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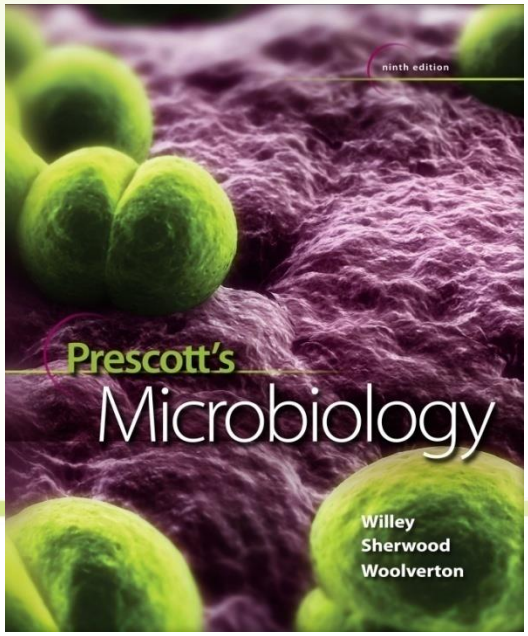


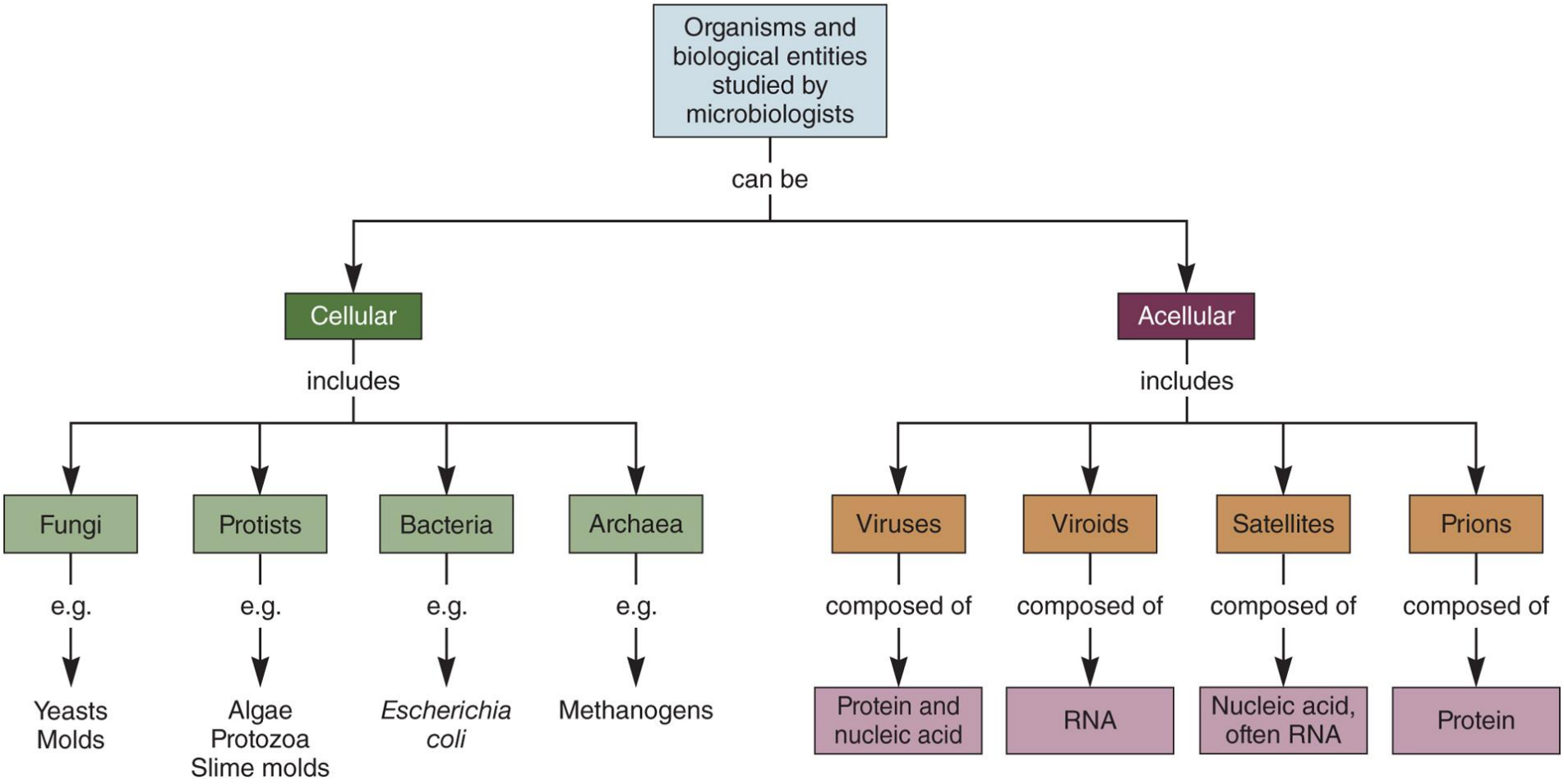
The Evolution of Microorganisms and Microbiology

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 المشروبات, antibiotics, and vitamins
- Some cause disease in plants and animals

Members of the Microbial World

- Organisms and acellular entities too small to be clearly seen by the unaided eye
  - some < 1 mm, some macroscopic
- These organisms are relatively simple in their construction and lack highly differentiated cells and distinct tissues

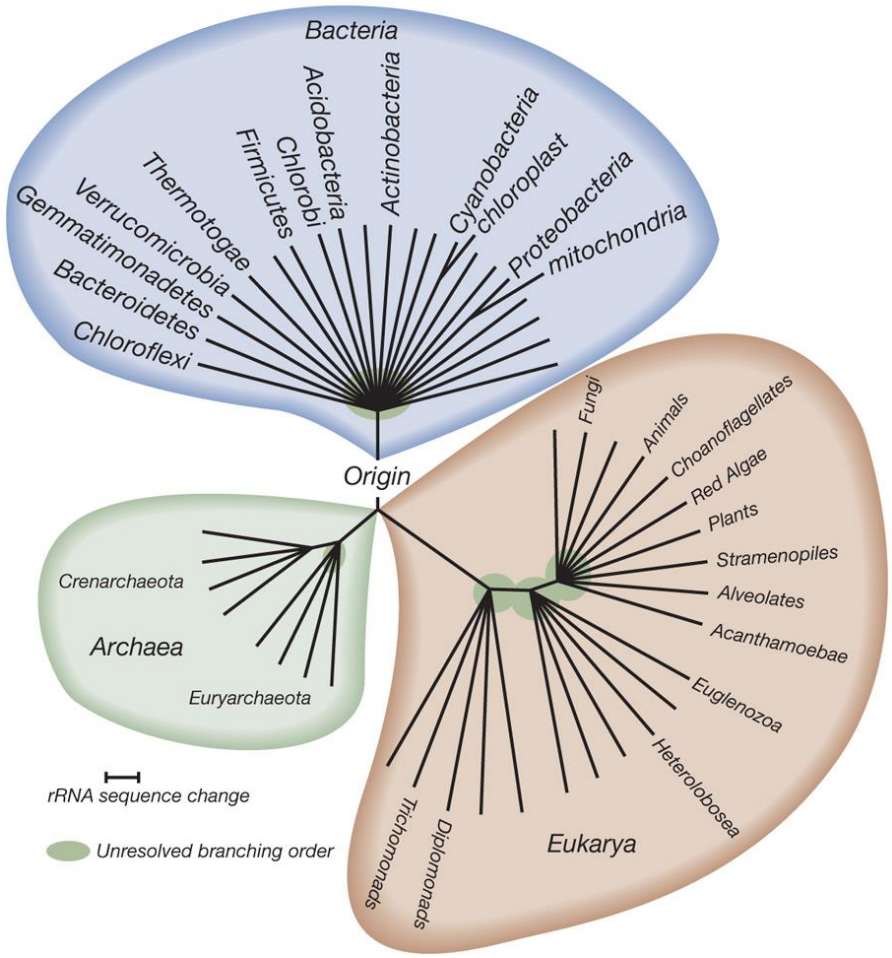


Type of Microbial Cells

- 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)*



Domain *Bacteria*

- Usually single-celled
- Majority have cell wall with peptidoglycan
- Most lack a membrane-bound nucleus
- Ubiquitous واسع الانتشار 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* - *E*ukaryotic

- Protists – generally larger than *Bacteria* and *Archaea*
  - algae – photosynthetic
  - protozoa – may be motile, “hunters, grazers”
  - slime molds – two life cycle stages
  - water molds – devastating مدمّر disease in plants
- Fungi
  - yeast - unicellular
  - mold - multicellular

Acellular Infectious Agents

- Viruses
  - smallest of all microbes
  - requires host cell to replicate
  - cause range of diseases, some cancers
- Viroids and virusoids
  - infectious agents composed of RNA
- Prions – infectious proteins

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 descendents of a single, pure microbial culture
  - may be biovars, serovars, morphovars, pathovars
- binomial nomenclature
  - genus and species epithet

Microbiology - Origins

- Study of microorganisms
- Tools used for the study
  - microscopes
  - culture techniques
  - molecular genetics
  - genomics

Discovery of Microorganisms

- Antony van Leeuwenhoek (1632-1723)
  - first person to observe and describe microorganisms *accurately*

(a)

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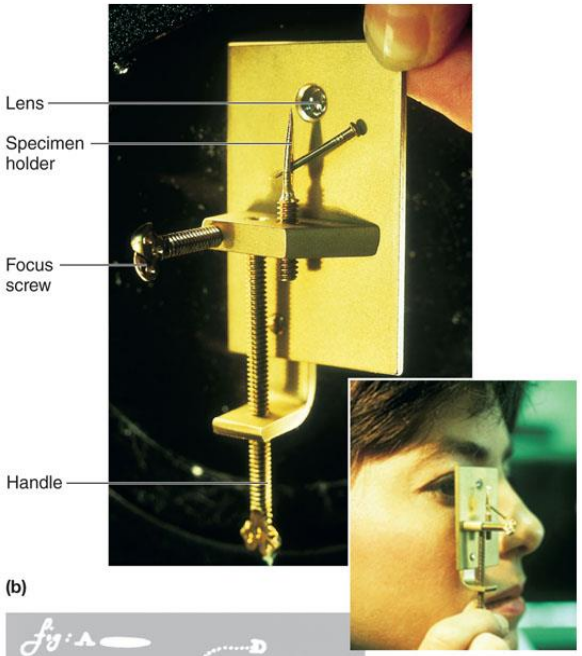

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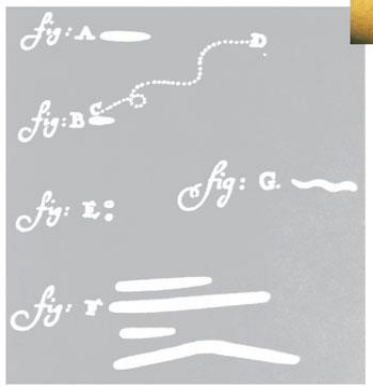

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The Role of Microorganisms in Disease

- 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

Some Evidence…

- Louis Pasteur
  - demonstrated microorganisms carried out fermentations, helping French wine industry
  - developed pasteurization to avoid wine spoilage by microbes
  - showed that the pébrine disease of silkworms was caused by a protozoan

Other Evidence…

- Joseph Lister
  - provided indirect evidence that microorganisms were the causal agents of disease
  - developed a system of surgery designed to prevent microorganisms from entering wounds as well as methods for treating instruments and surgical dressings
  - his patients had fewer postoperative infections

Final Proof…

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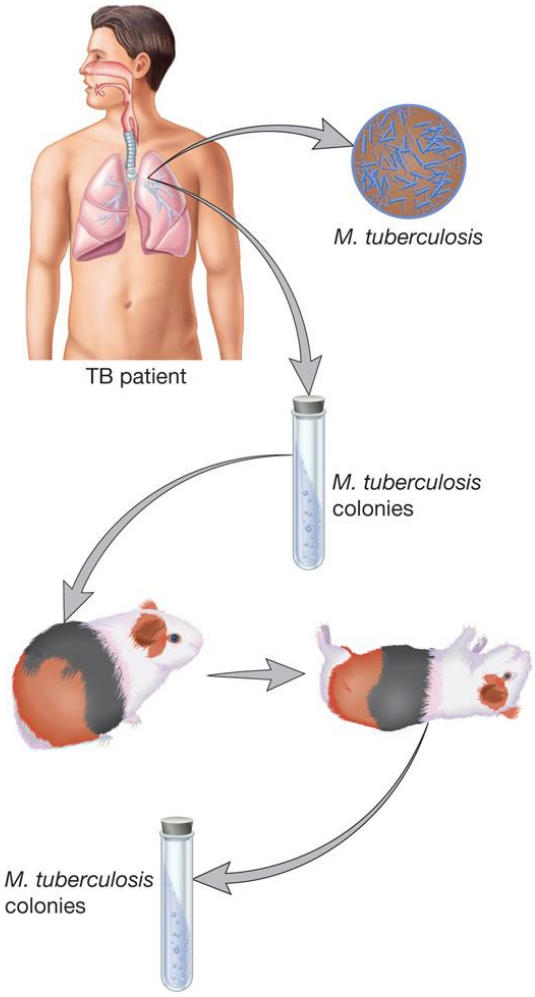
- Robert Koch (1843-1910)
  - established the relationship between *Bacillus anthracis* and anthrax
  - used criteria developed by his teacher Jacob Henle (1809-1895)
  - these criteria now known as Koch's postulates
    - still used today to establish the link between a particular microorganism and a particular disease

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. *Mycobacterium 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

Other Developments…

- 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

- once established, led to study of host defenses - immunology
- Edward Jenner (ca. 1798)
  - used a vaccination procedure to protect individuals from smallpox

    NOTE: this preceded the work establishing the role of microorganisms in disease!

More Developments…

- Emil von Behring (1854-1917) and Shibasaburo Kitasato (1852-1931)
  - developed antitoxins for diphtheria and tetanus
  - evidence for humoral (antibody-based) immunity
- Elie Metchnikoff (1845-1916)
  - discovered bacteria-engulfing, phagocytic cells in the blood
  - evidence for cellular immunity

The Development of Industrial Microbiology and Microbial Ecology

- Louis Pasteur
  - demonstrated that alcohol fermentations and other fermentations were the result of microbial activity
  - developed the process of pasteurization to preserve wine during storage

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

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

More Fields…

- Microbial ecology is concerned with the relationship of organisms with their environment
  - less than 1% of earth's microbial population has been cultured
- Agricultural microbiology is concerned with the impact of microorganisms on agriculture
  - food safety microbiology
  - animal and plant pathogens

More Fields….

- Industrial microbiology began in the 1800s
  - fermentation
  - antibiotic production
  - production of cheese, bread, etc.
- Microbial physiology studies metabolic pathways of microorganisms

More Fields….

- Molecular biology, microbial genetics, 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