DEPTH OF BIOLOGY

Unit-3

Genomics is the study of genes and DNA in an organism.

Proteomics is the study of proteins, which are made from genes and perform most of the cell's work.

Gene sequencing-

Gene sequencing is the process of finding the exact order of bases (A, T, C, G) in a DNA segment or gene.

These bases are the "letters" of DNA, and their order gives the instructions for making proteins.

Steps of Gene Sequencing -

DNA is collected
(from blood, saliva, tissue, etc.)

DNA is broken into small pieces

Special machines read the sequence

(They detect the order of A, T, C, and G).

Computer joins and analyzes the sequence

Result: Full gene code is known

Why is Gene Sequencing Important?

To find mutations that cause diseases
For genetic testing and diagnosis
In research and drug development
To study evolution and genetic diversity

Microarray Technique

Microarray is a lab tool used to study thousands of genes at once.
It shows which genes are active (on) or inactive (off) in a cell.

Basic Principle:
Based on base pairing: DNA sticks to its matching strand (A with T, C with G).
It uses a chip (glass slide) with spots of known DNA.

Applications:

To study gene expression in diseases like cancer
To compare healthy vs. diseased cells
In drug research and personalized medicine
For identifying genetic markers

Steps -

Collect mRNA from cells (it shows active genes).

Convert mRNA to cDNA (copy DNA) and label with colors (e.g., red and green).

Add cDNA to microarray chip.

cDNA binds (hybridizes) to matching DNA spots on the chip.

Scanner reads the chip and shows which genes are active by color and brightness.

Microarray = Many genes tested at once →

Shows which genes are "on" or "off"

SDS-PAGE

SDS-PAGE stands for Sodium Dodecyl Sulfate PolyAcrylamide Gel Electrophoresis.

It is a lab technique used to separate proteins based on their size (molecular weight).

Principle:

SDS is a detergent that gives all proteins a negative charge and unfolds them (removes shape).

When an electric current is applied, the proteins move through the polyacrylamide gel.

Smaller proteins move faster, so they go further.

Steps (Simple):

Mix proteins with SDS

→ Proteins become negatively charged and unfolded.

Load proteins into gel wells

Run electric current

→ Proteins move through the gel.

Stain the gel

→ Proteins appear as bands.

Compare bands

→ You can measure protein size and compare samples.

Applications:

To check protein purity

To estimate protein size

In research, diagnostics, and vaccine development

SDS-PAGE = Separates proteins by size, using gel and electricity

Gene Therapy-

Gene therapy is a technique that treats or prevents diseases by fixing faulty genes in a person's cells.

How It Works :-

Find the faulty gene causing the disease.
Insert a healthy copy of the gene into the body.
The healthy gene makes the correct protein, helping the body work properly.

Types of Gene Transfer Techniques:-

1. Viral Method (Using Vectors)-
Modified viruses are used to carry and insert the gene into cells.

Common viruses: Adenovirus, Lentivirus, Retrovirus Used in gene therapy

2. Microinjection

A tiny needle is used to inject DNA directly into the cell nucleus.

Mostly used in animal research (like making transgenic mice).

3. Electroporation

Electric pulses are applied to make tiny holes in the cell membrane.

DNA enters through these holes.

Common in plant and bacterial cells.

4. Liposome-Mediated Transfer

DNA is packed in fat bubbles (liposomes) which fuse with the cell membrane.

Easy and safe for animal cells.

5. Gene Gun (Biolistics)
DNA-coated tiny gold or tungsten particles are shot into cells.
Common in plant cells.

6. Calcium Phosphate Method
DNA is mixed with calcium phosphate, forming a precipitate that enters cells.
Used in labs for mammalian cell transfection.

7. Agrobacterium-Mediated Transfer (Plants Only)
A bacterium (Agrobacterium tumefaciens) naturally inserts DNA into plant cells.
Used in plant genetic engineering.

Clinical Applications of Gene Therapy-

Gene therapy is now being used or tested to treat many diseases, especially genetic disorders and some types of cancer.

1. Genetic Diseases:
Severe Combined Immunodeficiency (SCID) – first successful gene therapy.

Sickle Cell Anemia – correcting faulty hemoglobin gene.

Cystic Fibrosis – replacing the CFTR gene.

Hemophilia – delivering clotting factor genes.

2. Eye Diseases:
Leber's Congenital Amaurosis (LCA) – restoring vision using gene therapy (Luxturna).

3. Cancer:
CAR-T Cell Therapy – T-cells are genetically modified to fight blood cancers (like leukemia and lymphoma).

4. Neurological Disorders:
Spinal Muscular Atrophy (SMA) – gene therapy drug (Zolgensma) helps children with motor neuron disease.

Recent Advances in Gene Therapy

1. CRISPR Gene Editing:
A powerful tool that can cut and fix faulty genes with high precision.
Used in trials for sickle cell anemia, beta-thalassemia, and more.
2. mRNA-based Gene Therapy:
Inspired by COVID-19 vaccines.
Being tested for diseases like cancer, genetic disorders, and infections.

3. Safer Viral Vectors:
New AAV (Adeno-associated viruses) are safer and more efficient for gene delivery.