**The History and Scope of Microbiology**

* **Microbiology is the study of microorganisms usually less than 1mm in diameter which requires some form of magnification ( Microscope) to be seen clearly** 
  1. **Examples:**
     1. **Viruses**
     2. **Bacteria**
     3. **Fungi**
     4. **Algae**
     5. **Protozoa's**
* **Some organisms studies by microbiologists CAN be visualized without the aid of amplification [bread molds (fungus) and filamentous algae]**
  1. **These organisms are included in the discipline of microbiology because of similarities in properties and techniques used to study them**
* **Techniques necessary to isolate and culture microorganisms:**
  1. **Isolation**
  2. **Sterilization**
  3. **Culture in artificial media**
* **Microbiology may be divided in different branches for specific types of organisms:**
  1. **Virology - viruses**
  2. **Bacteriology - bacteria**
  3. **Phycology - algae**
  4. **Mycology - fungi**
     1. **Protozoology – protozoa**

**Microbiologists may be interested in various characteristics or activities of microorganisms:**

* **Microbial morphology**
* **Microbial cytology**
* **Microbial physiology**
* **Microbial ecology**
* **Microbial genetics and molecular biology**
* **Microbial taxonomy**

**HISTORY OF MICROBIOLOGY**

* One of the most important discoveries of biology occurred in 1665, with the help of a crude microscope, when **Robert Hooke** stated that life’s smallest structural units were cells.
* **ANTONY VAN LEEUWENHOEK** First to observe living microbes.His single-lens magnified 50-300X magnification. Between 1674-1723 he wrote series of papers describing his observations of bacteria, algae, protozoa, and fungi **(Animalcules)**
* **SPONTANEOUS GENERATION-**Early belief that some forms of life could arise from “vital forces” present in nonliving or decomposing matter, abiogenesis. In other words, organisms can arise form non-living matter.
* In 1670 **LOUIS JABLOT** conducted an experiment in which he divided a hay infusion that had been boiled into two containers: a heated container that was closed to the air and a heated container that was freely open to the air. Only the open vessel developed microorganisms. This further helped to disprove abiogenesis.
* **LOUIS PASTEUR (1822 - 1895)** Disproved spontaneous generation of microbes by preventing “dust particles” from reaching the sterile broth. In 1861 completes experiments that lays to rest spontaneous generation. Showed microbes caused fermentation and spoilage. He trapped airborne organisms in cotton; he also heated the necks of flasks, drawing them out into long curves, sterilized the media, and left the flasks open to the air. In this way Pasteur disproved the theory of spontaneous generation.
* **Brefeld,. O (1872-1912)** - Introduced and developed the methed of growing microbes in pure culture.

**Micoorganisms cause disease**

* Oliver Holmes (1773 - 1843)-showed that sepsis could be transmitted by hands of medical student and may cause disease
* M. J. Berkeley (ca. 1845) -demonstrated that the Great Potato Blight of Ireland was caused by a Fungus
* Louis Pasteur (1822 - 1895)- showed that the pébrine disease of silkworms was caused by a protozoan parasite
* **Edward Jenner (ca. 1798): Develop the first Vaccine and used a vaccination procedure to protect individuals from smallpox.**
* **Vaccination:** Inoculation of healthy individuals with weakened (or attenuated) forms of microorganisms, that would otherwise cause disease, to provide protection, or active immunity from disease upon later exposure.

**GOLDEN AGE OF MICROBIOLOGY**

* The period from 1860 to 1900 is often named the Golden Age of Microbiology. During this period, rapid advances, spear-headed by Louis Pasteur and Robert Koch, led to the establishment of microbiology as a science.
* **Louis Pasteur(1822-1895) : “Father of bacteriology and immunology”**
* Discovered Pasteurization technique
* Developed the germ theory in **1798**
* Also developed vaccines
* In 1864 Pasteur established the relationship between microbes and disease in preventing wine from spoiling by using the process termed pasteurization. This process kills bacteria in the alcohol by heat, thus preventing the formation of acetic acid (vinegar).
* His discovery of pasteurization, lead Pasteur to introduce the “germ theory of disease” in 1864. Pasteur stated that diseases are caused by the growth of microbes in the body and not by sins, bad character, or poverty, etc.
* **Developed vaccines including those for chicken cholera, anthrax, and rabies.**
* Pasteur and Roux reported that incubating cultures longer than normal in the lab resulted in ATTENUATED bacteria that could no longer cause disease.
* Working with chicken cholera (caused by *Pasteurella multocida*), they noticed that animals injected with attenuated cultures were resistant to the disease.
* Pasteur and Chamberland developed other vaccines:

Attenuated anthrax vaccine - Chemical and heat treatment (potassium bichromate),

* Attenuated rabies vaccine- Propagated the virus in rabbitfollowing injection of infected brain and spinal cord extracts
* .**Robert Koch (1843 - 1910)-**

1. Developed pure culture methods.
2. Identified cause of anthrax ( *Bacillus anthrax*) , TB ( *Mycobacterium tubercullosis*) , & cholera ( *Vibrio cholera*).

In 1860 developed an elaborate technique to isolate & identify specific Pathogens that cause specific diseases.

He isolated the anthrax bacterium. Using criteria developed by his teacher, Jacob Henle (1809-1895), established the relationship between *Bacillus anthracis* and anthrax. His criteria became known as Koch’s Postulates and are still used to establish the link between a particular microorganism and a particular disease.

**Koch’s Postulates-**

* **The causative (etiological) agent must be present in all affected organisms but absent in healthy individuals**
* **The agent must be capable of being isolated and cultured in pure form**
* **When the cultured agent is introduced to a healthy organism, the same disease must occur**
* **The same causative agent must be isolated again from the affected host**
* **Smith, E P (1888-1920)** - Added the fourth rule to Koch’s postulates, did classical work on many bacterial disease such as the wilts of cucurbits and solanaceus plants and rot of crucifers.

**Passive immunization**

* **Work by Emil von Behring (1845-1917) and Shibasaburo Kitasato (1852-1931)**

**Antibodies raised to inactivated diphtheria toxin by injection different host (rabbit) with the toxin (a toxoid form)**

**Antiserum recovered**

1. **Contains antibodies specific for the toxin**
2. **Protection from disease when injected non -immune subject.**

* JOHN TYNDALL (1820 – 1893) In **1876** discovered that there were two different types of bacteria.

a) Heat sensitive or heat labile forms (vegetative cells) easily destroyed by boiling.

b) Heat resistant types known as an endospore

Tyndall demonstrated that alternate process of heating & cooling if repeated five times, can kill all the endospores. This is known as Sterilization process or Tyndallization

* **Ferdinand Cohn**- In 1876, a German botanist, Ferdinand Cohn, also discovered “heat-resistant forms of bacteria”. This bacteria are now termed endospores.( *Bacillus* species and *Clostridium* species)
* **Joseph Lister (1827 - 1912)**

1. developed a system of surgery designed to prevent microorganisms from entering wounds – phenol (Carbolic Acid) sprayed in air around surgical incision
2. Decreased number of post-operative infections in patients
3. his published findings (1867) transformed the practice of surgery

* **Paul Ehrlich** - In the 1890’s proposed a theory of immunity in which antibodies were responsible for immunity( Antitoxin). In addition, he is known as the father of modern chemotherapy. He speculated about some “magic bullet” that would selectively find and destroy pathogens but not harm the host (Selective Toxicity). He also develop a staining procedure to identify tubercle bacilli.
* **Burril, T J (1878) -** Observed that fire blight of pear is caused by a bacterium .
* **E. J. Butler :-** (Edwin John Butler 1874-1943)
* He was the father of Modern Plant pathology and father of Indian Mycology.
* He worked at IARI for 20 year from 1901-1920.
* He was the founder of first director of imperial Mycological institute, Kew, England (1920-1935).
* Monograph: pythiaceous and allied fungi.
* Books: a) Fungi and disease in Plant (1918)

b) Fungi in India

c) Plant Pathology

* **Alexender Flaming :-** (1880-1929)

He discovered the first antibiotic penicillin. This was effective against bacteria borne disease of humans & animals. In 1928 Fleming observed that the growth of the bacterium *staphyloccus aureus* was inhibited in the areas surrounding the colony of a mold that had contaminated a Petri plate. The mold was identified as *Penicillium notatum,* and its active compound was named penicillin.

* **Walter Hesse ( 1846-1911):** Used Agar as a solidifying agent to harden media. Agar is extracted from seaweeds red algae.
* **Rechard Petri ( 1852-1921):** Used agar dish to provide a large area to grow.
* **Christian Gram ( 1853-1935):** Staining method that demonstrate bacteria and distinguish between Gram positive and Gram negative bacteria.
* **George W. Beadle and Edward L. Tatum (ca. 1941)**

1. studied the relationship between genes and enzymes using the bread mold, *Neurospora*
2. Precursor🡪 ornithine 🡪 citrulline 🡪 arginine
3. One gene, one polypeptide hypothesis

* **Salvadore Luria and Max Delbruck (ca. 1943)**

Demonstrated spontaneous gene mutations in bacteria (not directed by the environment)

* **Oswald T. Avery, Colin M. MacLeod, and Maclyn McCarty (1944)**

Following initial studies by Frederick Griffith (1928) they provided evidence that deoxyribonucleic acid (DNA) was the genetic material and carried genetic information during **transformation. Worked with *Streptococcus pneumoniae* (rough and smooth)**

* In the 1970s new discoveries in microbiology led to the development of recombinant DNA technology and genetic engineering

**Scope of Industrially microbiology**

1. **Medical microbiology, including immunology**
2. **Food and Dairy microbiology**
3. **Public Health microbiology (Epidemiology)**
4. **Industrial microbiology**
5. **Environmental microbiology**
6. **Agricultural microbiology**
7. **Genetic Engineering**
8. **Investigation**

**Industrial microbiology**

* 1. Uses microorganisms, typically grown on a large scale, to produce products or carry out chemical transformation
  2. Originated with alcoholic fermentation processes. Later on processes such as production of pharmaceuticals, food additives, enzymes, and chemicals were developed
  3. Major organisms used are fungi and *Streptomyces,* Classic methods are used to select for high-yielding microbial variants.
  4. The manipulation of organisms in order to yield a specific product has many applications to the real world like the production of some antibiotics, vitamins, enzymes, amino acids, solvents, alcohol and daily products. Microorganisms play a big role in the industry, with multiple ways to be used.
  5. Medicinally, microbes can be used for creating antibiotics in order to treat diseases. Microbes can also be used for the food industry as well. Microbes are very useful in creating some of the mass produced products that are consumed by people.
  6. The chemical industry also uses microorganisms in order to synthesis amino acids and organic solvents. Microbes can also be used in an agricultural application for use as a biopesticide and biofertilizer instead of using dangerous chemicals and or inoculants to help plant proliferation.
  7. Major Idustrial products from microbes

|  |  |  |
| --- | --- | --- |
| **Group** | **Product** | **Organism** |
| Industrial chemicals | Ethanol  Lactic acid | *Saccharomyces cerevisiae*  *Lactobacillus bulgaricus* |
| Enzymes | a-amylase  Proteases  Lipases | *Bacillus subtilis*  *Bacillus species*  *Saccharomyces lipolytica* |
| Antibiotics | Penicillin  Streptomycin  Chlorampenicol | *Penicillium chrysogenum*  *Streptomyces griseus*  *Streptomyces venezuelae* |
| Vitamins | Riboflavin  Vitamin B12 | *Ashbya gossypi*  *Pseudomonas dentrificians* |

* **Food industry application**

**Fermentation :** Fermentation is a reaction where sugar can be converted into a gas, alcohols or acids. Fermentation happens anaerobically, which means microorganisms that go through fermentation can function without the presence of oxygen.

* Yeasts and bacteria are commonly used to mass produce multiple products. Drinking alcohol is a product that is produced by yeasts and bacteria. Alcohol that can be consumed is also known as ethanol, and ethanol is used to power automobiles as a fuel source. Algae, yeasts and bacteria are commonly used to mass produce Single cell protein products.
* Drinking alcohol is produced from natural sugars like glucose. Carbon dioxide is produced as a side product in this reaction and can be used to make bread, and can also be used to carbonate beverages.
* Fermentation Wine : Alcoholic beverages like beer and wine are fermented by microorganisms when there is no oxygen present.
* **The Medical application**: industrial microbiology is the production of new drugs synthesized in a specific organism for medical purposes. Production of antibiotics is necessary for the treatment of many bacterial infections. Some natural occurring antibiotics and precursors, are produced through a process called fermentation.
* The microorganisms grow in a liquid media where the population size is controlled in order to yield the greatest amount of product. In this environment nutrient, pH, temperature, and oxygen are controlled also in order to maximize the amount of cells and cause them not to die before the production of the antibiotic of interest. Once the antibiotic is produced it must be extracted in order to yield an income.
* Vitamins also get produced in massive quantities either by fermentation or biotransformation. . The fermentation process is another common way to produce riboflavin. The most common organism used for production of riboflavin through fermentation is *Eremothecium ashbyii*. Probiotics produced by *Lectobacilus.*
* Microbial biotransformation can be used to produce steroid medicaments. Steroids can be consumed either orally or by injection. Steroids play a big role in the control of arthritis. Cortisone is an anti-inflammatory drug that fights against arthritis, as well as several skin diseases.
* **Agriculture application**
* Biopesticide is a pesticide derived from a living organism or natural occurring substances. Biochemical pesticides can also be produced from naturally ocurring substances that can control pest populations in a non-toxic matter.
* The demand for agricultural products is constantly increasing due to the need of various fertilizers and pesticides. There are long term effects of the overuse of chemical fertilizers and pesticides. Due to the excessive use of chemical fertilizers and pesticides, the soil becomes infertile and a non-sufficient use for growing crops. For that matter, biofertelizers, biopesticides and organic farming come to the rescue.
* An example of a biochemical pesticide is garlic and pepper based insecticides, these work by repelling insects from the desired location. Microbial pesticides, usually a virus, bacterium, or fungus are used to control pest populations in a more specific manner. The most commonly used microbe for the production of microbial bio-pesticides is *Bacillus thuringiensis* also known as Bt.
* Some microbes used in Biopesticides Fungus- *Trichodrma viride, Trichodrma harzianum, Aspergillus niger, Fusarium chlamydosporum, Paeciliomyces* *lilacinus, Beauvaria bassiana,* Bacteria*- Bacillus subtilis, Bacillus thuringiensis, Bacillus putida, Pseudomonas fluorescence,*Virus-Nuclear polyhedrosis virus. Some microbes used in Biofertilzer production viz. *Rhizobium, Azotobacter,Azospirillum, Bacillus megateria, Mycorhiza* etc. The gibberellins, plant growth stimulators, are produced commercially by Gibberella fujikuroi, the conidial state of the fungus Fusarium moniliforme, and are used as plant regulators. They increase the yield of vegetables and accelerate the development of biennials.

**Chemical application**

* Synthesis of amino acids and organic solvents can also be made using microbes. The synthesis of essential amino acids such as are L-Methionine, L-Lysine, L-Tryptophan and the non-essential amino acid L-Glutamic acid are used today mainly for feed, food, and pharmaceutical industries.
* The production of these amino acids is due to *Corynebacterium glutamicum* and fermentation.
* *C.glutamicum* was engineered to be able to produce L-lysine and L-Glutamic acid is large quantities. L-Glutamic acid had a high demand for production because this amino acid is used to produce Monosodium glutamate (MSG) a food flavoring agent

**Properties of a useful industrial microbe include**

1. Produces spores or can be easily inoculated
2. Grows rapidly on a large scale in inexpensive medium
3. Produces desired product quickly
4. Should not be pathogenic
5. Amenable to genetic manipulation

**Microbial products of industrial interest include**

1. Microbial cells-Single cell protein
2. Enzymes
3. Antibiotics, steroids, alkaloids
4. Food additives
5. *Commodity chemicals*

* Inexpensive chemicals produced in bulk-Biofertilizers, Biofules, Biopesticides, Bioherbicides etc
* Include ethanol, citric acid, and many others