The History and Scope of Microbiology

Dr.Anupam Porwal
Department of Biotechnology

- **Microbiology is the study of microorganisms usually less than 1mm in diameter which requires some form of magnification (Microscope) to be seen clearly**
  - **Examples:**
    - **Viruses**
    - **Bacteria**
    - **Fungi**
    - **Algae**
    - **Protozoa's**

- **Some organisms studies by microbiologists CAN be visualized without the aid of amplification [bread molds (fungus) and filamentous algae]**
  - **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:**
  - **Isolation**
  - **Sterilization**
  - **Culture in artificial media**

- **Microbiology may be interested in specific types of organisms:**
  - **Virology - viruses**
  - **Bacteriology - bacteria**
  - **Phycology - algae**
  - **Mycology - fungi**
  - **Protozoology - protozoa**

- **Microbiologists may have a more applied focus:**
  - **Medical microbiology, including immunology**
  - **Food and Dairy microbiology**
  - **Public Health microbiology (Epidemiology)**
  - **Industrial microbiology**
  - **Agricultural microbiology**

- **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**

II. Historical Perspectives

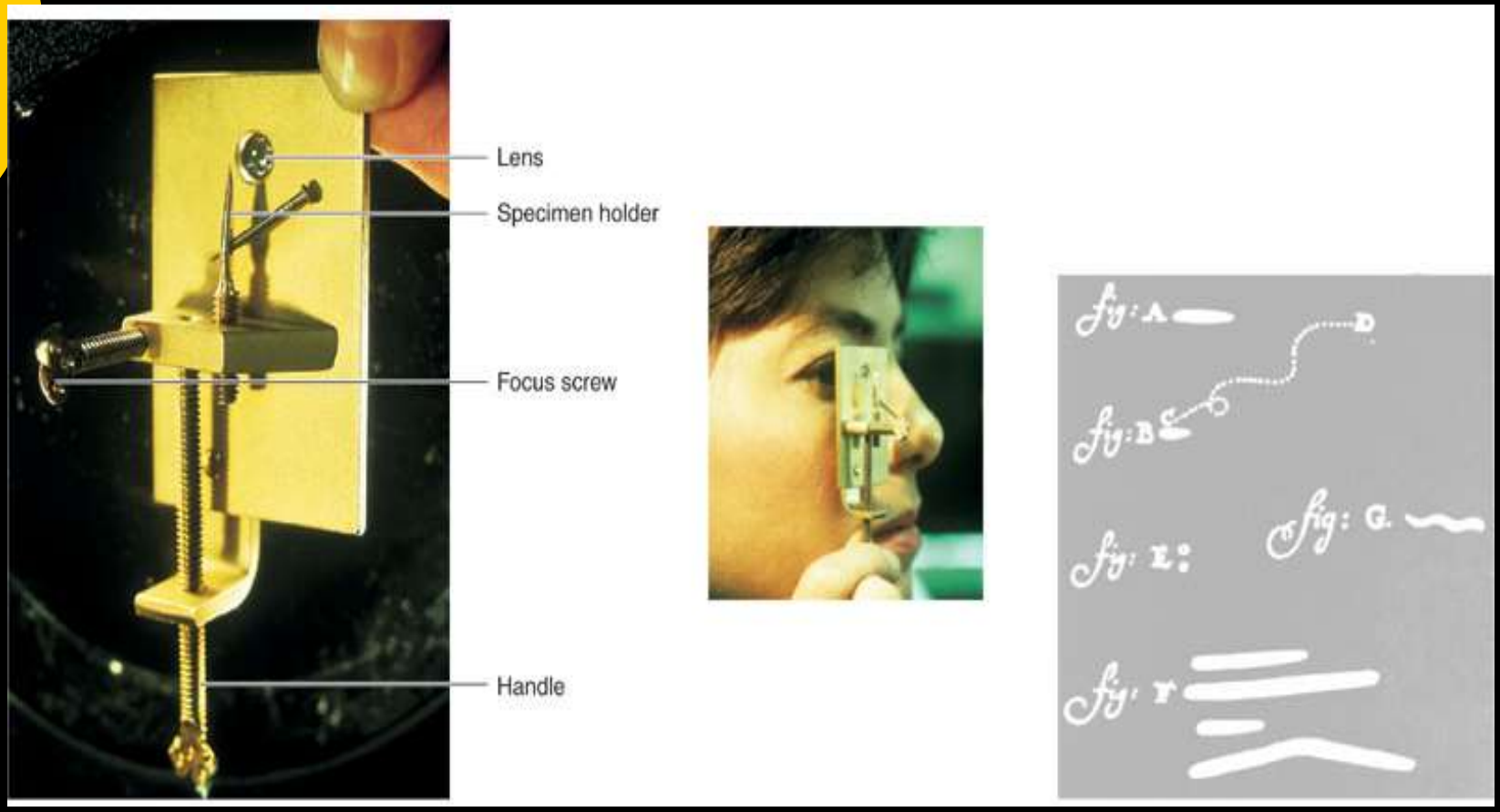
ROBERT HOOKE

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)**

ANTONY VAN LEEUWENHOEK



III. Spontaneous Generation

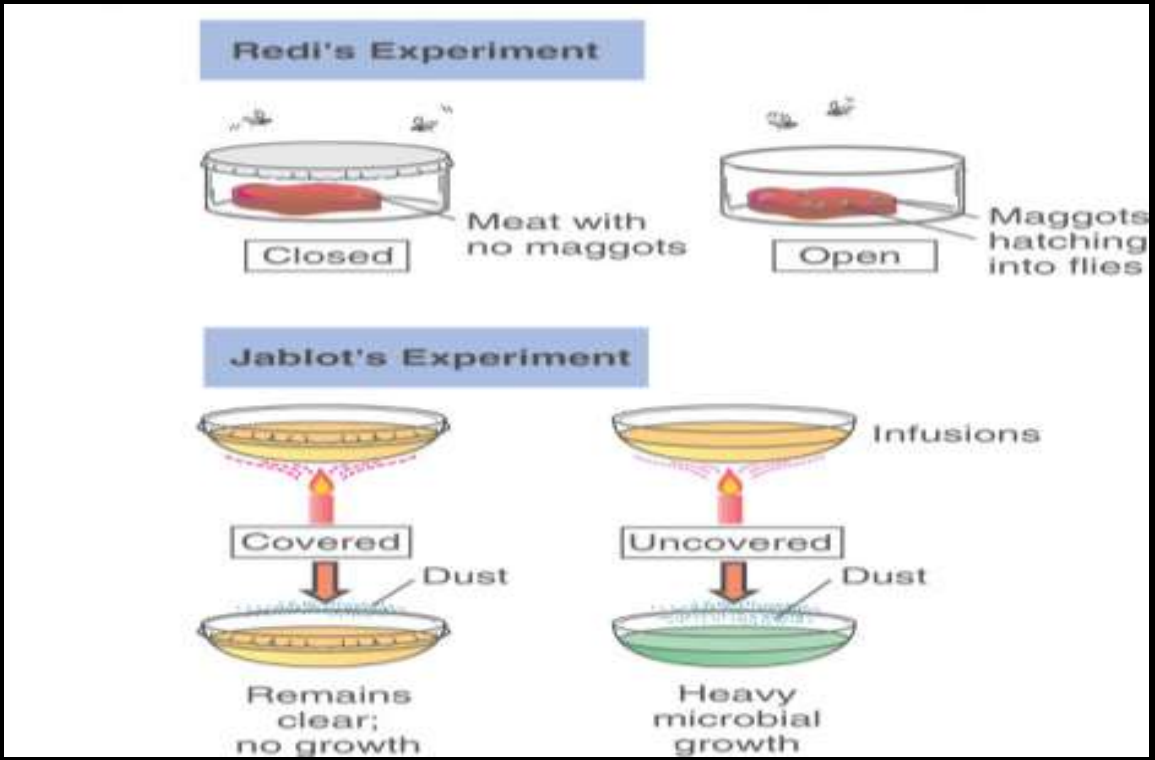
SPONTANEOUS GENERATION

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.

LOUIS JABLOT

In 1670 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.

REDI'S and JABLOT'S EXPERIMENTS

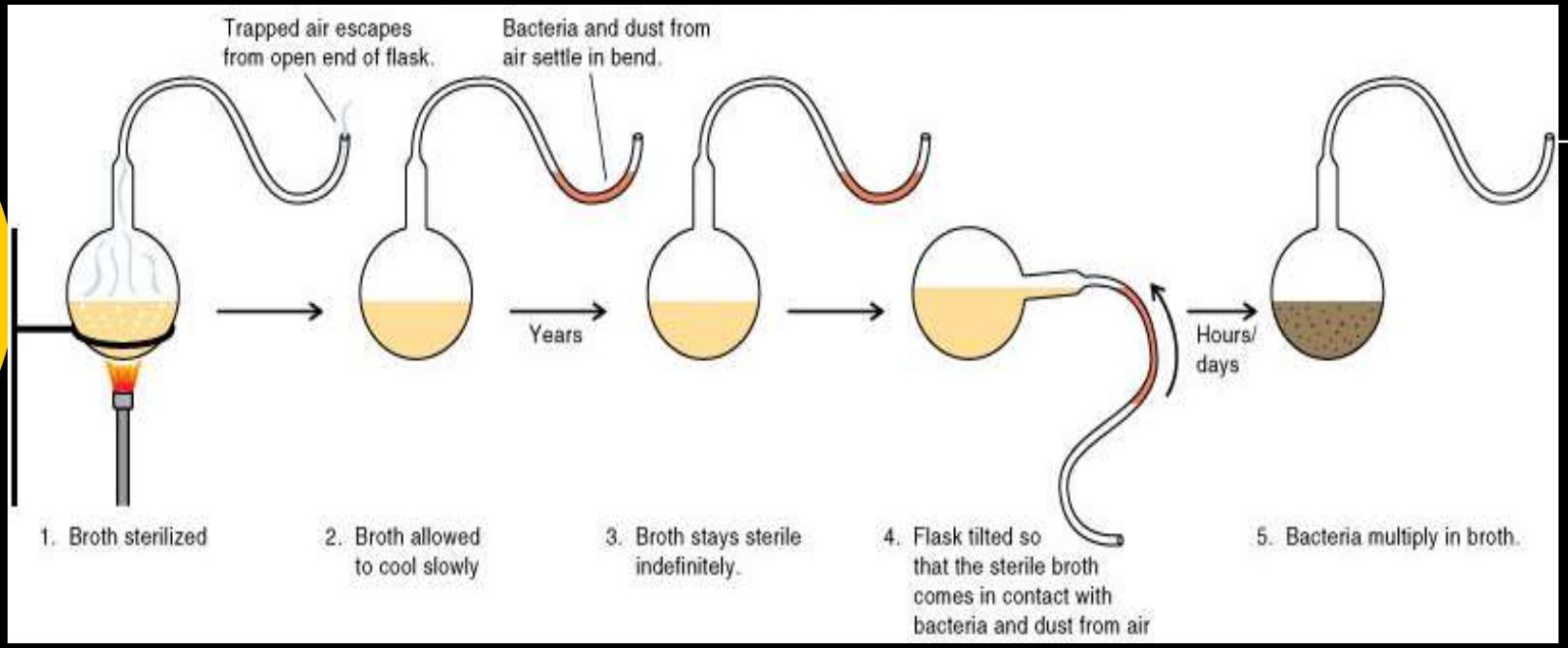


- **Disproved by:**
  - **Schwann, Friedrich Schroder and von Dusch (1830s) – Air allowed to enter flask but only after passing through a heated tube or sterile wool**
  - **John Tyndall (1820-1893) – Omission of dust → no growth. Demonstrated heat resistant forms of bacteria (endospores)**

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

PASTEUR'S EXPERIMENT



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

IV. Role of Micoorganisms in Disease

Demonstrations that micoorganisms cause disease

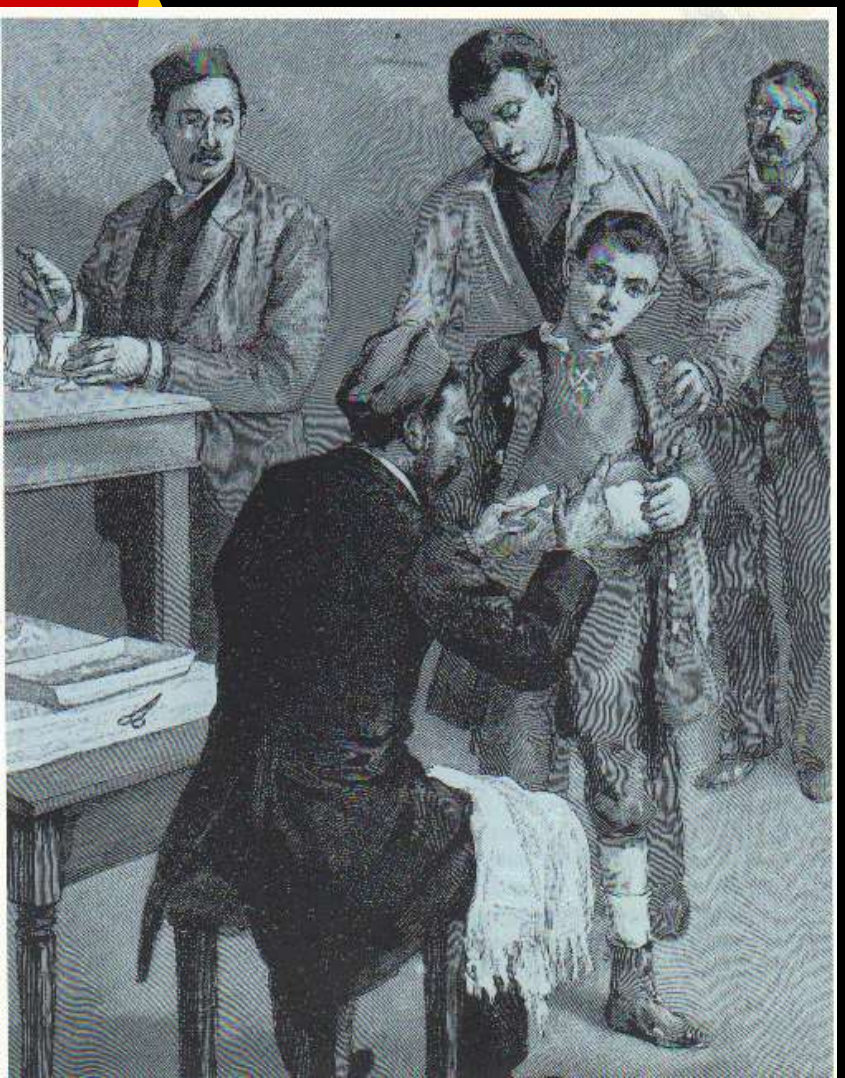
- **Oliver Holmes (1773 - 1843)**
  - **showed that sepsis could be transmitted by hands of medical student and may cause disease**
  - **M. J. Berkeley (ca. 1845)**
  - **demonstrated that the Great Potato Blight of Ireland was caused by a Fungus**
- **Louis Pasteur (1822 - 1895)**
  - **showed that 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
- Louis Pasteur
  - developed other vaccines including those for chicken cholera, anthrax, and rabies

History

- 1796 – First vaccine (smallpox)
  Edward Jenner

History



- 1885 - Vaccine against

  Rabies

  Louis Pasteur

- **Robert Koch (1843 - 1910),**
  - **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:**

History

- 1884 Koch's Postulates of Disease Transmission

  Robert Koch

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**

Development of Culture Media

- **Why?**
  - **To enable the isolation of pure cultures (only one type of organism)**
- **Especially important during Koch's period**
- **Gelatin not useful as solidifying agent (melts at >28 °C and some bacteria hydrolyze it with enzymes)**
- **Fannie Hesse, the wife of one of Koch's assistants, proposed using agar**
  - **Not digested by most bacteria**
  - **Melts at 100 °C**
  - **Used today - ~2% in solid media**
- **Richard Petri, another of Koch's assistants, developed the Petri dish**

Development of Vaccines and Antisera

- **Edward Jenner in 1796 discovered that cowpox (vaccinia) induced protection against human smallpox**
  - **Called procedure vaccination**

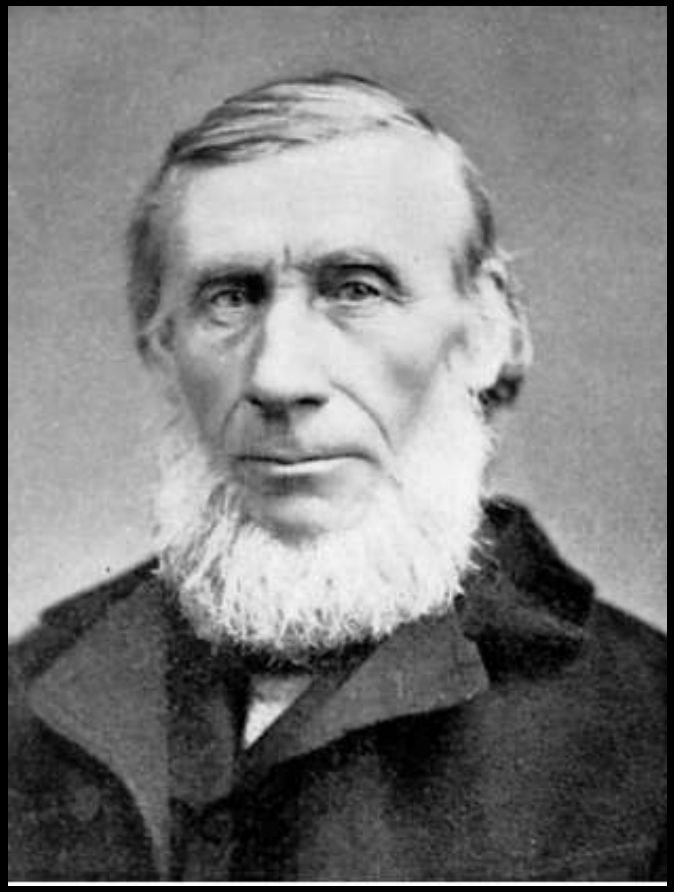
- **Vaccination:**
  - **Inoculation of healthy individuals with weakened (or attenuated) forms of microorganisms, that would otherwise cause disease, to provide protection, or active immunity from disease upon later exposure.**

- **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 rabbit following injection of infected brain and spinal cord extracts**

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

John Tyndall



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)

Anthrax bacillus

GERM THEORY OF DISEASE

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

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).

LOUIS PASTEUR

His discover 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.

Louis Pasteur
1822 – 1895

*Developed the germ theory in 1798
*Also developed vaccine against anthrax.
*Pasteurization technique
*Developed the germ theory of disease

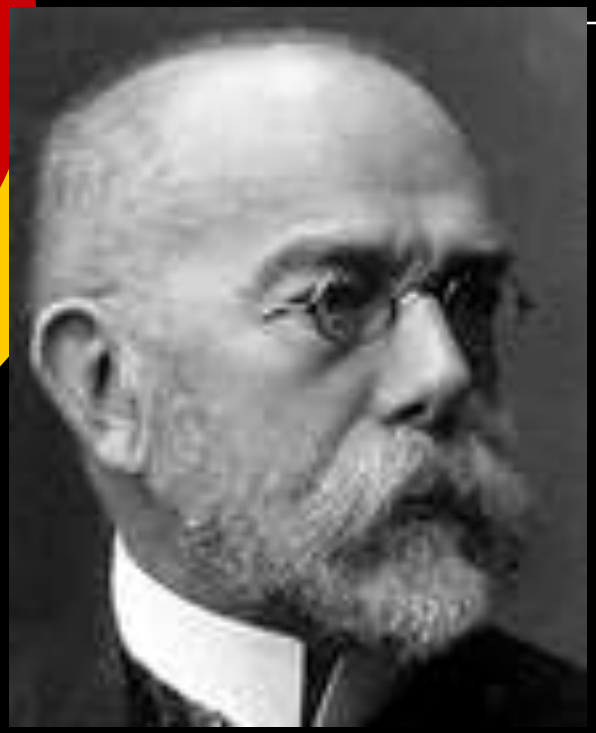
"Father of bacteriology and immunology"

- **Joseph Lister (1827 - 1912)**
  - **developed a system of surgery designed to prevent microorganisms from entering wounds – phenol (Carbolic Acid) sprayed in air around surgical incision**
  - **Decreased number of post-operative infections in patients**
  - **his published findings (1867) transformed the practice of surgery**

History: Joseph Lister

- 1867 Antiseptic Surgery(Carbolic acid- Phenol)

Robert Koch
1843 – 1910

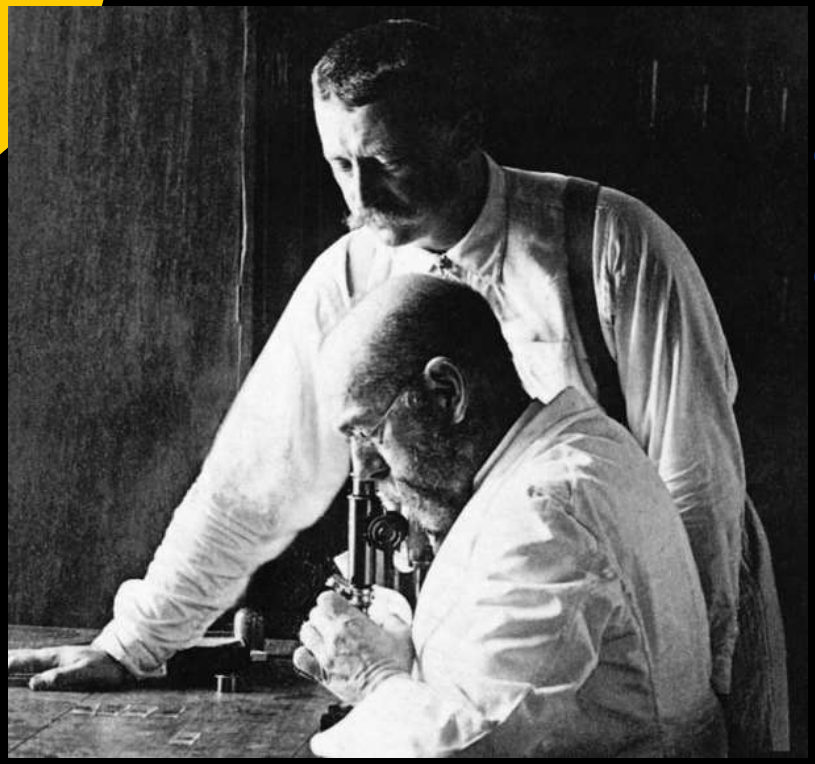


- In 1860 developed an elaborate technique to isolate & identify specific Pathogens that cause specific diseases.
- He isolated the anthrax bacterium.

GERM THEORY OF DISEASE

In 1876 Robert Koch proved the "germ theory of disease" by showing that bacteria actually caused disease. Koch established a sequence of experimental steps for directly relating a specific microbe to a specific disease called **KOCH'S POSTULATES**

ROBERT KOCH



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

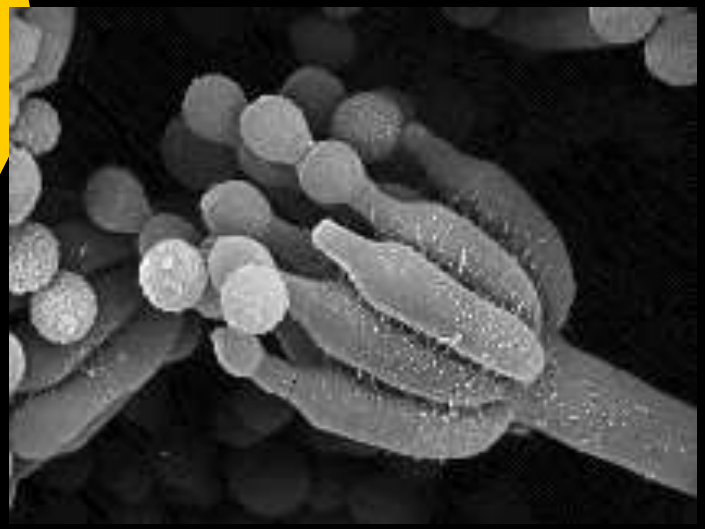
PAUL EHRLICH

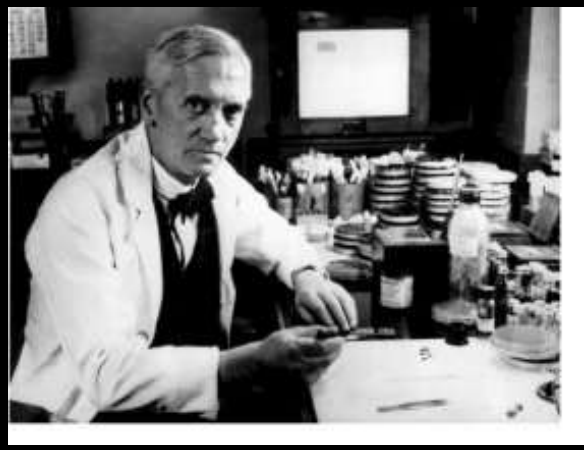
In the 1890's Ehrlich proposed a theory of immunity in which antibodies were responsible for immunity(Antitoxin). In addition, he is known as the father of modern chemotherapy. He speculated about some "magic bullet" that would selectively find and destroy pathogens but not harm the host (Selective Toxicity). He also develop a staining procedure to identify tubercle bacilli.

ALEXANDER FLEMING

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.

History





- 1929 Discovery of Penicillin (first antibiotic) Alexander Fleming

History

- 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.

History

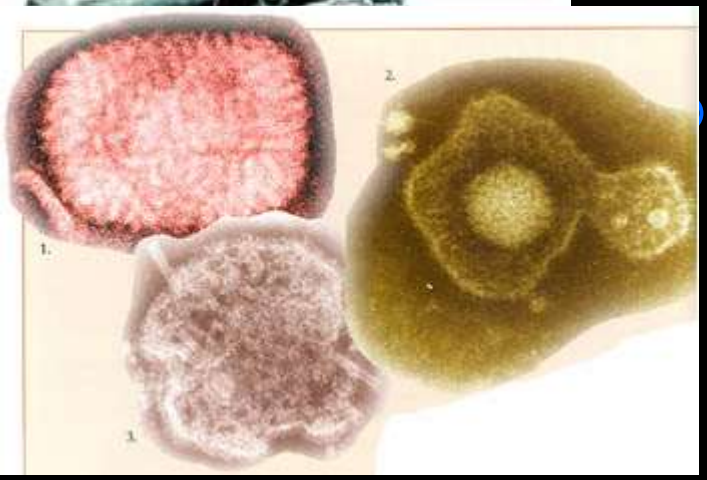
- Raymond Sabouraud (1890-1910): Develop culture media to study yeast and molds.
- Dimitri Ivanovski (1892): Tobacco mosaic virus could pass through filters used to remove bacteria.
- Selman Waksman (1940): Discovered a number of antibiotic such as Tetracycline and Streptomycin.

History

- Reska (1938) – First Electron Microscope

- **The electron microscope is capable of magnifying biological specimens up to one million times. These computer enhanced images of 1. smallpox, 2. herpes simplex, and 3. mumps are magnified, respectively, 150,000, 150,000 and 90,000 times.**

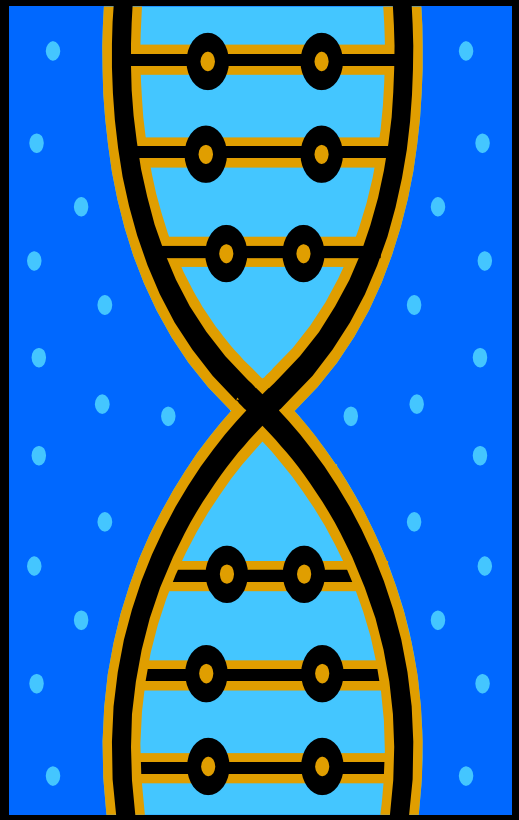
- To study detail structures of viruses.



WATSON and CRICK, FRANKLIN, and WILKINS

In 1953 Watson and Crick determined the structure of DNA. They used their research, together with the research of Franklin and Wilkins to determine the structure of the DNA molecule.

DNA



V. How Microorganism Affect Their Environment

- **Louis Pasteur**
  - **demonstrated that alcoholic fermentations were the result of microbial activity,**
  - **that some organisms could decrease alcohol yield and sour the product, and**
  - **that some fermentations were aerobic and some anaerobic;**
  - **he also developed the process of pasteurization to preserve wine during storage**

VI. Microorganisms in the 20th Century

Important Early Discoveries

- **George W. Beadle and Edward L. Tatum (ca. 1941)**
  - **studied the relationship between genes and enzymes using the bread mold, *Neurospora***
  - **Precursor→ ornithine → citrulline → arginine**
  - **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**

- There are two types of microorganisms:
  - Prokaryotes
    - have a relatively simple morphology and lack a true membrane-bound nucleus
  - Eukaryotes
    - are morphologically complex and have a true, membrane-bound nucleus

- **Organisms can be divided into five kingdoms:**
  - **the *Monera* or *Procaryotae*,**
  - ***Protista*,**
  - ***Fungi*,**
  - ***Animalia*, and**
  - ***Plantae***