Introduction, history and scope of microbiology

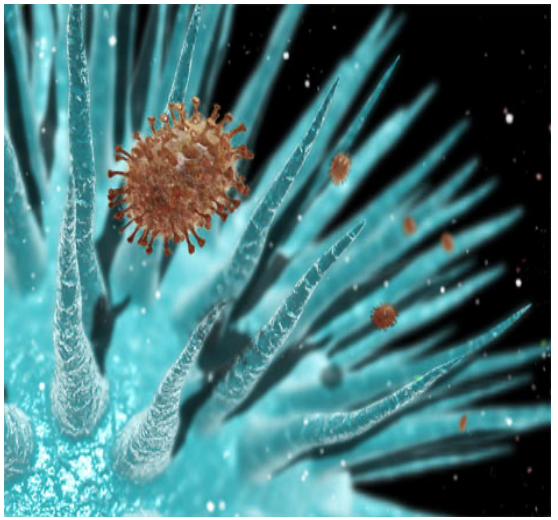
Dr. Ariyah Terasawat

General Microbiology

- Microbiolgy (Mikros, “small”, Bioc, “life”, logia, “study of microscopic organisms.
- Microorganisms can be too small to be seen by the naked eye such as bacteria, viruses, etc.…Or big enough such as the bread mold, some algae, etc..
- Microbiology encompasses numerous sub-disciplines including virology, mycology, parasitology, and bacteriology.

Bacteria

Virus



The Science of Microbiology

- Microbiology revolves around two themes:
  1. Understanding basic life processes
     - Microbes are excellent models for understanding cellular processes in unicellular *and* multicellular organisms
  2. Applying that knowledge to the benefit of humans
     - Microbes play important roles in medicine, agriculture, and industry

Taxonomy is a subset of systemics.

Systemics is the study of organisms in order to place organisms having similar characteristics into the same group.

Taxonomy has three components:

- ***Classification***: The arrangement of organisms into groups based on similar characteristics, evolutionary similarity or common ancestry. These groups are also called taxa.
- ***Nomenclature***: The name given to each organism. Each name must be unique and should depict the dominant characteristic of the organism.
- ***Identification***: The process of observing and classifying organisms into a standard group that is recognized throughout the biological community.

Taxonomy has two functions

- First to identify and describe as completely as possible to the basic taxonomic unit or species and
- second, to devise a method for arranging and cataloguing these species.

Benefits

To distinguish one individual from another, we need to establish certain criteria and this art of biological classification is known as taxonomy or systematics.

Taxonomy is therefore, the systematic arrangement of organisms in groups or categories called taxa (taxon-singular).

Microbial Taxonomy

- Classification Systems
- Levels of Classification
- Definition of “Species”
- Nomenclature
- Useful Properties in Microbial Classification
- Microbial Phylogeny

Levels of Classification

- Taxon:
  - A group or “level” of classification
  - Hierarchical; broad divisions are divided up into smaller divisions:
    - Kingdom (Not used by most bacteriologists)
    - Phylum (Called “Division” by botanists)
    - Class
    - Order
    - Family
    - Genus (plural: Genera)
    - Species (Both singular & plural)

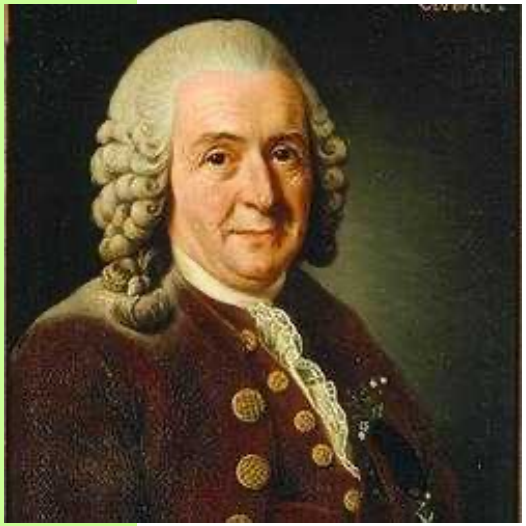
Definition of “Species”

- The “basic unit” of taxonomy, representing a specific, recognized type of organism
- For sexually reproducing organisms, a fundamental definition of “species” has been reproductive compatibility
- This definition fails for many microbial species (including bacteria), because they do not reproduce sexually

- **Definition of "species" in microbiology:**
  - **Classic definition: A collection of microbial strains that share many properties and differ significantly from other groups of strains**
  - **Species are identified by comparison with known "type strains": well-characterized pure cultures; references for the identification of unknowns**

ATCC	American Type Culture Collection	**Manassas, Virginia**
NCTC	National Collection of Type Cultures	**Public Health England, UK**
BCCM	Belgium Coordinated Collection of Microorganisms	**Ghent, Belgium**
CIP	Collection d'Institut Pasteur	**Paris, France**
DSMZ	Deutsche Sammlung von Mikroorganismen und Zellkulturen	**Braunschweig, Germany**
JCM	Japan Collection of Microorganisms	**Saitama, Japan**
NCCB	Netherlands Culture Collection of Bacteria	**Utrecht, Netherlands**
NCIMB	National Collection of industrial, Marine and food bacteria	**Aberdeen, Scotland**
ICMP	International Collection of Microorganisms from Plants	**Auckland, New Zealand**
TISTR	Thailand Institute of Scientific and Technological Research	**Bangkok, Thailand**

History of taxonomy

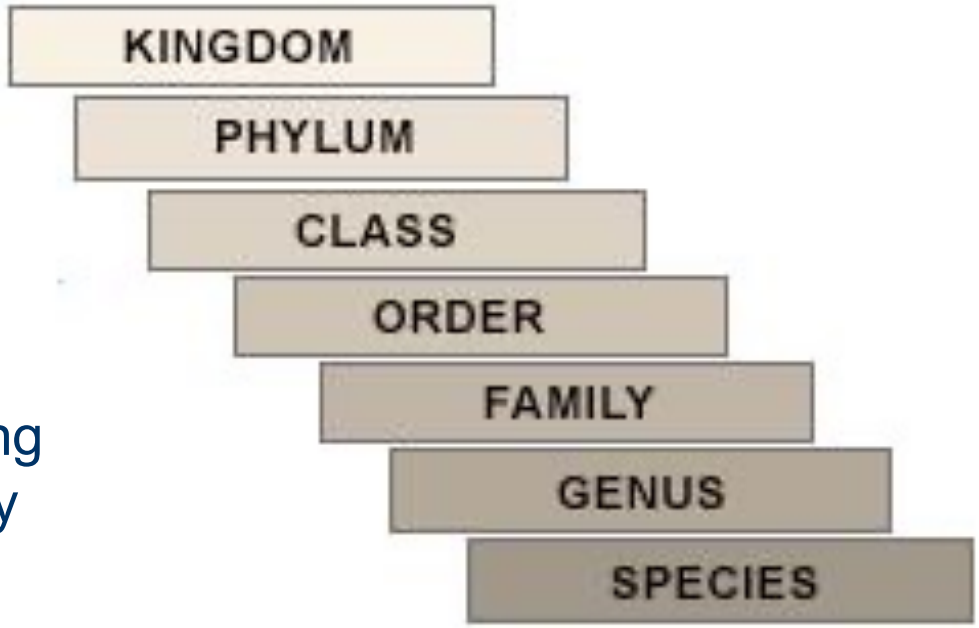


*A Swedish naturalist named **Carolus Linnaeus** is considered the **'Father of Taxonomy'** since 1700s

*His two most important contributions to taxonomy were:
- A hierarchical classification system
- The system of **binomial nomenclature**

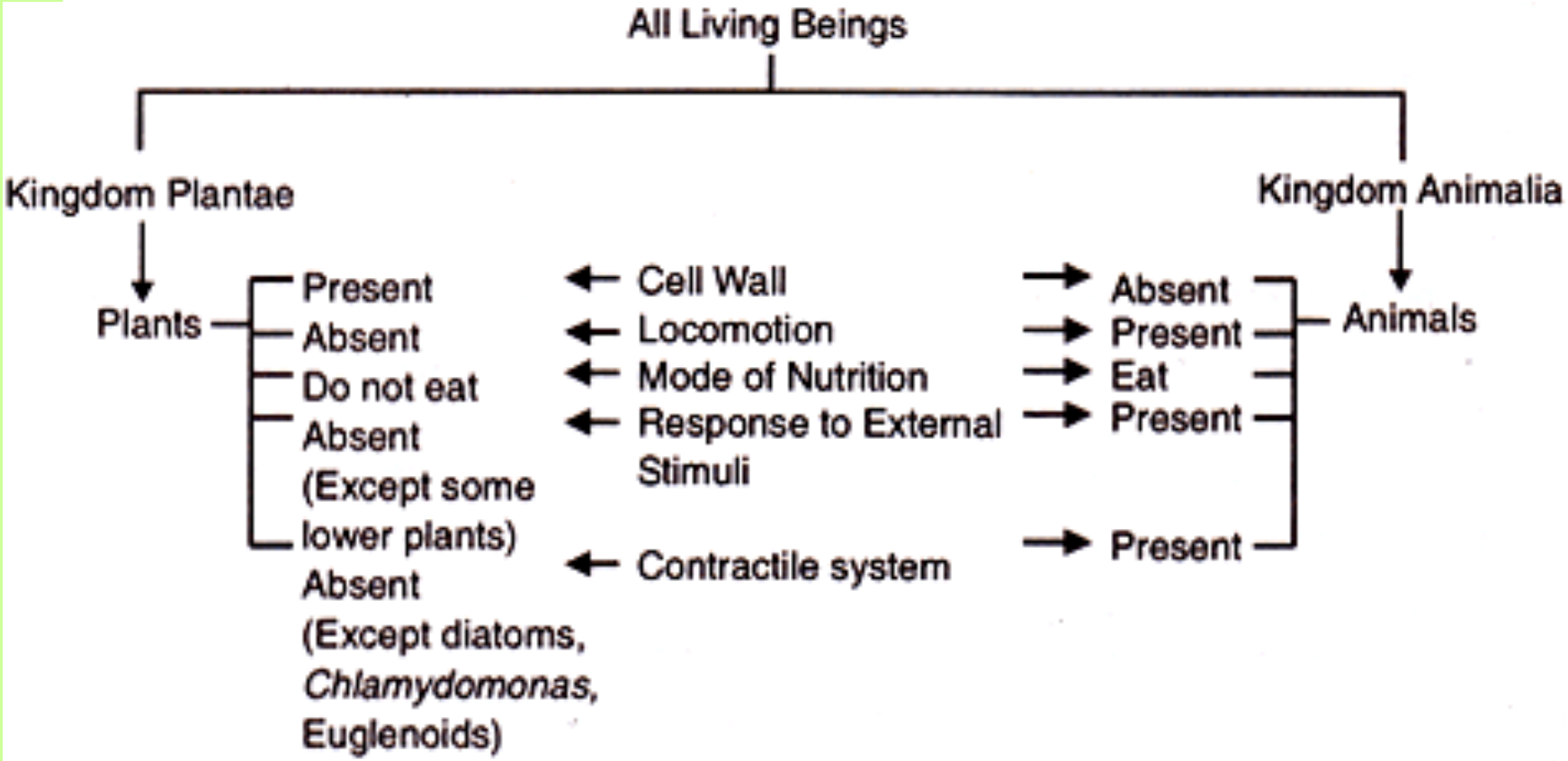
*He proposed that there were three broad groups, called **kingdoms**, into which the whole of nature could fit. These kingdoms were **animals, plants, and minerals.**

***Binomial nomenclature** meant naming species in 2 words : genus , followed by species.

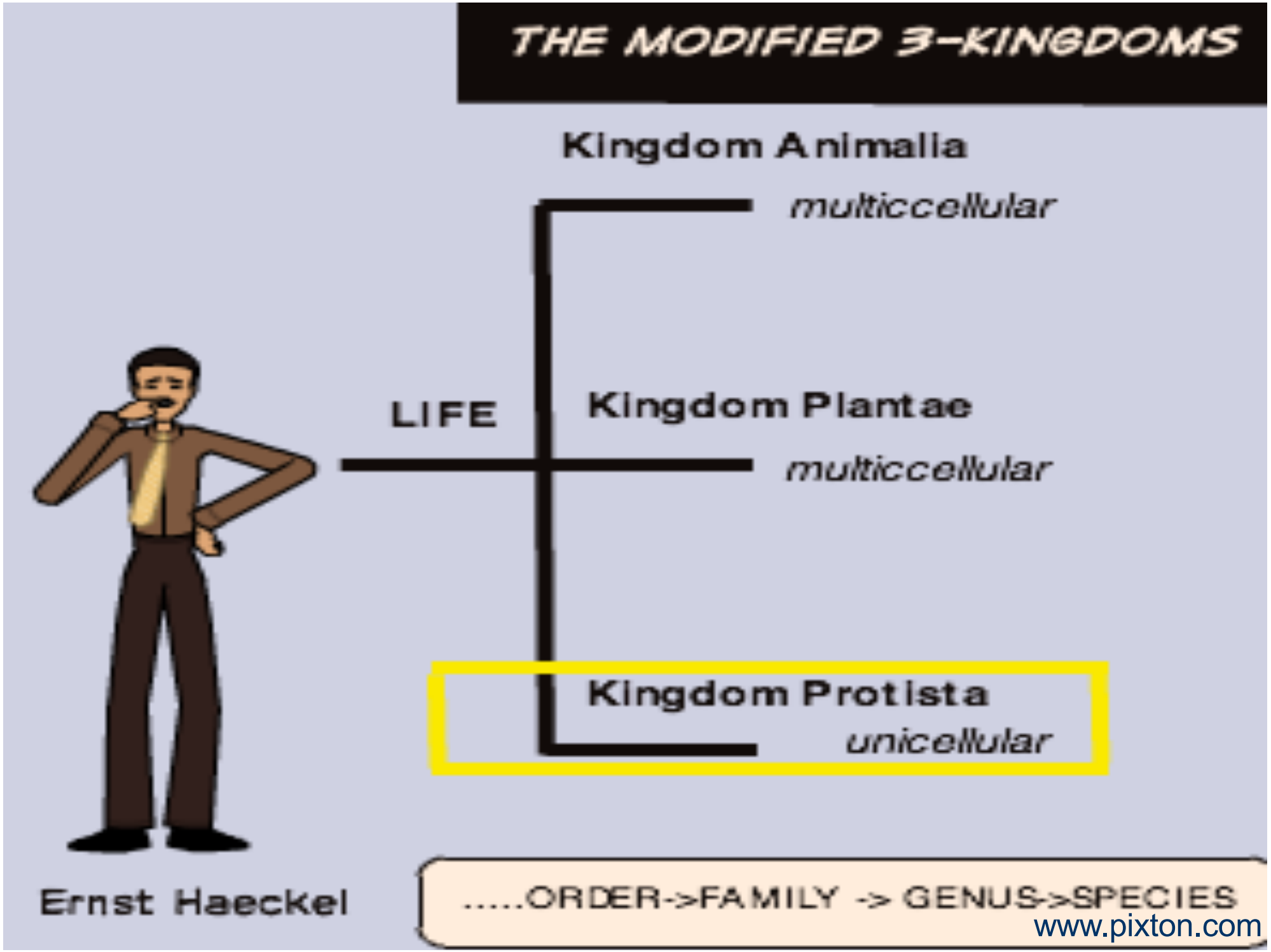


2 Kingdom classification

•The two kingdom classification system was given by **Carlous Linaaeus** in 1758.

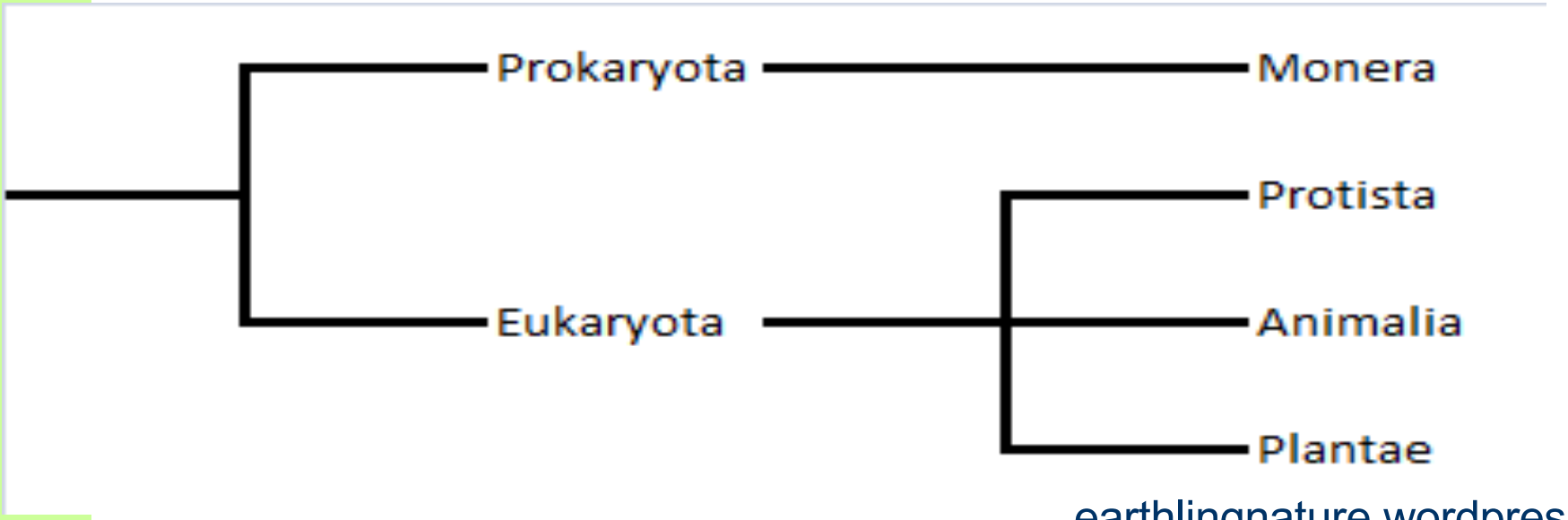


• He then divided each kingdom into classes and later grouped the classes into phyla for animals and divisions for plants.


THE MODIFIED 3-KINGDOMS
Kingdom Animalia
multiccellular
LIFE
Kingdom Plantae
multiccellular
Kingdom Protista
unicellular
Ernst Haeckel
.....ORDER->FAMILY -> GENUS->SPECIES
www.pixton.com

4 Kingdom classification

* The **development of optic and electronic microscopy** showed important differences in cells, mainly according to **the presence or absence of distinct nucleus**, leading *Édouard Chatton* to distinguish organisms in prokaryotes (without a distinct nucleus) and eukaryotes (with a distinct nucleus) in a paper from 1925.
* Based on it, **Copeland** proposed a four-kingdom system, moving prokaryotic organisms, bacteria and “blue-green algae”, into the kingdom Monera.

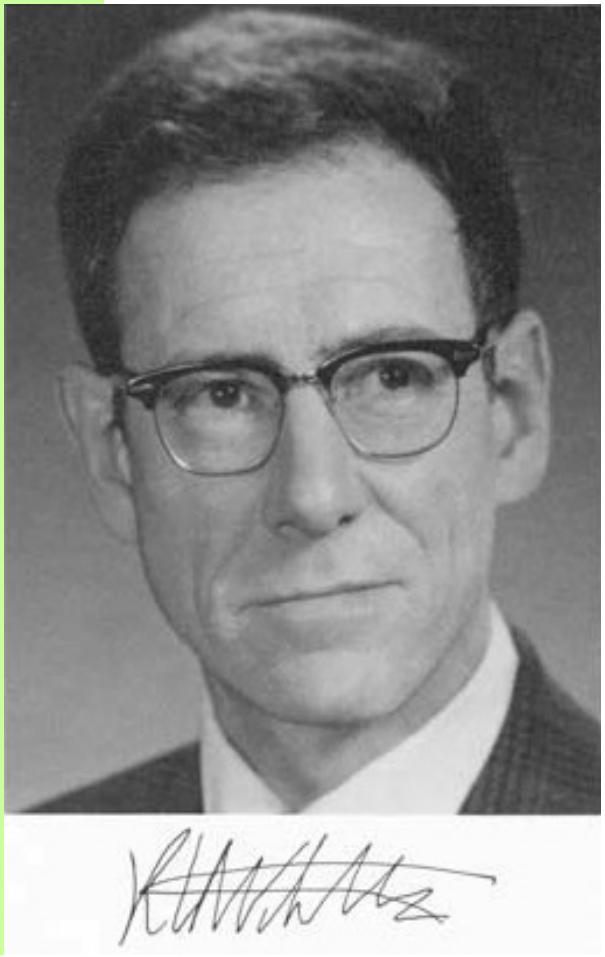


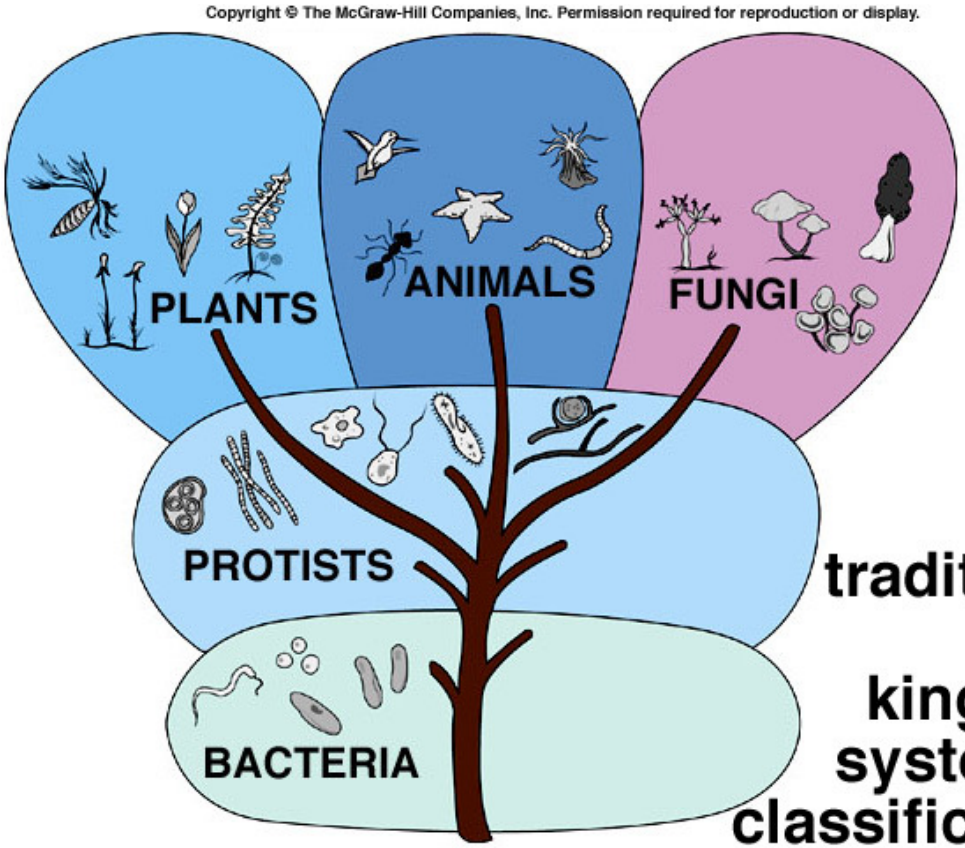
earthlingnature.wordpress.com

5 Kingdom classification

**The position of fungi was not well established, oscillating between kingdoms Protista and Plantae.

So, in 1969, **Robert Whittaker** proposed a *fifth kingdom* to include them, the called ***Kingdom Fungi.***





The traditional five-kingdom system of classification

Property	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell organization	Mostly unicellular	Mostly unicellular	Multicellular and unicellular	Mostly Multicellular	Mostly Multicellular
Cell wall	Present in most	Present in some: absent in others	Present	Present	absent
Nutritional class	Phototrophic,heterotrophic or chemoautotrophic	Heterotrophic and phototrophic	Heterotrophic	phototrophic	Heterotrophic
Mode of nutrition	Absorptive	Absorptive or ingestive	Absorptive	Mostly Absorptive	Mostly ingestive
Motility	Motile or non motile	Motile or nonmotile	Nonmotile	Mostly nonmotile	Mostly Motile

3 Kingdom classification

*The three-domain system is a biological classification introduced by Carl Woese in 1977 that divides cellular life forms into **archaea, bacteria, and eukaryote** domains.

*In particular, it emphasizes the separation of prokaryotes into two groups, originally called Eubacteria (now Bacteria) and Archaebacteria (now Archaea).

*Woese argued that, on the basis of differences in **16S rRNA genes**, these two groups and the eukaryotes each arose separately from *an ancestor with poorly developed genetic machinery, often called a progenote.*

Carl Woese and Ralph S. Wolfe (1977) proposed a new six-kingdom taxonomy.

This came about with the discovery of archaea, which are prokaryotes that lives in oxygen- deprived environments

Woese's six-kingdom taxonomy consists of:

- Eubacteria (has rigid cell wall)
- Archaebacteria (anaerobes that live in swamps, marshes, and in the intestines of mammals)
- Protista (unicellular eukaryotes and algae)
- Fungi (multicellular forms and single-cell yeasts)
- Plantae
- Animalia

Woese determined that archaebacteria and eubacteria are two groups by studying the **rRNA** sequences in prokaryotic cells.
Woese used three major criteria to define his six kingdoms. These are:

- ***Cell type.*** Eukaryotic cells (cells having a distinct nucleus) and prokaryotic cell (cells not having a distinct nucleus)
- ***Level of organization****.* Organisms that live in a colony or alone and one-cell organisms and multicell organisms.
- ***Nutrition***. Ingestion (animal), absorption (fungi), or photosynthesis (plants).

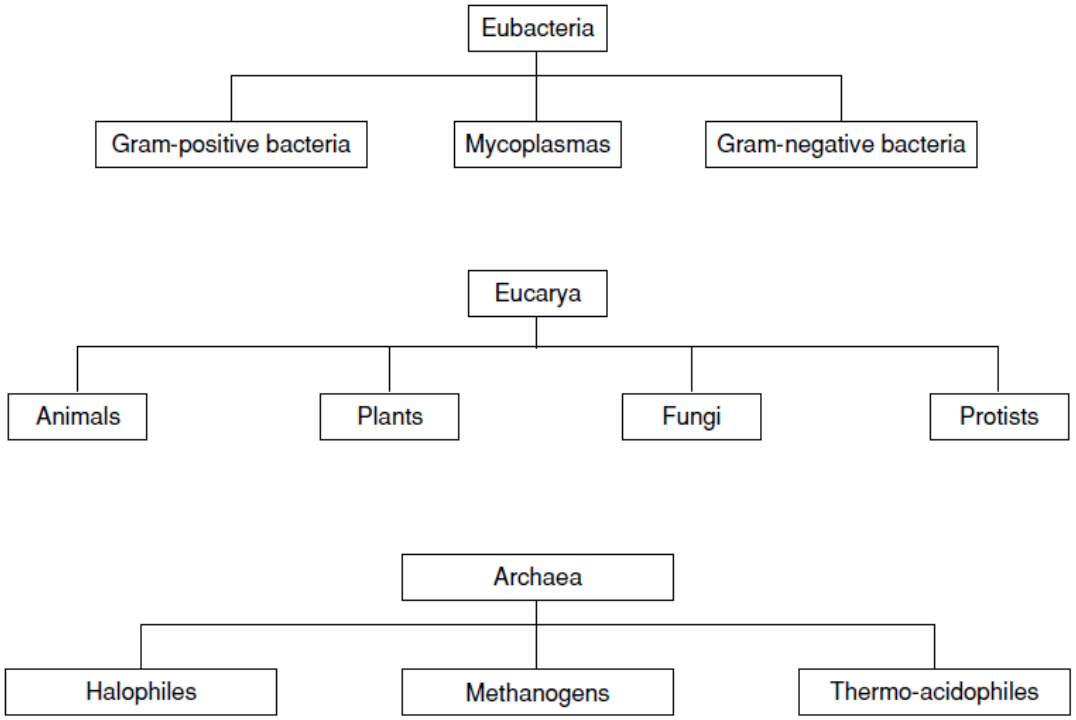
In the 1990s Woese studied rRNA sequences in prokaryotic cells (archaebacteria and eubacteria) proving that these organisms should be divided into two distinct groups.

Today organisms are grouped into three categories called domains that are represented as bacteria, archaea, and eukaryotes.

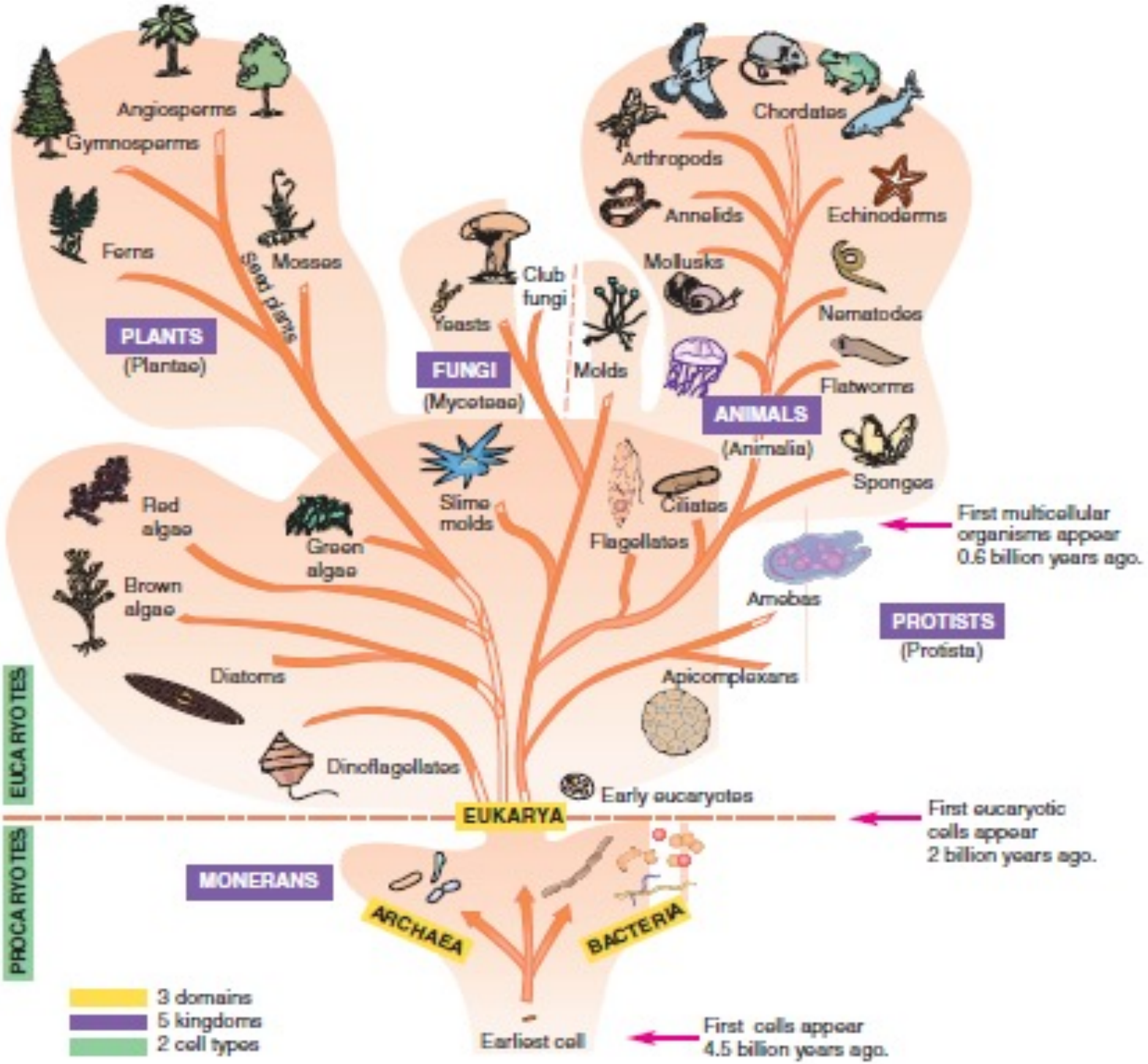
Archaea lack muramic acid in the cell walls.

Bacteria have a cell wall composed of peptidoglycan and muramic acid. Bacteria also have membrane lipids with ester-linked, straight-chained fatty acids that resemble eukaryotic membrane lipids. Most prokaryotes are bacteria. Bacteria also have plasmids, which are small, double-stranded DNA molecules that are extrachromosomal.

Eukarya are of the domain eukarya and have a defined nucleus and membrane bound organelles.



Linnaeus 1735 2 kingdoms	Haeckel 1866 3 kingdoms	Chatton 1925 2 empires	Copeland 1938 4 kingdoms	Whittaker 1969 5 kingdoms	Woese et al. 1977 6 kingdoms	Woese et al. 1990 3 domains	Cavalier-Smith 2004 6 kingdoms
					Eubacteria	Bacteria	
(not treated)	Protista	Prokaryota	Monera	Monera	Archaebacteria	Archaea	Bacteria
			Protoctista	Protista	Protista		Protozoa Chromista
		Eukaryota		Fungi	Fungi	Eukarya	Fungi
Vegetabilia	Plantae		Plantae	Plantae	Plantae		Plantae
Animalia	Animalia		Animalia	Animalia	Animalia		Animalia


Angiosperms
Gymnosperms
Ferns
Mosses
seed plants
PLANTS
(Plantae)
Chordates
Arthropods
Annelids
Echinoderms
Mollusks
Nematodes
Flatworms
ANIMALS
(Animalia)
Sponges
Club fungi
Yeasts
Molds
FUNGI
(Mycotaea)
Slime molds
Ciliates
Flagellates
Amobas
PROTISTS
(Protista)
First multicellular organisms appear 0.6 billion years ago.
Red algae
Green algae
Brown algae
Diatoms
Dinoflagellates
Apicomplexans
Early eucaryotes
EUCARYOTES
EUKARYA
First eucaryotic cells appear 2 billion years ago.
PROCARYOTES
MONERANS
ARCHAEA
BACTERIA
Earliest cell
First cells appear 4.5 billion years ago.
3 domains
5 kingdoms
2 cell types

Prokaryotic vs Eukaryotic Cells

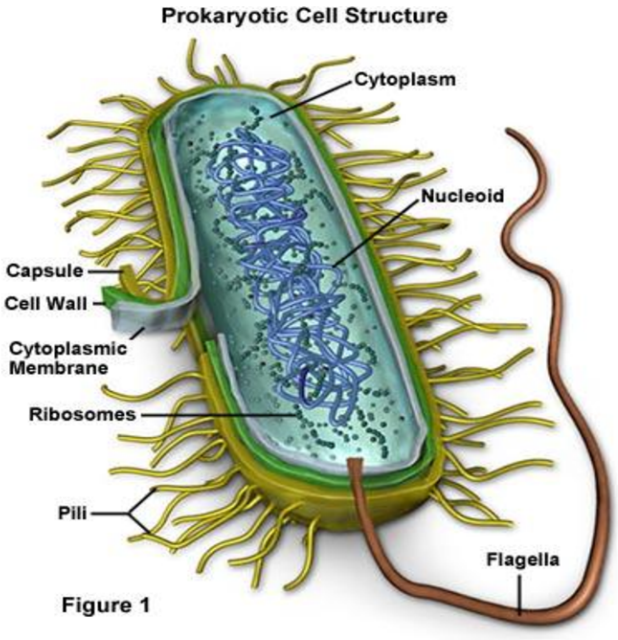
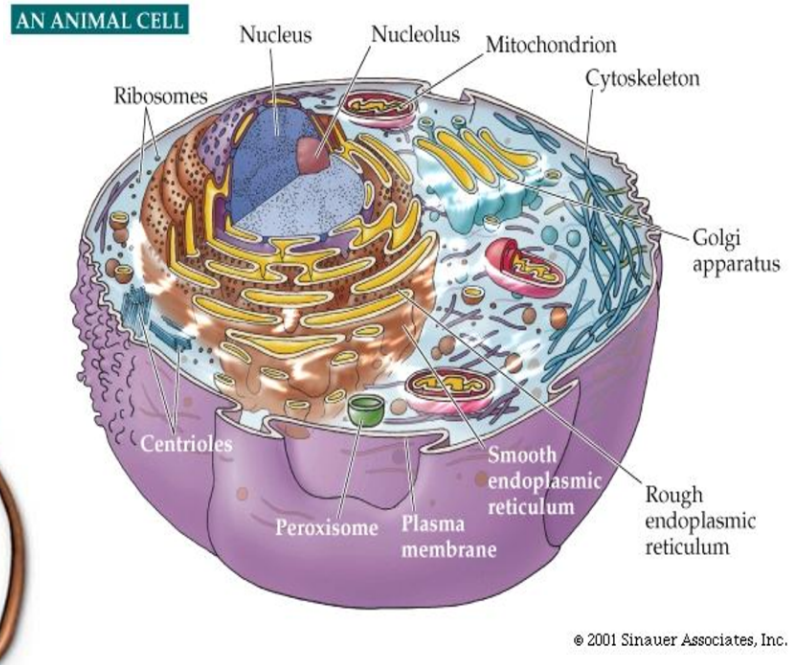


Figure 1



mid-1700s, Swedish botanist Carl Linnaeus - a taxonomy for living organisms

Linnaeus' taxonomy grouped living things into two kingdoms: plants and animals

Haeckel (1866) - Protista, - include microorganisms, is a heterogenous group consisting of protozoa, algae, fungi and bacteria.

Although each one of these groups has distinct characteristics, within a group organisms show a great deal of similarity.

1969 Robert H. Whitteker - five kingdom classification

Monera, protista, plantae (plants), fungi, and animalia (animals).

Monera **are organisms that lack a nucleus and membrane-bounded organelles, such as bacteria.**

Protista **are organisms that have either a single cell or no distinct tissues and organs, such as protozoa. This group includes unicellular eukaryotes and algae.**

Fungi **are organisms that use absorption to acquire food. These include multicellular fungi and single-cell yeast.**
Animalia and plantae include only multicellular organisms

Carl Woese and Ralph S. Wolfe (1977) proposed a new six-kingdom taxonomy. This came about with the discovery of archaea, which are prokaryotes that lives in oxygen- deprived environments

Classification of organisms

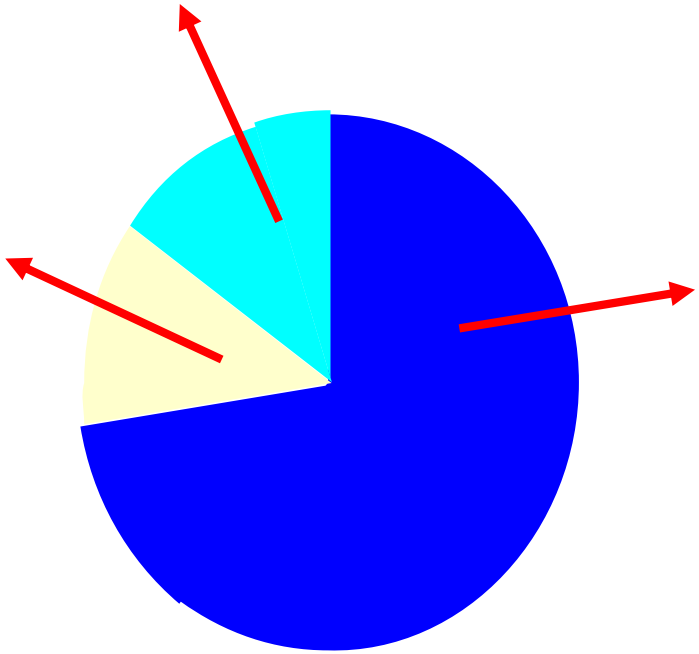
- Microbiologist believe that organisms should be divided among three domains

Bacteria

prokaryotic or single cell

Archaea

Prokaryotic but different from bacteria



Eucarya

Larger than prokaryote, algae, slime mold

- **Viruses are not classified in any kingdom**
- **They are 10.000x smaller than bacteria**
- **Invade host cell in order to replicate**

Five Kingdom System

- Monera
- Protista
- Fungi
- Animalia
- Plantae

Classification

Classifying microorganisms has always been a challenge for taxonomists, as they are diverse.

Some microorganisms are motile like animals, but also have cell walls and are photosynthetic like plants…..

These observations eventually led them to the development of a classification scheme, that divided organisms into Five kingdoms.

Three Domain system

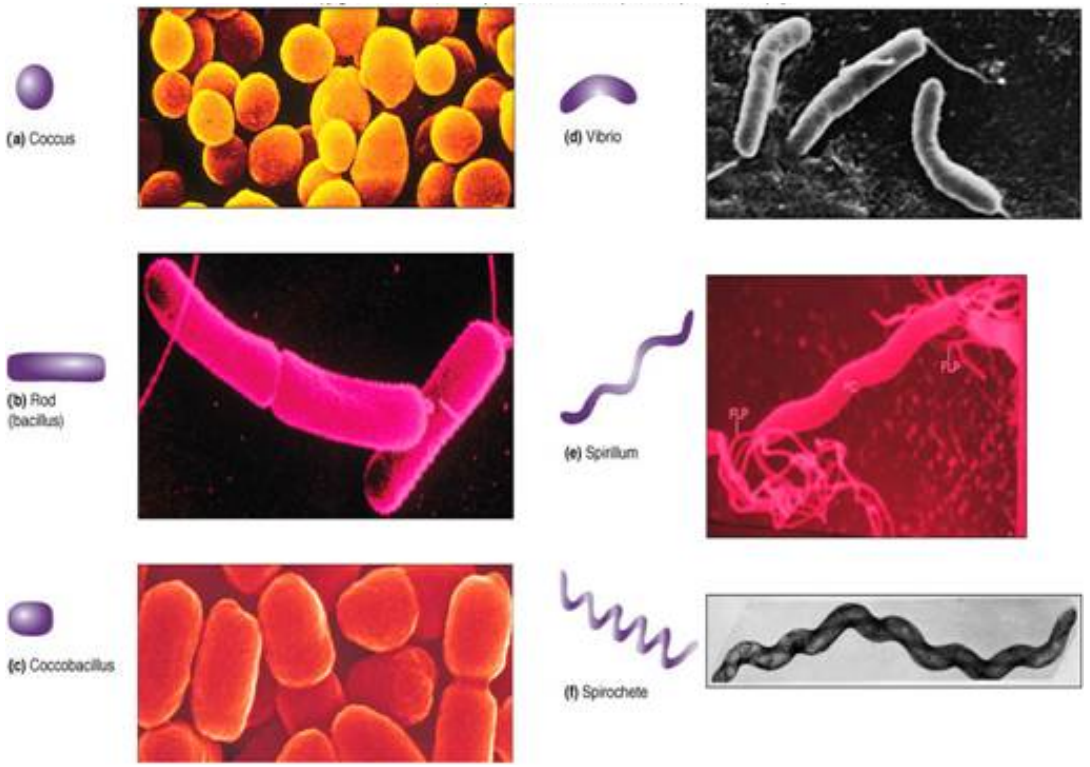
- Bacteria
- Archea
- Eucarya

- Carl Woese in 1970's proposed this system.

Bacteria

- Prokaryotes
- Single-celled organisms
- Cell wall → Peptidoglycan.
- Abundant in Soil, water, air and are the normal resident of skin, nose, mouth and intestine.
- Some live in extreme temperatures.
- They have harmful aspects but are usually beneficial as well.


bacillus (rod)
coccus (spherical)
spirillum (spiral)
spirochaete (corkscrew)
vibrio (comma)
chain of cocci
cluster of cocci
pair of cocci
chain of bacilli


(a) Coccus
(d) Vibrio
(b) Rod (bacillus)
(e) Spirillum
(c) Coccobacillus
(f) Spirochete

Archea

- These are bacteria but are different due to their rRNA sequence.
- Cell wall composition is change as they lack peptidoglycan but contains lipids.
- Unique feature is that some are methanogens.
- Archea are found in environments that are too hostile for other life forms.
- No pathogenic archea have yet been identified.

Eucarya

- Multicellular organisms.
- The true nucleus is one of the distinguishing features of eukaryotes
- Contains microbes classified as protists or fungi.
- Animals and plants are also included in this group.

Protists

- These are larger than prokaryotes.
- It includes unicellular algae, protozoa, slime molds and water molds.

Algae

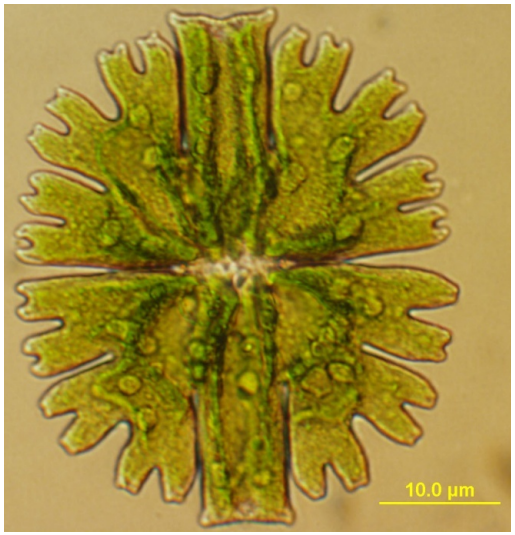
- The term algae has long been used to denote all organisms that produce Oxygen as a product of photosynthesis.
- All algae contain chlorophyll in their chloroplast.
- Many algal species are unicellular.
- Other algae may form extremely large multicellular structures.

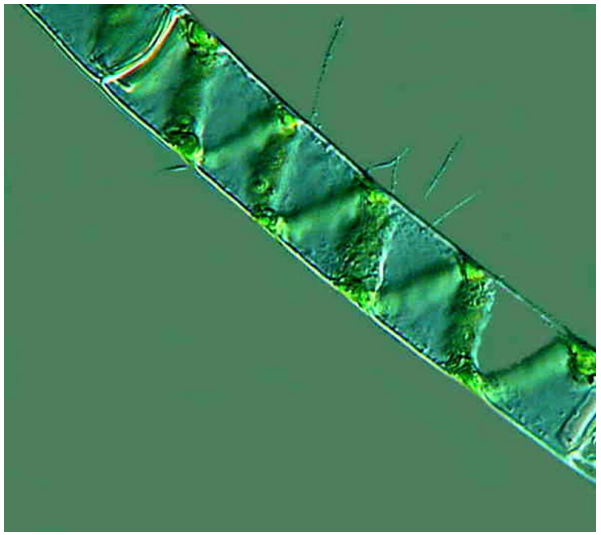
- A number of algae produce toxins that are poisonous to humans and other animals.

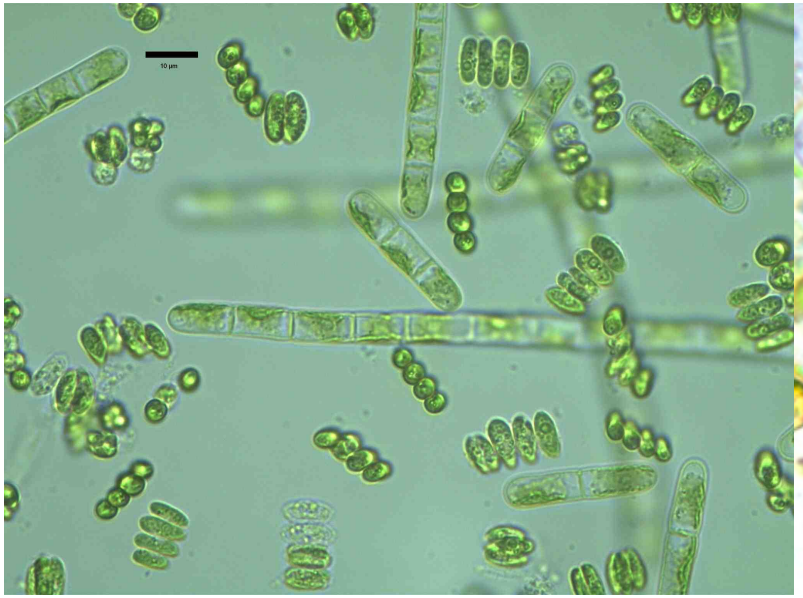
- Dinoflagellates, a unicellular alga, cause algal blooms, or red tides, in the ocean. It produces neurotoxins which is accumulated in the shellfish, as shellfish feeds on this organism. Ingestion of these shellfish by humans results in paralytic shellfish poisoning and can lead to death.

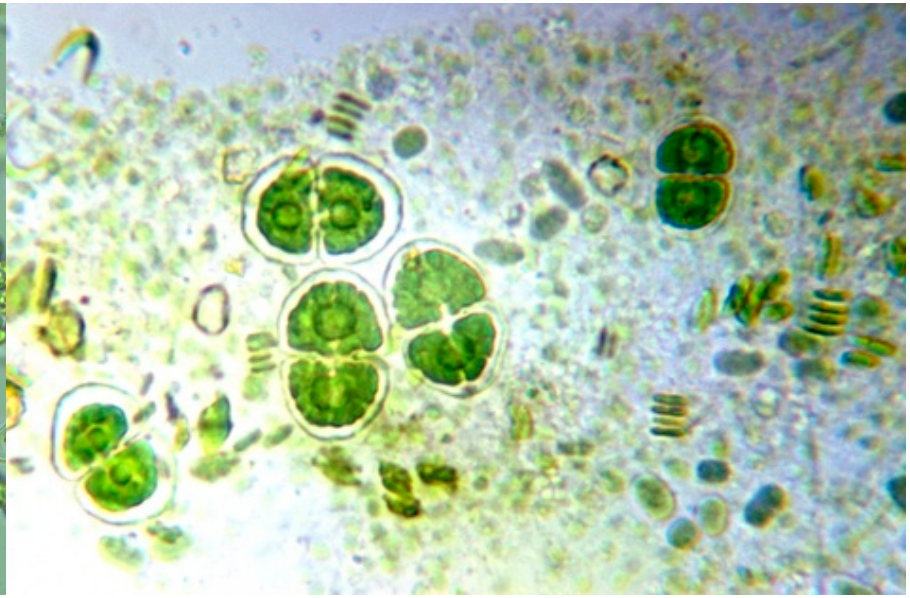
- Together with cyanobacteria (blue green algae), it produces about 75% of planet's Oxygen.

- It forms foundation of aquatic food chains.


10.0 µm



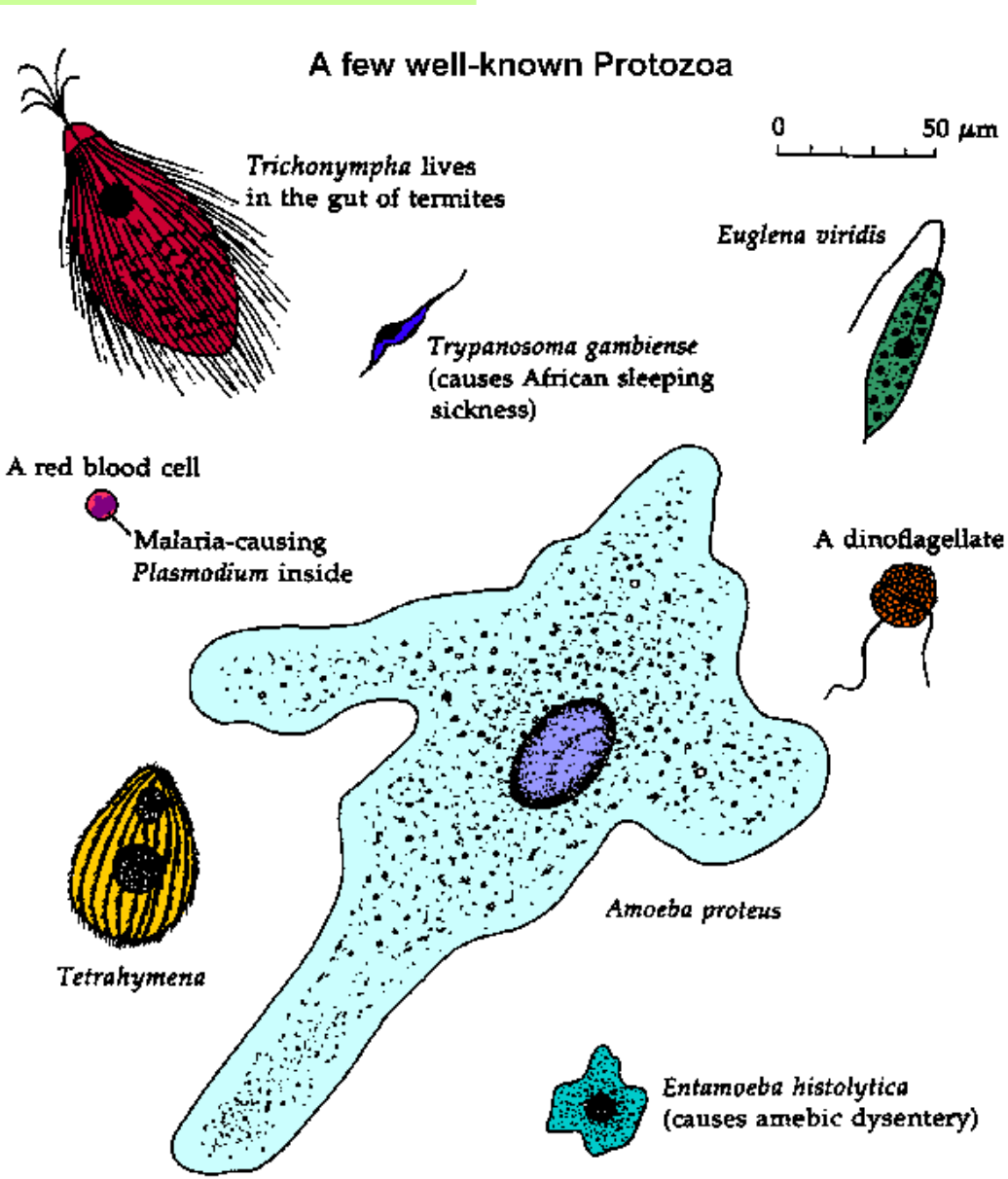


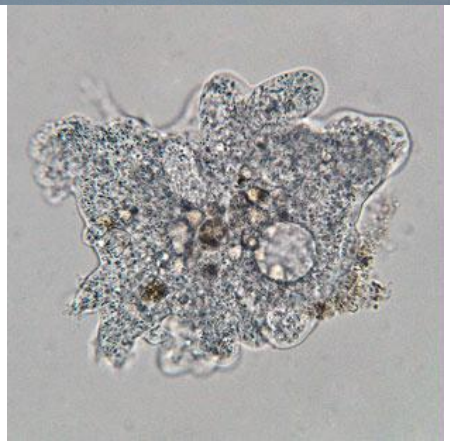


Protozoa

- Protozoa are unicellular non photosynthetic protists.
- It seems likely that the ancestors of these protozoa were algae that became heterotrophs—the nutritional requirements of such organisms are met by organic compounds.
- Adaptation to a heterotrophic mode of life was sometimes accompanied by loss of chloroplasts, and algae thus gave rise to the closely related protozoa. Similar events have been observed in the laboratory to be the result of either mutation or physiologic adaptation.

- Many free living protozoa's are hunter of microbes.
- They obtain nutrients by digesting organic matter and microbes.
- They are present in different environments, some are normal inhabitants of intestines of animals and helps them in digesting cellulose.
- Few of them causes diseases in animals and humans.


A few well-known Protozoa
0
50 μm
Trichonympha lives in the gut of termites
Trypanosoma gambiense (causes African sleeping sickness)
Euglena viridis
A red blood cell
Malaria-causing Plasmodium inside
A dinoflagellate
Tetrahymena
Amoeba proteus
Entamoeba histolytica (causes amebic dysentery)



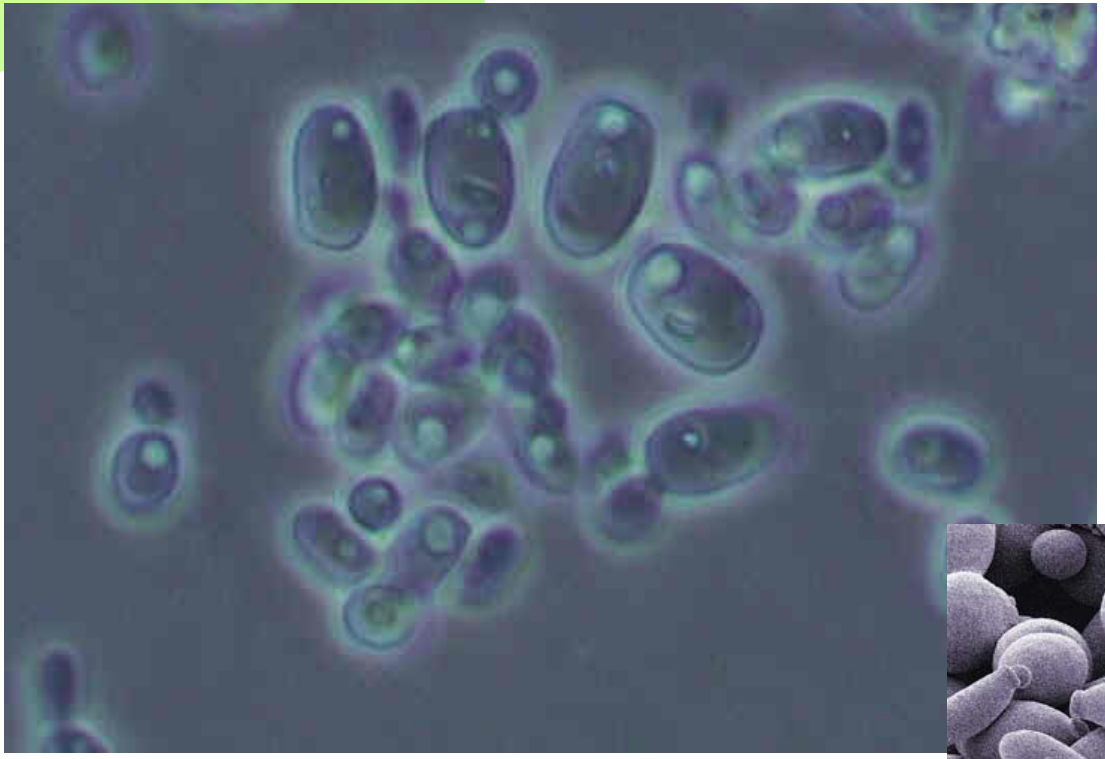
Slime molds

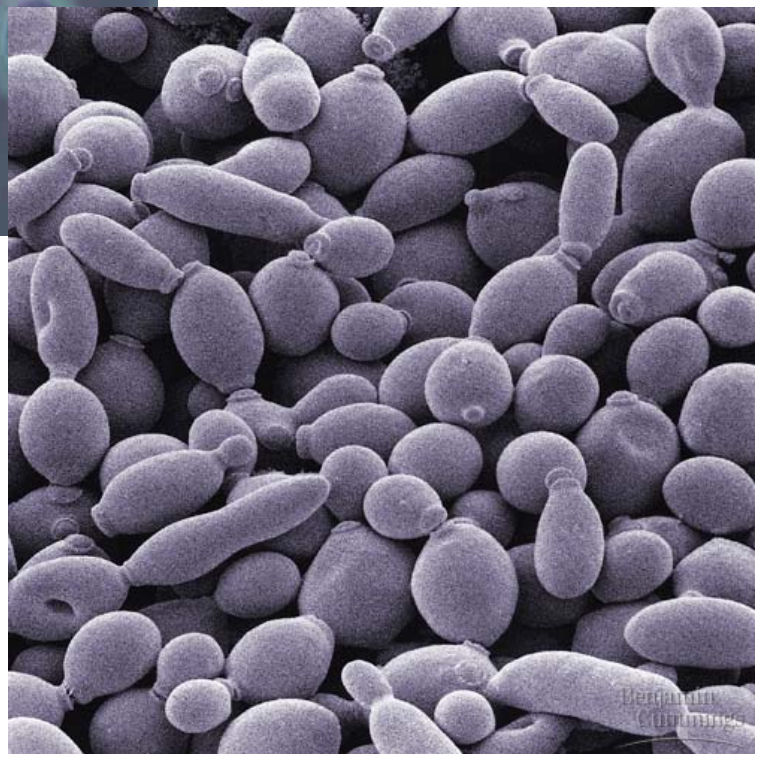
- These organisms are characterized by the presence, as a stage in their life cycle, of an ameboid multinucleate mass of cytoplasm called a **plasmodium.** The plasmodium of a slime mold is analogous to the mycelium of a true fungus. Both are coenocytic (an organism made up of a multinucleate, continuous mass of protoplasm enclosed by one cell wall). In slime molds the cytoplasm can flow in all directions. This flow causes the plasmodium to migrate in the direction of its food source, frequently bacteria.

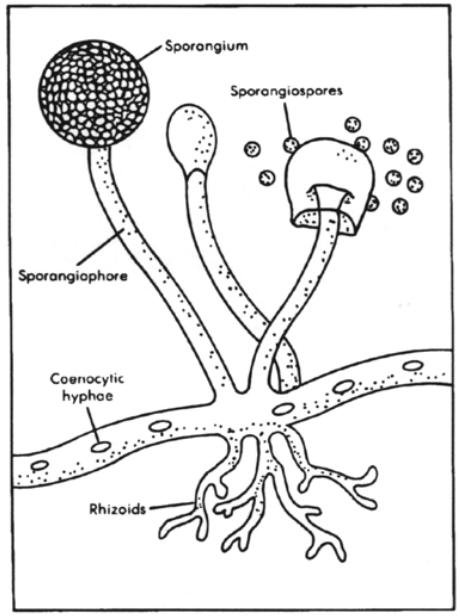
- The life cycle of the slime molds depends upon interdependency of living forms. The growth of slime molds depends on nutrients provided by bacterial or, in some cases, plant cells. Reproduction of the slime molds via plasmodia can depend on intercellular recognition and fusion of cells from the same species.

Fungi

- Diverse group of microorganism that range from unicellular (yeasts) to multicellular fungi (molds and mushrooms).
- They absorb nutrients from environment including organic molecules, that they use as carbon and energy source.
- They have metabolic capabilities, so many fungi are beneficial in making bread rise, producing antibiotics, decomposition of dead organic matter.
- Some causes diseases in humans, animals and plants.






Sporangium
Sporangiospores
Sporangiophore
Coenocytic hyphae
Rhizoids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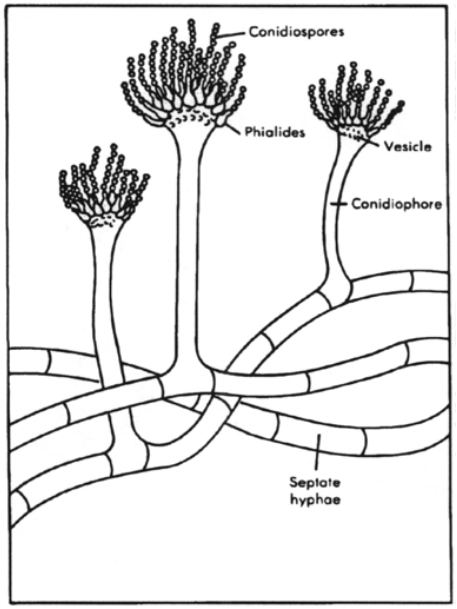
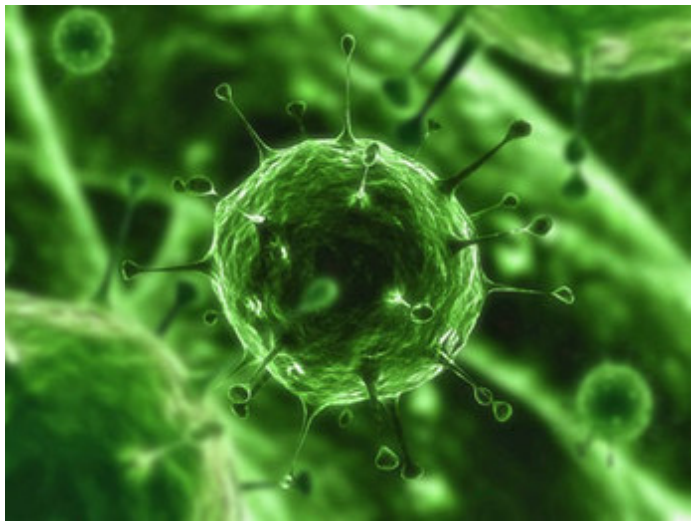

Conidiospores
Phialides
Vesicle
Conidiophore
Septate hyphae

- The fungi are non photosynthetic protists growing as a mass of branching, interlacing filaments (“hyphae”) known as a **mycelium.**
- These tubes, made of polysaccharides such as chitin, are homologous with cell walls. **Yeasts,** do not form a mycelium but are easily recognized as fungi by the nature of their sexual reproductive processes.
- The fungi probably represent an evolutionary offshoot of the protozoa; they are unrelated to the actinomycetes, mycelial bacteria that they superficially resemble. The major subdivisions (phyla) of fungi are Chytridiomycota, Zygomycota (the zygomycetes), Ascomycota (the ascomycetes), Basidiomycota (the basidiomycetes), and the “deuteromycetes” (or imperfect fungi).

HISTORY OF MICROBIOLOGY

Introduction

- Microbiology is the study of organisms that are too small to be seen by the naked eye.
- The microbes have coexisted with humans from the beginning of civilization providing both beneficial and detrimental roles to human life.
- Although not always recognized at the time microbes have dramaticallv



History – alerting microbes

- History of microbiology starts in the 3rd century BC with Hippocrates recording ideas of infections and diseases
- Malaria – *Plasmodium falciparum*

  Mosquito borne infectious disease thought to have killed Alexander the great (323 BC)
- Bulbonic plague – *Yersinis pestis*

  Caused black death in Europe (1347-1351)

  Between 25-40% of Europe died
- Potato blight – *Phytophthora Infestans*

  caused Irish potato famine (1845-1849)

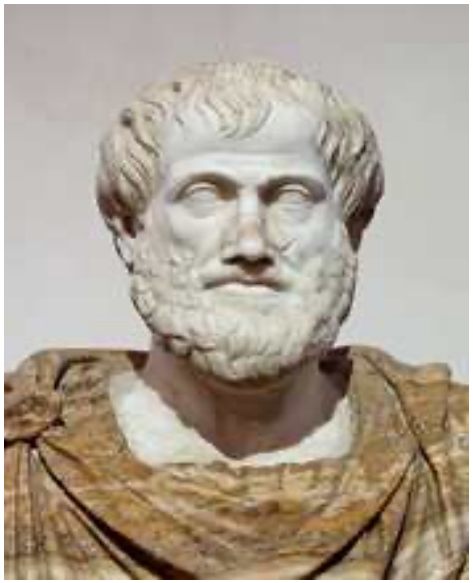
  potato crops were wiped out

Aristotle

- The belief in the spontaneous generation of life from nonliving matter was introduced by Aristotle, who lived around 350 BC.
- According to Aristotle it was,

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

- This belief remained unchallenged for more than 2000



Antony Van Leeuwenhoek (1632)

- The first accurate description of microbes was reported in 1674 by Anton von Leeuwenhoek a Dutch lens maker.
- He was the first person to see and describe living microbes.
- He observed and described microorganisms as “Animalcules”.

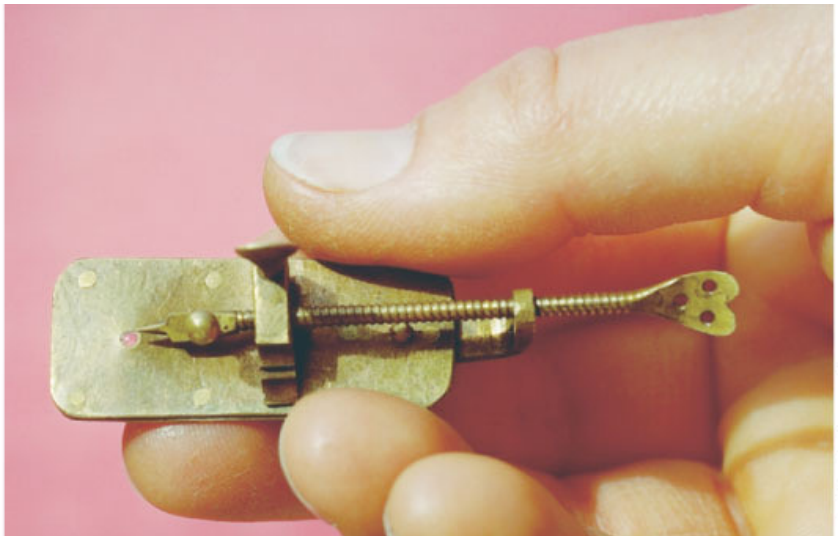
Antony Van Leeuwenhoek (1632)

- He is "the Father of Microbiology", and considered to be the first microbiologist
- *Leeuwenhoek made more than 500 optical lenses.*
- *He also created at least 25 microscopes, of differing types, of which only nine survived*
- he was the first to observe and describe single-celled organisms, which he originally referred to as *animalcules*

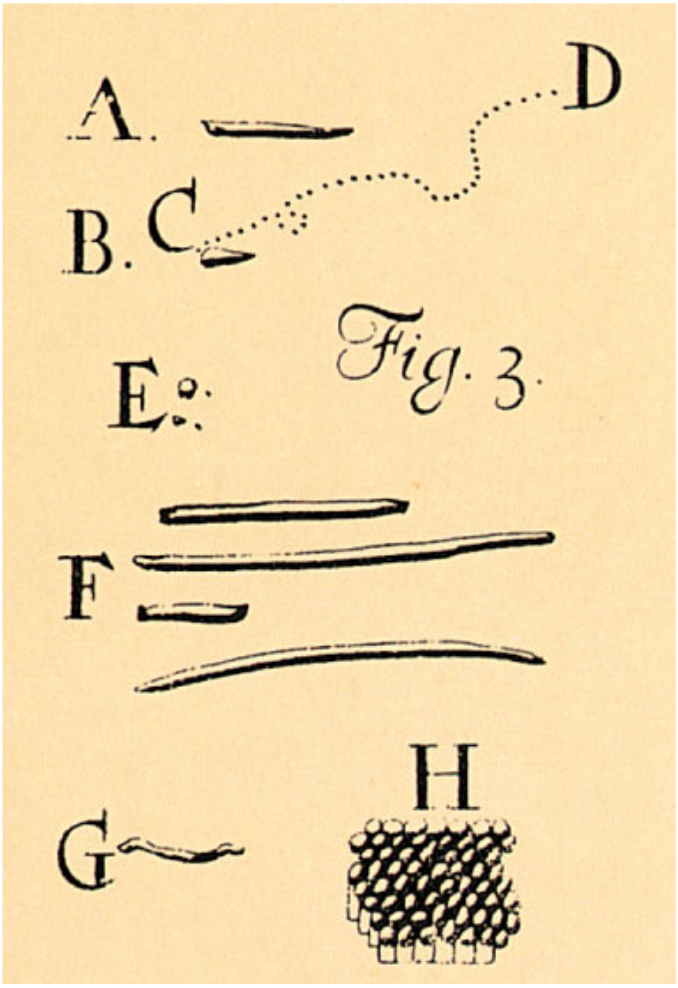
Antony Van Leeuwenhoek (1632)

- He was the first to publish extensive and accurate observations of microorganisms
- In 1673, he sent a detailed letter to the royal society of London describing bacteria
- His work really advanced the microbiology field
- However the big advance in the microbiology field was not seen until bacterial culturing starts

Antony Van Leeuwenhoek (1632)



The Antony Van Leeuwenhoek microscope



Antony Van Leeuwenhoek drawings of bacteria

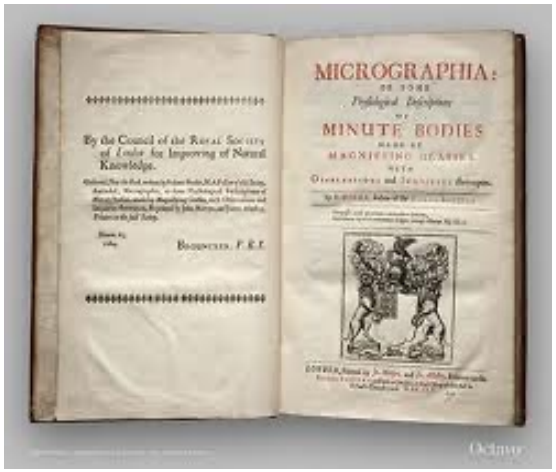
Robert Hooke (1665)

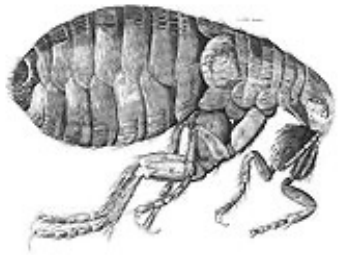
•The English father of microscopy

•Re-confirmed Antony van Leeuwenhoek's discoveries of the existence of tiny living organisms

•He made a copy of Leeunwenhoek's microscope and improved upon his design

•He wrote Micrographia, the first book describing observations made through a microscope.

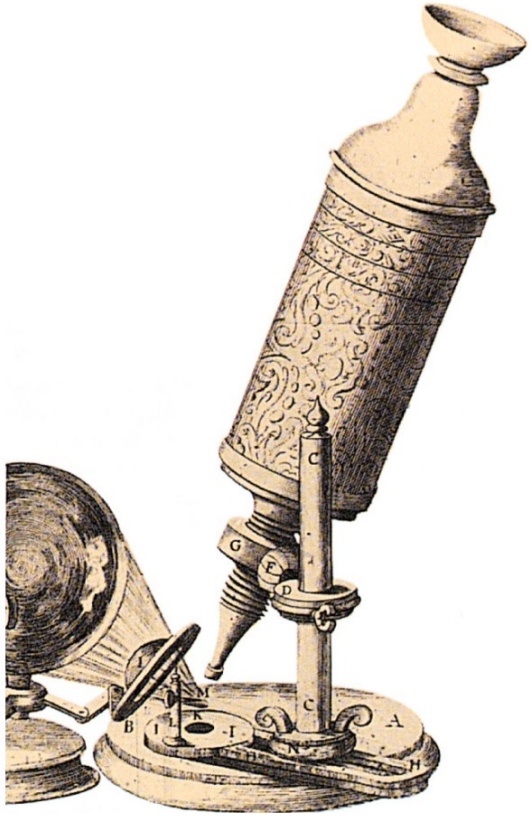




flea and louse drawing

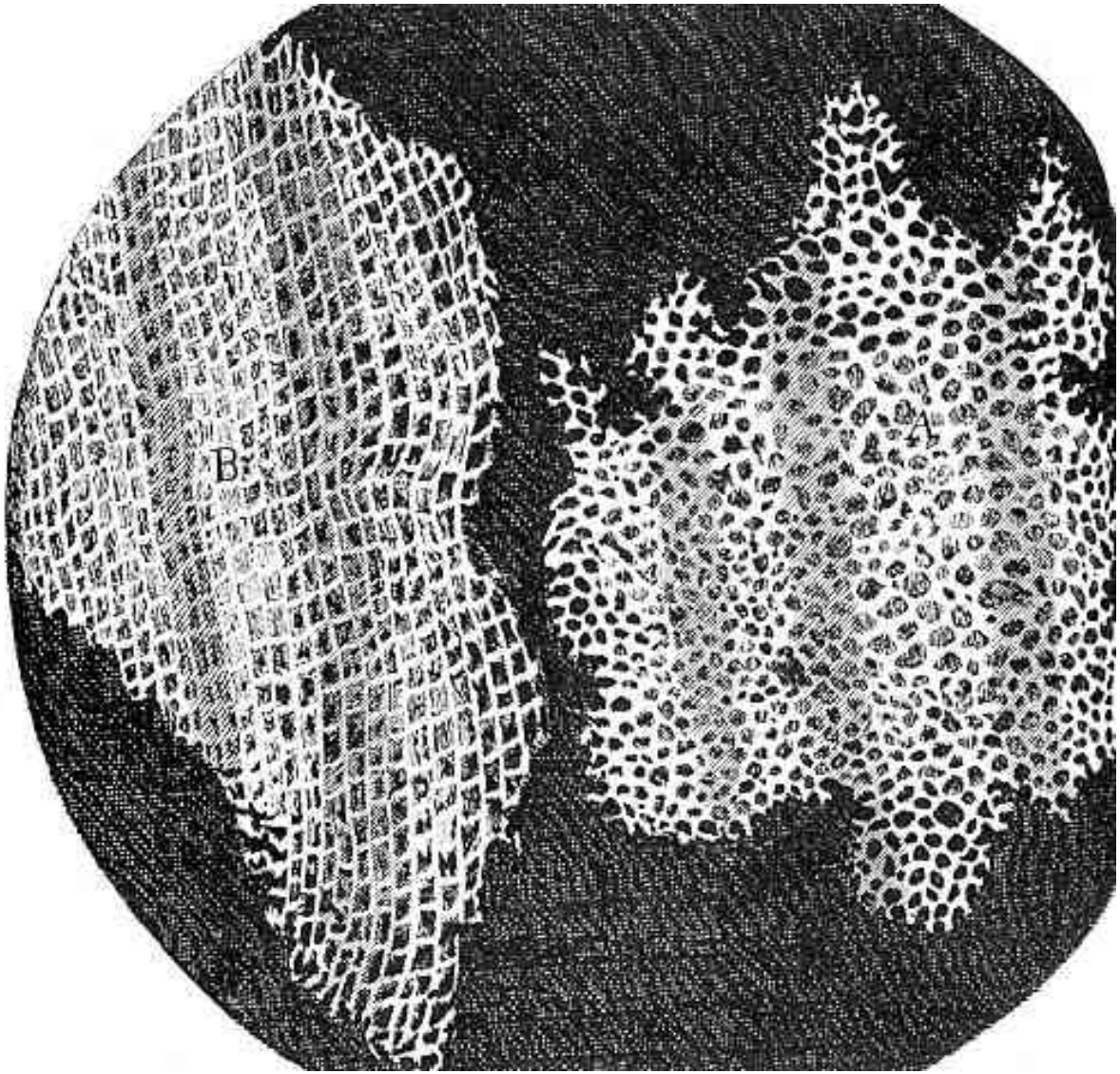
obtained from micrographia

Robert Hooke and early microscopy



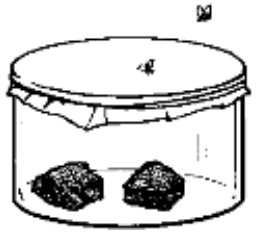
The Robert Hooke microscope

Fruiting bodies of mold, round structures contain spores of the mold as published in the micrographia


B
A

Francesco Redi – Theory of biogenesis

- The spontaneous generation was controverted by Francesco Redi, who showed that fly maggots do not arise from decaying meat if the meat is covered to prevent the entry of flies.
- He disproved spontaneous generation of maggots.
- This arose questions on Aristotle's theory of Abiogenesis.



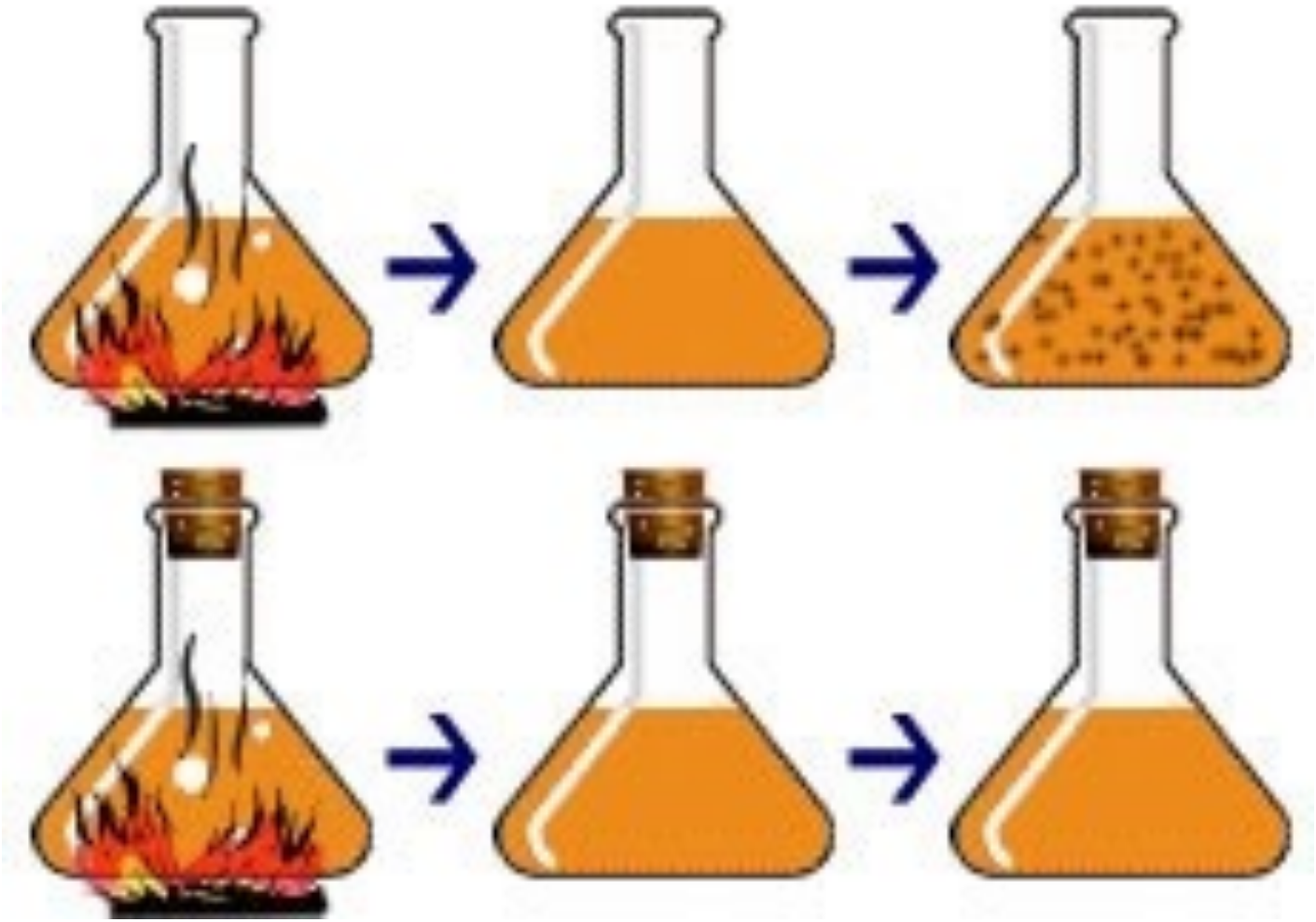
John Needham

- Spontaneous generation for small organisms again gained favor when John Needham showed that if a broth was boiled and then allowed to sit in the open air, it became cloudy

Lazzaro Spallanzani

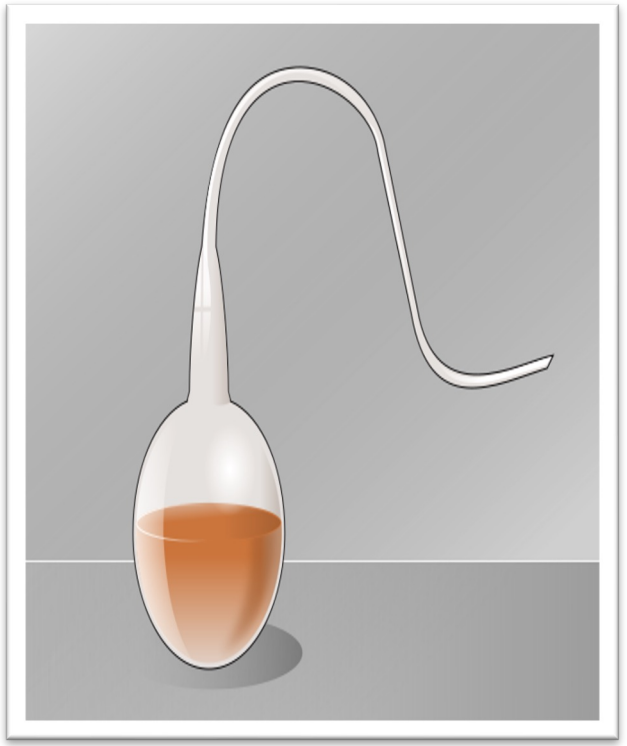
- Lazzaro Spallanzani disputed the theory by demonstrating the air carrying germs to the culture medium.
- Repeated Needham's experiment in boiled sealed flasks.
- No growth was observed until the flasks were opened.
- Then Spallanzani showed that microbes come from air and that boiling the microbes can kill it.

Needham vs. Lazzaro



Louis Pasteur and the golden era of microbiology

- Louis Pasteur is known as the father of medical microbiology and he worked in the middle and late 1800s.
- He proved that fermentation was caused by microbial agents.
- He exposed boiled broths to the air, in vessels that contained a filter to prevent all particles from passing through to the growth medium, and also in vessels with no filter at all, with air being admitted via a curved tube

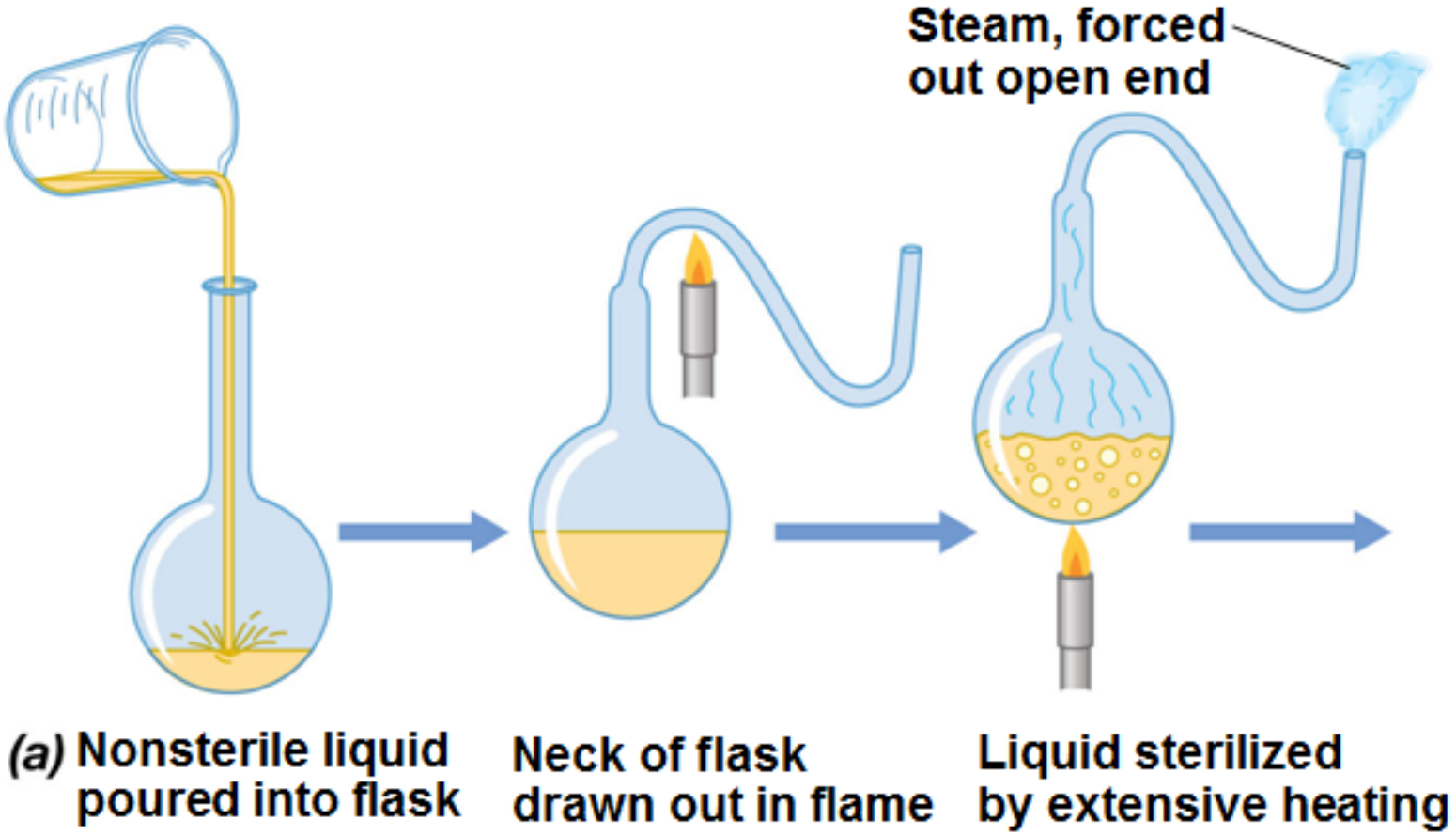


- No microorganism was able to grow on the broth during Pasteur's experiment.
- This proved that the living organisms living in that broth came from the outside, as spores on dust, rather than been spontaneously created.
- Louis Pasteur therefore supported the germ theory and he further stated that microorganisms are the causes of infectious diseases.
- He also demonstrated that bacteria could be removed by boiling and then cooling the liquid which gave rise to pasteurisation.

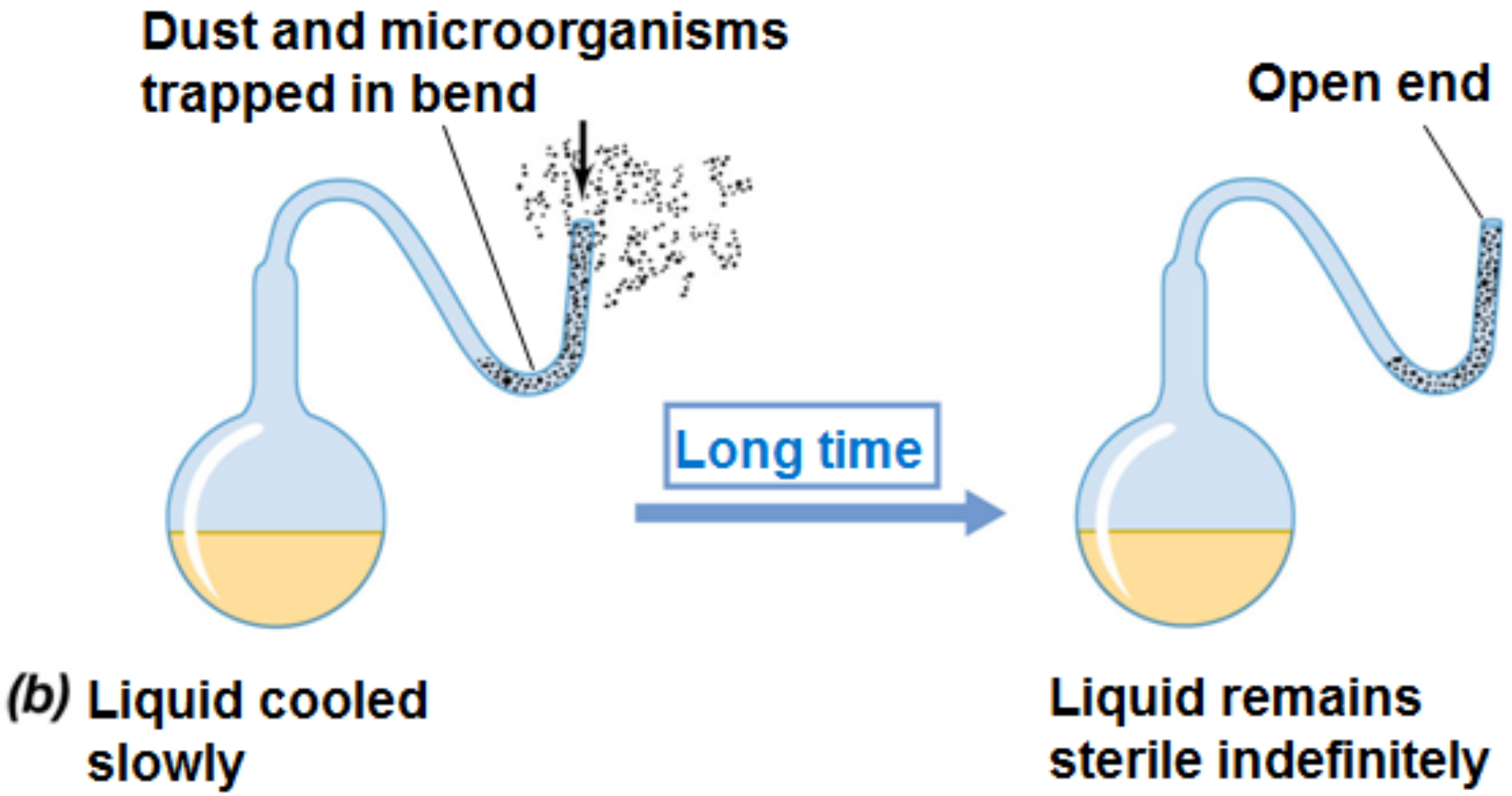
Louis Pasteur (1822–1895)

- Discovered that alcoholic fermentation was a biologically mediated process (originally thought to be purely chemical)
- Developed vaccines for anthrax, cholera, and rabies
- Led to the development of methods for controlling the growth of microorganisms (aseptic technique)

Pasteur's swan-necked flask experiment



Pasteur's swan-necked flask experiment



Pasteur's swan-necked flask experiment

(c) Flask tipped so microorganism-laden dust contacts sterile liquid

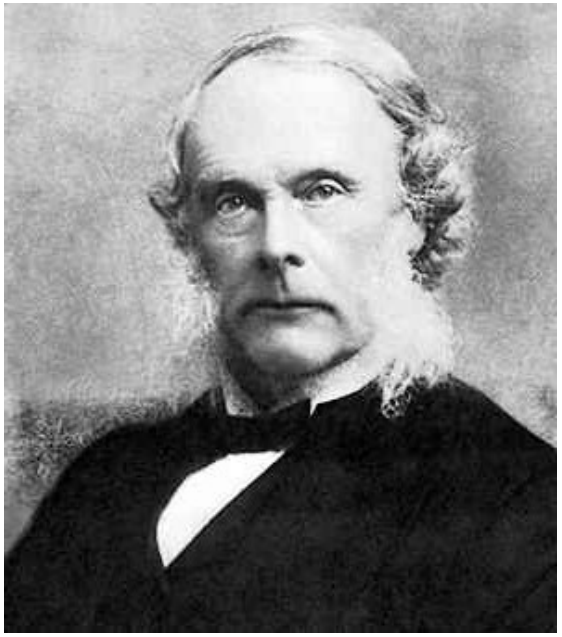
Liquid putrefies

Pasteur is well known for his work on,

- Proposing germ theory of diseases.
- Development of sterilization techniques.
- Development of methods for growth of microbes.
- Pasteurization.
- Studies on Anthrax, Rabies and cholera.
- A Rabies vaccine and live attenuated Anthrax.

Joseph Lister

- Lord Joseph Lister is known as the father of antiseptic surgery and he proved that wound infections were due to microorganisms.
- He developed a method to destroy microorganisms in the operating theater by spraying a mist of carbolic acid into the air.
- This dramatically reduced the number of people dying due to surgical sepsis.



Robert Koch- Father of Bacteriology

Koch's postulates

Four criteria that were established by Robert Koch to identify the causative agent of a particular disease.

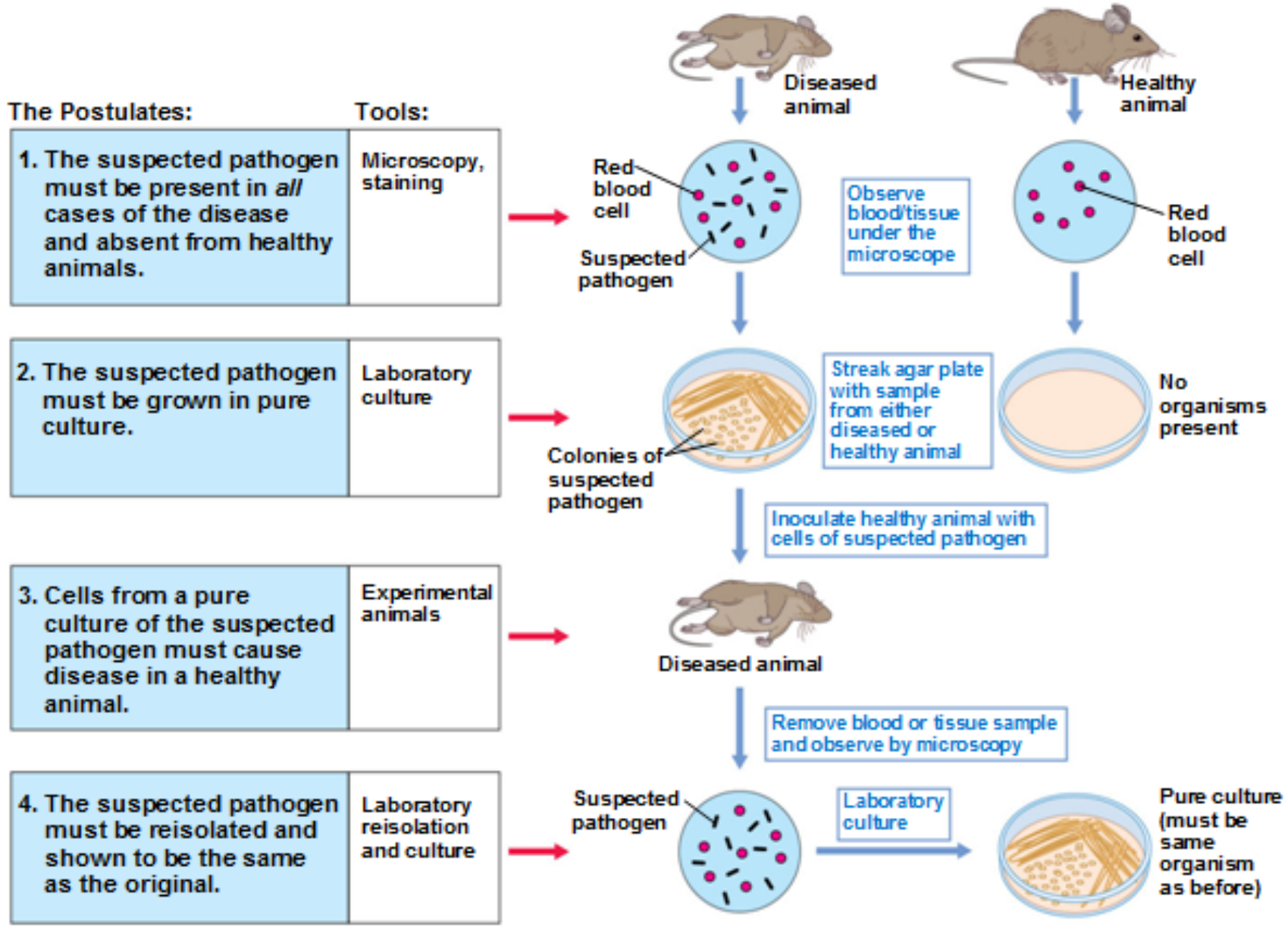
1. The microorganism or other pathogen must be present in all cases of the disease.
2. The pathogen can be isolated from the disease host and grown in pure culture.
3. The pathogen from the pure culture must cause the disease when inoculated into a healthy, susceptible laboratory animal.
4. The pathogen must be reisolated from the new host and shown to be the same as the originally inoculated pathogen.

Robert Koch's other contributions to science

- Staining technique for bacteria
- Hanging drop method to detect motility
- Method for isolating pure culture of bacteria by planting on solid medium
- Koch's postulates

Koch's postulates/ Germ theory

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



Koch's postulates for proving cause and effect in infectious diseases.

Sick mouse

Spleen of sick mouse

Grew on bacterial plates until getting pure culture

Isolate the same bacteria from the second mouse

Sick…

Inject healthy mouse with suspected bacteria

Koch, Infectious Disease, and Pure Culture Microbiology

- Koch's Postulates Today
  - Koch's postulates apply for diseases that have an appropriate animal model
  - Animal models not always available
    - For example, cholera, rickettsias, chlamydias
  - Remain "gold standard" in medical microbiology, but not always possible to satisfy all postulates for every infectious disease
- Koch and the Rise of Pure Cultures
  - Discovered that using solid media provided a simple way of obtaining pure cultures
  - Began with potato slices, but eventually devised uniform and reproducible nutrient solutions solidified with gelatin and agar

Discovery of microbes

- Hansen 1874 – Leprosy bacillus
- Neisser 1879 – Gonococcus
- Eberth 1880 – Typhoid bacillus
- Ogston 1881 – Staphylococcus
- Loeffler 1884 – Diptheria bacillus
- Nicolaier 1884 – Tetanus bacillus in soil
- Fraenkel 1886 – Pneumococcus
- Weicheselbaum 1887 - meningococcus

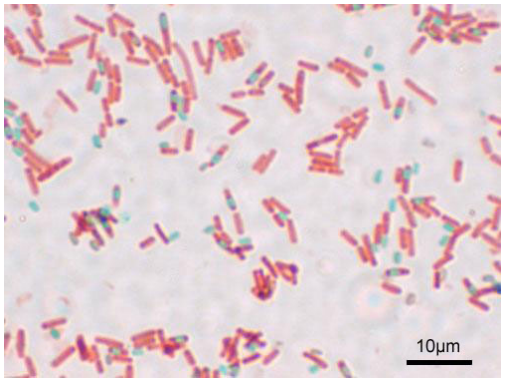
Edward Jenner – Father of vaccination

- Also known as the ‘Father of immunology’ Edward Jenner was an English scientist and is famous for his discovery of smallpox vaccine.
- This was the first successful vaccine ever to be developed.
- Jenner observed that pus from blisters in milkmaids who developed the less deadly cowpox was somehow protecting these women from the more virulent smallpox.
- In 1796, Jenner tested his theory by injecting pus from cowpox into an eight year old boy. The boy was inoculated again and later tested, but showed no signs of disease.
- This led him to his discovery of smallpox vaccine.

Other contributors

- Edward Jenner (1796) **vaccinates** people to protect them from smallpox

- Ferdinand Cohn (1828–1898): founded the field of bacterial classification and discovered bacterial endospores



Bacillus subtilis endospore stained in blue

This young girl in Bangladesh was infected with smallpox in 1973 caused by virola virus

Other milestones in immunization

- 1897- Killed vaccine against plague
- 1897- Killed vaccine against typhoid fever
- 1924- BCG vaccine (Albert Calmette & Camille Guerin)
- 1938- Vaccine against yellow fever
- 1953- Killed polio vaccine(Jonas Salk)
- 1963- Vaccine against Hepatitis B
- 1979- smallpox officially declared eradicated

Defense against microorganisms

- 1891 – Paul Ehlrich proposed that antibodies are responsible for immunity
- 1910 – cure for syphilis was discovered
- 1928 – penicillin was discovered by Alexander Fleming
- 1935 – Gerhard J. Domagk used prontosil a chemically synthesized antimetabolite, to kill streptococcus in mice.
- 1940 – Selman Waksman and H.Boyd Woodruff discovered Actinomycin, the first antibiotic to be obtained pure from soli.
- 1944 – W.H.Feldman and H.C.Hinshaw successfully treat tuberculosis with streptomycin
- 1953 – first useful fungal antibiotic Nyastatin developed.

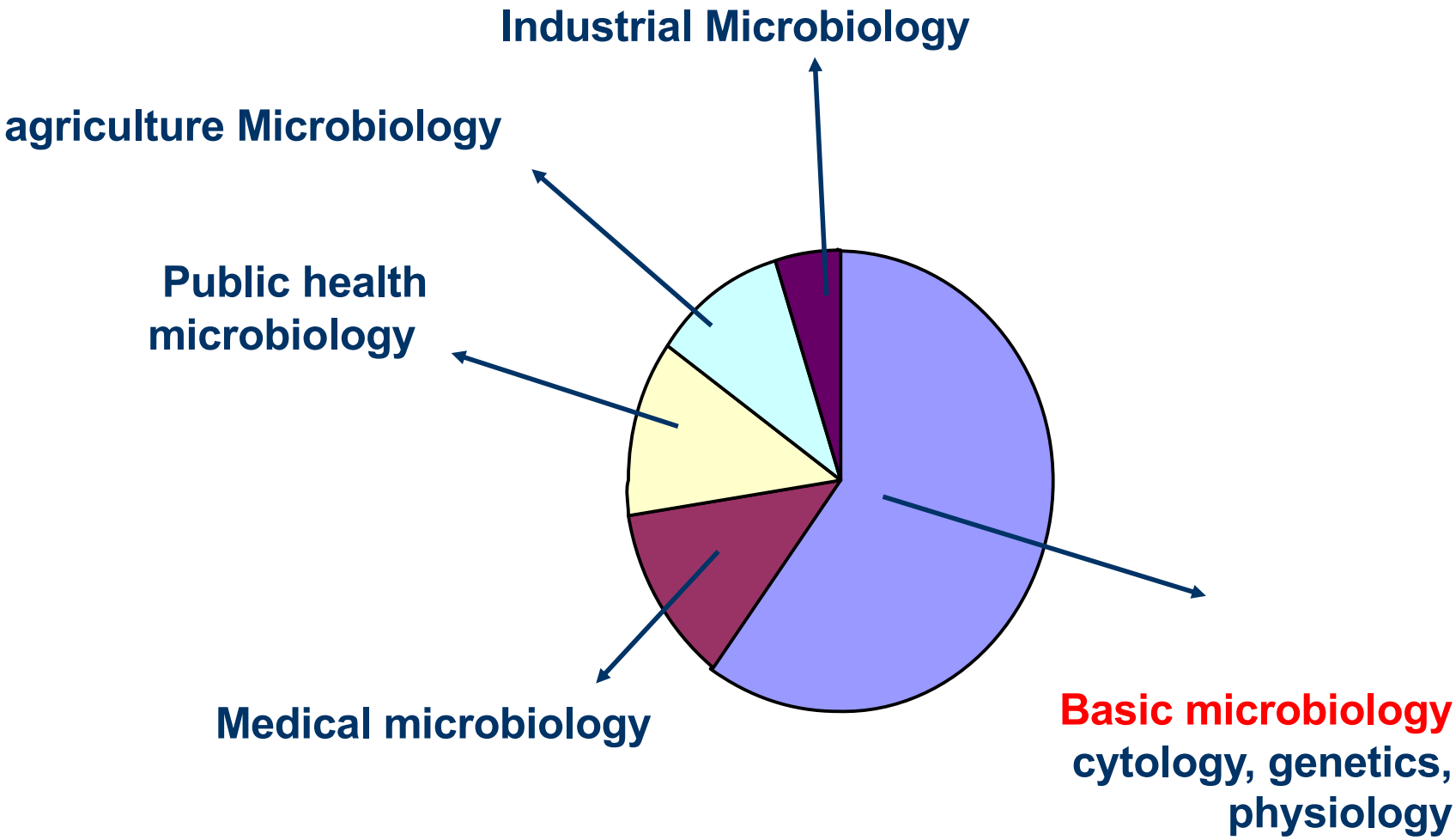
Major contributors in microbiology

Giants of the early days of microbiology and their major contributions

Investigator	*Nationality*	*Dates*[a]	*Contributions*
Robert Hooke	English	1664	Discovery of microorganisms (fungi)
Antoni van Leeuwenhoek	Dutch	1684	Discovery of bacteria
Edward Jenner	English	1798	Vaccination (smallpox)
Louis Pasteur	French	Mid- to late 1800s	Mechanism of fermentation, defeat of spontaneous generation, rabies and other vaccines, principles of immunization
Joseph Lister	English	1867	Methods for preventing infections during surgeries
Ferdinand Cohn	German	1876	Discovery of endospores
Robert Koch	German	Late 1800s	Koch's postulates, pure culture microbiology, discovery of agents of tuberculosis and cholera
Sergei Winogradsky	Russian	Late 1800s to mid-1900s	Chemolithotrophy and chemoautotrophy, nitrogen fixation, sulfur bacteria
Martinus Beijerinck	Dutch	Late 1800s to 1920	Enrichment culture technique, discovery of many metabolic groups of bacteria, concept of a virus

General Microbiology fields

Applied microbiology



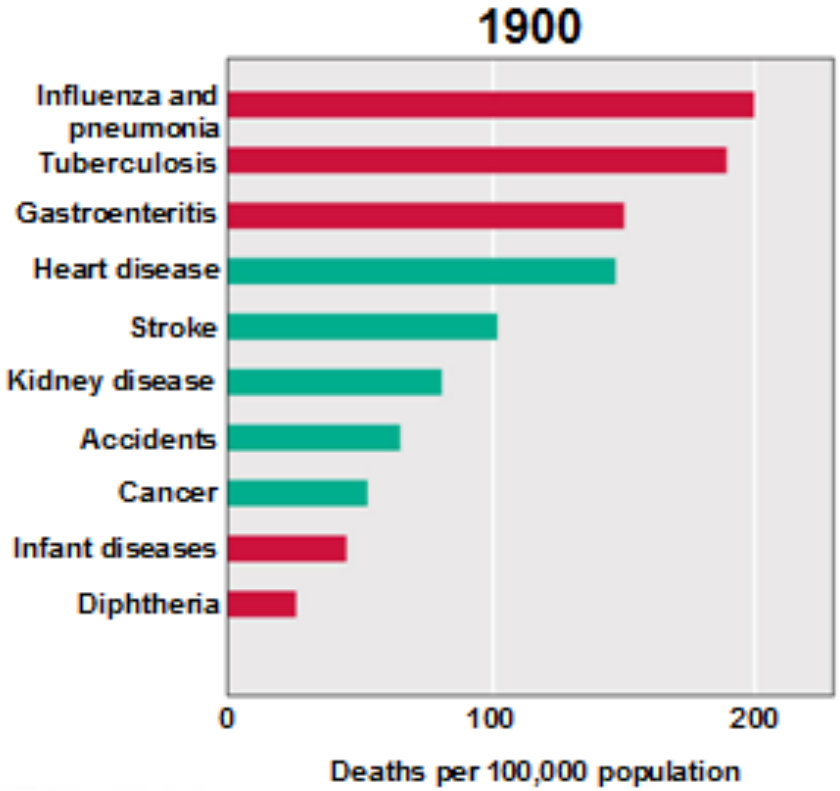
Microbes = disease?

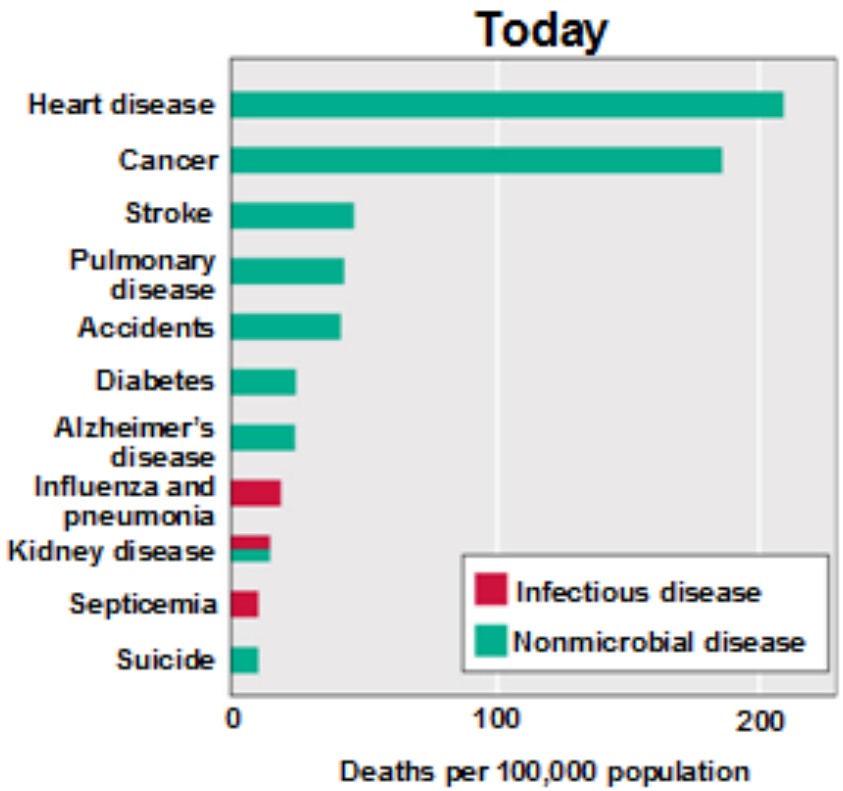
- When we think of microbial organisms we immediately think of disease, but in fact the great majority of microorganisms are **beneficial** to us and the planet**.**
- Of all known species of bacteria **87%** are **beneficial**
- **10%** are **opportunistic pathogens (cause diseases only under certain conditions)**
- Only **3%** are **true pathogens**

Microbes and human health

- Normal microbiota: from the moment we are born we live with a great number of microorganisms that grow and divide on or inside our body. These microorganisms can be extremely beneficial to us (e.g. bacteria that synthesize vitamin K and B in our gut) .
- Pathogenic: microorganisms cause infectious diseases (that can be transmitted from person to person). We know bacterial (e.g. cholera), viral (e.g. AIDS, flu), and protozoan (e.g. malaria) diseases.

Death rates for the leading causes of death in the United States: 1900 & today





The Impact of Microorganisms on Humans

- **Microorganisms and Agriculture**
  - Many aspects of agriculture depend on microbial activities
  - **Positive impacts**
    - nitrogen-fixing bacteria
    - cellulose-degrading microbes in the rumen
    - Insect pest control by microorganisms: *Bacillus thuringiensis*.
    - Recycling of vital elements: C, N, O, S and P converted by microorganisms into forms that can be used by plants and animals
  - **Negative impacts**
    - diseases in plants and animals

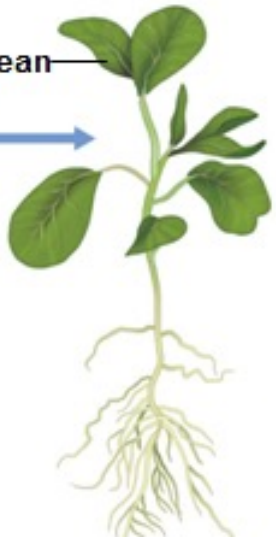
Microorganisms in modern agriculture

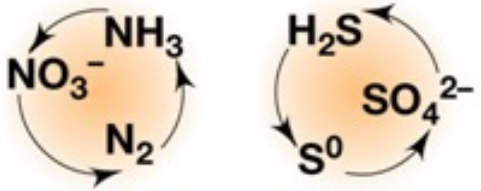
(a)

$N_2 + 8H \rightarrow 2NH_3 + H_2$

(b)

Soybean plant

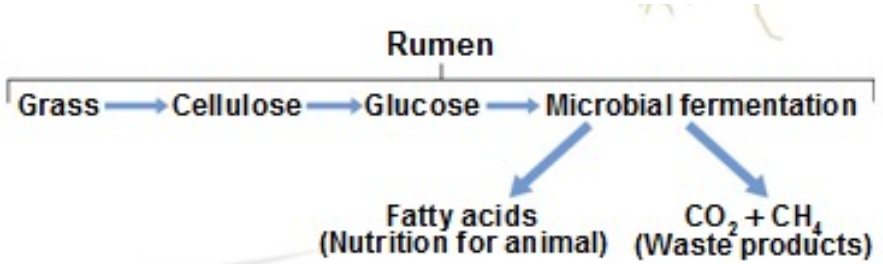




N-cycle S-cycle

(c)

Nitrogen fixing bacteria



(d)

Cellulose degrading bacteria

The Impact of Microorganisms on Humans

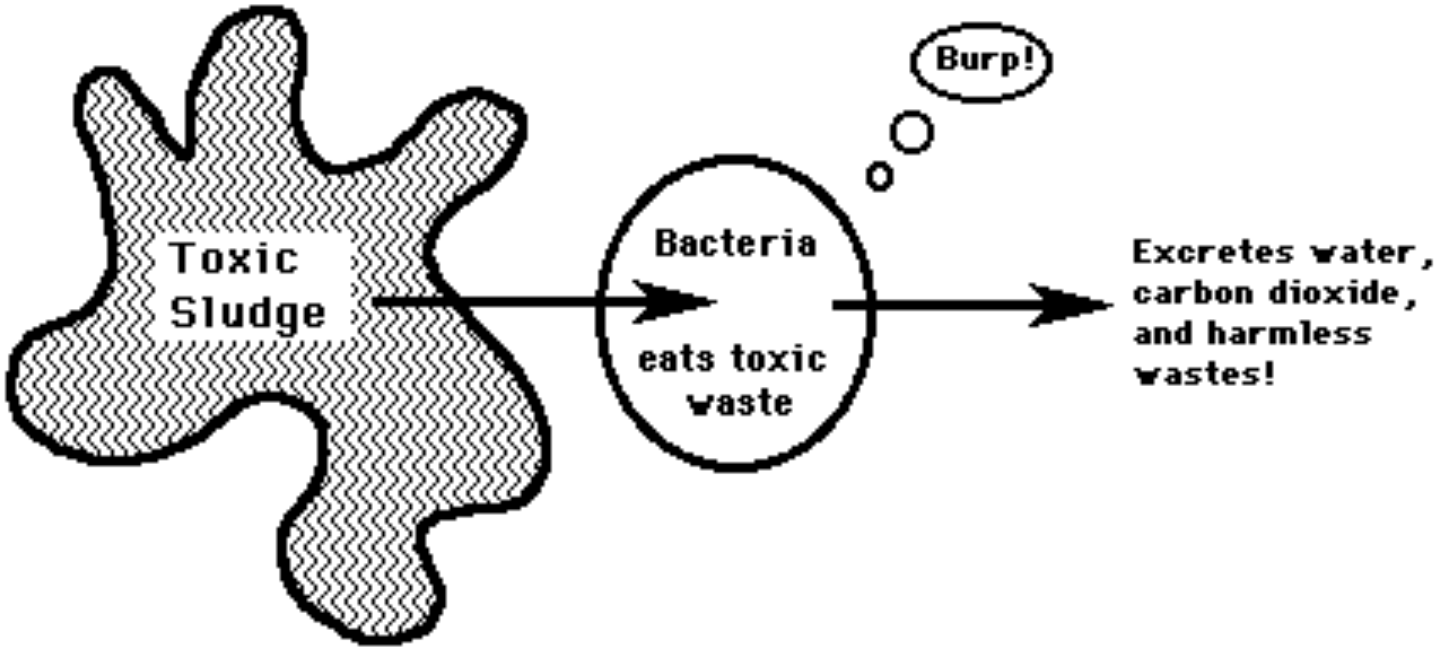
- Microorganisms and Food
  - **Negative impacts**
    - Food spoilage by microorganisms requires specialized preservation of many foods
  - **Positive impacts**
    - Microbial transformations (typically fermentations) yield
      - dairy products (e.g., cheeses, yogurt, buttermilk)
      - other food products (e.g., pickles, breads, beer)

The Impact of Microorganisms on Humans

- Microorganisms, Energy, and the Environment The role of microbes in *biofuels* production
  - For example, methane, ethanol, hydrogen

The Impact of Microorganisms on Humans

The role of microbes in cleaning up pollutants & toxic wastes (*bioremediation*)



The Impact of Microorganisms on Humans

- Microorganisms and Their Genetic Resources
  - Exploitation of microbes for production of antibiotics, enzymes, and various chemicals
  - Genetic engineering of microbes to generate products of value to humans, such as insulin (*biotechnology*)

Branches of microbiology

- Medical microbiology
- Pharmaceutical microbiology
- Industrial microbiology
- Microbial biotechnology
- Food microbiology
- Soil microbiology
- Agricultural microbiology
- Aquatic microbiology
- Air microbiology
- Epidemiology

Scope and importance of microbiology

- **Production of antibiotics-**

Name of bacteria/fungi	Name of antibiotics
Streptomyces aureofaciens	Aureomycin (Tetracycline)
Streptomyces venezuelae	Chloramphenicol
Streptomyces erythraeus	Erythromycin
Pencillium notatum	Pencillin
Pencillium griseofulvum	Griseofulvum

- **In alcohol & vinegar industry-**
  - In first step
  - $C_6H_{12}O_6 \longrightarrow 2C_2H_5\text{-}OH + 2CO_2$
    glucose ethanol carbon dioxide
  - In second step, aerobic bacteria (*Acetobacter aceti* and *Mycoderma aceti*) oxidize the alcohol into acetic acid.

- **Vitamin production-**
  - Riboflavins(B2)- Clostridium butylicum
  - Cobalamine(B12)- Pseudomonas denitrificans
  - Vit. A,C,D &E – Algae
  - High content of vit. B1,B12 & C – Fungi
- **Baking industry-**
  - Yeast is used for manufacturing of bread
  - Kneaded flour + yeast ⟶ fermenation ⟶ converts starch into sugar ⟶ sugar converts into alcohol and carbon dioxide with the help of enzyme, zymase.
  - Carbon dioxide effervesces are released which makes bread spongy, get swollen and light weight

- **Production of acids and enzymes –**

Microorganism	Acids
Penicillum glaucum/ Aspergillus gallomyces	Gallic acid
mucor	Citric acid
Aspergillus niger	Gluconic acid
microorganisams	Enzymes
Aspergillus oryzae	Amylase
Bacillus subtilis	protase
Saccharomyces cerevisiae	Invertase
Streptococcus purogens	Streptokinase

- **Cosmetic and perfume-**

➢ Some species of lichens like Evernia and Ramatina are used for making perfume and soaps and carrageenin which is extracted from sea weed used in manifacturing ice cream, paints and shmpoo etc.

- **Used in production of dairy products –**
- Dairy products are manufactured due to bacterial activity

Microorganism	Products
Lactobacillus lactis	Cheese
Streptococcus lactis	Curd, butter
Streptococcus lactis *Streptococcus cremoris*	Butter milk
Lactobacillus lactis	Cheese

- **Agriculture and soil industry-**
- Nitrogen is essential for growth of plant and they use nitrogen in the form of nitrates.
- Nitrogen fixation is done by many m.o like algae (Anabina, Nostoc), bacteria (Nitrosomonas and nitrobacter), root nodules of leguminous plants (Rhizobium leguminosarum)

- **Used as food-**
  - Algae Gelidium, Gracilaria produce agar agar (jelly sub.) used for manifacturing ice cream.
  - Laminaria (seaweeds) contain lot of iodine which is imp. Mineral for thyroid gland

Reference

- A brief history of microbiology- https://www.cliffsnotes.com/study-guides/biology/microbiology/introduction-to-microbiology/a-brief-history-of-microbiology.
- Microorganisms- https://en.wikipedia.org/wiki/Microorganism.
- History- https://en.wikipedia.org/wiki/Microorganism.
- History of microbiology- http://www.slideshare.net/sarathy4/history-of-microbiology-10692521.
- www.actforlibraries.org
- University of Maryland website
- Medical microbiology by Dr. Clifton Franklund