



---

○ The History and Scope  
of Microbiology

# *Microorganisms and Microbiology*

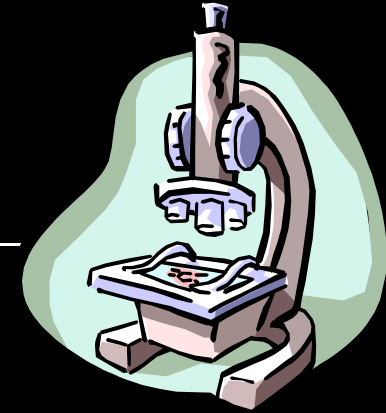


# Concepts

---

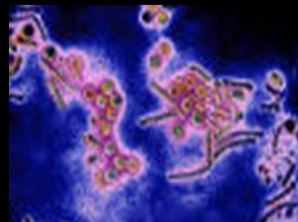
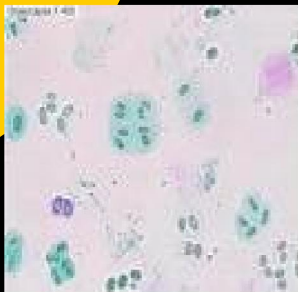
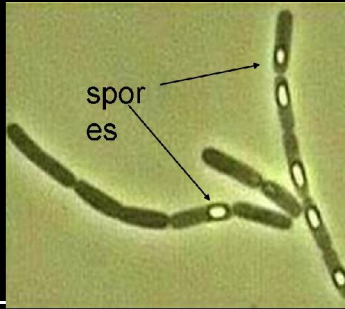
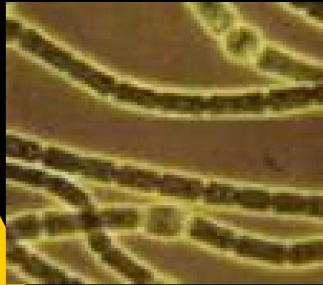
- Microorganisms are responsible for many of the changes observed in organic and inorganic matter (e.g., fermentation and the carbon, nitrogen and sulfur cycles that occurred in nature.
- The development of microbiology as a scientific discipline has depended on the availability of the microscope and the ability to isolate and grow pure cultures of microorganisms.
- Microbiology is a large discipline, which has a great impact on other areas of biology and general human welfare

# 1.1 What is a microbe?



The word microbe (microorganism) is used to describe an organism that is so small that can not be seen without the use of a microscope. Viruses, bacteria, fungi, protozoa and some algae are all included in this category.

**Our world is populated by invisible creatures too small to be seen with the unaided eye. These life forms, the microbes or microorganisms, may be seen only by magnifying their image with a microscope.**



# Microbial world

**Organisms (living)**

**Infectious agents (non-living)**

Prokaryotes  
(unicellular)

eukaryotes

viruses

viroids

prions

Eubacteria

Archaea

Algae  
(unicellular or multicellular)

Fungi  
(unicellular or multicellular)

Protozoa  
(unicellular)

Other  
(multicellular organisms)



# The size and cell type of microbes

Most of the bacteria, protozoa, and fungi are single-celled microorganisms, and even the multicelled microbes do not have a great range of cell types. Viruses are not even cells, just genetic material surrounded by a protein coat and incapable of independent existence.



# The size and cell type of microb

---

Microbe	Approximate range of sizes	Cell type
Viruses	0.01-0.25 $\mu\text{m}$	Acellular
Bacteria	0.1-10 $\mu\text{m}$	Prokaryote
Fungi	2 $\mu\text{m}$ ->1m	Eukaryote
Protozoa	2-1000 $\mu\text{m}$	Eukaryote
Algae	1 $\mu\text{m}$ -several meters	Eukaryote

---



# 1.2 The importance of

# microbiology

Microbes impinge on all aspects of life, just a few of these are listed below:

The environment



Medicine



Food



Biotechnology




Research

- 
- 
- The environment
  - Medicine
  - Food
  - Biotechnology
  - Research



Press here to  
continue






---

Microbes are responsible for the geochemical cycles. They are found in association with plants in symbiotic relationships. Some microbes are devastating plant pathogens, but others may act as biological control agents against diseases.






---

The disease-causing ability of some microbes is well known. However, microorganisms have also provided us with the means of their control in the form of antibiotics and other medically important drugs.

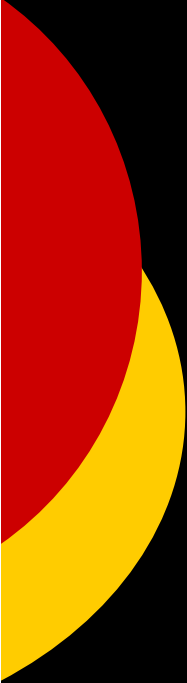




---

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






---

Traditionally microbes have been used to synthesize important chemicals. The advent of genetic engineering techniques has led to the cloning of polypeptides into microbes.





Microbes have been used as model organisms for the investigation of biochemical and genetical processes. Millions of copies of the same single cell can be produced very quickly and give plenty of homogeneous experimental material. Most people have no ethical objections to experiments with these microorganisms.





## 1.3 Microbes in our lives

---

- Microorganisms as Disease Agents
- Microorganisms and Agriculture
- Microorganisms and the Food Industry
- Microorganisms, Energy, and the Environment
- Microorganisms and the Future



Microbial  
physiology

Microbial  
genetics

Microbial  
Morphology

Virolog  
y

Parasitolo  
gy

Mycolog  
y

Branches of  
Microbiology

Protozoolo  
gy

Bacteriolo  
gy

Microbial  
ecology

Microbial  
taxonomy

Molecular  
biology

Phycology or  
Algology



## *The future of microbiology is bright*

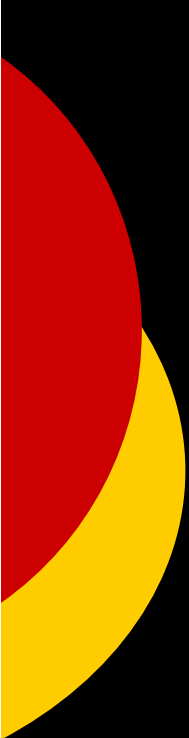
---

Microbiology is one of the most rewarding of professions, because it gives its practitioners the opportunity to be in contact with all the other natural science and thus to contribute in many different ways to the betterment of human life.



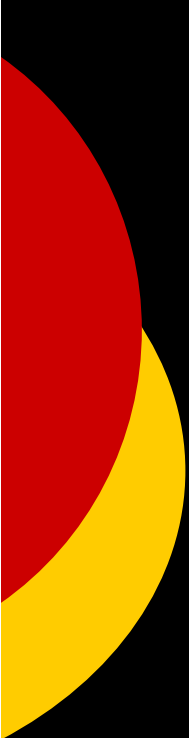
---

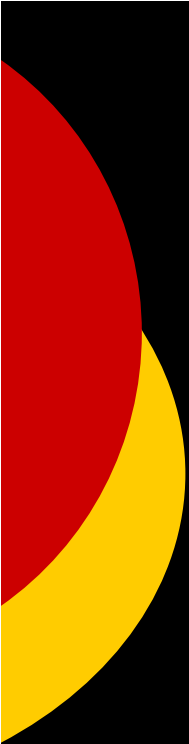
○ **I. Introduction to Microbiology**

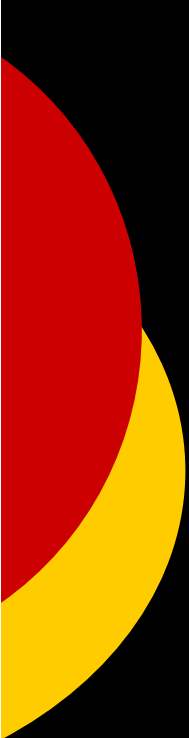
- 
- 
- **Microbiology is the study of microorganisms usually less than 1mm in diameter which requires some form of magnification to be seen clearly**

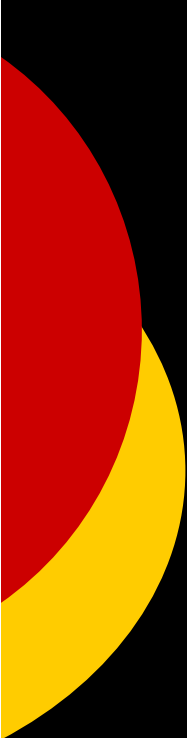
- **Examples:**

- **Viruses**
- **Bacteria**
- **Fungi**
- **Algae**
- **Protozoans**

- 
- 
- **Some organisms studied 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**

- 
- 
- **Microbiologists may be interested in specific types of organisms:**
    - **Virologists - viruses**
    - **Bacteriologists - bacteria**
    - **Phycologists or Algologists - algae**
    - **Mycologists - fungi**
    - **Protozoologists - protozoa**

- 
- 
- **Microbiologists may have a more applied focus:**
    - **Medical microbiology, including immunology**
    - **Food and dairy microbiology**
    - **Public health microbiology**
    - **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

---



## Early Discoveries

---

- **Lucretius, a Roman philosopher (98-55 B.C.), and Girolamo Fracastoro, a physician (1478-1553) believed invisible creatures were responsible for disease**
- **Franscesco Stelluti observed bees and weevils using a microscope in the early 1600s**
- **Anton van Leeuwenhoek (1632 - 1723) was the first to report microorganisms (Royal Society) (Animalcules)**
  - **50-300X magnification**



---

○ **III. Spontaneous Generation**



---

- **Spontaneous Generation**

- **The belief that life could originate from non-living or decomposing matter**



---

○ **Supported by:**

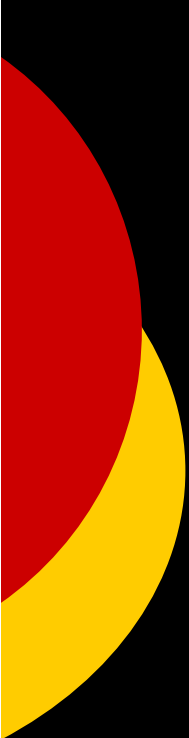
- **Aristotle (384-322 BC) – Believed that imple invertebrates could arise by spontaneous generation**
- **John Needham (1713-1781) – Boiled mutton broth, then sealed and still observed growth after a period of time**
- **Lazarro Spallanzani (1729-1799) No growth in sealed flask after boiling – proposed that air was needed for growth of organisms**
- **Felix Pouchet (1859) – Proved growth without contamination from air**



---

○ **Disproved by:**

- **Francesco Redi (1626-1697) – maggot unable to grow on meat if meat was covered with gauze**
- **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)**
    - **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;**
    - **no growth was observed because dust particles carrying organisms did not reach the medium, instead they were trapped in the neck of the flask; if the necks were broken, dust would settle and the organisms would grow; in this way Pasteur disproved the theory of spontaneous generation**



---

○ **IV. Role of Microorganisms in  
Disease**



## Demonstrations that microorganisms cause disease

---

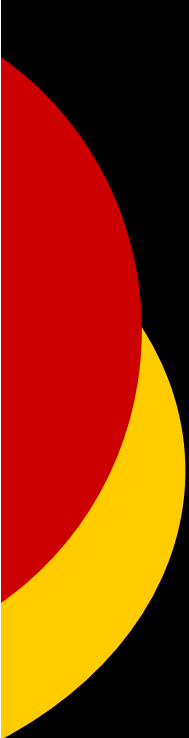
- **Agostino Bassi (1773 - 1856)**
  - **showed that a silkworm disease was caused by a fungus**
- **M. J. Berkeley (ca. 1845)**
  - **demonstrated that the Great Potato Blight of Ireland was caused by a Fungus**
- **Louis Pasteur**
  - **showed that the pébrine disease of silkworms was caused by a protozoan parasite**

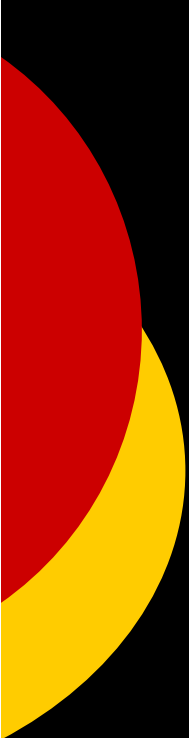


---

○ **Joseph Lister (1827 - 1912)**

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

- 
- 
- **Charles Chamberland (1851 - 1908)**
    - **identified viruses as disease-causing agents – Tobacco Mosaic Virus**
  - **Edward Jenner (ca. 1798)**
    - **used a vaccination procedure to protect individuals from smallpox**
  - **Louis Pasteur**
    - **developed other vaccines including those for chicken cholera, anthrax, and rabies**

- 
- 
- Ignaz Semmelweiss (~1850) demonstrated that childbed fever (puerperal fever), caused by streptococcal infections, was transmitted to patients by doctor's hands
    - Pioneer of antiseptics in obstetrics
    - Women giving birth in hospitals by medical students and physicians were 4x more likely to contract puerperal fever compared to those by midwives



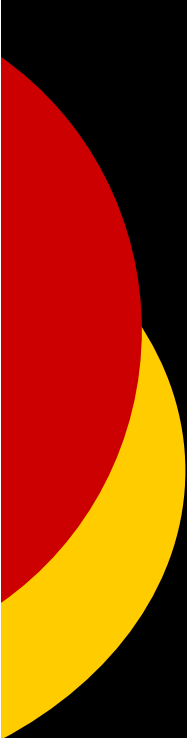
---

○ **Emil von Behring (1854 - 1917) and Shibasaburo Kitasato (1852 - 1931)**

- **induced the formation of diphtheria tetanus antitoxins in rabbits which were effectively used to treat humans thus demonstrating humoral immunity**

○ **Elie Metchnikoff (1845 - 1916)**

- **demonstrated the existence of phagocytic cells in the blood, thus demonstrating cell-mediated immunity**

- 
- 
- **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:



## 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 degrees Celsius 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 degrees Celsius**
  - **Used today - ~2% in solid media**
- **Richard Petri, another of Koch's assistants, developed the Petri dish**





# Development of Vaccines and Antisera

---

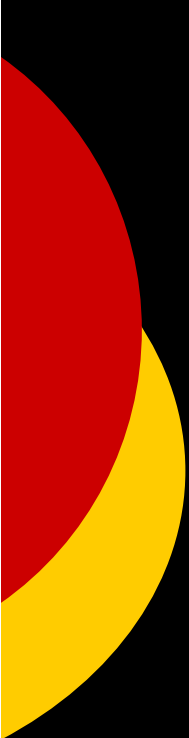
- **Edward Jenner in 1796 discovered that cowpox (vaccinia) induced protection against human smallpox**
  - **Called procedure vaccination**

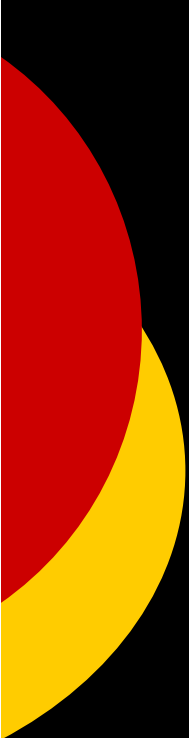


---

○ **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 nonimmune subject**



---

- **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**



---

○ **Sergei Winogradsky (1856 - 1953)**

- **worked with soil bacteria and discovered that they could oxidize iron, sulfur, and ammonia to obtain energy;**
- **he also studied anaerobic nitrogen-fixation and cellulose decomposition**





---

- **Martinus Beijerinck (1851 - 1931)**

- **isolated aerobic nitrogen-fixing soil bacteria (Azotobacter and Rhizobium) and sulfate reducing Bacteria**

- **Beijerinck and Winogradsky**

- **pioneered the use of enrichment cultures and selective media**



---

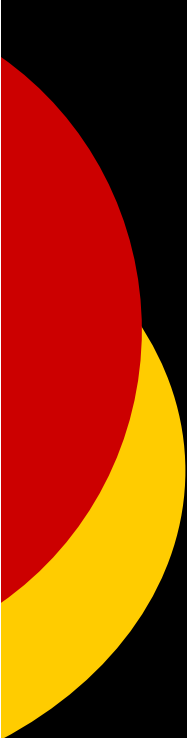
○ **VI. Microorganisms in the 20<sup>th</sup>  
Century**

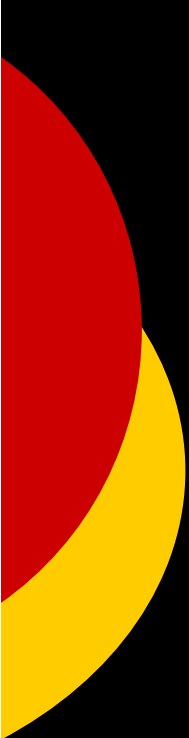


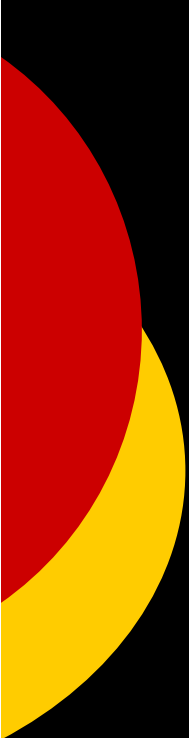
# Important Early Discoveries

---

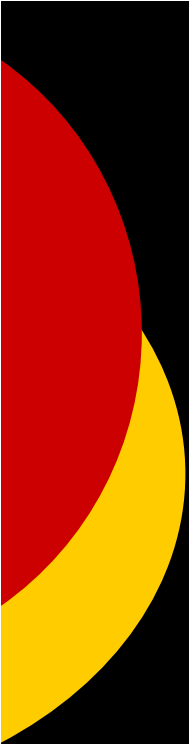
- **George W. Beadle and Edward L. Tatum (ca. 1941)**
  - **studied the relationship between genes and enzymes using the bread mold, *Neurospora***
  - **Precursor → ornithine → citrulline → arginine**
  - **One gene, one polypeptide hypothesis**
- **Salvadore Luria and Max Delbruck (ca. 1943)**
  - **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)**

- 
- 
- **Microbiology has played a major role in molecular biology and has been closely tied to the determination of the genetic code;**
    - **in studies on the mechanisms of DNA, ribonucleic acid (RNA), and protein synthesis;**
    - **and in studies on the regulation of gene expression and the control of enzyme activity**

- 
- 
- **Microorganisms are able to grow rapidly and in large amounts in the lab at reasonable cost**
    - **Valuable research tools for studying genetics, biochemistry, molecular biology and cell biology**

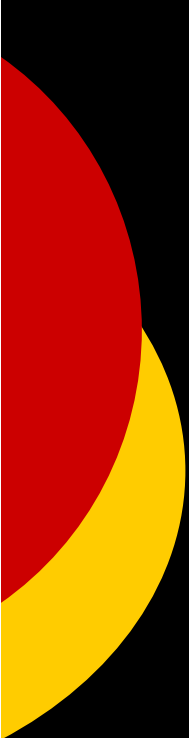
- 
- 
- **In the 1970s new discoveries in microbiology led to the development of recombinant DNA technology and genetic engineering**

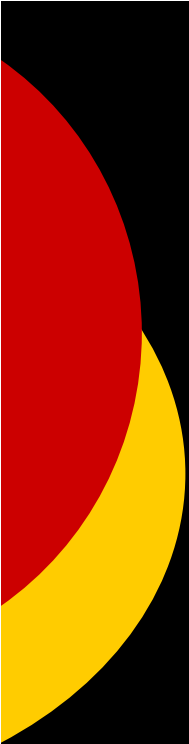


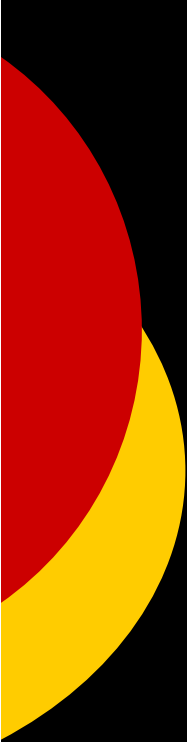
---

○ **VII. Differences Between  
Prokaryotic and Eukaryotic  
Cells**



- 
- 
- **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*

- 
- 
- **Alternative classification schemes involving several empires or domains with multiple kingdoms contained within have been proposed**
  - **Microbiologists are concerned primarily with members of the first three kingdoms and also with viruses, which are not classified with living organisms**