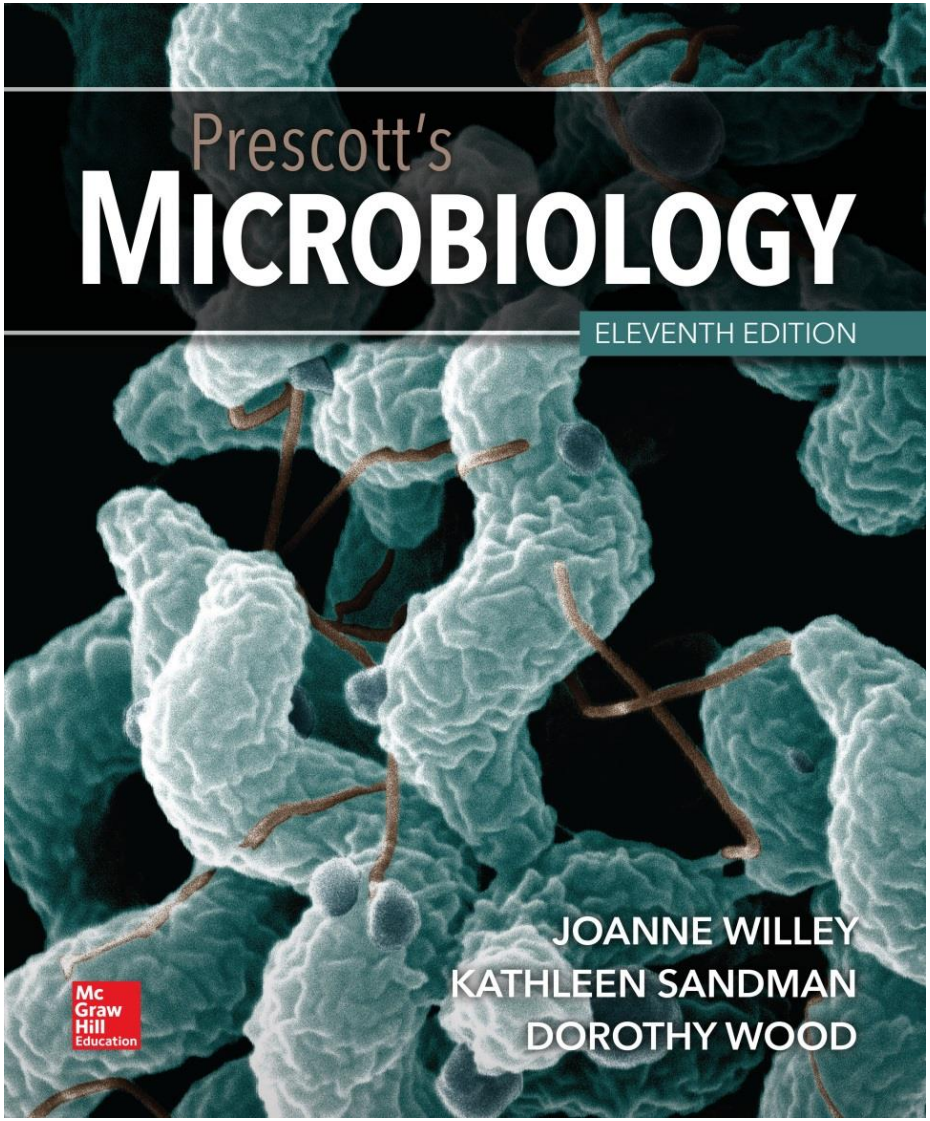

Prescott's MICROBIOLOGY

ELEVENTH EDITION

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Chapter 1

The Evolution of Microorganisms and Microbiology

The Importance of Microorganisms

Most populous and diverse group of organisms.

Found everywhere on the planet.

Play a major role in recycling essential elements.

Source of nutrients and some carry out photosynthesis.

Benefit society by their production of food, beverages, antibiotics, and vitamins.

Some cause disease in people, plants, or animals.

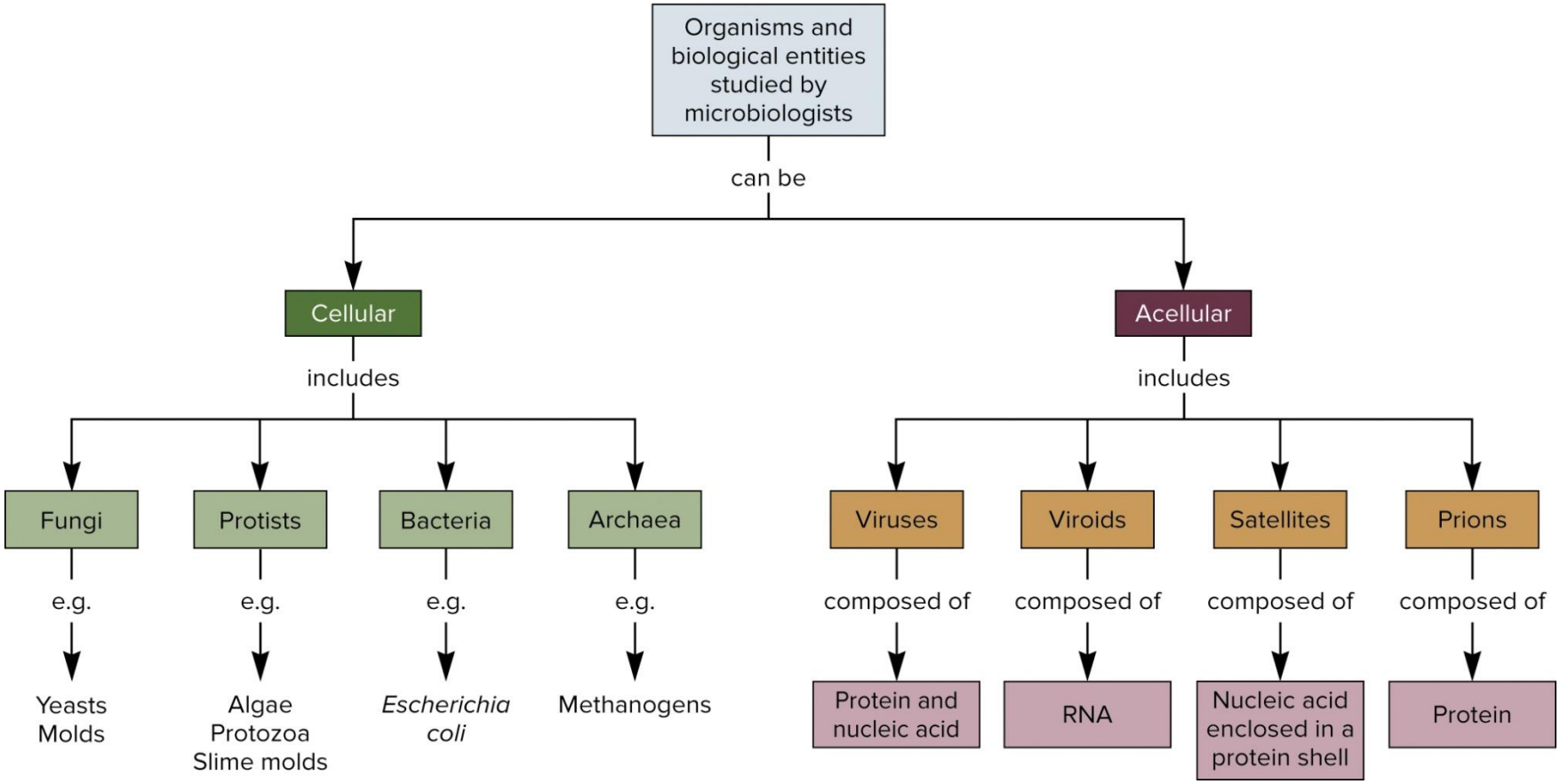
Members of the Microbial World

Organisms and acellular entities too small to be clearly seen by the unaided eye.

- Generally <1 mm, some macroscopic.

These organisms are relatively simple in their construction **and lack differentiated tissues**.

Divisions and Types of Microbes



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Types of Microbial Cells

Prokaryotic cells lack a true membrane-delimited nucleus.

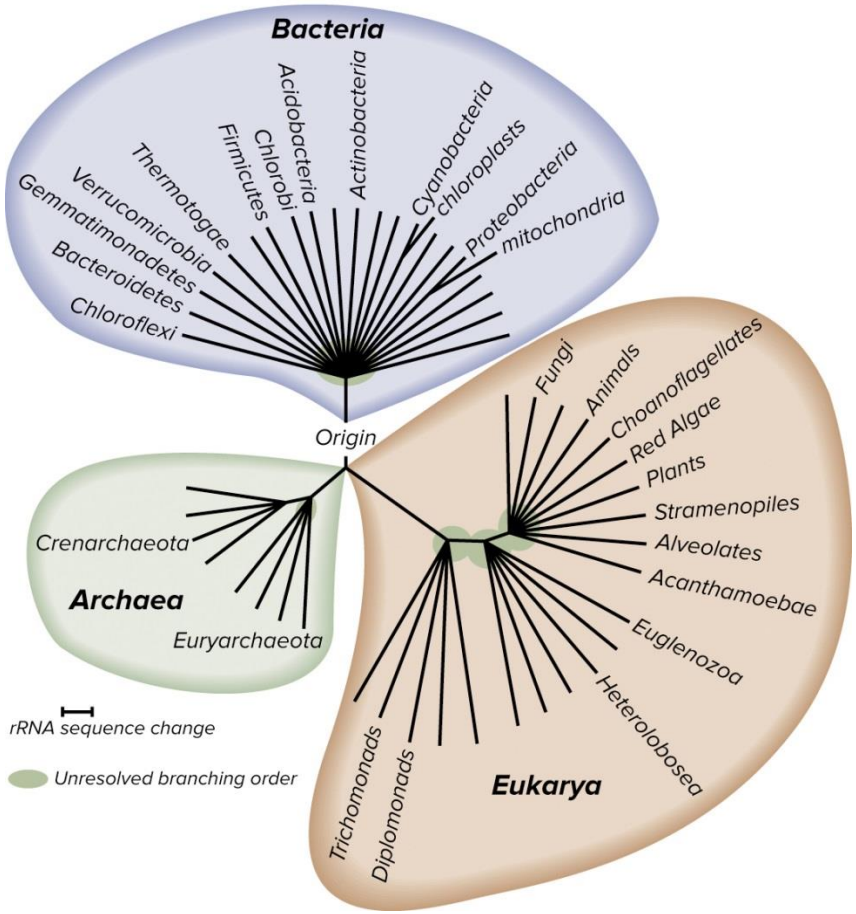
- This is not absolute!

Eukaryotic cells have a membrane-enclosed nucleus, are more complex morphologically, and are usually larger than prokaryotic cells.

Classification Schemes

Three domain system, based on a comparison of ***ribosomal RNA genes***, divides microorganisms into:

- *Bacteria* (true bacteria).
- *Archaea.*
- *Eukarya* (eukaryotes).



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Domain *Bacteria* and Domain *Archaea*

Domain *Bacteria*

Usually single-celled.

Majority have cell wall with peptidoglycan.

Most lack a membrane-bound nucleus.

Ubiquitous and some live in extreme environments.

Cyanobacteria produce significant amounts of oxygen.

Domain *Archaea*

Distinguished from *Bacteria* by unique rRNA gene sequences.

Lack peptidoglycan in cell walls.

Have unique membrane lipids.

Some have unusual metabolic characteristics.

Many live in extreme environments.

Domain *Eukarya*

Protists—generally larger than *Bacteria* and *Archaea.*

- Algae—photosynthetic.
- Protozoa—may be motile, “hunters, grazers”.
- Slime molds—two life cycle stages.
- Water molds—devastating disease in plants.

Fungi.

- Yeast—unicellular.
- Molds and mushrooms—multicellular.

Acellular Infectious Agents

Viruses.

- Smallest of all microbes.
- Requires host cell to replicate.
- Cause range of diseases, some cancers.

Viroids.

- Infectious agents composed of RNA.

Satellites.

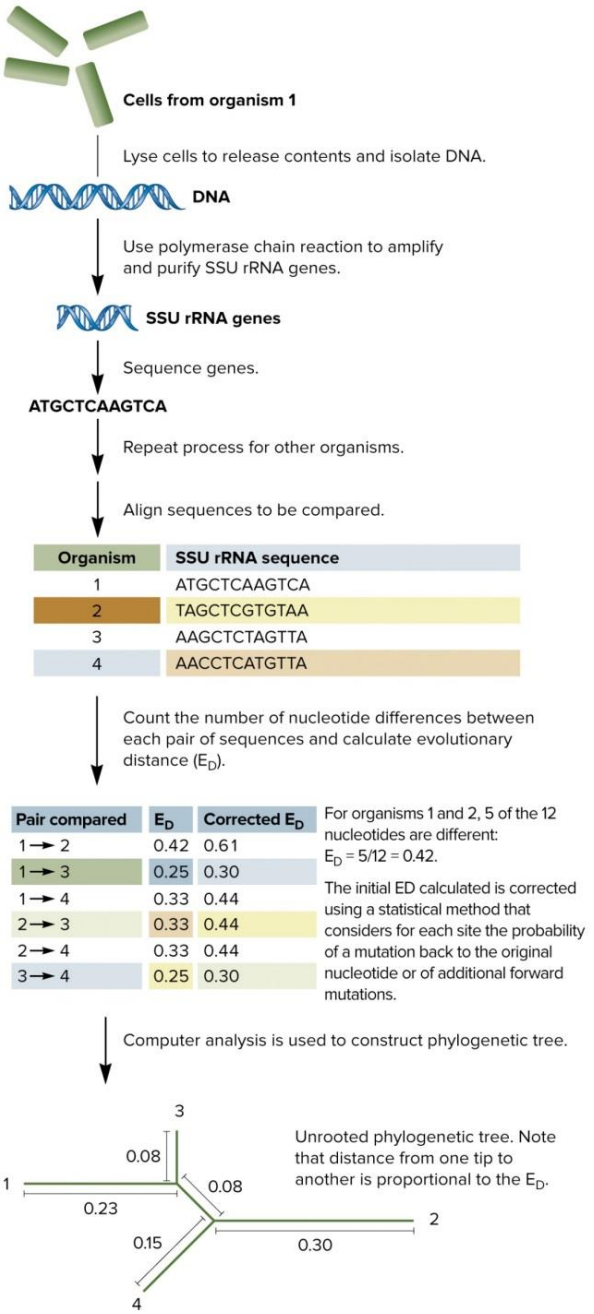
- Nucleic acid enclosed in protein shell.
- Must coinfect a host cell with a virus to complete life cycle.

Prions—Infectious proteins.

Evolution of the Three Domains of Life

Universal phylogenetic tree.

- Based on comparisons of small subunit rRNA (SSU rRNA).
- Aligned rRNA sequences from diverse organisms are compared and differences counted to derive a value of evolutionary distance.
- ***Relatedness, but not time of divergence, determined this way.***



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Last Universal Common Ancestor (LUCA)

The root or origin of modern life is on bacterial branch but nature still controversial.

Archaea and *Eukarya* evolved independently of *Bacteria.*

Archaea and *Eukarya* diverged from common ancestry.

Evolution of Cellular Microbes

Mutation of genetic material led to selected traits.

New genes and genotypes evolved—producing mosaic of genetic information.

Bacteria and *Archaea* increase genetic pool by horizontal gene transfer within the same generation.

Microbial Species

Eukaryotic microbes fit definition of reproducing isolated populations.

Bacteria and *Archaea* do not reproduce sexually and are referred to as strains.

- A strain consists of descendants of a single, pure microbial culture.
- May be *biovars, morphovars, serovars, and pathovars.*

Binomial nomenclature.

- Genus and species epithet.

1.3 Microbiology Advanced as New Tools for Studying Microbes Were Developed

a. Evaluate the importance of the contributions made by Hooke, Leeuwenhoek, Pasteur, Lister, Koch, Beijerinck, von Behring, Kitasato, Metchnikoff , and Winogradsky.

b. Outline a set of experiments that might be used to decide if a particular microbe is the causative agent of a disease.

c. Predict the difficulties that might arise when using Koch's postulates to determine if a microbe causes a disease unique to humans.

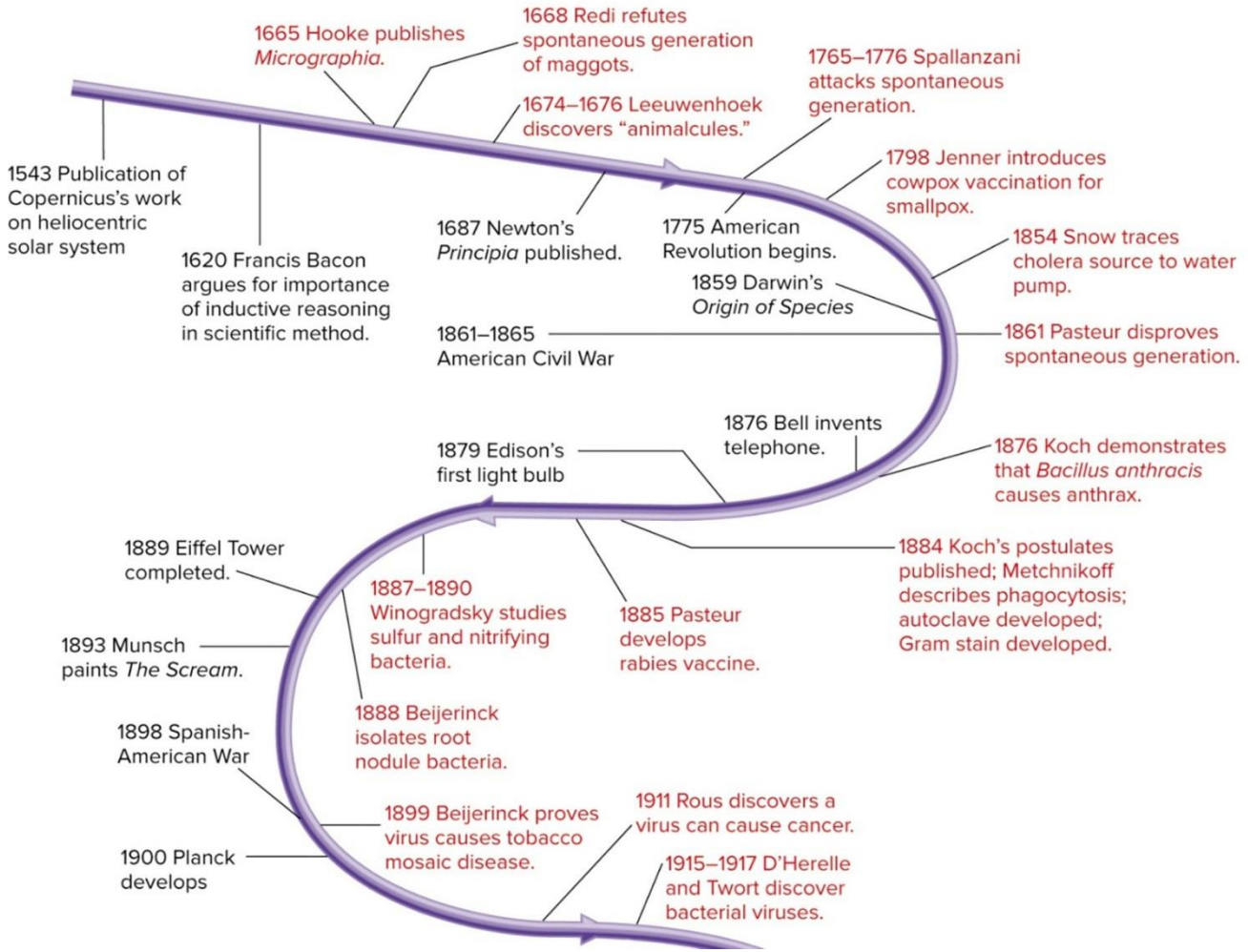
Microbiology—Origins

Study of microorganisms.

Tools used for the study.

- Microscopes.
- Culture techniques.
- Molecular genetics.
- Genomics.

Important Events in Microbiology (1665 to 1911)



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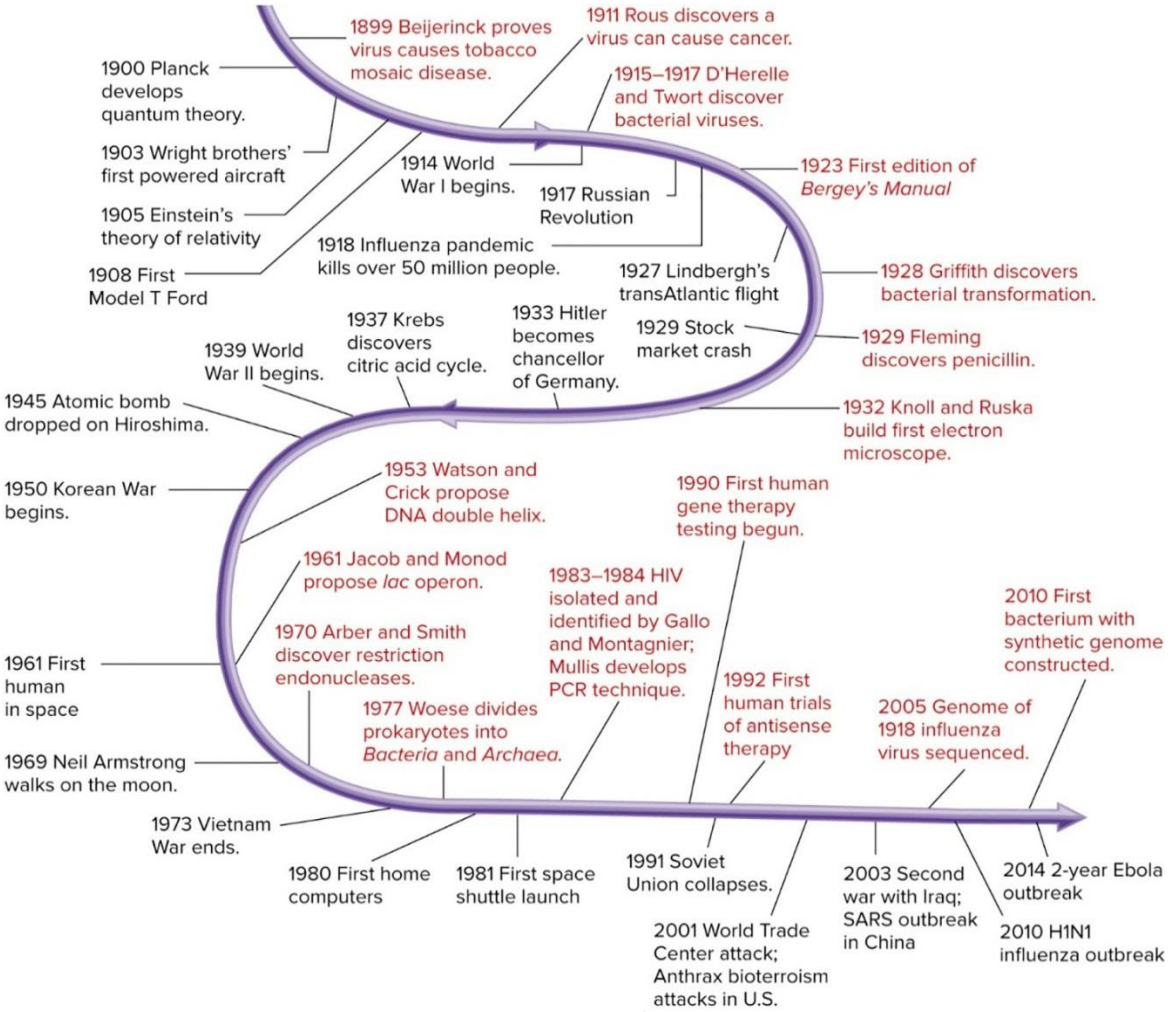
Important Events in Microbiology (1900 to 2010)



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Discovery of Microorganisms

Earliest microscopic observations.

- Francesco Stelluti: observed bees and weevils between 1625 to 1630.
- ***Robert Hooke***: published drawings of the fungus *Mucor* in his book, *Micrographia*, in 1665.
- ***Antony van Leeuwenhoek*** (1632 to 1723): First person to observe micro-organisms accurately.

(a)

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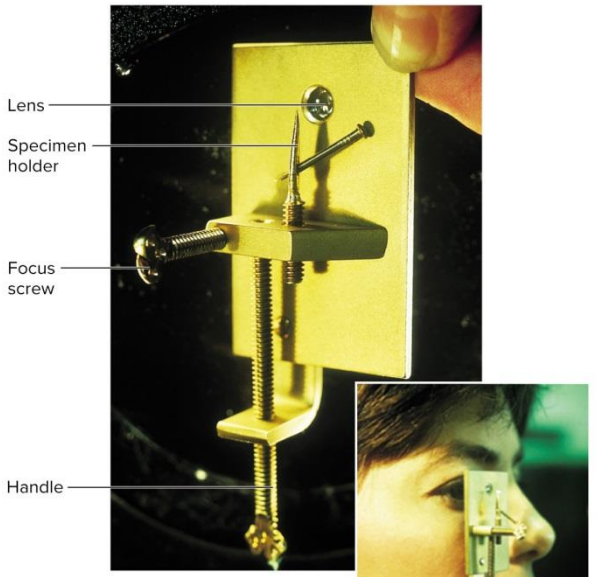

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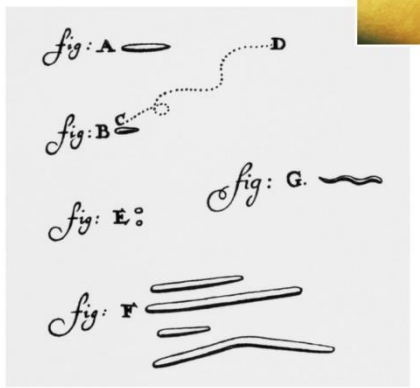

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The Conflict Over Spontaneous Generation

Spontaneous generation.

- Idea that living organisms can develop from nonliving or decomposing matter.

Francesco Redi (1626 to 1697).

- Discredited spontaneous generation.
- ***Showed that maggots on decaying meat came from fly eggs.***

John Needham (1713 to 1781).

- His experiment: mutton broth in flasks → boiled →sealed.
- ***Results: broth became cloudy and contained microorganisms.***

Lazzaro Spallanzani (1729 to 1799).

- His experiment: water and seeds in flasks → sealed → boiled.
- ***Results: no growth of microorganisms***.

Louis Pasteur (1822 to 1895)

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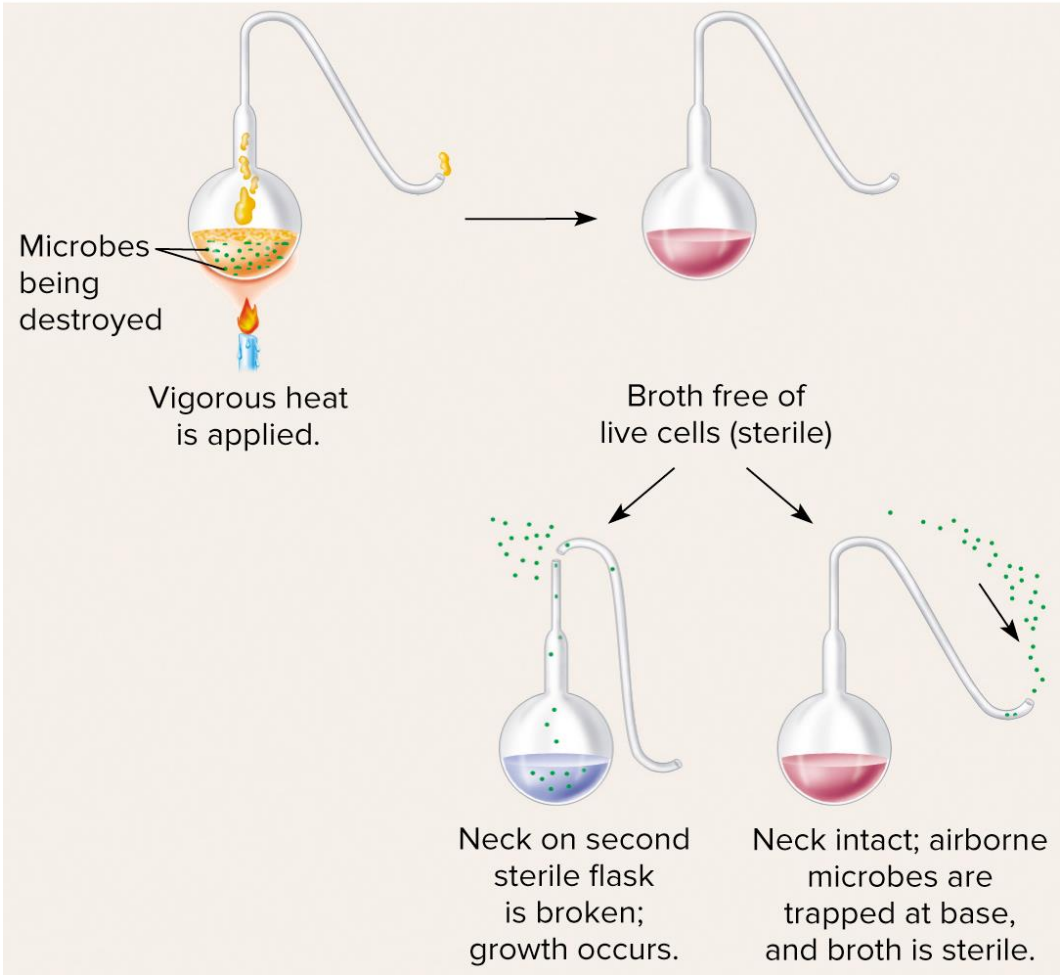
***'Swan-neck flask' experiments*.**

- ***Placed nutrient solution in flasks.***
- ***Created flasks with long, curved necks.***
- ***Boiled the solutions.***
- ***Left flasks exposed to air.***

Results: no growth of microorganisms.

Swan-Necked Flask Experiments of Pasteur



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Final Blow to Theory of Spontaneous Generation

John Tyndall (1820 to 1893).

- Demonstrated that dust carries microorganisms.
- Showed **that if dust was absent, nutrient broths remained sterile, even if directly exposed to air.**
- Also provided evidence for the existence of exceptionally heat-resistant forms of bacteria.

Ferdinand Cohn (1828 to 1898).

- Heat-resistant bacteria could produce endospores.

The Role of Microorganisms in Disease

Was *not* immediately obvious.

Infectious disease believed to be due to supernatural forces or imbalances of 4 bodily-fluid 'humors'.

Establishing connection depended on. development of techniques for studying microbes.

Further Early Evidence for the Relationship Between Microorganisms and Disease

Louis Pasteur (1822 to 1895).

- Demonstrated microorganisms carried out. fermentations, helping French wine industry and publishing papers on fermentation from 1857 to 1860.
- Developed pasteurization to avoid wine spoilage by microbes.

Even More Evidence for the Relationship Between Microorganisms and Disease

Joseph Lister (1827 to 1912).

- Provided indirect evidence that microorganisms were the causal agents of disease.
- *Developed an antiseptic surgery system to prevent microorganisms from entering wounds.*
- His patients had fewer postoperative infections.

Final Proof

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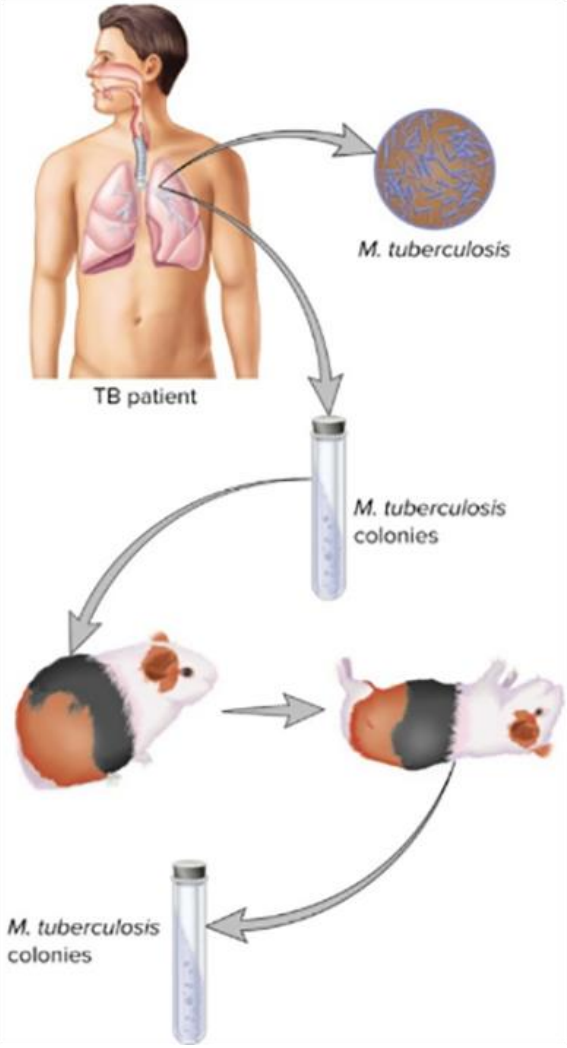
Robert Koch (1843 to 1910).

- Established the relationship between *Bacillus anthracis* and anthrax.
- Used criteria developed by his teacher Jacob Henle (1809 to 1885).
- These criteria now known as *"Koch's postulates"* are still used today to establish the link between a particular microorganism and a particular disease.

Koch's Postulates and Tuberculosis

Postulate	Experimentation
1. The microorganism must be present in every case of the disease but absent from healthy organisms.	Koch developed a staining technique to examine human tissue. *M. tuberculosis* could be identified in diseased tissue.
2. The suspected microorganisms must be isolated and grown in a pure culture.	Koch grew *M. tuberculosis* in pure culture on coagulated blood serum.
3. The same disease must result when the isolated microorganism is inoculated into a healthy host.	Koch injected cells from the pure culture of *M. tuberculosis* into guinea pigs. The guinea pigs subsequently died of tuberculosis.
4. The same microorganisms must be isolated again from the diseased host.	Koch isolated *M. tuberculosis* in pure culture on coagulated blood serum from the dead guinea pigs.



Limitations of Koch's Postulates

Some organisms cannot be grown in pure culture.

Using humans in completing the postulates is unethical.

Molecular and genetic evidence may replace and overcome these limits.

The Development of Techniques for Studying Microbial Pathogens

Koch's work led to discovery or development of.

- Agar.
- Petri dishes.
- Nutrient broth and nutrient agar.
- Methods for isolating microorganisms.

Charles Chamberland (1851 to 1908).

- Developed *porcelain bacterial filters* used by Ivanoski and Beijerinck to study tobacco mosaic disease.
  - ***Determined that extracts from diseased plants had infectious agents present which were smaller than bacteria and passed through the filters.***
  - Infectious agents were eventually shown to be viruses.

Other Development

Pasteur and Roux.

- Discovered that incubation of cultures for long intervals between transfers caused pathogens to lose their ability to cause disease (***termed 'attenuation***').

Pasteur and his coworkers.

- Developed vaccines for chicken cholera, anthrax, and rabies.

Immunological Studies

Led to study of host defenses—immunology.

Edward Jenner (1749 to 1823).

- Used vaccination procedure to protect against smallpox.

Emil von Behring (1854 to 1917) and Shibasaburo ***Kitasato*** (1852 to 1931).

- Developed antitoxins for diphtheria.

Elie Metchnikoff (1845 to 1916).

- Discovered bacteria-engulfing, phagocytic cells in blood.

Microbial Ecology

Sergei Winogradsky (1856 to 1953) and ***Martinus*** Beijerinck (1851 to 1931).

- Studied soil microorganisms and discovered numerous interesting metabolic processes (for example, nitrogen fixation).
- Pioneered the use of enrichment cultures and selective media.

Microbiology Has Basic and Applied Aspects

Basic aspects are concerned with individual groups of microbes, microbial physiology, genetics, molecular biology, and taxonomy.

Applied aspects are concerned with practical problems—disease, water, food, and industrial microbiology.

Molecular and Genomic Methods

Led to a second golden age of microbiology (rapid expansion of knowledge).

Discoveries.

- Restriction endonucleases (Arber and Smith).
- First novel recombinant molecule (Jackson, Symons, Berg).
- DNA sequencing methods (Woese, Sanger).
- Bioinformatics and genomic sequencing and analysis.

Major Fields in Microbiology

Medical microbiology—diseases of humans and animals.

Public health microbiology—control and spread of communicable diseases.

Immunology—how the immune system protects a host from pathogens.

Microbial ecology is concerned with the relationship of organisms with their environment.

Agricultural microbiology is concerned with the impact of microorganisms on food production.

Food microbiology—microbes used to make food and beverages as well as spoilage microbes.

More Microbiology Fields

Industrial microbiology.

- Penicillin and other antibiotics.
- Vaccines, steroids, alcohols and other solvents, vitamins, amino acids, enzymes, and biofuels.

Microbial physiology studies metabolic pathways of microorganisms.

Microbial genetics, molecular biology, and bioinformatics study the nature of genetic information and how it regulates the development and function of cells and organisms.

Microbes are a model system of genomics.