SQBI 1303 MICROBIOLOGY

INTRODUCTION TO MICROBIOLOGY

Adibah Yahya, PhD

Robert Hooke

Microscopy (1677 -1884)

Antony van Leeuwenhoek

Culture method (1882-1887)

Defense or Control of Microbe (1796 - 1928)

Alexander falmming

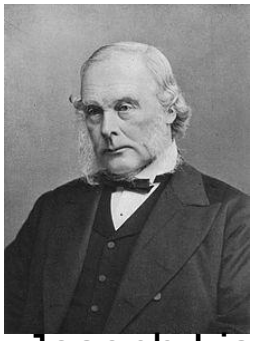
Paul Ehrlich

Joseph Lister

Paul Ehrlich

Germ theory and disease (1860-1876)

Louis Pasteur



Joseph Lister

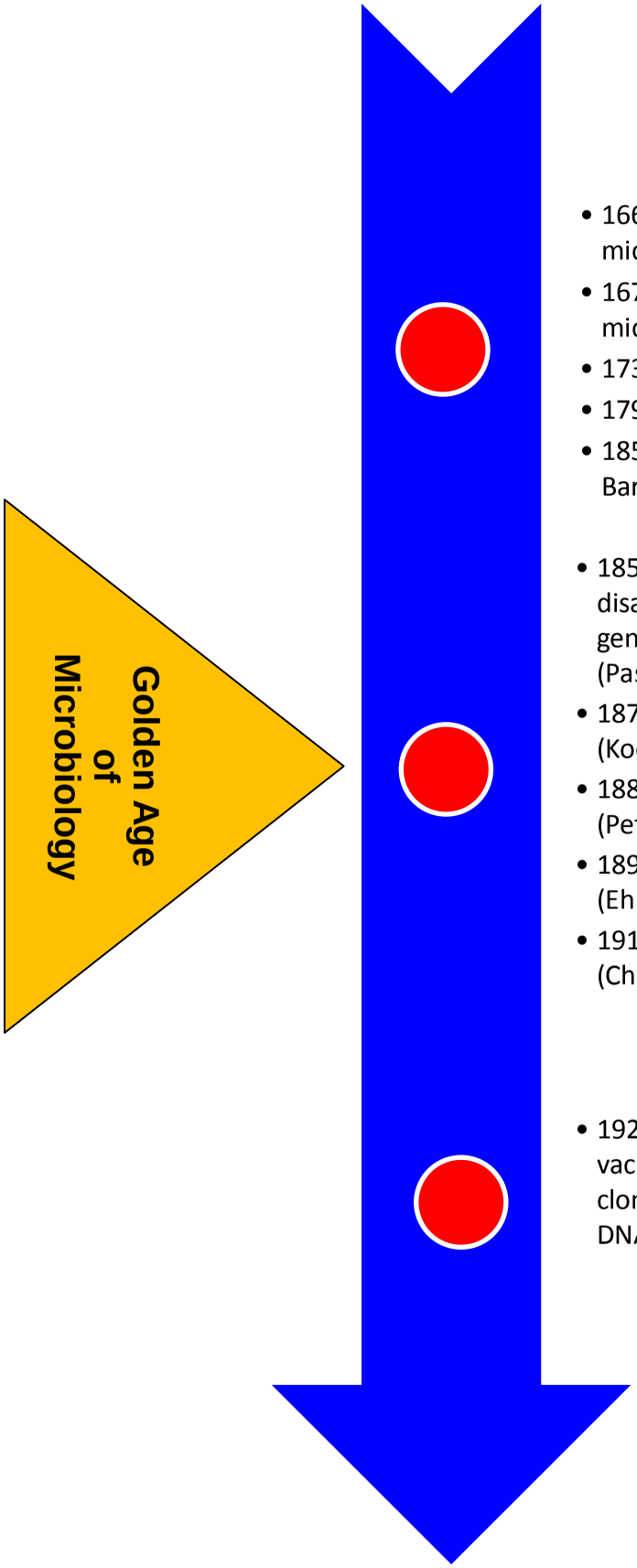
Virology (1892-1899)

Martinus Beijerinck

Molecular Methods (1977-1995)

Gilbert & Sanger

Dmitri Iosifovich Ivanovski



- 1665 - First observation of microorganisms (Hooke)
- 1673 - First observation of living microbes (Leeuwenhoek)
- 1735 - Microbial nomenclature
- 1798 – First vaccine (Jenner)
- 1853 – Fungal plant disease (De Bary)

- 1857 - 1864 : Fermentation, disapprove spontaneous generation and pasteurization (Pasteur)
- 1876 - Germ theory of disease (Koch)
- 1887 – discovery of Petri dish (Petri)
- 1890 – Theory of Immunity (Ehrlich)
- 1910 – Tripanosoma cruzi (Chagas) & Syphilis (Ehrlich)

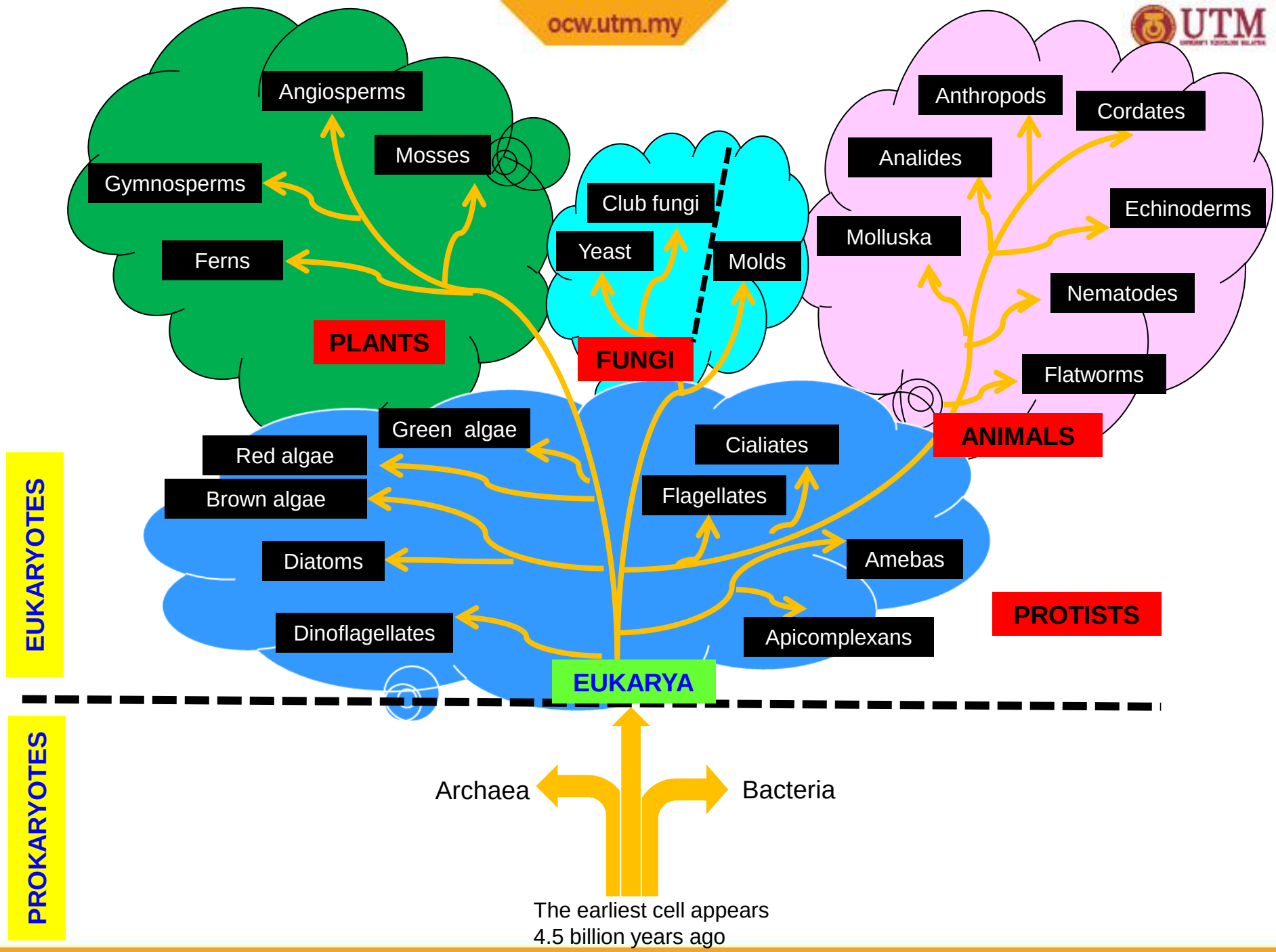
- 1928 – 1997 : development of vaccine, DNA structure, DNA cloning, Genetic engineering, DNA sequencing

1. What are Microbes

- Microbes are small organisms, generally smaller than human eye can detect

- Typical microbes are
  - **bacteria** (in Kingdom Monera)
  - **protozoa** (in Kingdom Protista)
  - **algae** (in Kingdom Protista or Plantae, depending on taxonomy)
  - **fungi** (in Kingdom Fungi)

- Note: only members of the Kingdom Animalia (and most Plantae) are not considered microbes


Angiosperms
Mosses
Gymnosperms
Ferns
PLANTS
Club fungi
Yeast
Molds
FUNGI
Anthropods
Cordates
Analides
Echinoderms
Molluska
Nematodes
Flatworms
ANIMALS
Green algae
Red algae
Brown algae
Diatoms
Dinoflagellates
Cialiates
Flagellates
Amebas
Apicomplexans
PROTISTS
EUKARYOTES
EUKARYA
PROKARYOTES
Archaea
Bacteria
The earliest cell appears
4.5 billion years ago

Viruses

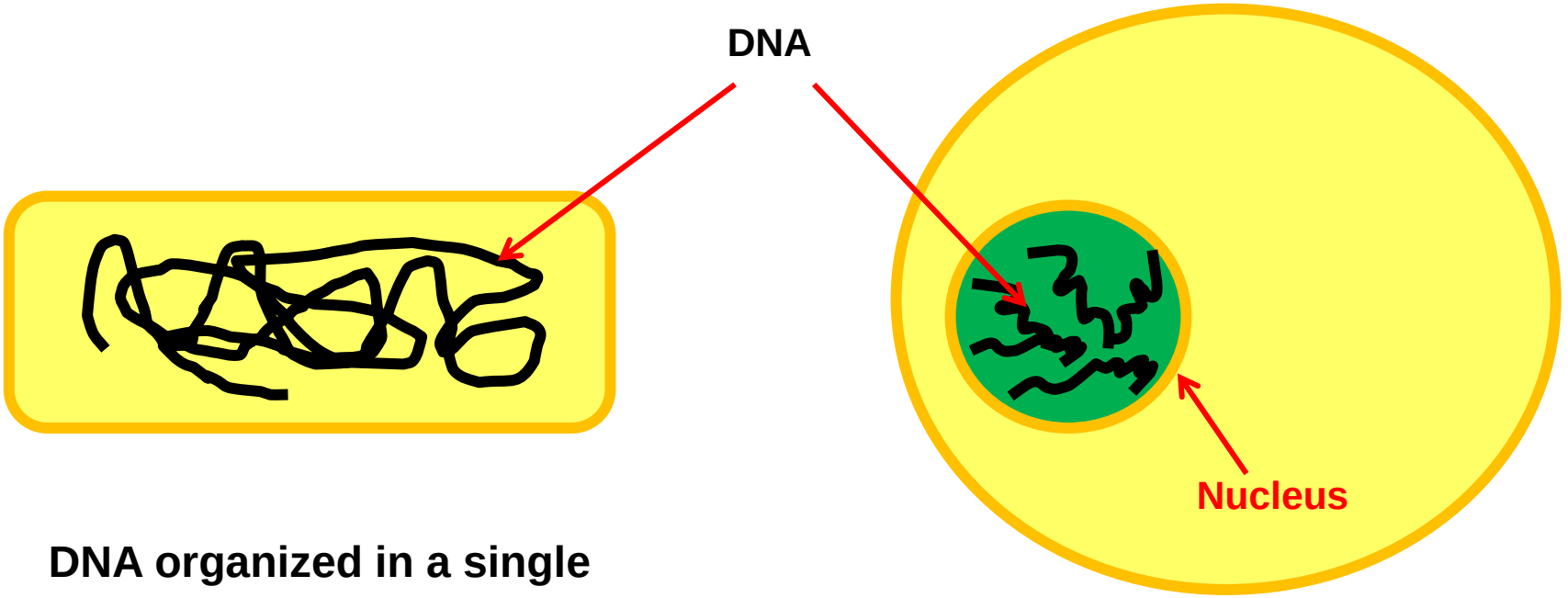
- are also considered as microbes but it is not cells. Viruses is often called an informational parasite.

- Viruses are classified separately. Each Kingdom has its own associated viruses (e.g., HIV virus that causes AIDS cannot infect bacteria or plants, or for that matter other mammals).

- Many microbes live as single cells or cell clusters; some multicellular (e.g. filamentous multicells), but not as complex as animals and plants

2. The Structure of Microbes

- Two basic cell architectures: prokaryotes & eukaryotes



DNA organized in a single chromosome. No true nucleus

DNA organized in multiple chromosomes inside a nucleus

2. The Structure of Microbes

Prokaryotes

- "pro" = before, + "karyos" = nucleus
- Includes **bacteria** and **cyanobacteria** (formerly blue-green algae)
- Simple architecture not understood until EM technology in 1940's
- Sample electron micrographs
- Typical sizes: 1 um diameter

2. The Structure of Microbes

Eukaryotes

- "eu" = true, & "caryos" = nucleus

- Typically contain membrane-bounded organelles (e.g. mitochondria, lysosomes, endoplasmic reticulum, Golgi bodies)

- Typical sizes: from 5 μm (yeast cells) to 50 or 100 μm. A few cells (such as bird eggs) are enormous, and some cells (such as animal nerve cells) can attain lengths of many meters, even though small in diameter.

- Includes protists, fungi, animals and plants.

3. The Variety of Bacteria

Various shapes of bacteria

- **Rods** = **bacilli** (*sing.* **bacillus**).

✓ Such as *Pseudomonas aeruginosa*, a common opportunistic pathogen and widely distributed soil bacteria ; appear as long bacilli bacteria under the light microscope

✓ Others such as *Bacillus subtilis*, *Thiobacillus acidophilus*

- **Spheres** = **cocci** (*sing.* **coccus**).

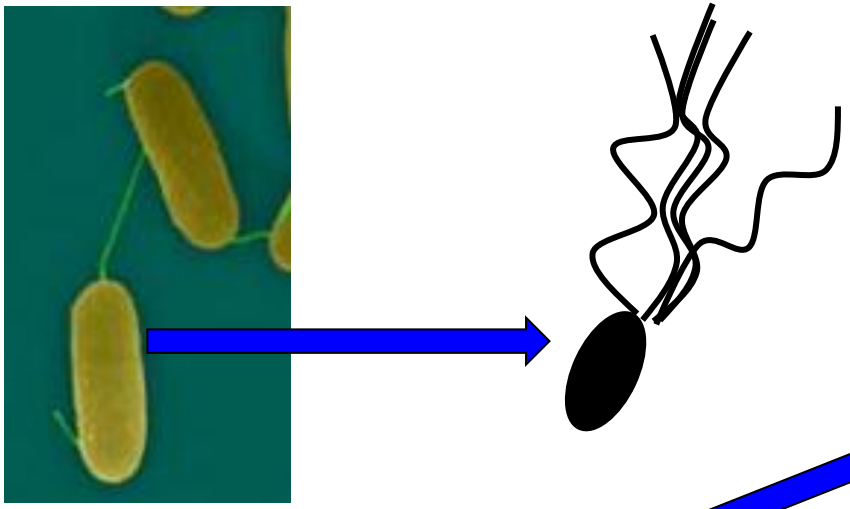
✓ Such as *Staphylococcus aureus, Micrococcus* sp.

- **Spiral** forms = **spirilla** (*sing.* **spirillum**).

✓ Such as *Borrelia burgdorferi (*causes Lyme disesase), *Leptospirillum*

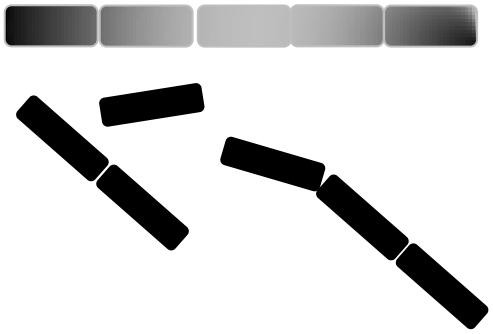
Rods bacilli

Pseudomonas aeruginosa



Thiobacillus ferrooxidans

Bacillus subtilis



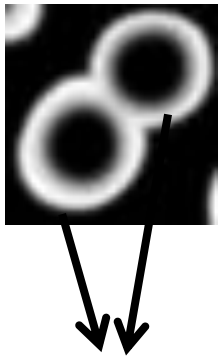
Spore core (DNA)

Spore coat

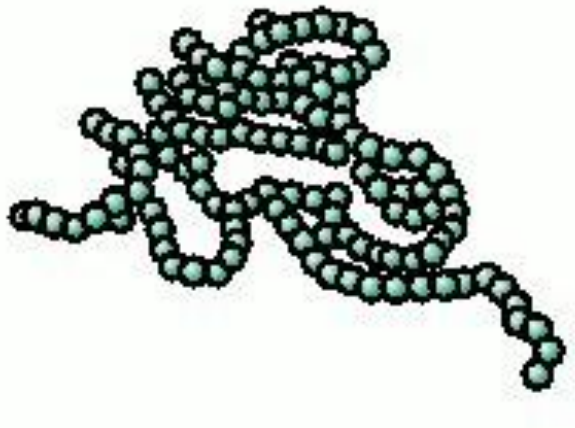
Sporulating bacilli

TEM image of bacilli-form

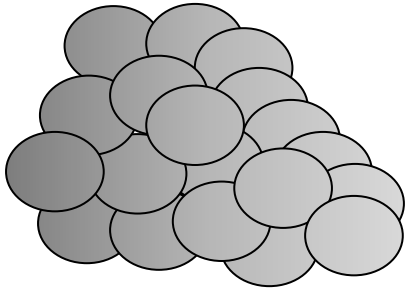
Cocci



Diplococci – consists of 2 coccus cells present in pair

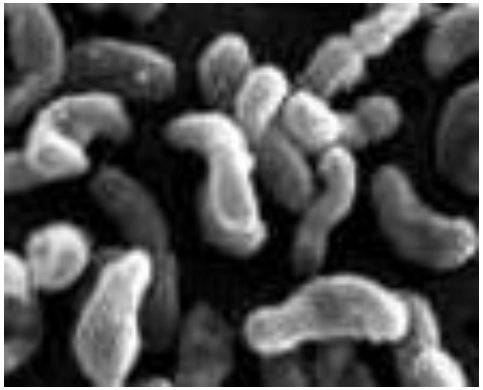


Streptococci – coccus arranged in filamentous of many coccus cells

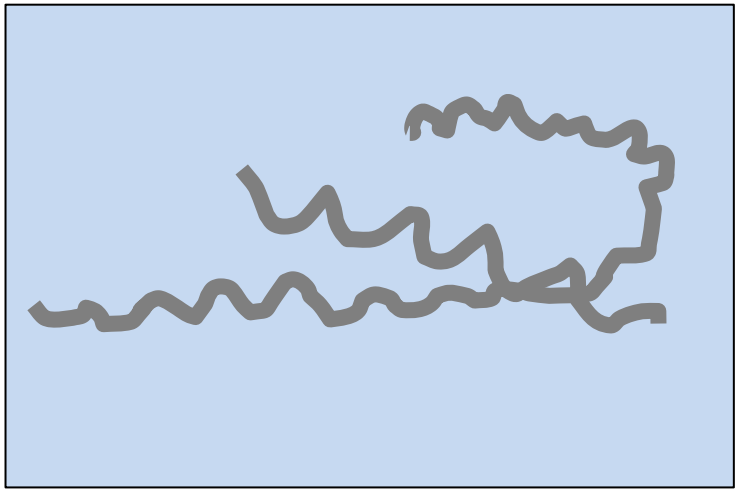


Staphylococci – cluster of coccus cells (grape-like arrangement)

Spirilla



Vibrio



Spirillum

3. The Variety of Bacteria

- **Filamentous**

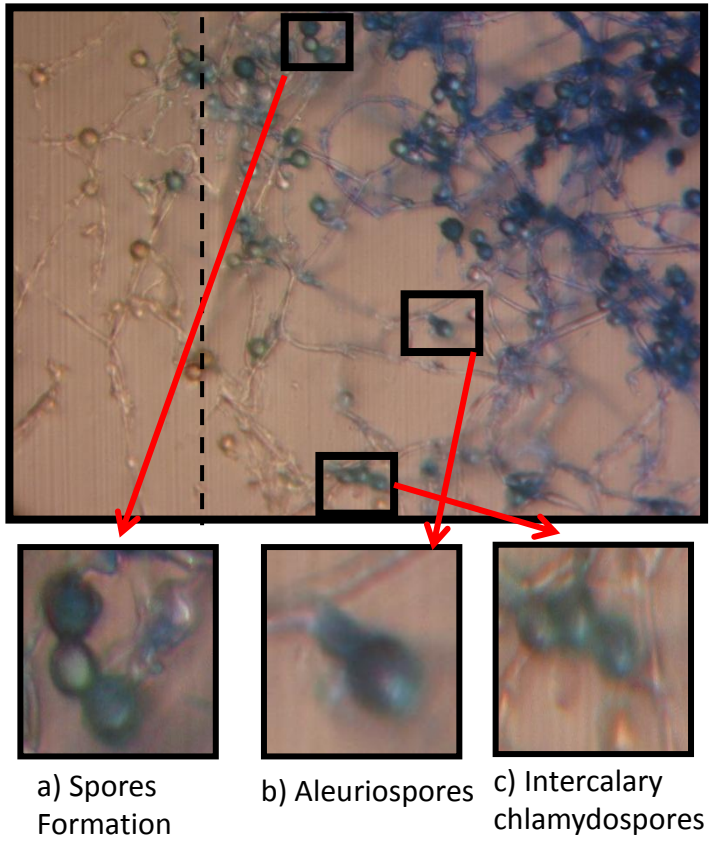
✓Common among actinomycetes. Many grow in branching filamentous network called **mycelium**.

- **Pleiomorphic**

✓ Some bacteria lack distinct shape; typical of **Mycoplasmas** (also called Acholeplasmas). These organisms lack cell walls, so have no well defined shape.

- **Square bacteria**: discovered 1981, a halophile from Red Sea shore

Filamentous Microbes

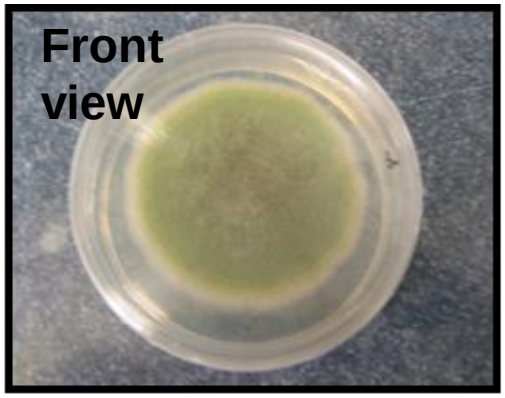


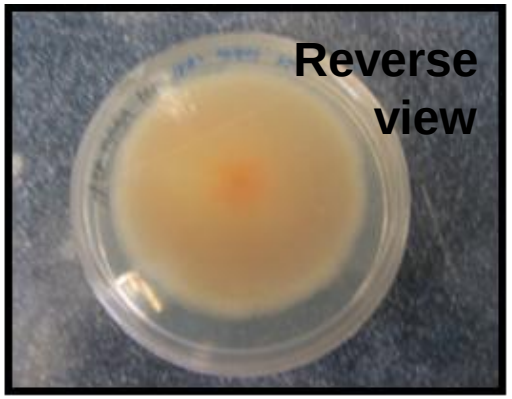
a) Spores Formation

b) Aleuriospores

c) Intercalary chlamydospores

Fungal spore observed under light microscope





Filamentous fungi grown on Potato Dextrose agar

3. The Variety of Bacteria

Bacterial Nomenclature

- Named by the Linnaean system: **Genus + species**.

Examples:

1. *Escherichia* (genus) *coli* (species). Named after Theodor Escherich, German bacteriologist who discovered this organism in intestinal tract in 1885. He called it *Bacterium coli*, but it was subsequently renamed in his honor.

2. *Bacillus megaterium*; a large rod shaped organism, member of the Genus *Bacillus*.

3. *Streptococcus faecalis*; fecal organism, member of the streptococci, a large genus, some members live in or on animal hosts.

3. The Variety of Bacteria

Bacterial Nomenclature

In general :

- Name often reveals some characteristic feature.
- Note: ***Bacillus*** (one genus of bacteria, italicized)
  vs bacilli (general term for rods, not italicized)

4. What do microbes do?

EAT, GROW, AND DIVIDE ≡ SURVIVAL

Table showing the growth rates of different organims

Organisms	Time required to consume body weight
Human	180 days
Pig	20 days
Yeast	30 minutes
Lactobacillus	10 minutes
Micrococcus	3 minutes

4. What do microbes do?

Growth rates can be phenomenally fast:

e.g. some bacteria can reproduce every 20 min. under optimal conditions. 2 hours, could have 271 bacteria = 2.4 x 1021. Bacterial cell weighs ca. 10-12 g., so 24 hours growth weighs 2.4 x 1010grams = 2.4 x 107 kg = 26,400 tons.

4. What do microbes do?

Physiology: what kinds of foods do they eat? How do they extract energy?

Lots of extraordinary : e.g. some bacteria can use up to 150 different chemicals as the ONLY source of carbon.

Imagine your life if you could do this !!

4. What do microbes do?

Bacteria in animal gut are important for animals to digest food.

In some animals, bacteria are obligatory, animals cannot survive without them

4. What do microbes do?

Many human foodstuffs are produced by bacteria or fungi.

E.g. yogurt, cheese, and other sour milk products; saurkraut; beer, wine, and all other alcoholic beverages; vinegar.

4. What do microbes do?

Bacteria rarely enjoy continued ample food, so much time spent in dormant or near-dormant states.

Bacteria can survive with minimal metabolism in very extreme environments, including antarctic ice, rocks (as far as a mile below earth's surface), boiling sulfur springs, and more.

4. What do microbes do?

Bacteria have many sophisticated mechanisms for handling lack of food

This include secreting antibiotics and other toxins ("get rid of the competition"), modifying intracellular metabolism, and producing modified structures for dormancy (spores, cysts, endospores).

5. Why is microbiology important?

- **Disease**. Since discovery of infectious microbes, most infectious diseases controlled by sanitation, preventive medicine, and chemotherapy.

- **Agriculture**. microbes vital in processing materials in soil, e.g. nitrogen, sulfur, etc.

- **Food and drink**. Microbial fermentations responsible for all alcoholic beverages, breads, pickles, cheeses, etc. Control of food and drink spoilage is major concern of food industry.

5. Why is microbiology important?

- **Chemical products**. Microbes have incredible variety of metabolic tricks; can be used to produce acetone and other commercial solvents, pharmaceuticals, antibiotics, preservatives, etc.

- **Basic research**. Microbes grow fast, produce enormous # of offspring. Easy to find events that occur only 1 in a billion times if have 100 billion bacteria in test tube. Crucial to modern biology.

5. Why is microbiology important?

- **Biotechnology.** E.g. genetic engineering, ability to move genes freely from one organism to another, select genes of interest and amplify their expression. Bacteria are natural hosts for such activities.

- **Modern Biotechnology**. Multicolour biotechnology (green biotech, red biotech, white biotech, black/grey biotect). Metabolic engineering, protein engineering, tissue engineering, biorefining technology

THE GOOD, THE BAD AND THE UGLY

- Causative agents of diseases and emerging diseases

- Beneficial Microbes

- Winogradsky & Beijerinck: recycling carbon & nitrogen
- Sewage treatment: recycling water
- Bioremediation: clean up of pollutants
- Biological control: Insect control by microbial toxin
- Traditional Biotechnology (Fermentation, industrial microbiology)
  - **Sourdough and yoghurt**
  - **Antibiotics, citric acid, lactic acid**

- Modern Microbial Biotechnology & Genetic Engineering
  - Proteins: IGF, Insulin, GH, interferon, factor VIII, tissue plasminogen activator, erytropoietin, beta-endorphin
  - Vaccines: Hepatitis B, Malaria, influenza
  - Improved early diagnostics: monoclonal antibodies
  - Gene therapy: Adenosine deaminase cystic fibrosis, muscular dystrophy
  - Genetic improvement in industrial strains
  - Agricultural applications: flavor, shelf life, color, texture, damage protection.

- Importance of Normal microflora
  - Protection
  - Digestion and energy: ruminants & termites

Proof that microbes cause disease:

- 1546: Hieronymus Fracastorius wrote "On Contagion", the first known discussion of the phenomenon of contagious infection.
- 1835 Agostino Bassi de Lodi showed that a disease affecting silkworms was caused by a fungus - the first microorganism to be recognized as a contagious agent of animal disease.
- 1847: Ignaz Semmelweiss (1818-1865), decided that doctors in Vienna hospitals were spreading childbed fever while delivering babies. He started forcing doctors under his supervision to wash their hands before touching patients.
- 1857: Louis Pasteur proposed the "germ theory" of disease.
- 1867: Joseph Lister (1827-1912) introduced antiseptics in surgery. By spraying carbolic acid on surgical instruments, wounds and dressings, he reduced surgical mortality due to bacterial infection considerably.
- 1876: Robert Koch (1843-1910). German bacteriologist was the first to cultivate anthrax bacteria outside the body using blood serum at body temperature. Building on pasteur's "germ theory", he subsequently published **"Koch's postulates"** (1884),

So,…

In your opinion, who are the microbiologists ?