DNA Technology and Research

by Sophia

WHAT'S COVERED

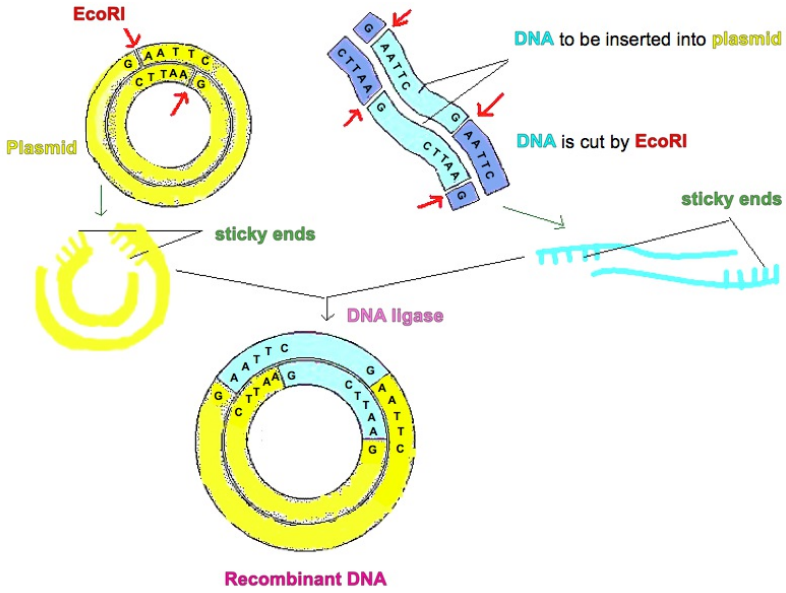
In this lesson, you will learn about the role of recombinant DNA technology in genetic engineering. Specifically, this lesson will cover:

1. Recombinant DNA Technology

Genetic engineering is a process which involves the alteration of the genes of an organism.**Recombinant DNA** is a tool used in genetic engineering; a short segment of DNA from one organism is "recombined" with the DNA of another organism.

One of the first attempts to create recombinant DNA was to help people with diabetes. At the time, the only way to prevent someone with diabetes from starving to death (remember, type I diabetics can't produce insulin and therefore can't move sugar from their blood to their hungry cells) was to give them cow's insulin. Cow's insulin was expensive, difficult to come by and didn't work well; people with diabetes had very foreshortening, poor-quality lives.

Scientists used genetic engineering to rapidly produce human insulin, which is far more effective than cow's insulin. They used **restriction enzymes** to introduce cuts into DNA extracted from cells swabbed from the inside of your cheek, for example. These cuts reduced the human genome to smaller-sized pieces that are easier to manage. They then took these pieces and inserted them into small circles of DNA called **plasmid DNA**. In the diagram below the dark strand is the human DNA, while the yellow is the plasmid. These plasmids are relatively easy to insert into **transformation** (briefly opening holes in a cell's plasma membrane so DNA outside the cell can be taken in and expressed). The plasmids also contain instructions for how to get rid of cells that didn't take up the correct DNA, as well as instructions for producing the protein encoded in the recombinant DNA.



This technology was used to introduce the gene for human insulin into E. coli, which grows rapidly and can produce this effective treatment for diabetes very cheaply. Thanks to this **transgenic organism** (an organism that contains genes from another organism), people with diabetes can live long, healthy lives.

TERMS TO KNOW

Genetic Engineering

Manipulating an organism's DNA to create a genetically modified organism (mice, crops).

Recombinant DNA

A DNA molecule that contains DNA from multiple species, often used with bacteria (example: using recombinant DNA to stimulate E. coli to produce human insulin).

Restriction Enzyme

Enzymes that cut apart specific segments of DNA.

Plasmid DNA

DNA that is separate from a chromosome but can code for a protein, are often circular, double-stranded and common in bacteria.

Transformation

A method of introducing new genes into cells (often bacterial cells).

Transgenic Organism

Organisms that contain genes from another organism.

2. Genetic Engineering Applications

Since the use of genetic engineering to create a therapy for diabetics, the technology has continued to improve, and the number of applications has increased.

For example, instead of isolating a whole bunch of DNA, cutting it up with restriction enzymes and hoping the correct gene gets inserted into one of your billions of plasmids, we can use **polymerase chain reaction (PCR)** to copy the precise gene in a couple of hours.

Besides creating medicinal proteins and molecules, **genetically modified organisms (GMOs)** can be used to make our environment cleaner and safer. For example, bacteria can be genetically modified to have genes that allow them to eat oil. These GMOs have been deployed at oil spills. This genetic engineering application is called **bioremediation**.

Genetic engineering has also been used to make food more affordable and more nutritious. Plants are being used in genetic engineering, and they can produce genetically modified foods. These genetically modified foods can be pest resistant and more resilient. They also can be genetically modified to do things like provide more vitamins.

In a way, this technology isn't new; people have been selectively breeding animals and hybridizing plants for thousands of years. Everything we eat has been "genetically modified" over generations. The benefit of genetic engineering technology is that it is more precise, so it introduces less risk of including harmful DNA along with the beneficial DNA. It's also faster and cheaper; reverting back to old insulin technology, for example, would be a death sentence to a lot of diabetics.

TERMS TO KNOW

Polymerase Chain Reaction (PCR)
Genetic technology that allows scientists to copy DNA quickly.

Genetically Modified Organism (GMO)
An organism that contains foreign DNA produced by genetic engineering.

Bioremediation
Using genetically modified organisms to clean pollutants.

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3. Gene Therapy

Gene therapy is a process that's used to help fix genetic diseases. As of right now, its use is not widely spread because it's still very experimental and costly. There are several ways gene therapy can be used. It is hoped that gene therapy can be used to replace or edit mutated genes.

> ↱ EXAMPLE You may have heard about the pregnant mother who has HIV. There was a very good chance her unborn children were going to contract the virus. CRISPR technology was used to alter the CCR5 receptors in the babies' T cells. This is a mutation that already exists in many people; people who are homozygous for this mutation are immune to HIV. Genetic engineering was used to give these babies a mutation that already exists and make them immune to their mother's HIV.

There are a couple of different ways in which genes can be inserted into a person in the process of gene therapy:

- Transformation: Briefly opening holes in a cell's plasma membrane so DNA outside the cell (such as recombinant plasmids) can be taken in and expressed.
- **Transfection**: A way in which genes can be inserted into a cell using a virus. A gene is inserted into a virus, and then the virus will be inserted into the person. It will transfer that gene to a target cell and integrate the DNA with the host's DNA.

There have been some different trials with gene therapy. One is with a disease called Severe Combined Immune Deficiency. Severe Combined Immune Deficiency is a type of disorder in which a person's immune

system doesn't work; they have to live in a bubble. Children with this disorder are often referred to as "bubble kids" because they literally have to live in a bubble and can't be exposed to any germs, due to their deficient immune system. Gene therapy has actually come a long way with this type of disease and helping to allow those children to lead a more normal life.
Cystic fibrosis is another example of a disease that has had some trials with gene therapy. With this disorder, scientists have used a virus to deliver normal copies of a gene to the respiratory system. With cystic fibrosis, you get a buildup of mucus in the respiratory system. By using this virus, they can deliver normal copies of the gene to the respiratory system to help with this condition.

The most common use of gene therapy thus far has been with cancer. It's had the biggest success thus far with gene therapy of any of the other diseases that they've done trials with.

TERMS TO KNOW

Gene Therapy

The process of replacing mutated genes with normally functioning genes; gene therapy can be done directly or with vectors (virus).

Transfection

A gene is inserted into a vector (virus) and injected into a person; the virus will deliver the gene into the host cells.

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4. Cloning

Cloning is the process of producing a genetic copy of a cell or an organism. So far, scientists have cloned bacteria in recombinant DNA technology and embryos for stem cell use. They've also cloned animals, one of the most famous examples being Dolly the sheep.

There are two different types of cloning that can be used:

- **Therapeutic cloning**: A type of cloning in which an embryo is cloned as a source of**embryonic stem cells**. These embryonic stem cells have undergone very little differentiation, so they are capable of becoming a wider variety of tissues (for organ transplants, for example). However, embryonic stem cells are difficult to come by, and there are ethical concerns. Research is ongoing to coax adult stem cells (such as those found in fat tissue) to differentiate into a wider variety of tissues.
- **Reproductive Cloning**: A type of cloning technology in which a cloned embryo is created. That cloned embryo is then transferred into a woman's uterus, where it can develop into a baby. The parents who are carriers of a genetic disorder, such as cystic fibrosis, would be able to ensure that their children (and all future generations) didn't carry genes that could make them or future generations sick. This is just one of the different ways that reproductive cloning is developing and being used.

Both therapeutic and reproductive cloning are in the very early stages of development. For example, often, cloned organisms have health problems. Scientists have noticed this with some of the cloned animals that they've produced—these animals tend to have a lot of health issues, and they will age faster than average. Additionally, there has been an ethical debate about altering the genetic makeup of an embryo before it's implanted. Many people consider this to be unnatural because rather than letting nature take its course, this process involves messing with aspects of biology that are typically out of people's hands. However, cloning can certainly be a useful tool.

TERMS TO KNOW

Cloning
The production of a genetic replica of a cell or organism.

Therapeutic Cloning
A type of cloning in which embryonic stem cells are used to produce organs or tissues.

Embryonic Stem Cells
Cells from an embryo that have not yet specialized and therefore can be coaxed to produce various types of organs and tissues.

Reproductive Cloning
A type of cloning in which a cloned embryo is implanted into a mother's uterus and allowed to develop into a baby.

SUMMARY

Recombinant DNA technology is used in genetic engineering. It often contains the DNA of more than one species. It often involves using restriction enzymes to cut sections out of DNA. This DNA is combined with plasmid DNA with the help of modification enzymes. From there it is placed (via transformation or transfection) in another organism (such as a bacterial cell) to replicate. Polymerase chain reaction (PCR) is an even faster, more precise way to isolate a useful gene and create a genetically modified organism (GMO); GMOs can be used in bioremediation, medical therapeutics, and agriculture. **Genetic engineering** can also be used in **gene therapy** to try and directly fix mutated genes (such as those found in cancer cells). Future technologies may be able to use **cloning** to create replacement organs or help parents with a genetic disorder have healthy babies.

Keep up the learning and have a great day!

Source: This work is adapted from Sophia Author Amanda Soderlind

ATTRIBUTIONS

- Recombinant DNA | **Author:** Wikipeda | **License:** Public Domain

TERMS TO KNOW

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Using genetically modified organisms to clean pollutants.

Cloning
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Embryonic Stem Cells
Cells from an embryo that have not yet specialized and therefore can be coaxed to produce various

types of organs and tissues.

Gene Therapy

The process of replacing mutated genes with normally functioning genes. Gene therapy can be done directly or with vectors (virus).

Genetic Engineering

Manipulating an organism’s DNA to create a genetically modified organism (GMOs).

Genetically Modified Organism (GMO)

An organism that contains DNA produced by genetic engineering (such as DNA from more than one species).

Plasmid DNA

DNA that is separate from a chromosome but can code for a protein. Plasmids are often circular, double-stranded and common in bacteria.

Polymerase Chain Reaction (PCR)

Genetic technology that allows scientists to copy DNA quickly.

Recombinant DNA

A DNA molecule that contains DNA from multiple species, often used with bacteria (example: using recombinant DNA to stimulate E. coli to produce human insulin).

Reproductive Cloning

A type of cloning in which a cloned embryo is implanted into a mother's uterus and allowed to develop into a baby.

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A type of cloning in which embryonic stem cells are used to produce organs or tissues.

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Organisms that contain genes from another organism.