Module 1 – The History and Scope of Microbiology

Lecture 1 – History of Microbiology

Importance of Microbiology:

The environment:

- Microbes are responsible for the cycling of carbon, nitrogen phosphorus (geochemical cycles)
- Maintain ecological balance on earth
- They are found in association with plants in symbiotic relationships, maintain soil fertility and may also be used to clean up the environment of toxic compounds (bio-remediation).
- Some are devastating plant pathogens, but others act as biological control agents against these diseases.

Medicine:

- Disease causing ability of some microbes such as
- Small Pox (Variola virus)
- Cholera (Vibrio cholera)
- Malaria (Plasmodium, protozoa) etc.
- They have also provided us with the means of their control in the form of antibiotics and other medically important drugs.

Food:

- Microorganisms have been used to produce food, from brewing and wine making, through cheese production and bread making, to manufacture of soy sauce.
- Microbes are also responsible for food spoilage.

Biotechnology:

- Commercial applications include the synthesis of acetone, organic acids, enzymes, alcohols and many drugs.
• Genetic engineering – bacteria can produce important therapeutic substances such as insulin, human growth hormone, and interferon.

Research:

• Because of their simple structure they are easier to study most life processes in simple unicellular organisms than in complex multicellular ones.
• Millions of copies of the same single cell can be produced in large numbers very quickly and at low cost to give plenty of homogenous experimental material.
• Because they reproduce very quickly, they are useful for studies involving the transfer of genetic information.

Brief history of microbiology

• Robert Hook (1665) – reported that life’s smallest structural units were ‘little boxes’ or ‘cells’. This marked the beginning of cell theory – that all living things are composed of cells.
• Van Leuwenhoek (1673) – discovered the ‘invisible’ world of microorganisms ‘animalcules’.
• Until second half of nineteenth century many believed that some forms of life could arise spontaneously from non-living matter – spontaneous generation.
• Francesco Redi (1668) – Strong opponent of spontaneous generation. He demonstrated that maggots appear on decaying meat only when flies are able to lay eggs on the meat.
• John Needham (1745) – claimed that microorganisms could arise spontaneously from heated nutrient broth.
• Lazzaro Spallanzani (1765) – repeated Needhams experiments and suggested that Needham’s results were due to microorganisms in the air entering the broth.
• Rudolf Virchow (1858) – concept of biogenesis – living cells can arise only from preexisting cells.
• Louis Pasteur (1822-1895) – Pasteur’s experiments on swan shaped necks resolved the controversy of spontaneous generation. His discoveries led to the development of aseptic techniques used in the laboratory and medical procedure to prevent contamination by microorganisms that are in the air.
Golden age of microbiology:

- Rapid advances in the science of microbiology were made between 1857 and 1914.

Fermentation and Pasteurization:

- Pasteur found that yeast ferments sugars to alcohols and that bacterium can oxidize the alcohol to acetic acid.
- Heating processes called pasteurization is used to kill bacteria in some alcoholic beverages and milk.

The Germ theory of disease:

- Agostino Bassi (1934) and Pasteur (1865) – showed a casual relationship between microorganisms and disease.
- Joseph Lister (1860s) – introduced the use of disinfectant to clean surgical dressings in order to control infection in humans
- Robert Koch (1876) – proved that microorganisms transmit disease – Koch’s postulates which are used today to prove that a particular microorganism causes a particular disease.
- Introduced pure cultures
- Koch’s postulates (Henle-Koch’s Postulates) are
  1. A specific organism should be found constantly in association with the disease.
  2. The organism should be isolated and grown in a pure culture in the laboratory.
  3. The pure culture when inoculated into a healthy susceptible animal should produce symptoms/lesions of the same disease
  4. From the inoculated animal, the microorganism should be isolated in pure culture.
  5. An additional criterion introduced is that specific antibodies to the causative organism should be demonstrable in patient’s serum.
• Angelina – American wife of Koch’s assistant suggested solidifying broths with agar as an aid to obtaining pure cultures.

• Koch also developed techniques for isolating organisms. Identified the bacillus that causes tuberculosis and anthrax, developed tuberculin and studied various diseases in Africa and Asia. His studies on Tuberculosis won him Nobel prize for philosophy and medicine in 1905.

**Vaccination:**

• Immunity is conferred by inoculation with a vaccine.

• Edward Jenner (1798) – demonstrated that inoculations with cowpox material provides humans with immunity from smallpox.

• Pasteur (1880) – discovered that avirulent bacteria could be used as a vaccine for chicken cholera; he coined the word vaccine.

• Modern vaccines are prepared from living avirulent microorganisms or killed pathogens, from isolated components of pathogens, and by recombinant DNA techniques.

**Emergence of special fields of Microbiology:**

**Immunology:**

• Immunization was first used against smallpox. Edward Jenner used fluid from cowpox blisters to immunize against it.

• Pasteur developed techniques to weaken organisms so they would produce immunity without producing disease.

• Elie Metchnikoff discovered that certain cells in the body would ingest microbes and named them as phagocytes.

**Industrial Microbiology and Microbial ecology:**

• Pasteur – fermentation technology and pasteurization. One of his most important discoveries was that some fermentative microorganisms were anaerobic and others were able to live either aerobically or anaerobically.
Microbial ecology – Two pioneers –

• **Sergei N. Winogradsky (1856-1953)** – Soil microbiology – discovered that soil bacteria could oxidize iron, sulfur and ammonia to obtain energy and many bacteria incorporate CO2 into organic matter. He also isolated anaerobic nitrogen fixing soil bacteria and studied the decomposition of cellulose.

• **Martinus Beijerinck (1851-1931)** – He isolated aerobic nitrogen fixing bacterium *Azotobacter*, a root nodule bacterium also capable of fixing nitrogen (later renamed as *Rhizobium*); and sulfate reducing bacteria. Both of them developed enrichment culture technique and use of selective media, which have been of great importance in microbiology.

Virology:

• **Beijerinck** characterized viruses as pathogenic molecules that could take over a host cells mechanisms for their own use

• **Wendell Stanley (1935)** – crystallized TMV and crystals consisted of protein and RNA.

• **Viruses** were first observed with an EM in 1939.

• **Alfred Hershey and Martha Chase (1952)** – demonstrated that the genetic material of some viruses is DNA

• James Watson and Francis Crick (1953) -determined the structure of DNA

Chemotherapy:

• There are two types of chemotherapeutic agents: synthetic drugs and antibiotics.

• **Elrlich (1910)** introduced an arsenic containing chemical called Salvarsan to treat Syphilis.

• **Alexander Fleming (1928)** – observed that the mold *Penicillium* inhibited the growth of bacteria and named the active ingredient as penicillin. Penicillin has been used clinically as an antibiotic since the 1940s. Domagk and others developed sulfa drugs.

• **Waksman and others** developed Streptomycin and other antibiotics derived from soil organisms.

• Researchers are tackling the problem of drug-resistant microbes.
Genetics and Molecular Biology:

- **1900** – Modern genetics began with the rediscovery of Gregor Mendel's principles of genetics.

- **Frederick Griffith (1928)** - discovered that previously harmless bacteria could change their nature and become capable of causing disease

- **Avery, McCarty and MacLeod (1940’s)** – showed that this genetic change was due to DNA. After this finding came the crucial discovery of the structure of DNA by Watson and Crick

- **Edward Tatum and George Beadle** – studied biochemical mutants of *Neurospora* to show how genetic information controls metabolism.

- **Barbara McClintock (1950)** – discovered that some genes could move from one location to another on a chromosome.

- Early 1960’s witnessed a further explosion of discoveries relating to the way DNA controls protein synthesis.

- **Francois Jacob and Jacques Monod (1961)** – discovered mRNA and later made the first major discoveries about regulation of gene function in bacteria.

- Microorganisms can now be genetically engineered to manufacture large amounts of human hormones and other urgently needed medical substances.

- Late 1960’s Paul Berg showed that fragments of human or animal DNA that code for important proteins can be attached to bacterial DNA. The resulting hybrid was the first example of recombinant DNA.

**Tomorrow’s history:**

Microbiology has been in the forefront of research in medicine and biology and continues to play a role in Genetic engineering and Gene therapy.

**Genetic engineering** – scientists are attempting to redesign microorganisms for a variety of purposes (drugs, hormones, vaccines and a variety of biologically important compounds)
rDNA technology – enabling us to produce improved varieties of plants and animals such as pest-resistant crops and may even enable us to correct genetic defects in human beings.

Human genome project:

- Microbial genetic techniques have made possible a colossal scientific undertaking HGP. Begun in 1990 and supposed to complete by 2005 was completed in May 2000.
- Humans have just over 30,000 genes instead of estimates that ranged up to 142,000 genes. 3 billion base pairs in the human genome do not all code for useful genes (75% of them code for ‘junk DNA’)
- Over 100 microbial genomes have been sequenced so far.
- Approx. 113 genes have come to human genome directly from bacteria.
- Venter has sequenced mouse genome and reports that humans have only 300 genes not found in the mouse.

Scope of microbiology

The microbiology has influence on genetics, agriculture, food science, ecology, immunology and various fields.

Genetics: Mainly involves engineered microbes to make hormones, vaccine, antibiotics and many other useful products for human being.

Agriculture: The influence of microbes on agriculture; the prevention of the diseases that mainly damage the useful crops.

Food science: It involves the prevention of spoilage of food and food borne diseases and the uses of microbes to produce cheese, yoghurt, pickles and beer.

Immunology: The study of immune system which protect the body from pathogens.

Medicine: deals with the identification of plans and measures to cure diseases of human and animals which are infectious to them.
**Industry:** it involves use of microbes to produce antibiotics, steroids, alcohol, vitamins and amino acids etc.

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Module 1 – The History and scope of microbiology

Lecture 2 – Members of the microbial world, scope, relevance and future of microbiology

Two fundamentally different types of cells exist, Prokaryotic cells having a simpler morphology and lack a true membrane de-limited nucleus. All bacteria are prokaryotic.

- Eukaryotic cells have a membrane-bound nucleus; are more complex morphologically and larger than prokaryotes. Algae, fungi, protozoa, higher plants, and animals are eukaryotes
- For many years biologists have divided organisms into five kingdoms; Monera, Protists, Fungi, Animalia and Plantae.
- In the last few decades great progress in three areas has been made that affect microbial classification.
  - First – detailed structure of microbial cells has been studied using EM
  - Second – microbiologists have determined the biochemical and physiological characteristics of many different microorganisms
  - Third – sequences of nucleic acids and proteins from a wide variety of organisms have been compared.
- It is now clear that there are two quite different groups of prokaryotic organisms; Bacteria and Archaea.
- The differences between bacteria, archaea and eukaryotes seem so great that many microbiologists proposed that organisms should be divided among three domains; Bacteria (the true bacteria or eubacteria), Archaea and Eucarya (all eukaryotic organisms).
Members of microbial world

There are five major members of microorganisms, Archaea, Bacteria, Algae, Protozoa, and Fungi. The Archaea and Bacteria are prokaryotic cells. Unicellular algae and protozoa and fungi are eukaryotic cells.

Archaea

The Archaea are a group of single-celled microorganisms. They have no cell nucleus or any other membrane-bound organelles within their cells. Archaea and bacteria are quite similar in size and shape, although a few archaea have very unusual shapes, such as the flat and square-shaped cells. Similarity to bacteria, archaea possess genes and several metabolic pathways that are more closely related to those of eukaryotes, notably the enzymes involved in transcription and translation. The archaea biochemistry is unique, such as presence of ether lipids in their cell membranes. Archaea use a much greater variety of sources of energy than eukaryotes: ranging from familiar organic compounds such as sugars, to ammonia, metal ions or even hydrogen gas. Archaea reproduce asexually by binary fission, fragmentation, or budding; unlike bacteria and eukaryotes, no known species form spores. Initially archaea were seen as extremophiles that lived in harsh environments, such as hot springs and salt lakes, but they are now found in a broad range of habitats, including soils, oceans, marshland. Archaea play roles in both the carbon cycle and the nitrogen cycle. No archaeapathogens or parasites are known, but they are often mutualists or commensals. Methanogens are used in biogas production and sewage treatment, and enzymes from extremophile archaea that can endure high temperatures and organic solvents are exploited in biotechnology.

Bacteria

Bacteria are a large domain of prokaryotic microorganisms. Bacteria are present in most habitats on Earth, growing in soil, acidic hot springs, radioactive waste water, organic matter and live bodies of plants and animals. Bacteria have many shapes and sizes. Bacterial cells are about one tenth the size of eukaryotic cells and 0.5–5.0 micrometres in length. Most bacterial species are either spherical, called cocci or rod-shaped, called bacilli. Some rod-shaped bacteria are slightly curved called vibrio or
comma-shaped. Many bacterial species exist as single cells and associate in characteristic patterns such as form pairs called diploids, form chains, and group together in clusters. Bacteria can also be elongated to form filaments.

The bacterial cell is surrounded by cell membrane, which encloses the contents of the cell and acts as a barrier to hold nutrients, proteins and other essential components of the cytoplasm within the cell. They lack a true nucleus, mitochondria, chloroplasts, Golgi apparatus and endoplasmic reticulum. Most bacteria do not have a membrane-bound nucleus, and their genetic material is typically a single circular chromosome located in the cytoplasm in an irregularly shaped body called the nucleoid. The nucleoid contains the chromosome with associated proteins and RNA. The bacteria contain ribosomes for the production of proteins but different from those of eukaryotes and Archaea. Some bacteria produce intracellular nutrient storage granules, such as glycogen, polyphosphate, sulfur or polyhydroxyalkanoates. These granules enable bacteria to store compounds for later use. Certain bacterial species, such as the photosynthetic Cyanobacteria produce internal gas vesicles which they use to regulate their buoyancy – allowing them to move up or down into water layers with different light intensities and nutrient levels. The cell wall is present on the outside of the cytoplasmic membrane. A common bacterial cell wall material is peptidoglycan which is a polymer contains two sugar derivatives N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM) joined by glycosidic bond. A peptide chain of four alternating D- and L-amino acids called tetrapeptide is connected to the carboxyl group of the NAM. The amino acids present in the tetrapeptide include L-alanine, D-alanine, D-glutamic acid, and either lysine or diaminopimilic acid (DAP). The carboxyl group of terminal D-alanine is connected directly to amino group of DAD. The peptide interbridge connects the tetrapeptide chains.
There are two different types of cell wall in bacteria, called Gram-positive and Gram-negative. Gram-positive bacteria possess a thick cell wall containing many layers of peptidoglycan and teichoic acids. In contrast, Gram-negative bacteria have a relatively thin cell wall consisting of a few layers of peptidoglycan surrounded by a second lipid membrane containing lipopolysaccharides and lipoproteins. They have many surface structures such as flagella, pili and fimbriae. Flagella are rigid protein structures about 20 nanometers in diameter and up to 20 micrometres in length that are used for motility. Flagella are driven by the energy released by the transfer of ions down an electrochemical gradient across the cell membrane. Fimbriae are fine filaments of protein, just 2–10 nanometers in diameter and up to several micrometers in length. They are distributed over the surface of the cell, and resemble fine hairs. Fimbriae are involved in attachment to solid surfaces or to other cells and are essential for the virulence of some bacterial pathogens. Pili are cellular appendages, slightly larger than fimbriae that can transfer genetic material between bacterial cells in a process called conjugation. Capsules or slime layers are produced by bacteria to surround their cells, and vary in structural complexity such as disorganized slime layer and highly structured capsule or glycocalyx. These structures protect cells from engulfment by eukaryotic cells, such as macrophages. They can also act as antigens and be involved in cell recognition. Gram-positive bacteria, such as Bacillus, Clostridium, Sporohalobacter, Anaerobacter and Helio bacterium, can form highly resistant, dormant structures called endospores. Endospores have cytoplasm containing DNA and ribosomes surrounded by a cortex layer and protected by an
impermeable and rigid coat. Endospores can survive extreme physical and chemical stresses, such as high levels of UV light, gamma radiation, detergents, disinfectants, heat, freezing, pressure and desiccation thereby help in surviving in harsh conditions. The bacteria mainly reproduced by binary fission which involves chromosome replication followed by cell division.

But bacteria recombine their genetic materials by three ways:-

1) **Conjugation** occurs when a bacterium passes DNA to a second bacterium through a tube (sexpilus) that temporarily joins two cells; this occurs only between bacteria in the same or closely related species.

2) **Transformation** involves bacteria taking up free pieces of DNA secreted by live bacteria or released by dead bacteria.

3) **Transduction**: Bacteriophages transfer portions of bacterial DNA from one cell to another.

    The bacteria are classified based on their source of energy, carbon and hydrogen/electron source are of following type:

Based on carbon source: Autotrophs whose main carbon source is carbon dioxide and heterotrophs whose carbon source is reduced organic molecules.

Based on energy source: Phototrophs are the microorganisms which uses the light as their energy source and chemotrophs who get their energy by oxidation of organic and inorganic compounds.

Based on hydrogen and electron source: Lithotrophs the microorganisms in which the electron source is reduced inorganic molecule and organotrophs whose electron source is organic molecules.
The bacterial growth mainly involves increase in cell mass and cell division. Under favorable condition bacteria grow in geometric progression i.e. doubles at regular intervals. This growth is called exponential growth. The bacterial growth can be divided into four phases as:

Lag phase: The population remains temporarily unchanged and no apparent cell division though cell may be growing in volume and mass.

Log phase: Where the cells are dividing regularly by binary fission and growing by geometric progression. The cells divide at constant rate based on growth medium.

Stationary phase: The population growth is limited due to nutrients exhaustion, accumulation of inhibitory metabolites or end products and limitation of biological spaces.

Death phase: Due to limitation of nutrients bacteria die and no more cell divisions.

The generation time of bacteria and growth rate can be calculated from the growth curve by the equation: 

\[ G = \frac{t}{n} \]

where \( t \) = time interval in hours or minutes

\( B = \) number of bacteria at the beginning of a time interval.

\( b = \) number of bacteria at the end of the time interval.

\( n = \) number of generations.
\[ b = B \times 2^n \] (This equation is an expression of growth by binary fission).

Solving for \( n \): \[ \log b = \log B + n\log 2. \]

\[ n = \frac{\log b - \log B}{\log 2} \]

**Algae**

They are photosynthetic eukaryotes. They have different types of photosynthetic pigments i.e. chlorophyll such as blue, red, brown and green. They are mostly found in moist environment. They are microscopic and float in surface waters (phytoplankton) and live attached to rocky coasts (seaweeds). Size ranges from 0.5 um to over 50 m long. Lack vascular tissues- no true roots, stems, or leaves. They mainly reproduced by both sexual and asexual modes of reproduction and have no multicellular reproductive organs. They are many different types of algae such as:

**Red algae:** Their size and complexity vary from thin films growing on rocks to complex filaments. Their accessory pigments called phycobilins mask the chlorophyll a and give them their red color. Due to these specialized pigments, red algae are often able to photosynthesize in deeper water than other algae. Red algae do not have flagella. They have many benefits such used as food and laboratory product i.e. agar used to grow bacteria and fungi is derived from red algae.

**Green algae:** They are found mostly in fresh waters and on land. Most species float in rivers, lakes, reservoirs, and creeks. They can also live on rocks, soil, and tree bark. Green algae are organisms with a variety of body forms including single cells, filaments, colonies, and thalli. They possess the same photosynthetic pigments (chlorophyll a and b) and some green algae have stiff cell walls composed of cellulose, as do plants.

**Dinoflagellates**

Found in warm, Tropical Ocean. They are mainly unicellular. Green and colorless forms, phagotrophic and parasitic. They are biflagellate. Their nucleus is unusual. Some are bioluminescent forms- light up when water is disturbed and they always reproduced by asexually.
Brown algae:

They are known as cold water algae and found in rocky coast in temperate zone or open sea. Most brown algae contain the pigment fucoxanthin, which is responsible for the distinctive greenish-brown color. They are multicellular and reproduced by flagellated spores.

Diatoms:

They are most common types of phytoplankton and also known as golden-brown algae. They are mostly unicellular and can exist as colonies in the shape of filaments or ribbons. Their cell wall made of silica called a frustule. They are commonly used in studies of water quality. Some diatoms are capable of movement via flagellation. They reproduced by asexual for several generations, then sexual.

Fungi

They are eukaryotic organisms that include yeasts, molds and mushrooms. They are non-photosynthetic and contain no chlorophyll pigments. Most of them are multicellular and some are unicellular e.g. yeast. They are non-motile and lack true leaves, roots and stems. Fungi need warm, moist places to grow. They are found mainly in moist foods, damp tree barks, and wet bathroom tiles etc. **Fungi are heterotrophs that feed by absorption.** They absorb small organic molecules from the surrounding medium. The enzymes and hydrolytic enzymes secreted by the fungus break down food outside its body into simpler compounds that the fungus can absorb and use. The absorptive mode of nutrition is associated with the ecological roles of fungi as decomposers, parasites, and mutualistic symbionts. Saprobic fungi absorb nutrients from nonliving organisms. Parasitic fungi absorb nutrients from the cells of living hosts. The fungal cells contain membrane-bound nuclei with chromosomes that contain DNA with noncoding regions called introns and coding regions called exons. They also possess membrane-bound cytoplasmic organelles such as mitochondria, sterol-containing membranes, and ribosomes of the 80S type. They have soluble carbohydrates and storage compounds, including sugar alcohols, disaccharides, and polysaccharides. Fungi lack chloroplasts and are heterotrophic organisms, requiring preformed organic compounds as energy sources. Fungi possess a
cell wall and vacuoles. They reproduce by both sexual and asexual means and produce spores. They have haploid nuclei. The cells of most fungi grow as tubular, elongated, and thread-like structures are called hyphae which may contain multiple nuclei. Some species grow as single-celled yeasts that reproduce by budding or binary fission. The fungal cell wall is composed of glucans and chitin. Most fungi grow as hyphae which are cylindrical, thread-like structures 2–10 µm in diameter and up to several centimeters in length. Hyphae grow at their tips; new hyphae are typically formed by a process called branching, or growing hyphal tips bifurcate giving rise to two parallel-growing hyphae. Hyphae can be either septate or coenocytic: septate hyphae are divided into compartments separated by cross walls, with each compartment containing one or more nuclei; coenocytic hyphae are not compartmentalized. Fungal reproduction is complex. They reproduced by both sexually and asexually. Asexual reproduction via vegetative spores (conidia) or through mycelial fragmentation. Sexual reproduction involves joining of hyphae is called conjugation, two mating strains with different nuclei form continuous membrane is known as plasmogamy and sometimes then nuclei are fused is called karyogamy.

Protozoa

Protozoa are parasitic and animal-like protists because of their motility. Their sizes range from 10 to 52 micrometers. They moved by flagella, hair-like structures called cilia and foot-like structures called pseudopodia. Protozoa absorb food by their cell membranes e.g., amoebas, surround food and engulf it. All protozoa digest their food in stomach-like compartments called vacuoles. Protozoa can reproduce by binary fission or multiple fission. Some protozoa reproduce sexually, some asexually, while some use a combination. They cause many diseases in human such as malaria, amoebiasis and leishmaniasis etc.
The scope and relevance of microbiology

Microbes influence human society in countless ways. Sometimes, the influence of microorganisms on human life is beneficial, whereas at other times, it is detrimental. For example, microorganisms are required for the production of bread, cheese, yogurt, alcohol, wine, beer, antibiotics (e.g., penicillin, streptomycin, and chloramphenicol), vaccines, vitamins and enzymes. Many products of microbes contribute to public health as aids to nutrition, other products are used to interrupt the spread of disease, and still others hold promise for improving the quality of life in the years ahead. Microbes are also an important and essential component of an ecosystem. Molds and bacteria play key roles in the cycling of important nutrients in plant nutrition particularly those of carbon, nitrogen and sulphur. Bacteria referred to as nitrogen fixers live in the soil where they convert vast quantities of nitrogen in air into a form that plants can use. Microorganisms also play major roles in energy production. Natural gas (methane) is a product of bacterial activity, arising from the metabolism of methanogenic bacteria. Microorganisms are also being used to clean up pollution caused by human activities, a process called bioremediation (the introduction of microbes to restore stability to disturbed or polluted environments). Bacteria and fungi have been used to consume spilled oil, solvents, pesticides and other environmentally toxic substances.

Agricultural microbiology – try to combat plant diseases that attack important food crops, work on methods to increase soil fertility and crop yields etc. Currently there is a great interest in using bacterial or viral insect pathogens as substitute for chemical pesticides.

Microbial ecology – biogeochemical cycles – bioremediation to reduce pollution effects

Food and dairy microbiology – try to prevent microbial spoilage of food and transmission of food borne diseases such as botulism and salmonellolis. Use microorganisms to make foods such as cheese, yogurt, pickles and beers.

Industrial microbiology – used to make products such as antibiotics, vaccines, steroids, alcohols and other solvents, vitamins, amino acids and enzymes.
**Microbial physiology and Biochemistry** – study the synthesis of antibiotics and toxins, microbial energy production, microbial nitrogen fixation, effects of chemical and physical agents on microbial growth and survival etc.

**Microbial genetics and Molecular biology** – nature of genetic information and how it regulated the development and function of cells and organisms. Development of new microbial strains that are more efficient in synthesizing useful products.

**Genetic engineering** – arisen from work of microbial genetics and molecular biology. Engineered microorganisms are used to make hormones, antibiotics, vaccines and other products. New genes can be inserted into plants and animals.

**Areas impacted by microbes include:**

**Medicine:** Microbes produce valuable chemicals such as antibiotics. Many antibiotics are produced by common soil bacteria called Streptomyces and actinomycetes. The ability of Streptomyces cultures to inhibit the growth of other bacteria leads to discovery of many antibiotics. Streptomycin is an antibiotic and was the first used for tuberculosis. It is produced by actinobacterium *Streptomyces griseus*. Many antibiotics are produced by microbes such as Rifampicin produced by *Amycolatopsis rifamycinica*, Chloramphenicol by bacterium *Streptomyces venezuelae* and Actinomycin D produced by genus *Streptomyces* etc.

**Industry:** The microorganisms are used for the production of food, either human or animal. Yogurt, cheese, chocolate, and silage (animal food) are all produced by industrial microbiology processes. Lactic acid bacteria and *Bifidobacteria* are amongst the most important groups of microorganisms used in the food industry. The microorganisms used in industrial processes may be natural isolates; laboratory selected mutants or genetically engineered organisms.

**Ecology:** Microbial life plays a primary role in regulating biogeochemical systems in all environment such as frozen environments and acidic lakes, to hydrothermal vents at the bottom of deepest oceans, and human small intestine. Microbes, often engage in
symbiotic relationships (either positive or negative) with other organisms, and these relationships affect the ecosystem. They are the backbone of all ecosystems. Other microbes are decomposers, with the ability to recycle nutrients from other organisms' waste products. These microbes play a vital role in biogeochemical cycles. Thenitrogen cycle, the phosphorus cycle and the carbon cycle all depend on microorganisms in one way or another.

Presently, microbiologists facing many challenges to solvemany of society’s problems including combating disease, reducing environmental pollution, and maintaining improving the world’s food supply.

**Future of microbiology:**

- Future challenges such as finding new ways to combat disease, reduce pollution and feed the world’s population.
- AIDS, hemorrhagic fevers and other infectious diseases
- Create new drugs, vaccines. Use the techniques in molecular biology and rDNA to solve the problems
- Host-pathogen relationships
- Study the role of microorganisms as
- Sources of high-quality food and other practical products such as enzymes for industrial application
- Degrade pollutants and toxic wastes
- Used as vectors to treat diseases and enhance agricultural productivity

Microbial diversity – less than 1% of the earth’s microbial population has been cultured. Develop isolation techniques and work needs to be done on microorganisms living in extreme environments. Discovery of new organisms may lead to further advances in industrial processes and enhanced environmental control

- Microbe – microbe interactions.
- Analysis of genome – advances in the field of bioinformatics
• Symbiotic relationships – knowledge can help improve our appreciation of the living world, and improvements in the health of plant, livestock’s and humans.

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