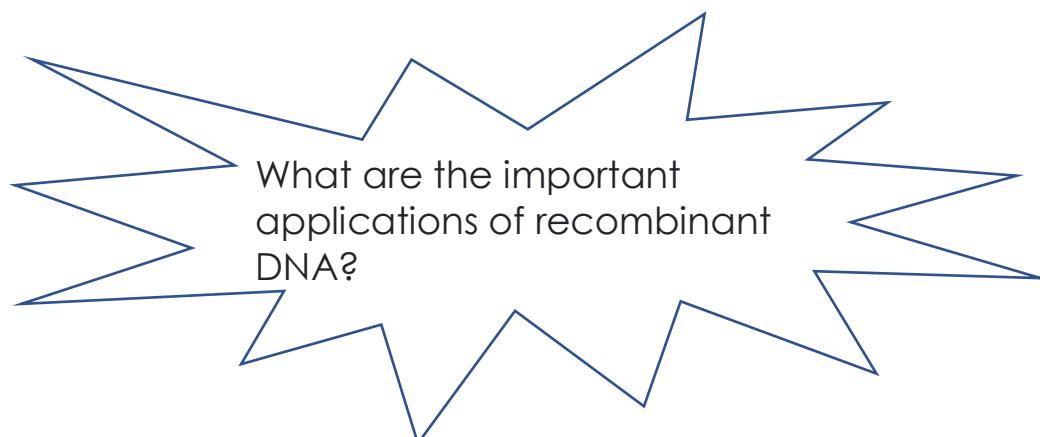
This proof of principle demonstration of the translational medical benefits of genetic modification pioneered a trend in biotechnology for molecular cloning methods to transfer genes expressing desirable traits into another host organism thereby producing favorable characteristics. This now involves both prokaryotes such as bacteria (comparatively routine to modify genetically by rDNA technology) and eukaryotes including yeast,

plants, insects, and mammals (comparatively complex to manipulate via rDNA technology).



Recombinant DNA

- Molecules of DNA from two different species that are inserted into host organism to produce new genetic combinations that are of value to science, medicine, agriculture, and industry.
- It is often shortened to rDNA.
- It is an artificially made DNA strand that is formed by the combination of two or more gene sequences. This new combination may or may not occur naturally but is engineered specifically for a purpose to be used in one of the many applications of recombinant DNA.



The three important applications are (1) agricultural applications (applications in crop improvement), (2) medicinal applications (applications in medicines), and (3) industrial applications.

I. Agricultural applications (applications in crop improvement)

Genetic engineering has several potential applications in crop improvement, such as given below:

1. Distant hybridization

With the advancement of genetic engineering, it is now possible to transfer genes between distantly related species. The barriers of gene transfer between species or even genera have been overcome. The desirable genes can be transferred even from lower organisms to higher organisms through recombinant DNA technology.

2. Development of transgenic plants

Genetically transformed plants which contain foreign genes are called transgenic plants. Resistance to diseases, insects and pests, herbicides, drought; metal toxicity tolerance; induction of male sterility for plant breeding purpose; and improvement of quality can be achieved through this recombinant DNA technology. BT-cotton resistant to bollworms is a glaring example.

3. Development of root nodules in cereal crops

Leguminous plants have root nodules which contain nitrogen-fixing bacteria *Rhizobium*. These bacteria convert the free atmospheric nitrogen into nitrates in the root nodules. The bacterial genes responsible for this nitrogen fixation can be transferred now to cereal crops like wheat, rice, maize, barley, etc. through the techniques of genetic engineering thus making these crops too capable of fixing atmospheric nitrogen.

4. Development of C₄ plants

Improvement in yield can be achieved by improving the photosynthetic efficiency of crop plants. The photosynthetic rate can be increased by conversion of C₃ plants into C₄ plants, which can be achieved either through protoplasm fusion or recombinant DNA technology. C₄ plants have higher potential rate of biomass production than C₃ plants. Most C₄ plants (sorghum, sugarcane, maize, some grasses) are grown in tropical and subtropical zones.

II. Medicinal applications (applications in medicines)

Biotechnology, especially genetic engineering, plays an important role in the production of antibiotics, hormones, vaccines, and interferon in the field of medicines.

1. Production of antibiotics

Penicillium and Streptomyces fungi are used for mass production of famous antibiotics penicillin and streptomycin. Genetically efficient strains of these fungi have been developed to greatly increase the yield of these antibiotics.

2. Production of hormone insulin

Insulin, a hormone used by diabetics, is usually extracted from the pancreas of cows and pigs. This insulin is slightly different in structure from human insulin. As a result, it leads to allergic reactions in about 5% patients. Human gene for insulin production has been incorporated into bacterial DNA and such genetically engineered bacteria are used for large-scale production of insulin.

3. Production of vaccines

Vaccines are now produced by transfer of antigen-coding genes to disease-causing bacteria. Such antibodies provide protection against the infection by the same bacteria or virus.

4. Production of interferon

Interferons are virus-induced proteins produced by virus-infected cells. Interferons are antiviral in action and act as first line of defense against viruses causing serious infections, including breast cancer and lymph node malignancy. Natural interferon is produced in very small quantity from human blood cells. It is thus very costly also. It is now possible to produce interferon by recombinant DNA technology at a much cheaper rate.

5. Production of enzymes

Some useful enzymes can also be produced by recombinant DNA technique. For instance, enzyme urokinase, which is used to

dissolve blood clots, has been produced by genetically engineered microorganisms.

6. Gene therapy

Genetic engineering may one day enable the medical scientists to replace the defective genes responsible for hereditary diseases (e.g., hemophilia, phenylketonuria, alkaptonuria) with normal genes. This new system of therapy is called gene therapy.

7. Solution of disputed parentage

Disputed cases of parentage can now be solved most accurately by recombinant technology than by blood tests.

8. Diagnosis of disease

Recombinant DNA technology has provided a broad range of tools to help physicians in the diagnosis of diseases. Most of these involve the construction of probes: short segments of single-stranded DNA attached to a radioactive or fluorescent marker. Such probes are now used for the identification of infectious agents, for instance, food poisoning *Salmonella*, pus-forming *Staphylococcus*, hepatitis virus, HIV, etc. By testing the DNA of prospective genetic disorder carrier parents, their genotype can be determined and their chances of producing an afflicted child can be predicted.

9. Production of transgenic animals

Animals which carry foreign genes are called transgenic animals.

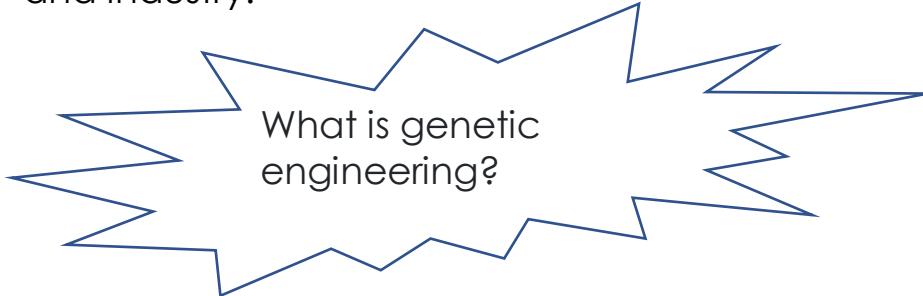
Examples:

Cow, sheep, goat – therapeutic human proteins in their milk.
Fish like common carp, catfish, salmon and goldfish contain human growth hormone (hGH).

III. Industrial applications

In industries, recombinant DNA technique will help in the production of chemical compounds of commercial importance, improvement of existing fermentation processes, and production

of proteins from wastes. This can be achieved by developing more efficient strains of microorganisms. Specially developed microorganisms may be used even to clean up the pollutants. Thus, biotechnology, especially recombinant DNA technology, has many useful applications in crop improvement, medicines, and industry.



Genetic engineering

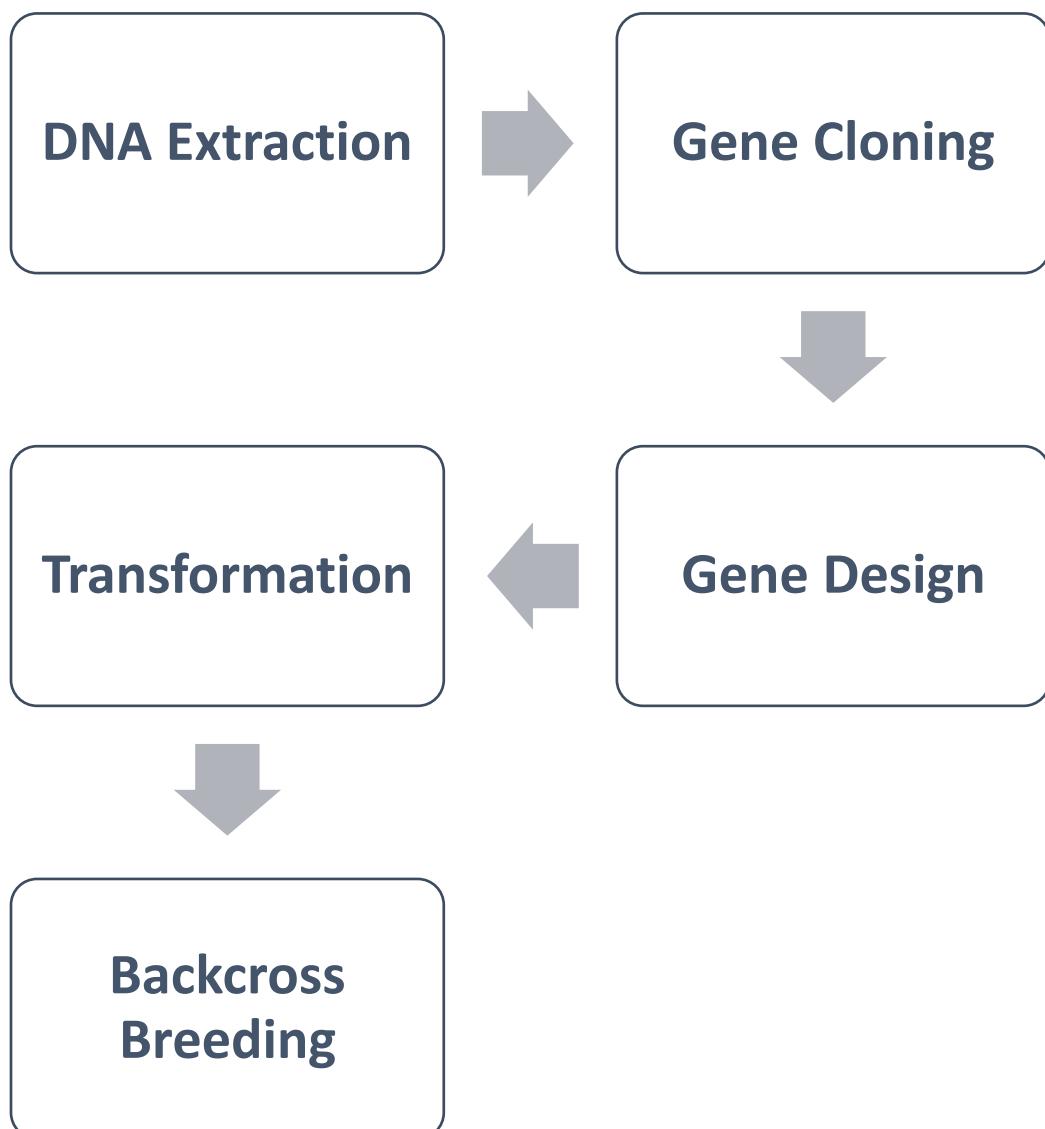
- It is the process of using rDNA technology to alter the genetic makeup of an organism. Traditionally, humans have manipulated genomes indirectly by controlling breeding and selecting offspring with desired traits.
- It involves the direct manipulation of one or more genes. Most often, a gene from another species is added to an organism's genome to give it a desired phenotype.
- It is the artificial modification of an organism's genetic composition. Genetic engineering typically involves transferring genes from one organism into another organism of a different species to give the latter specific traits of the former. The resulting organism is called a transgenic or genetically modified organism (GMO).

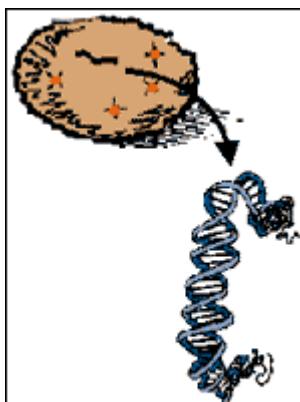
GENETICALLY MODIFIED ORGANISM



Source: <https://www.slideshare.net/mobile/dineshbhati5209000/genetically-modified-organisms-34236637>

Five Basic Processes in Genetic Engineering



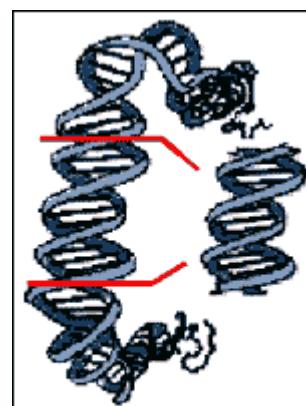


Extracting DNA from
and organism.

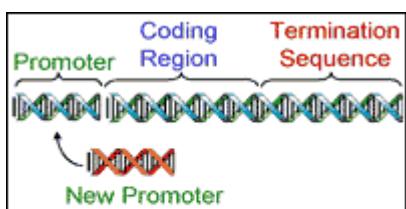
Step 1: DNA extraction

The process of genetic engineering requires the successful completion of a series of five steps.

DNA extraction is the first step in the genetic engineering process. In order to work with DNA, scientists must extract it from the desired organism. A sample of an organism containing the gene of interest is taken through a series of steps to remove the DNA.



Selecting a gene for
cloning



Replacing an existing
promoter with a new promoter.

Step 3: Gene design

Once a gene has been cloned, genetic engineers begin the third step, designing the gene to work once inside a different organism. This is done in a test tube by cutting the gene apart with enzymes and replacing gene regions that have been separated.

Step 4: Transformation (e.g., plants)

The modified gene is now ready for the fourth step in the process, transformation, or gene insertion.

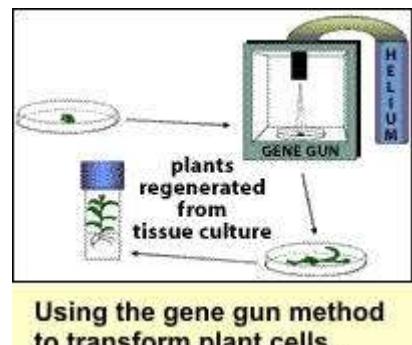
Since plants have millions of cells, it would be impossible to insert a copy of the transgene into every cell. Therefore, tissue culture is used to propagate masses of undifferentiated plant cells called callus. These are the cells to which the new transgene will be added.

The new gene is inserted into some of the cells using various techniques. Some of the more common methods include the gene gun, agrobacterium,

microfibers, and electroporation.

The main goal of each of these methods is to transport the new gene(s) and deliver them into the nucleus of a cell without killing it.

Transformed plant cells are then regenerated into transgenic plants. The transgenic plants are grown to maturity in greenhouses, and the seed they produce, which has inherited the transgene, is collected. The genetic engineer's job is now complete. He/she will hand the transgenic seeds over to a plant breeder who is responsible for the final step.



Using the gene gun method to transform plant cells.

Step 5 : Backcross breeding (e.g., engineered crop)



Backcross breeding

Transgenic plants are crossed with elite breeding lines using traditional plant breeding methods to combine the desired traits of elite parents and the transgene into a single line. The offspring are repeatedly crossed back to the elite line to obtain a high-yielding transgenic line. The result will be a plant with a yield potential close to current hybrids that expresses the trait encoded by the new transgene.

(Source:

<http://passel-test.unl.edu/beta/pages/informationmodule.php?idinformationmodule=957879329&topicorder=3&maxto=9&minto=1>

PERFORMANCE TASK: SEQUENCING

Directions: Arrange the processes of genetic engineering in ascending numerical order. Write your answers in your notebook.

- I. Gene design
- II. Transformation
- III. DNA extraction
- IV. Backcross breeding
- V. Gene cloning

1. _____
2. _____
3. _____
4. _____
5. _____

III. WHAT I HAVE LEARNED

POST-TEST

A. MATCHING TYPE. Match column A with column B. Write your answers in your notebook.

A

1. Transformation
2. DNA extraction
3. Recombinant DNA
4. Gene cloning
5. Agricultural application
6. Genetic engineering
7. Gene design
8. Medicinal application
9. Backcross breeding
10. Industrial application

B

- A. Crop improvement
- B. Extraction of DNA from a donor organism
- C. Gene insertion into vector genome
- D. Combination of two DNA molecules form new genetic combination
- E. Produce a genetically engineered product

F. Production of antibiotics, hormones, and vaccines

G. Copying of DNA from donor organism

H. Alters the genetic makeup of an organism

I. Designing of gene from a different organism

J. Production of chemical compounds

B. Read and understand each item carefully. Write your answers in your notebook.

1. Discuss the applications of recombinant DNA.

2. List down at least three important applications of recombinant DNA in daily life.

a. _____

b. _____

c. _____

REFERENCES

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Layout Artist

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SYNOPSIS

The recombinant DNA sometimes referred to as "genetic engineering" can benefit people in several ways. It has been exploited to provide selective improvement in various specialties that includes agriculture, medicine, and industries. Its applications have been become evident to every situation as it has been already applied nowadays.

However, it has always been a topic of controversy as the balance aims to reach between the benefits accrued to humans and attendant ethical consideration is open to debate.

ANSWER KEY	
PRE-TEST	1. Recombinant DNA 2. Agricultural application 3. Medicinal application 4. Deoxyribonucleic acid 5. Industrial application 6. Genetic engineering 7. Genes 8. Gene cloning 9. Donor organism 10. Vector genome
PERFORMANCE TASK: SEQUENCING	1. III 2. V 3. I 4. II 5. IV
POST-TEST	A. B. C. D. E. F. G. H. I. J.
B. Answers may vary	

ABOUT THE AUTHOR



RUSSEL C. CADAY finished his Bachelor's Degree in Secondary Education major in Biological Sciences at Negros Oriental State University, Bais Campus II in 2017. He is currently pursuing his Master's Degree in Education major in General Science at Central Philippine State University, San Carlos Campus. Currently, he is a teacher I at Owacan Provincial Community High School of Jimalalud District in the Division of Negros Oriental.