Fundamentals, History and Evolution of Microbiology

Introduction

- Microbiology is a branch of science that deals with the study of diverse groups of microorganisms that include bacteria, fungi, algae and protozoa. It also includes viruses and acellular components that are sometimes considered non-living.
- Microbiology has been derived from Greek words micros (small), bios (life) and logos (science). The name microbiology indicates that it includes microorganisms that cannot be seen with the naked eye. However there are some microbes that can be seen with naked eyes such as filamentous algae, bread moulds, mushrooms, and some bacterias.
- Most of the microorganisms are unicellular, meaning they perform all their cellular functions in a single cell while some are multicellular. They can be prokaryotic in nature, meaning they do not have a membrane-bound nucleus or they can also be eukaryotic, having a membrane-bound nucleus.

Evolution of Microorganisms

- The evolution of microorganisms has been in process since 2 billion years ago. The majority of life forms on the Earth are microbial. Studying the evolution of microbiology will help in understanding the origin of other life forms.
- The evolution of microbiology and microorganisms is an ongoing process because microbes are one life form that have a greater possibility of genetic variation, by methods such as genome reduction and horizontal gene transfer.
- In 1969, R.H Whittaker gave a classification system where he classified organisms based on mode of nutrition and cell type into five five kingdoms:

Five Kingdom Classification

- **Monera:** This group includes prokaryotic and unicellular organisms such as bacteria.
- **Protista:** This group includes eukaryotic and unicellular organisms such as algae.
- **Fungi:** This group includes eukaryotic and multicellular organisms that cannot perform photosynthesis such as yeast, mould and mushroom.
- **Plantae:** This group includes eukaryotic and multicellular organisms that contain chlorophyll and can synthesise their own food such as ferns and mosses.
- **Animalia:** This group includes eukaryotic, multicellular organisms that cannot perform photosynthesis that can respond to stimuli and have a specialised nervous system. Example: insects, birds, human and fish, etc.

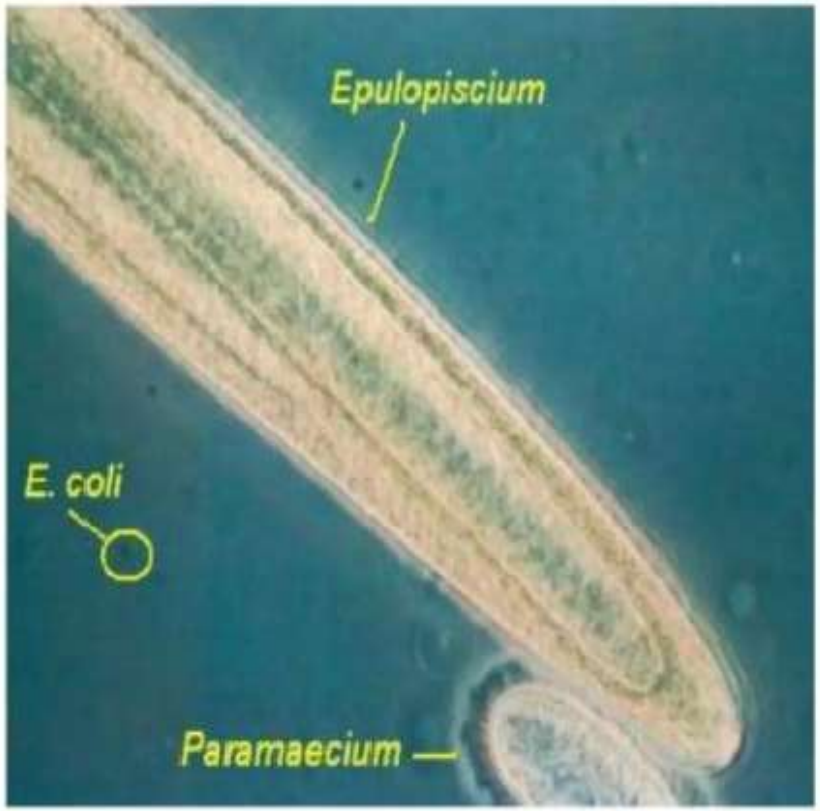
Carl Woese Classification

- In 1978 Carl Woese divided organisms into three domains that are applicable till today. The three domains are:
- **Bacteria:** They have a cell wall that is made up of peptidoglycan.
- **Archaea:** Their cell walls, if present, lack peptidoglycan.
- **Eukarya:** This domain includes:
    1. Protists
    2. Fungi
    3. Plants
    4. Animals

What is Microbiology?

- Study of Microbes – too small to be seen with naked eye.
- Less than 1mm in diameter.
- Some are visible to the naked eye –

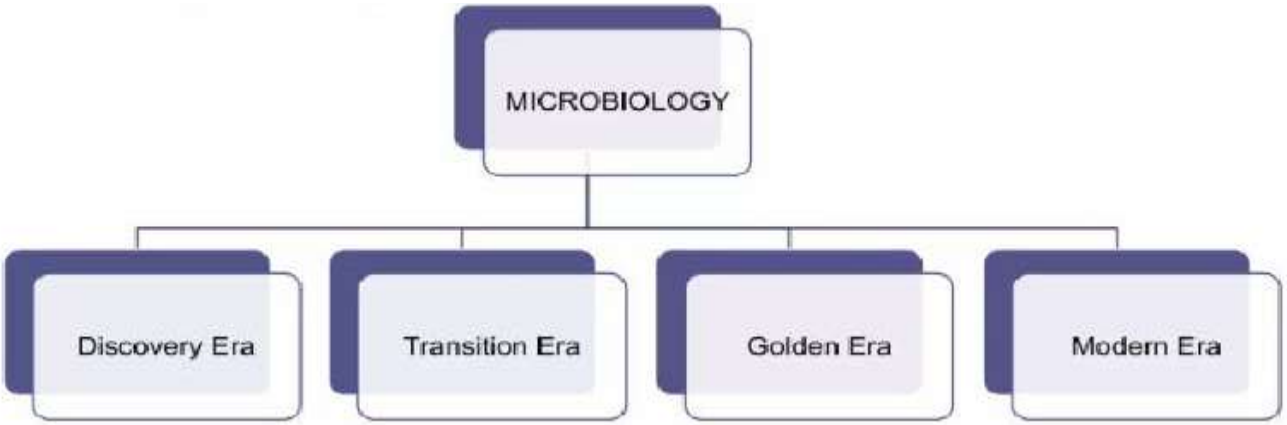
e.g.Bacterium
Epulopiscium,
filamentous algae, bread mould, mush rooms etc.



Role of Microbes

- Biological roles- decomposers, recyclers, symbionts
- Animal digestion - ruminants, methane
- Food Microbiology - yogurt, sauerkraut, Kim Chee, cheese, beer, bread etc.
- Food safety - prevent putrefication, disease etc.
- Pharmaceuticals- produce complex drug molecules. (ex. insulin)
- Bioremediation - using microbes to clean pollution
- Pathogenicity - bacteria and viruses that make us sick
- Fundamental Biology most biochemical pathways worked out with microbes

History of Microbiology



1.3 The history of microbiology

1.3.1 Discovering of organisms

- **Robert Hooke-** In 1665 said that living things were composed of little boxes he call them "CELLS"

- **Anton van Leeuwenhoek's 1632 - 1723**

➢ He discovered "microorganisms

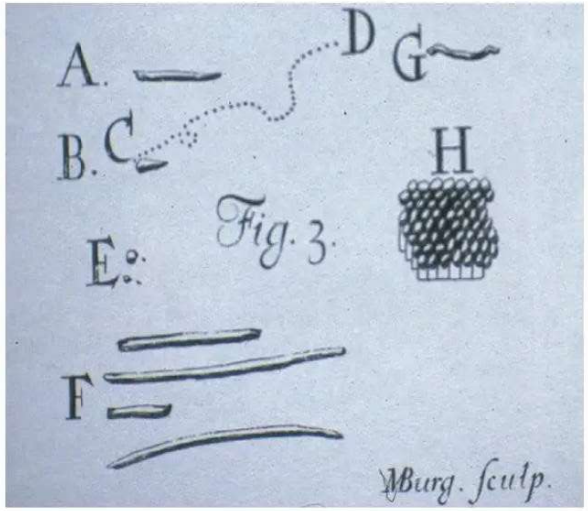
➢ He called these tiny living organisms "animalcules".

➢ He first described bacteria, protozoans and many cells of the human body.

- **Leeuwenhoek examined rain water, saliva, pepper decoctions, cork, leaves of plants , seminal fluid, scrappings of teeth etc.**

- **Portrayed several microorganisms and called them 'Animal cules'.**

- **Conveyed his findings in a series of letters to the British Royal Society, London during the mid 1670's.**



Leeuwenhoek's drawings of bacteria

1.3.2 Spontaneous generation

Aristotle: 384 – 322 B.C.

- According to Aristotle, it was *readily observable that* *All Living things come from non-living things*

"aphids arise from the dew which falls on plants, fleas from putrid matter, mice from dirty hay."

A

B

Transition Era

1.3.3 The controversy over spontaneous generation

- Controversy similar to one concerning the origin of life was witnessed in the case of the origin of microbes.
- The theory of "spontaneous generation" was believed by many scientists for centuries.
- They believed that life arose spontaneously from non-living things; which is "abiogenesis" theory.
- Meanwhile, there were opponents of this idea. The controversy was on for over 100 years.
- In 1868, an Italian scientist, **Francesco Redi**, after many smart experiments, disproved the theory of abiogenesis.
- **Francesco Redi** - Experiments on flies

❖ **Materials used**

Meat

Jar

✓ **Experiment**

Jar-1

- Left open
- Maggot formed

Jar-2

- Sealed
- No maggot

Jar-3

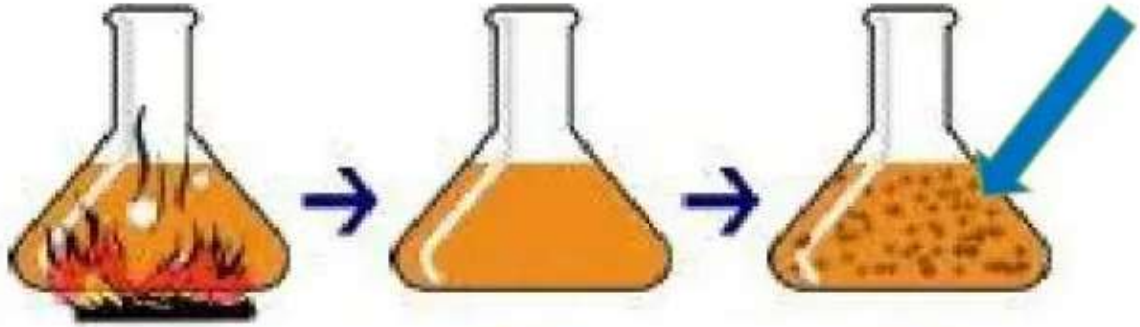
- Covered with net
- Maggot on surface

Q. What causes tiny living things to appear in decaying broth?

1. Needham's Hypothesis: Support spontaneous generation

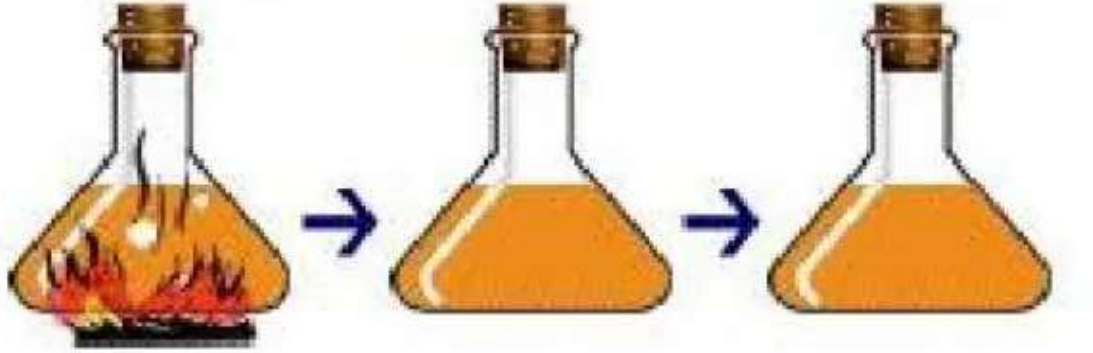
2. Spallazani's Hypothesis: Microbes come from the air, boiling will kill them.

Needham



1713 - 1781

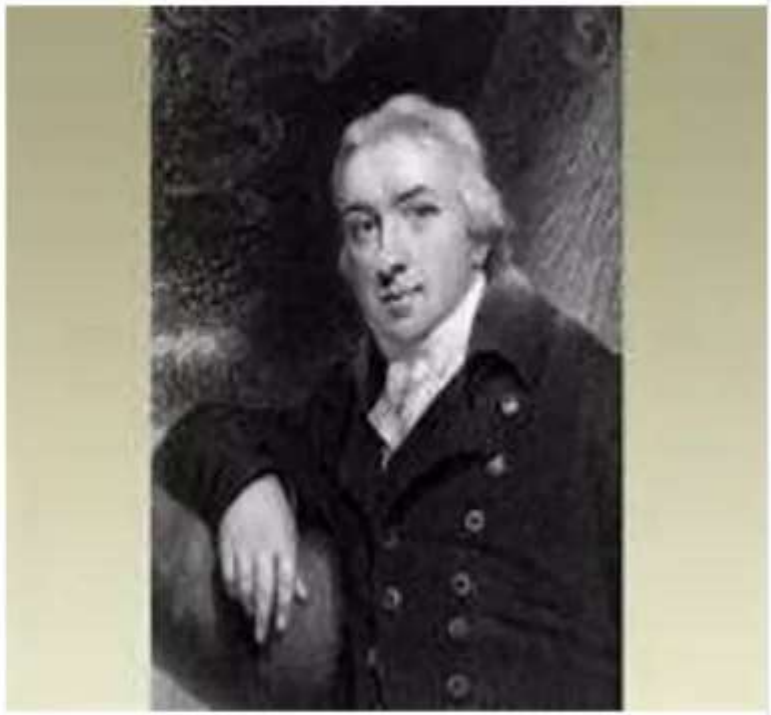
Spallazani



1729 - 1799

- **Edward Jenner** in 1796, had used vaccination with materials from cow pox lesions to protect people against small pox.

Edward Jenner



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Golden Era (1860-1910)

Experiment of Louis Pasteur

- Experiments in Swan –neck flasks - Disproved the theory of Abiogenesis.
- Boiled the flasks of broth – then left them open to the air and any of 'life force' — Life appears.
- The broth in Swan –neck flasks when left open in air and any of 'life force' — no life appears because the S- shaped curvature trapped the microbes.

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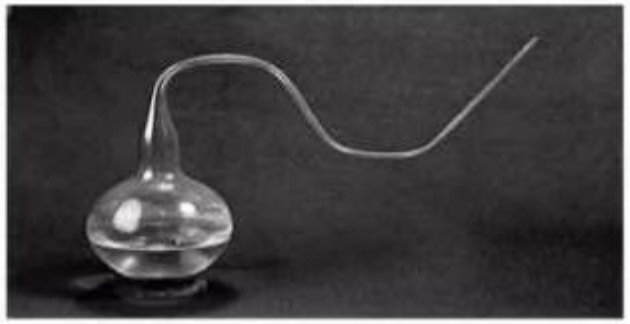

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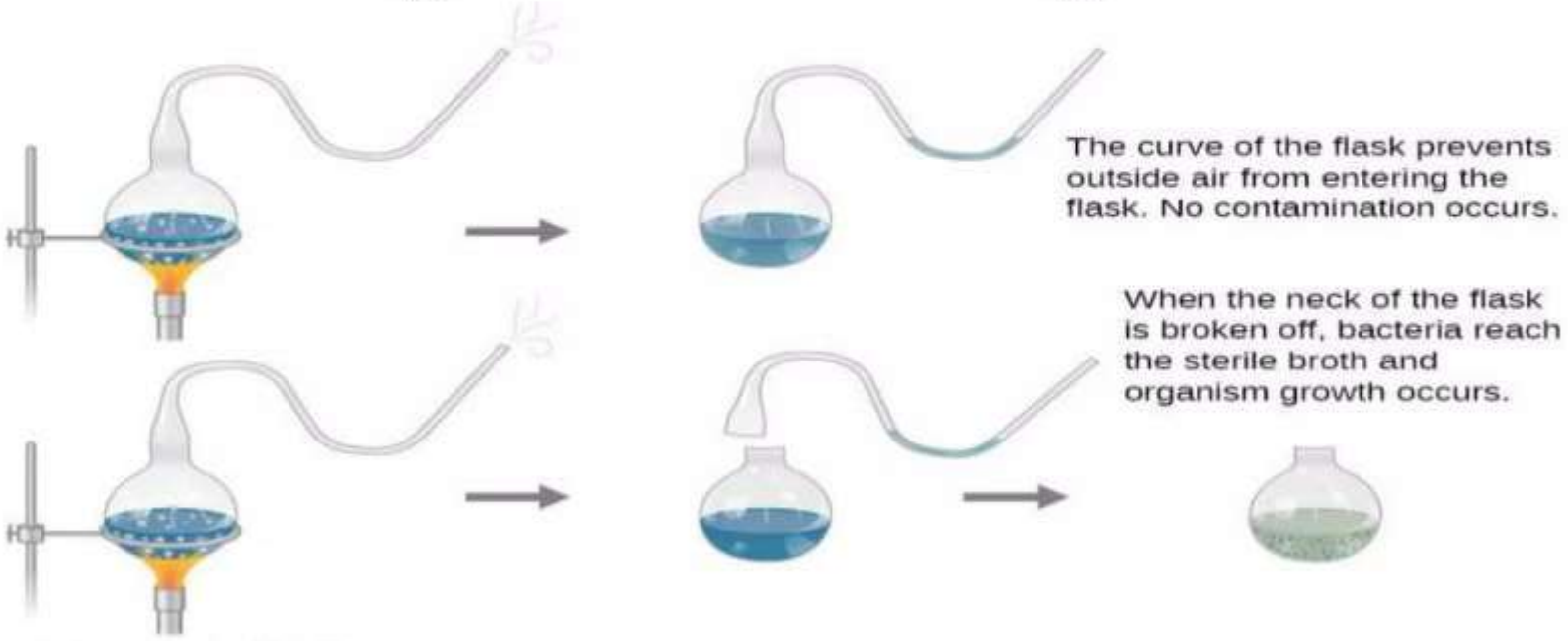

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❖ **Louis Pasteur**; the father of modern Microbiology.

- He described vaccine and vaccination to protect against microbial activity.
- Performed series of brilliant researches and experiments for the wine industry.
- Through his several experiments in the wine industry, was able to debunk the spontaneous generation hypothesis.
- Pasteur's swan- neck flasks used in his experiments on the spontaneous generation of microorganisms.

1822-1895

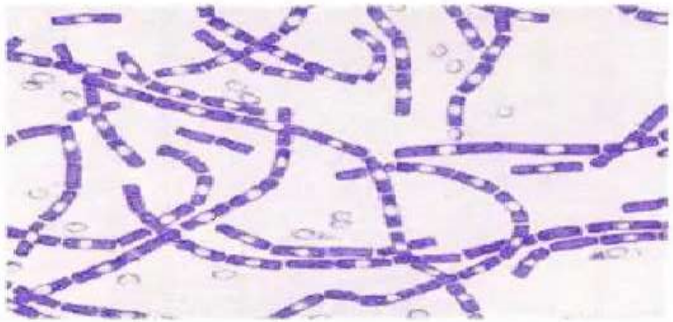
➢ **Pasteur's contributions**

- Demonstrated lactic acid fermentation
- Pasteur- why did wine sour? (converted sugars into alcohol)
  - ✓ Yeasts do the work of fermentation
- Bacteria cause spoilage
  - ✓ Pasteurization
- Pasteur developed anthrax vaccine
- Pasteur (1861) conflict over spontaneous generation – birth of microbiology as a science.

- **John Tyndall**(1820-1883):- different infusions require different boiling times to be sterilized.
- **Joseph Lister**(1867):- he discover the use antiseptic technique.
- **Robert Koch**(1843-1910):- (father of medical microbiology), discovered that bacteria caused diseases such as tuberculosis, anthrax etc.

- Koch established the microbial etiology of 3 important diseases of his day.
  1. Cholera (fecal-oral disease)
     - ✓ *Caused by Vibrio cholerae*
  2. Tuberculosis (pulmonary infection)
     - ✓ *Caused by Mycobacterium tuberculosis*
  3. Anthrax (sheep and cattle)
     - ✓ *Caused Bacillus anthracis*

- *Bacillus anthracis*
  - Gram (+), non-motile, aerobic, spore forming rod
  - Streptobacilli with central spores
  - Livestock
    - Sheep, cattle, goats
  - Handle hides, wool, goat hair, handicrafts made from infected animal

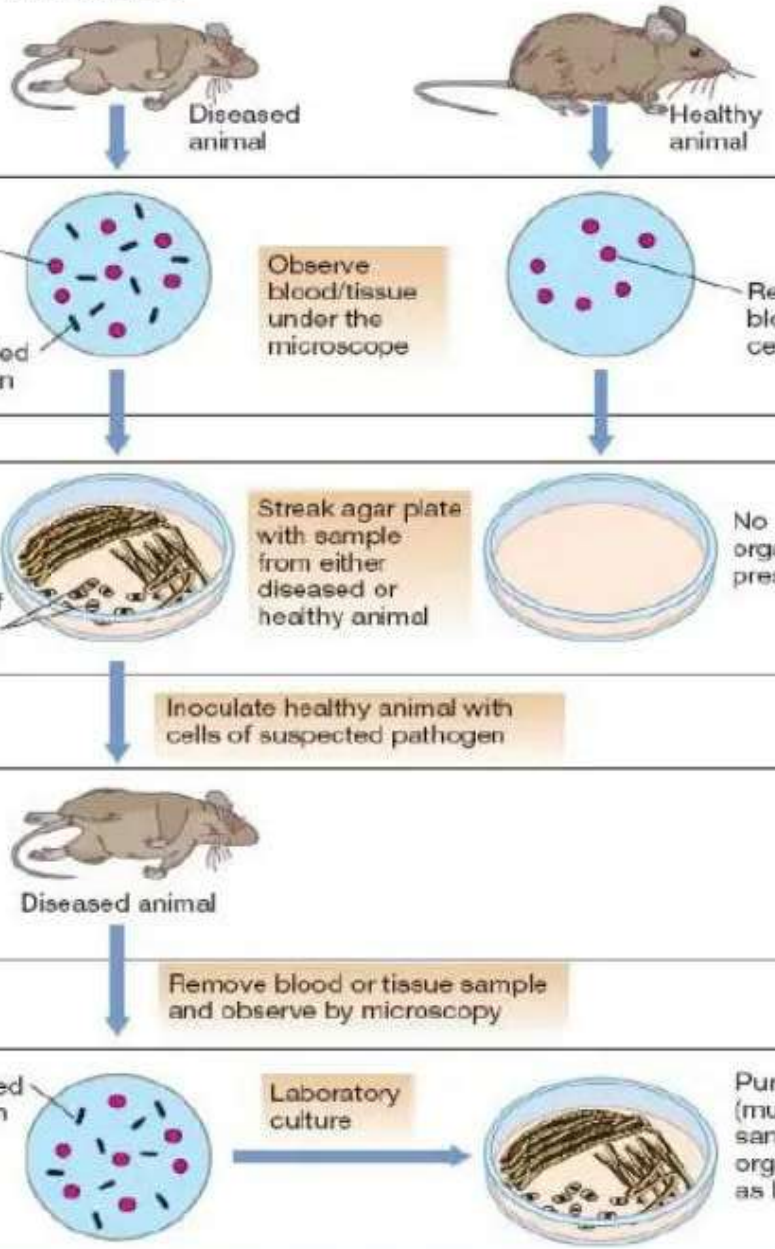


❖ **Robert Koch** develop germ theory of disease

Germ theory of disease

KOCH'S POSTULATES

The Postulates:	Tools:
1. The suspected pathogenic organism should be present in *all* cases of the disease and absent from healthy animals.	Microscopy, staining
2. The suspected organism should be grown in pure culture.	Laboratory culture
3. Cells from a pure culture of the suspected organism should cause disease in a healthy animal.	Experimental animal
4. The organism should be reisolated and shown to be the same as the original.	Laboratory reisolation



❖ Exceptions to Koch's Postulates

1. Some organisms have never been grown in pure culture on artificial media.

- ✓ *Mycobacterium leprae* causative agent of Leprosy, never grown in artificial media.
- ✓ Diseases associated with bacteria that live only within cells, such as the rickettsia and chlamydia, and diseases caused by some viruses and protozoan parasites.

2. In exclusively human diseases, it is not morally acceptable to inoculate a deadly pathogen into a "human guinea pig". E.g. HIV

3. The causative agents of several human diseases do not cause disease in any known experimental animals.

Fanne Eilshemius Hesse (1850 - 1934)

- One of Koch's assistant first proposed the use of agar in culture media.
- It was not attacked by most bacteria.
- Agar is better than gelatin because of its higher melting pointing (96°c) and solidifying (40 – 45°c)points.

Richard Petri (1887)

- He developed the Petri dish (plate), a container used for solid culture media.

Edward Jenner (1749-1823)

- First to prevent small pox.
- He discovered the technique of vaccination.

Alexander Flemming

- He discovered the penicillin from *penicillium notatum* that destroy several pathogenic bacteria.

Paul Erlich (1920)

- He discovered the treatment of syphilis by using arsenic
- He Studied toxins and antitoxins in quantitative terms & laid foundation of biological standardization.

1.4 Important events in the development of microbiology

Date	Microbiological History
1676	Leeuwenhoek discovers "animalcules"
1857	Pasteur shows that lactic acid fermentation is due to microbes
1861	Pasteur shows that microorganisms do not arise by spontaneous generation
1867	Lister publishes his work on antiseptic surgery
1869	Miescher discovers nucleic acids
1876-1877	Koch demonstrates that anthrax is caused by *B. anthrax*
1880	Laveran discovers Plasmodium, the cause of malaria
1881	Koch cultures bacteria on gelatin Pasteur develops anthrax vaccine

1884 Koch's postulates first published Metchnikoff describes phagocytosis Gram stain developed

1944 Avery shows that DNA carries information during transformation Waksman discovers streptomycin Watson and Crick propose the double helix structure for DNA

1961-1966 Cohen use plasmid vectors to clone genes in bacteria

1980Development of the scanning tunneling microscope

1983-1984 The polymerase chain reaction developed by Mullis

1990 First human gene-therapy testing begun

1997 Discovery of *Thiomargarita namibiensis*, the largest known bacterium, *Escherichia coli* genome sequenced

2000 Discovery that Vibrio cholerae has two separate chromosomes