BIOLOGY FOR ENGINEERS

UNIT II

BIODIVERSITY

Microbes –History and its types

Microbes, or microorganisms, are incredibly diverse and play crucial roles in ecosystems, health, and industry. Here's a concise breakdown:

History of Microbiology

1. **Ancient Observations**:
   - **Ancient Greece and Rome**: Early descriptions of disease and fermentation processes, though the microscopic nature of microbes was not understood.
2. **Development of Microscopy**:
   - **1670s**: Antonie van Leeuwenhoek, using a simple microscope, was the first to observe and describe single-celled organisms, which he called "animalcules."
   - **1800s**: Advances in microscopy by scientists like Robert Hooke (who coined the term "cell") furthered the understanding of microorganisms.
3. **Germ Theory of Disease**:
   - **1857-1861**: Louis Pasteur's experiments demonstrated that microorganisms are responsible for fermentation and disease, supporting the germ theory.
   - **1860s**: Joseph Lister applied germ theory to antiseptic techniques in surgery, dramatically reducing post-surgical infections.
4. **Discovery of Bacteria and Viruses**:
   - **1880s**: Robert Koch identified the specific bacteria causing diseases like tuberculosis and cholera, establishing Koch's postulates.
   - **1890s**: Dmitri Ivanovsky and Martinus Beijerinck discovered viruses, though their true nature wasn't understood until later.
5. **Modern Advances**:
   - **1950s**: The advent of electron microscopy revealed details of microbial structure and function.
   - **1970s**: The development of molecular techniques, including PCR and DNA sequencing, revolutionized microbiology by allowing for detailed genetic analysis.

Types of Microbes

1. **Bacteria**:
    - **Characteristics**: Single-celled organisms without a nucleus, with various shapes (e.g., rods, spheres, spirals).
    - **Examples**: *Escherichia coli*, *Staphylococcus aureus*.
    - **Roles**: Pathogens, decomposers, nitrogen fixers, and contributors to human microbiota.
2. **Archaea**:
    - **Characteristics**: Single-celled organisms similar to bacteria but with distinct genetic and biochemical differences.
    - **Examples**: Methanogens, halophiles.
    - **Roles**: Often found in extreme environments (e.g., hot springs, salt flats) and play roles in biogeochemical cycles.
3. **Fungi**:
    - **Characteristics**: Can be single-celled (yeasts) or multicellular (molds, mushrooms), with cell walls made of chitin.
    - **Examples**: *Saccharomyces cerevisiae* (yeast), *Penicillium* (mold).
    - **Roles**: Decomposers, symbionts (e.g., mycorrhizae with plants), and sources of antibiotics.
4. **Protists**:
    - **Characteristics**: A diverse group of mostly single-celled organisms with a nucleus, including protozoa and algae.
    - **Examples**: *Amoeba*, *Paramecium*, *Chlorella*.
    - **Roles**: Primary producers in aquatic environments, some are pathogens.
5. **Viruses**:
    - **Characteristics**: Acellular entities that consist of genetic material (DNA or RNA) surrounded by a protein coat.
    - **Examples**: Influenza virus, HIV.
    - **Roles**: Pathogens, important in gene transfer and evolution.
6. **Prions**:
    - **Characteristics**: Misfolded proteins that can induce other proteins to misfold.
    - **Examples**: Prions causing diseases like Creutzfeldt-Jakob disease.
    - **Roles**: Disease-causing agents with no nucleic acid component.

Economic Importance of Microbes

1. **Agriculture**:

- **Soil Fertility**: Certain bacteria and fungi, such as nitrogen-fixing *Rhizobium* species and mycorrhizal fungi, enhance soil fertility by fixing atmospheric nitrogen and increasing nutrient uptake for plants.
- **Biopesticides**: Microbes are used to control agricultural pests. For example, *Bacillus thuringiensis* produces toxins that target specific insects.

2. **Food Industry**:
   - **Fermentation**: Microbes are essential in the production of various foods and beverages. Yeasts like *Saccharomyces cerevisiae* are used in baking and brewing, while bacteria are involved in the fermentation of dairy products (e.g., yogurt, cheese).
   - **Food Preservation**: Fermentation helps preserve food by creating conditions that inhibit spoilage bacteria.
3. **Biotechnology**:
   - **Pharmaceuticals**: Microbes are used to produce antibiotics (e.g., penicillin from *Penicillium*), vaccines, and other pharmaceuticals. Genetic engineering techniques also use microbes to produce insulin, growth hormones, and other therapeutic proteins.
   - **Bioremediation**: Microbes are employed to clean up environmental pollutants, such as oil spills and heavy metal contamination, by breaking down harmful substances.
4. **Energy Production**:
   - **Biofuels**: Microbes are involved in the production of biofuels. For example, certain bacteria and algae can produce bioethanol and biodiesel, offering alternative energy sources.
5. **Industrial Processes**:
   - **Biocatalysts**: Enzymes from microbes are used as catalysts in various industrial processes, including the synthesis of chemicals and the processing of textiles.
6. **Health and Medicine**:
   - **Probiotics**: Beneficial bacteria, such as *Lactobacillus* and *Bifidobacterium*, are used as probiotics to promote gut health and treat digestive disorders.

Control of Microbes

Effective control of microbes is essential to prevent disease, maintain food safety, and protect industrial processes. Methods of microbial control include:

1. **Physical Methods**:
   - **Heat**: Sterilization methods such as autoclaving use high temperatures to kill microbes. Pasteurization involves heating liquids to kill pathogens without affecting the product's quality.
   - **Filtration**: Removes microbes from liquids or air. Filters with specific pore sizes can trap bacteria and viruses.

- **Radiation**: Ultraviolet (UV) and ionizing radiation are used to kill microbes or inhibit their growth, often in sterilization of surfaces and equipment.

2. **Chemical Methods**:
   - **Disinfectants and Antiseptics**: Chemicals like bleach, alcohol, and hydrogen peroxide kill or inhibit microbes on surfaces or skin.
   - **Antibiotics**: Target specific bacterial functions or structures to kill or inhibit bacterial growth. However, their misuse can lead to antibiotic resistance.
3. **Biological Methods**:
   - **Biocontrol Agents**: Using beneficial microbes to control pests and pathogens. For example, *Bacillus thuringiensis* used as a biological insecticide.
   - **Probiotics**: Competitive exclusion of pathogenic microbes in the gut or on surfaces.
4. **Environmental Controls**:
   - **Hygiene**: Regular handwashing, sanitization, and proper food handling practices reduce microbial contamination and spread of disease.
   - **Storage Conditions**: Proper refrigeration and preservation techniques prevent microbial growth in food.
5. **Genetic Engineering**:
   - **Modification of Microbes**: Genetically engineered microbes can be designed to produce antimicrobial substances or degrade pollutants more efficiently.