CHAPTER 9

BIOTECHNOLOGY: PRINCIPLES AND PROCESSES

CLASS 12TH

NCERT EXERCISE AND SOLUTIONS - BIOLOGY

Q. 1. **Can you list 10 recombinant proteins which are used in medical practice? Find out where they are used as therapeutics (use the internet).**

ANSWER:-

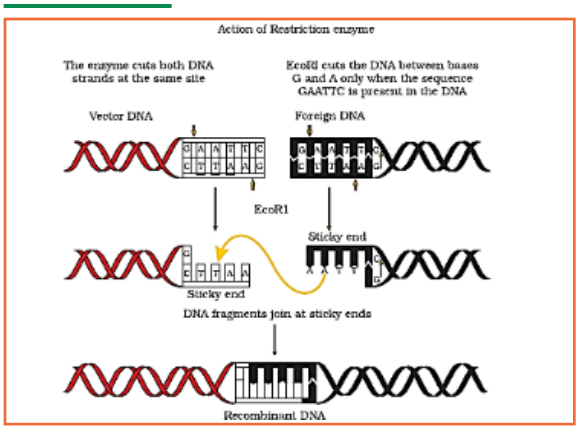
Recombinant proteins utilized in medical applications are produced through recombinant DNA technology. This process involves transferring specific genes from one organism to another using vectors and restriction enzymes as molecular tools.

Here are 10 examples of recombinant proteins:

Recombinant Protein	Therapeutic Application
Interferon- α	Used in the treatment of chronic hepatitis C
Insulin	Treats type I diabetes mellitus
Interferon- β	Used to manage herpes and viral enteritis
Interferon-B	Employed in the treatment of multiple sclerosis
Antithrombin III	Prevents blood clot formation
Human Recombinant Growth Hormone	Promotes growth in individuals
Coagulation Factor VIII	Treats haemophilia A
Coagulation Factor IX	Treats haemophilia B
DNAase I	Used in managing cystic fibrosis
Tissue Plasminogen Activator	Treats acute myocardial infarction

Q. 2. **Make a chart (with diagrammatic representation) showing a restriction enzyme, the substrate DNA on which it acts, the site at which it cuts DNA and the product it produces.**

ANSWER:-



Q. 3. **From what you have learnt, can you tell whether enzymes are bigger or DNA is bigger in molecular size? How did you know?**

ANSWER:-

Enzymes are smaller in size compared to DNA molecules. DNA serves as the genetic material crucial for the growth and functioning of living organisms. It contains instructions for the synthesis of both DNA and proteins. In contrast, enzymes are proteins produced from specific genes, which are small segments of DNA. These enzymes play a vital role in the formation of polypeptide chains.

Q. 4. **What would be the molar concentration of human DNA in a human cell? Consult your teacher.**

ANSWER:-

The molar concentration of human DNA in a cell is calculated as follows:

$6.023\times10^{23}\times$Total number of chromosomes

$= 6.023\times10^{23}\times46$

$= 2.77\times10^{23}$ moles

Thus, the molar concentration of DNA in each diploid human cell is 2.77×10^{23} moles.

Q. 5. **Do eukaryotic cells have restriction endonucleases? Justify your answer.**

ANSWER:-

Eukaryotic cells do not possess restriction endonucleases because their DNA is extensively methylated by the enzyme methylase, which protects it from the action of restriction enzymes. In contrast, prokaryotic cells have restriction enzymes that serve as a defence mechanism, preventing viral DNA invasion.

Q. 6. **Besides better aeration and mixing properties, what other advantages do stirred tank bioreactors have over shake flasks?**

ANSWER:-

Stirred tank bioreactors are designed for large-scale production of biotechnological products, while the shake flask method is used for small-scale production in laboratory settings.

Stirred tank bioreactors offer several advantages over shake flasks, including:

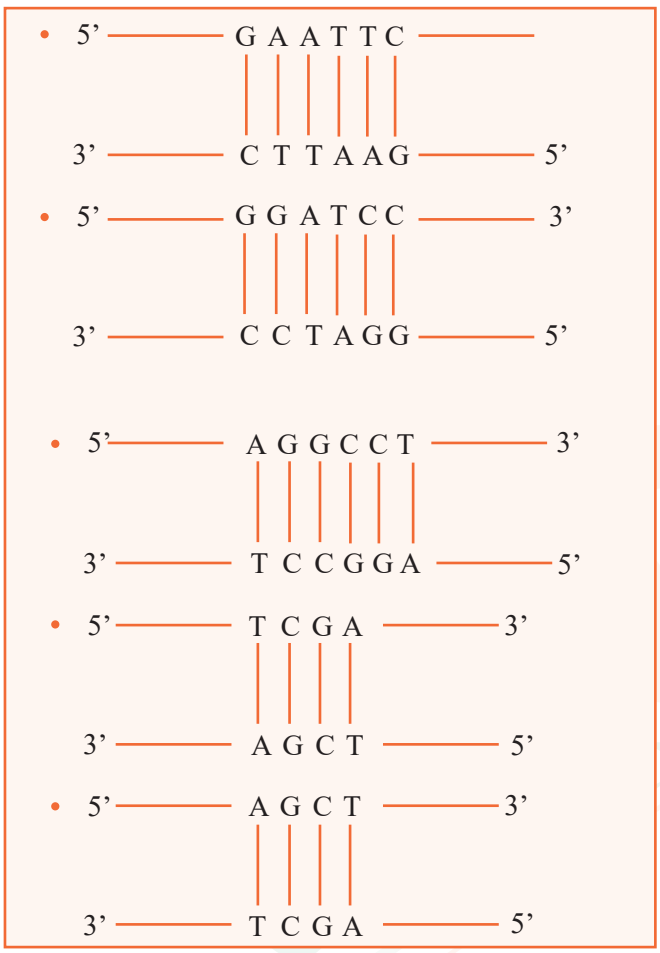
1. The ability to extract small samples of culture for testing and analysis.
2. A built-in control system to monitor and maintain optimal pH and temperature.
3. The inclusion of a foam breaker to manage and reduce foam formation during the process.

Q. 7. **Collect 5 examples of palindromic DNA sequences by consulting your teacher. Better try to create a palindromic sequence by following base-pair rules.**

ANSWER:-

A palindromic sequence in DNA is a segment that reads identically in both directions, whether from 5' to 3' or 3' to 5'. These sequences serve as recognition sites for restriction enzyme activity. Nearly all restriction enzymes recognize palindromic sequences.

Here are five examples of palindromic sequences:



Q. 8. Can you recall meiosis and indicate at what stage a recombinant DNA is made?

ANSWER:-

Meiosis is a type of cell division that results in a reduction of genetic material. It occurs in two stages: meiosis I and meiosis II.

During the pachytene stage of prophase I, homologous chromosomes undergo crossing over. This involves the exchange of genetic segments between non-sister chromatids, leading to the formation of recombinant DNA.

Q. 9. Can you think and answer how a reporter enzyme can be used to monitor transformation of host cells by foreign DNA in addition to a selectable marker?

ANSWER:-

A reporter gene can be used to track the transformation of host cells by foreign DNA. It acts as a selectable marker to determine whether the host cell has incorporated the foreign DNA or if the foreign gene is being expressed. Scientists place the reporter gene and the foreign gene together in the same DNA construct, which is then introduced into the host cell. The reporter gene helps identify successful uptake of the foreign genes or genes of interest. For instance, in jellyfish, the lac Z gene is a reporter gene that encodes a green fluorescent protein.

Q. 10. Describe briefly the following:

(a) Origin of replication
(b) Bioreactors
(c) Downstream processing

ANSWER:-

(a) **Origin of Replication:** The origin of replication is a specific DNA sequence in a genome where replication begins. This initiation process can occur in a uni-directional or bi-directional manner. Any DNA fragment linked to this sequence can replicate within host cells. The sequence also regulates the copy number of the associated DNA. Therefore, to generate multiple copies of the target DNA, it must be cloned into a vector with an origin sequence supporting a high copy number.

(b) **Bioreactor:** Bioreactors are large-scale vessels designed for the industrial production of biotechnological products from raw materials. These systems provide optimal conditions for the desired product by maintaining appropriate levels of pH, temperature, oxygen, and nutrients. Key features include oxygen delivery, foam control, and temperature and pH regulation systems. Additionally, they have a sampling port to extract small quantities of culture for analysis.

(c) **Downstream Processing:** Downstream processing refers to the purification and isolation of foreign gene products after the biosynthesis stage. The product undergoes various procedures to separate and purify it. Once purified, the product is formulated and subjected to clinical trials and quality assessments to ensure safety and efficacy.

Q. 11. Explain briefly

(a) PCR
(b) Restriction enzymes and DNA
(c) Chitinase

ANSWER:-

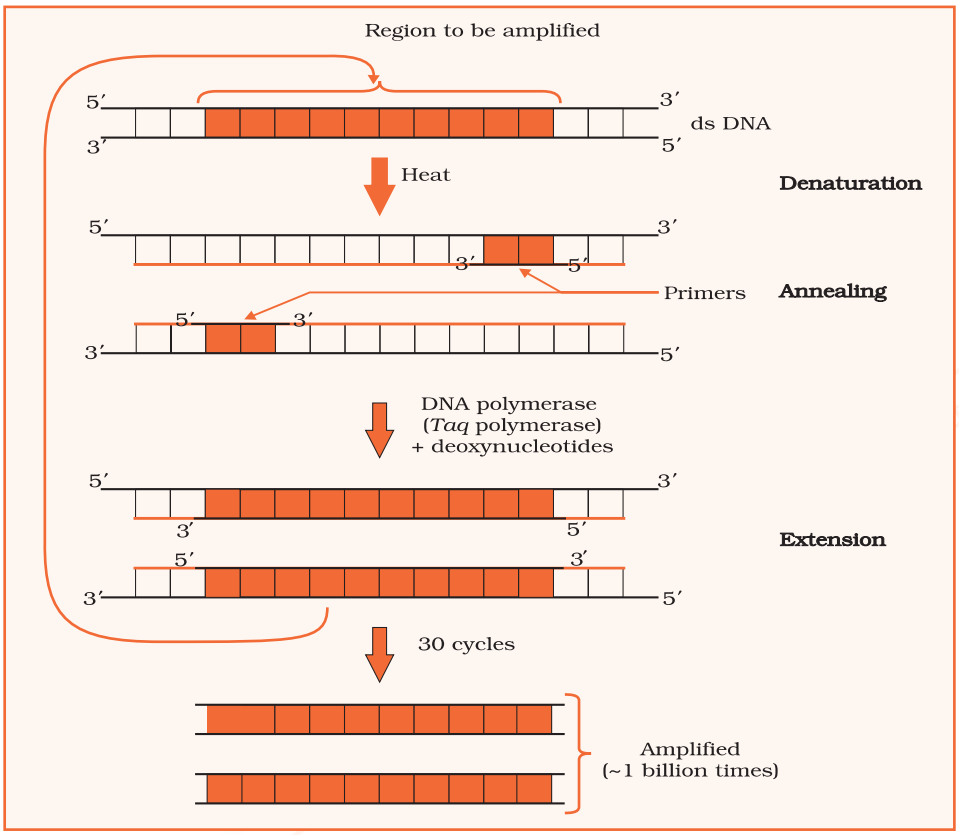
(a) **PCR:** Polymerase Chain Reaction (PCR) is a molecular biology technique used to amplify a specific gene or DNA fragment, generating multiple copies. It is commonly applied in gene manipulation. The process involves the in–vitro synthesis of DNA sequences using a template strand, a primer, and a thermostable DNA polymerase enzyme derived from the bacterium *Thermus aquaticus*. This enzyme utilizes deoxynucleotides (dNTPs) to extend the primer.

The three steps involved in PCR are:

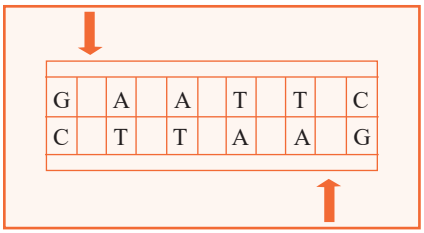
(i) The DNA molecules are initially heated to a high temperature to separate the two strands into single-stranded DNA. This step is known as denaturation.

(ii) The single-stranded DNA then serves as a template for the DNA polymerase enzyme to synthesize a new strand. This process, called annealing, results in the replication of the original DNA, and the procedure is repeated through multiple cycles to produce many copies of the recombinant DNA fragment.

(iii) The primer is extended by Taq DNA polymerase, which is isolated from *Thermus aquaticus*.



(b) Restriction Enzymes and DNA: In molecular biology, restriction enzymes act as molecular scissors, cutting DNA at specific locations. They play a crucial role in gene manipulation. These enzymes recognize a particular six-base pair sequence, known as the recognition sequence, and cleave the DNA at designated sites. For example, the recognition site for the EcoRI enzyme is illustrated below.



Restriction enzymes are categorized into two types:

(i) **Endonuclease:** This type of restriction enzyme cuts the DNA at specific internal sites. It plays a crucial role in genetic engineering. It is commonly used to make cuts in the DNA sequence, resulting in fragments with sticky ends, which can later be joined together using the enzyme DNA ligase.

(ii) **Exonuclease:** This type of restriction enzyme removes nucleotides from either the 3' or 5' ends of the DNA molecule.

(c) Chitinase: Chitinase is an enzyme that degrades chitin, a key component of the cell walls in fungi. This enzyme is used to break down the fungal cell walls, thereby releasing the DNA contained within the cell membrane for further analysis.

Q. 12. Discuss with your teacher and find out how to distinguish between

(a) Plasmid DNA and Chromosomal DNA

(b) RNA and DNA

(c) Exonuclease and Endonuclease

ANSWER:-

(a) Plasmid DNA and Chromosomal DNA

Plasmid DNA	Chromosomal DNA
Plasmid DNA is an extrachromosomal molecule found in bacteria, capable of replicating independently of chromosomal DNA.	Chromosomal DNA constitutes the entire genetic material of an organism, located within its chromosomes.

(b) RNA and DNA

RNA	DNA
Exists as a single-stranded molecule	Exists as a double-stranded molecule
Cannot replicate on its own	Capable of replication
Consist of ribose sugar	Consist of deoxyribose sugar
Pyrimidines include uracil and adenine	Pyrimidines include thymine and adenine
Serves as a component of ribosomes	Serves as a component of chromosomes

(c) Exonuclease and Endonuclease

Exonuclease	Endonuclease
A type of restriction enzyme that removes nucleotides from the 5' or 3' ends of the DNA molecule	A type of restriction enzyme that cuts within the DNA at specific sites to generate sticky ends