# Biotechnology

## Class XII

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# Chapter 1

# An Overview of Recombinant DNA Technology

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## EXERCISES

### 1. Discuss in brief how recombinant DNA technology was initially developed?

**Ans:** Recombinant DNA technology, also known as genetic engineering, was initially developed in the 1970s, marking a significant milestone in the field of molecular biology. The key breakthrough that paved the way for this technology was the discovery of restriction enzymes, also called restriction endonucleases, in the early 1970s.

Here's a brief overview of the development of recombinant DNA technology:

**Discovery of Restriction Enzymes (1970):**
Restriction enzymes are proteins produced by bacteria as a defense mechanism against invading viruses (bacteriophages). These enzymes can recognize specific DNA sequences and cut the DNA at those sites.

The discovery of restriction enzymes, such as EcoRI and HindII, allowed scientists to precisely cut DNA at specific locations, creating "sticky ends" that could easily pair with complementary sequences.

**DNA Cloning (1972):**
The concept of DNA cloning was introduced by Stanley Cohen, Herbert Boyer, and Paul Berg. They successfully inserted a DNA fragment from one organism into a plasmid (a small, circular piece of DNA) using restriction enzymes.

The plasmid, now containing the foreign DNA, was then introduced into bacteria, where it replicated along with the bacterial DNA.

**Development of Recombinant DNA (1973-1974):**
Paul Berg conducted the first successful gene splicing experiments in 1973. He combined DNA from the simian virus 40 (SV40) with that of the lambda bacteriophage using restriction enzymes.

In 1974, Cohen and Boyer achieved the first successful expression of a foreign gene. They inserted the gene for resistance to the antibiotic kanamycin into a plasmid, which was then introduced into Escherichia coli (E. coli) bacteria.

**Commercial Application (Late 1970s - Early 1980s):**
The development of recombinant DNA technology had a profound impact on biotechnology and medicine. It paved the way for the production of human insulin, growth hormone, and other therapeutic proteins using genetically engineered bacteria.

In 1982, the first genetically engineered product, human insulin, was approved for medical use.

The discovery and application of recombinant DNA technology opened up new possibilities for manipulating and studying genes, leading to advancements in biotechnology, medicine, agriculture, and various other fields.

## 2. Briefly discuss the application of rDNA technology in crop improvement and therapeutic.

**Ans:** Application of Recombinant DNA (rDNA) Technology in Crop Improvement:

**Genetically Modified (GM) Crops:**
rDNA technology has been used to create genetically modified crops with improved traits, such as resistance to pests, diseases, and environmental stresses.

Examples include Bt cotton, which produces a bacterial toxin to deter insect pests, and herbicide-resistant crops that can tolerate specific herbicides, allowing for more effective weed control.

**Increased Crop Yield:**
Genetic engineering can enhance crop yield by introducing genes that promote better photosynthesis, nutrient utilization, or resistance to adverse environmental conditions.

**Improved Nutritional Content:**
rDNA technology enables the development of crops with enhanced nutritional profiles. For instance, biofortified crops may be engineered to contain higher levels of essential vitamins and minerals.

**Drought and Salinity Tolerance:**
Scientists use genetic engineering to introduce genes that confer tolerance to drought or soil salinity, enabling crops to thrive in challenging environmental conditions.

Application of Recombinant DNA (rDNA) Technology in Therapeutics:

**Human Insulin Production:**
One of the earliest and most significant applications of rDNA technology in therapeutics was the production of human insulin. The human insulin gene was inserted into bacteria (such as Escherichia coli), which then produced the insulin protein for medical use.

**Pharmaceutical Protein Production:**
rDNA technology allows for the production of various therapeutic proteins in large quantities. This includes growth hormones, blood clotting factors, and enzymes used in the treatment of various medical conditions.

**Vaccines:**
The development of vaccines using rDNA technology has become more common. Recombinant DNA techniques enable the production of safer and more efficient vaccines, including those for hepatitis B and human papillomavirus (HPV).

**Gene Therapy:**
rDNA technology plays a crucial role in gene therapy, where defective or missing genes in individuals can be replaced or supplemented with functional ones. This holds promise for treating genetic disorders.

**Monoclonal Antibodies:**
Monoclonal antibodies, which are widely used in cancer treatment and other therapeutic applications, can be produced using rDNA technology. Genetically engineered cells are employed to manufacture these antibodies in large quantities.

In both crop improvement and therapeutic applications, rDNA technology has revolutionized the ability to manipulate and engineer genetic material for desired outcomes, contributing significantly to advancements in agriculture and medicine.

**3. Who discovered the Plasmid?**
**(a) Paul Berg**
**(b) Sir Alec Jeffreys**
**(c) Joshua Lederberg**
**(d) Kary Mullis**

**Ans:** The discovery of plasmids is attributed to Joshua Lederberg. Therefore, the correct answer is (c) Joshua Lederberg.

**4. Plasminogen activator and Urokinase are used as:**
**(a) Antiviral agent**
**(b) Blood clot dissolving drug**
**(c) Sugar lowering agent**
**(d) Cholesterol lowering agent**

**Ans:** (b) Blood clot dissolving drug

Plasminogen activators, such as tissue plasminogen activator (tPA) and urokinase, are used as blood clot dissolving drugs. They work by converting plasminogen into plasmin, an enzyme that breaks down fibrin clots in the blood. These drugs are often used in the treatment of conditions such as strokes and heart attacks where the prompt dissolution of blood clots is crucial.

**5. Assertion: Restriction endonuclease cuts DNA and isolated mostly from bacteria. Reason: Restriction endonuclease is a type of nuclease. (a) Both assertion and reason are true and the reason is the correct explanation of the assertion.**
**(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.**
**(c) Assertion is true but reason is false.**
**(d) Both assertion and reason are false.**

**Ans:** The correct answer is:

(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.

Explanation:

- The assertion is correct; restriction endonucleases are enzymes that cut DNA at specific recognition sequences. These enzymes are isolated mostly from bacteria.
- The reason is also true, but it doesn't directly explain why restriction endonucleases are isolated mostly from bacteria. The fact that restriction endonucleases are a type of nuclease is true, but it doesn't provide a specific explanation for their prevalence in bacteria. The primary reason for this is thought to be a defense mechanism in bacteria against invading viruses.

**6. Assertion: E.coli divides in 20 minutes while replicates its DNA in about 60 minutes. Reason: E.coli follows multifork replication mecha- nism.**
**(a) Both assertion and reason are true and the reason is the correct explanation of the assertion.**
**(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.**
**(c) Assertion is true but reason is false.**
**(d) Both assertion and reason are false.**

**Ans:** The correct answer is:

(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.

Explanation:

- The assertion is correct. E. coli has a relatively short generation time, and it can divide in approximately 20 minutes.

- The reason is also correct; E. coli follows multifork replication, where multiple replication forks proceed simultaneously along the bacterial chromosome. However, this reason doesn't directly explain why E. coli divides in 20 minutes while replicating its DNA in about 60 minutes. The short generation time is influenced by various factors, including the time it takes for DNA replication, but it's not solely determined by it. Other cellular processes, such as cell growth and division, contribute to the overall cell cycle duration.

## SUMMARY

• The methods used for manipulating nucleic acid/ genome (DNA) of an organism are collectively referred to as recombinant DNA (rDNA) technology or genetic engineering.
• The fundamental theme of rDNA technology is the isolation and propagation of a desired DNA molecule (gene) from a source with an aim to have its product in ample quantity. This technique is called gene cloning.