Lection 1

Aims and objectives of medical microbiology and immunology. Historical stages. Classifications and bacterial taxonomy.

Microbiology

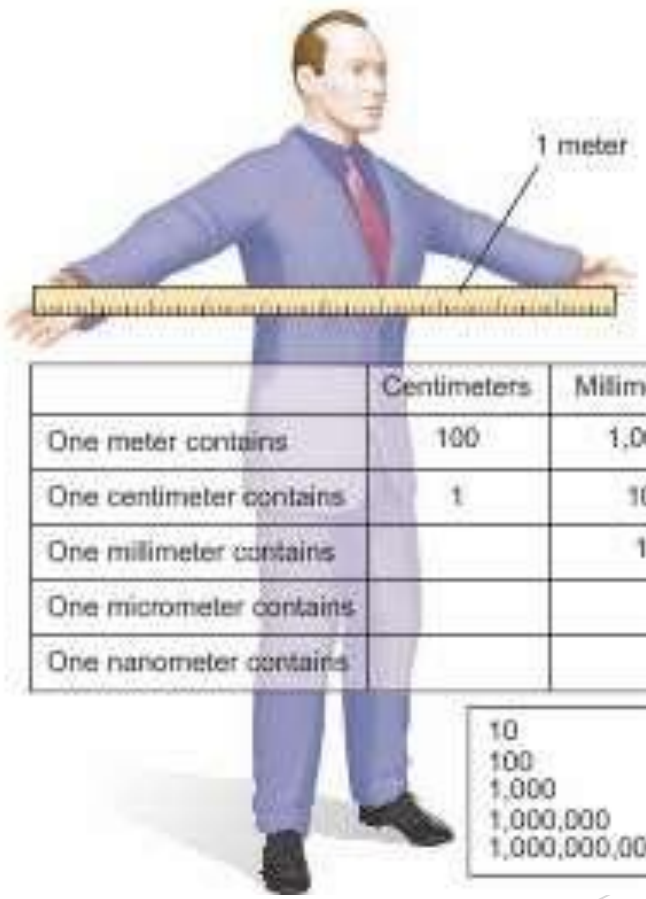
Microbiology – ***«mikros»-small, «bios»-*** **life,** ***«logos»-the study*****.**

Science of pattern, life activity and ecology of the microbes – smallest life forms of flora and fauna origin, which are invisible for the naked eye.

The size of microbes are measured in micrometers (mm) and nanometers (nm).

Metric unit of length

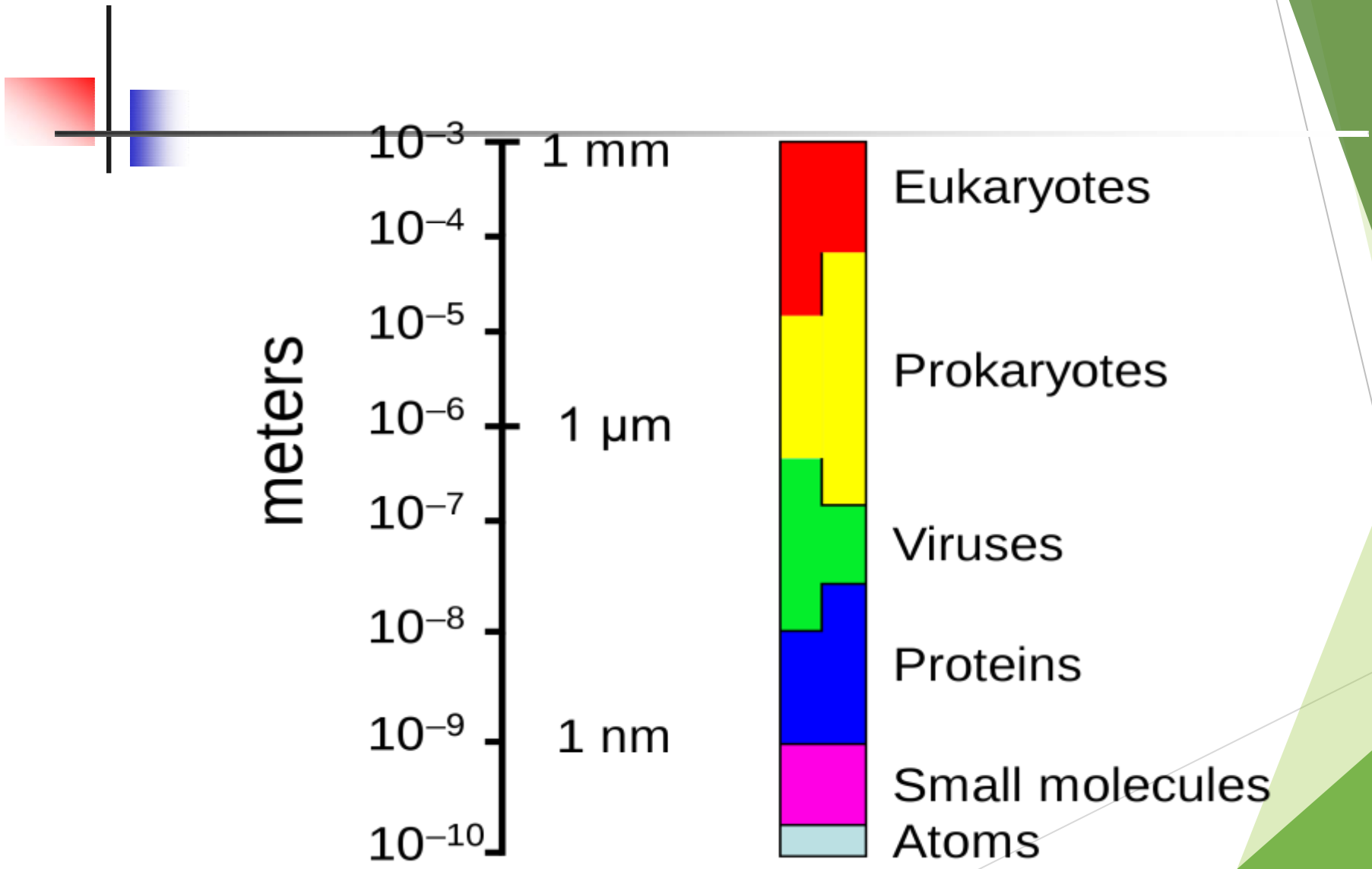
FIGURE 2-1. Representations of metric units of measure and numbers.



	Centimeters	Millimeters	Micrometers	Nanometers
One meter contains	100	1,000	1,000,000	1,000,000,000
One centimeter contains	1	10	10,000	10,000,000
One millimeter contains		1	1,000	1,000,000
One micrometer contains			1	1,000
One nanometer contains				1

$10 = 1 \times 10^1$
$100 = 1 \times 10^2$
$1{,}000 = 1 \times 10^3$
$1{,}000{,}000 = 1 \times 10^6$
$1{,}000{,}000{,}000 = 1 \times 10^9$

Relative scale for microbes

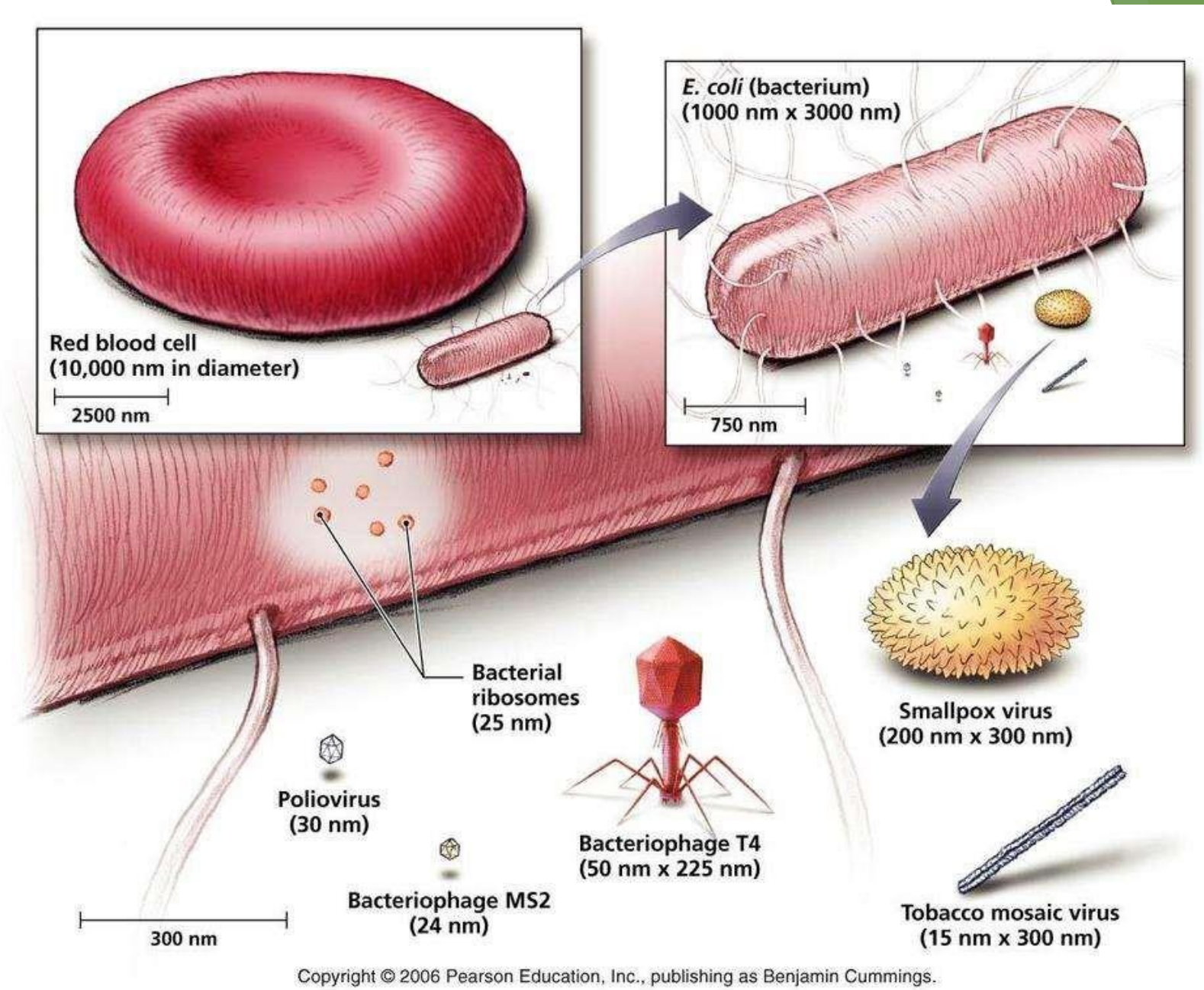


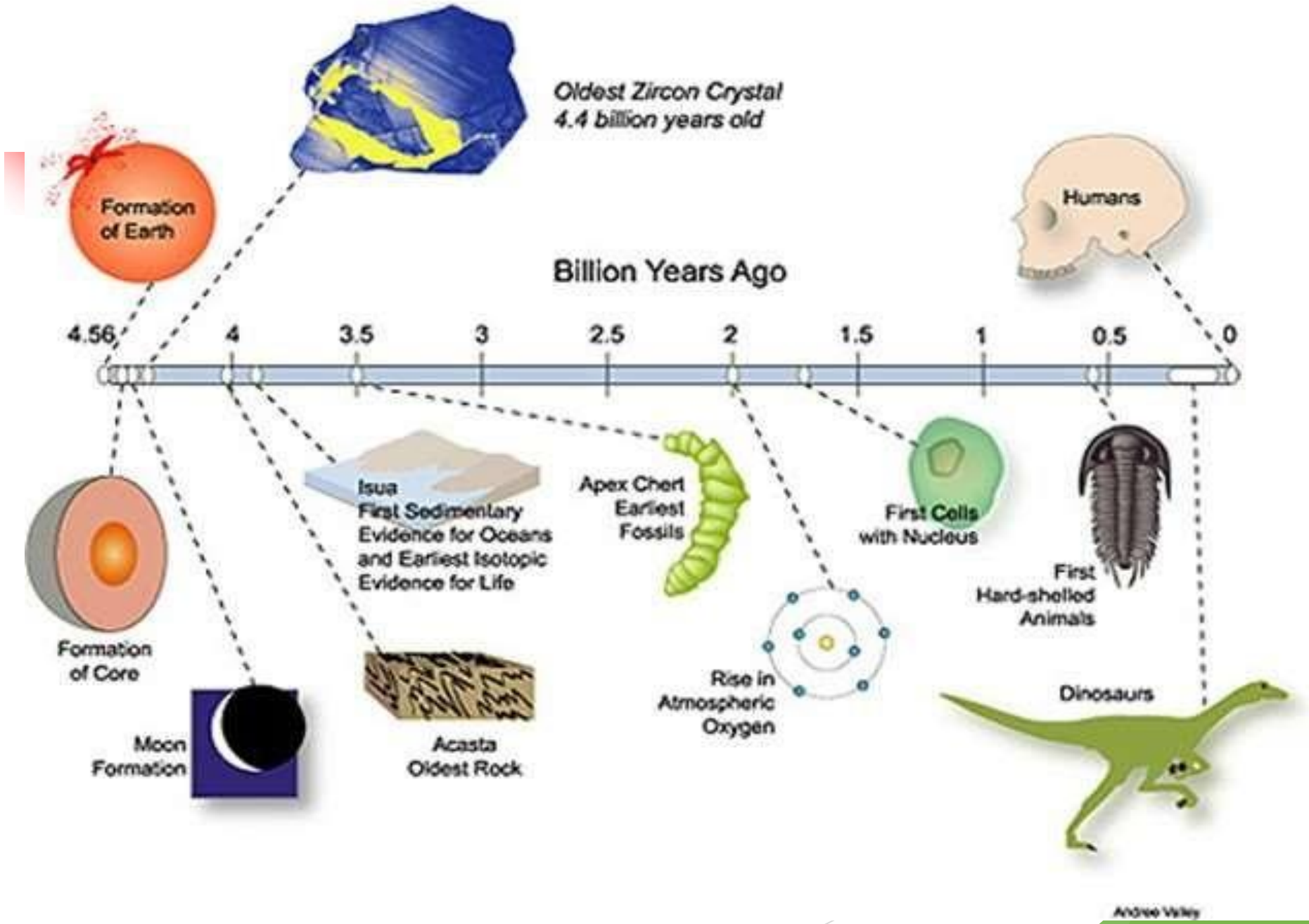
Sizes of microbes

TABLE 2-1 Relative Sizes of Microbes

MICROBE OR MICROBIAL STRUCTURE	DIMENSION(S)	APPROXIMATE SIZE (μm)
Viruses (most)	Diameter	0.01–0.3
Bacteria		
Cocci (spherical bacteria)	Diameter	average = 1
Bacilli (rod-shaped bacteria)	Width × length	average = 1 × 3
	Filaments (width)	1
Fungi		
Yeasts	Diameter	3–5
Septate hyphae (hyphae containing cross-walls)	Width	2–15
Aseptate hyphae (hyphae without cross-walls)	Width	10–30
Pond water protozoa		
Chlamydomonas	Length	5–12
Euglena	Length	35–55
Vorticella	Length	50–145
Paramecium	Length	180–300
Volvox[a]	Diameter	350–500
Stentor[a]	Length (when extended)	1,000–2,000

[a]These organisms are visible with the unaided human eye.




Oldest Zircon Crystal
4.4 billion years old
Formation of Earth
Humans
Billion Years Ago
4.56
4
3.5
3
2.5
2
1.5
1
0.5
0
Isua
First Sedimentary Evidence for Oceans and Earliest Isotopic Evidence for Life
Apex Chert
Earliest Fossils
First Cells with Nucleus
First Hard-shelled Animals
Formation of Core
Moon Formation
Acasta
Oldest Rock
Rise in Atmospheric Oxygen
Dinosaurs

Fields of Microbiology

- **Medical**
- **Veterinary**
- **Agricultural**
- **Marine**
- **Space**
- **Technical**

Medical Microbiology

- **Aims** – The study of pathogens for humans microorganisms and also diseases which are caused by them, pathogenesis of those illnesses, their laboratory diagnosis, treatment and prevention.
- **Objectives:**

-Further study of roles of particular species of pathogen microbes in the etiology and in the pathogenesis of different human diseases.

-Study of mechanisms of immunity formulation;

-Development of diagnostics methods.

-Method development of specific prevention and treatment.

Medical Microbiology

- Special medical microbiology
- Bacteriology
- Virology
- Mycology
- Protozoology
- Sanitary microbiology
- Clinical microbiology

Common medical microbiology

- Structure (morphology) of microbes
- Physiology of microbes
- Biochemistry of microbes
- Genetics of microbes
- Evolution of microbes
- Microbe ecology

Basics in medical microbiology.

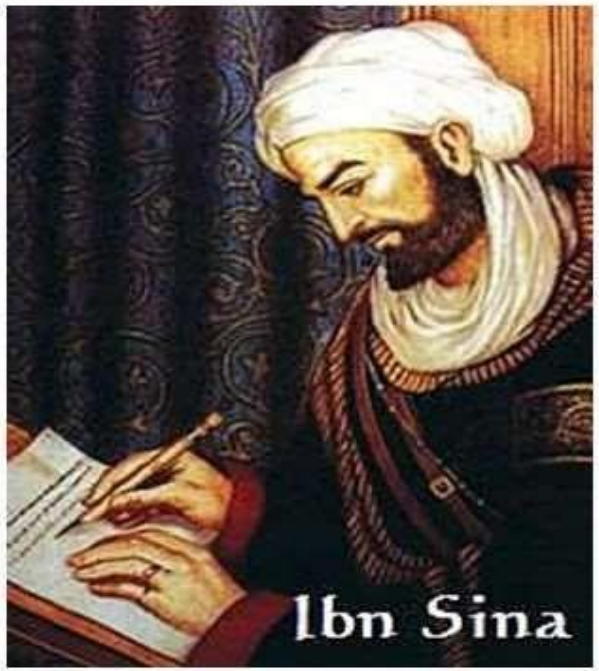
- Virology – science about viruses.
- Protozoology- science about simple organism
- Immunology- studies preventive processes in organism.
- Micology- science about fungies.
- Sanitar microbiology- studies micro organisms living in outer environment .
- Clinical-role of normal flora in formation of diseases, diagnostics and prevention.
- Pharmaceutical- studies technologies of getting microbiological, preventive and healing drugs.

The role of microbiology in the activity of the pharmacist

- ***The role of microbiology in the activity of the pharmacist:*** Understanding the principles of microbiology and human cell mechanisms allows **pharmacists** to discover antimicrobial drugs that would prevent an escalating number of communicable diseases. Pharmacists and microbiologists work synergistically to ensure that drug therapies target the opportunistic microbes without harming its human host
- Microbiology began to develop as a science from the second half of the 19th century. The history of the development of microbiology is divided into several stages:

History of Microbiology

- **Abū Alī al-Ḥusayn ibn Abd Allāh ibn Sīnā (Ibn Sina) (368-424 H , 980-1037 G).**
- His book ***The Canon of Medicine*** was one of the best references in medicine and pharmacology know for describing infectious diseases and quarantine them as control procedures.
In Pharmacology, he discussed how to effectively test new medicines.



Proof that microbes cause disease

- 1546: Hieronymus Fracastorius (Girolamo Fracastoro) wrote "On Contagion" ("De contagione et contagiosis morbis et curatione"), the 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

Nature study of infection diseases. (1)

- D.S. Samoylovic in the second half of XVIII century suggested that “plague is caused by special and absolutely excellent creature” and for warning the organism of upcoming disease it is suggested to inject weakened infectious onset. In 1771 he injects himself with infectious material taken from the human being recovering form plague.
- In 1796 E. Jenner showed that injects to the people of pathogen cowpox, prevent them of being infected by smallpox.

The first vaccination against smallpox made by E. Jenner.

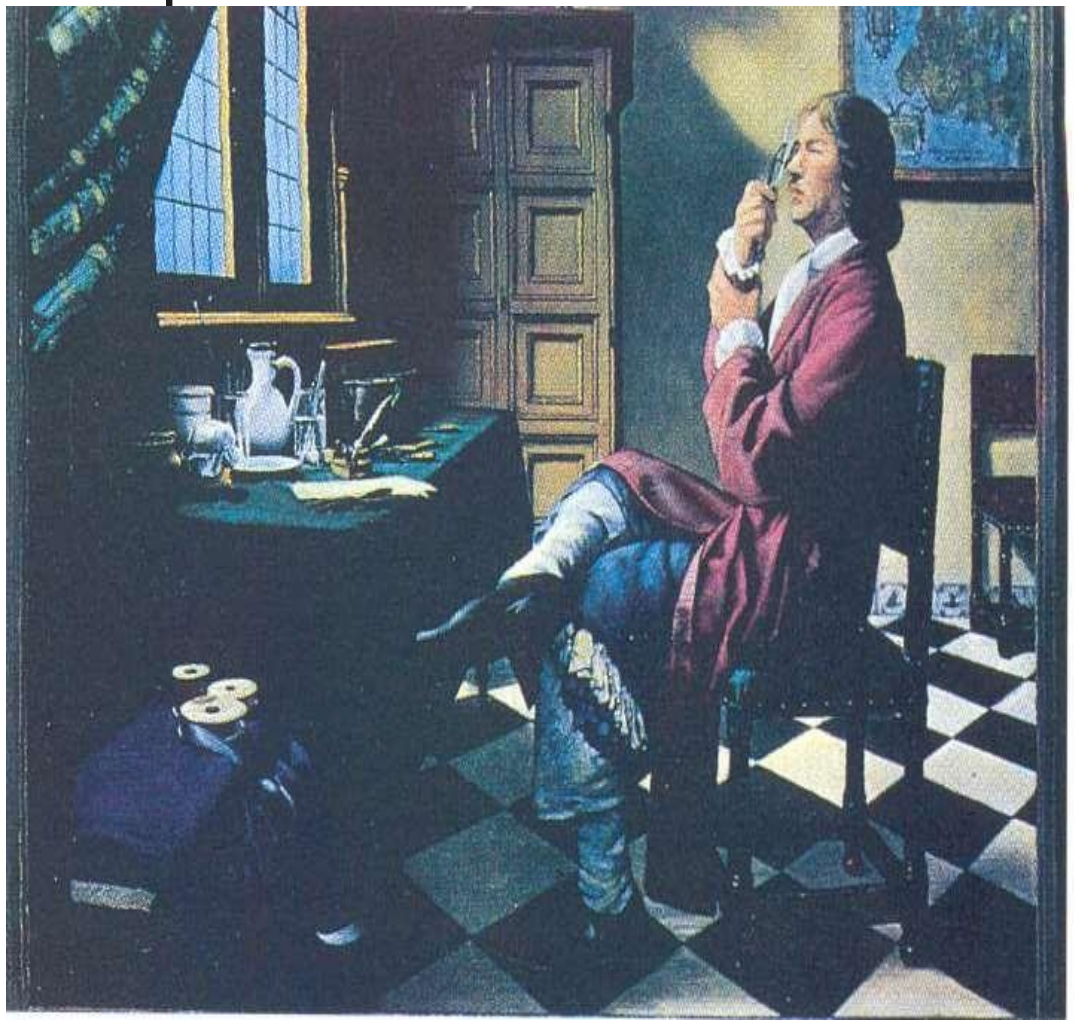
Antony Van Leeuwenhoek (1632-1723)

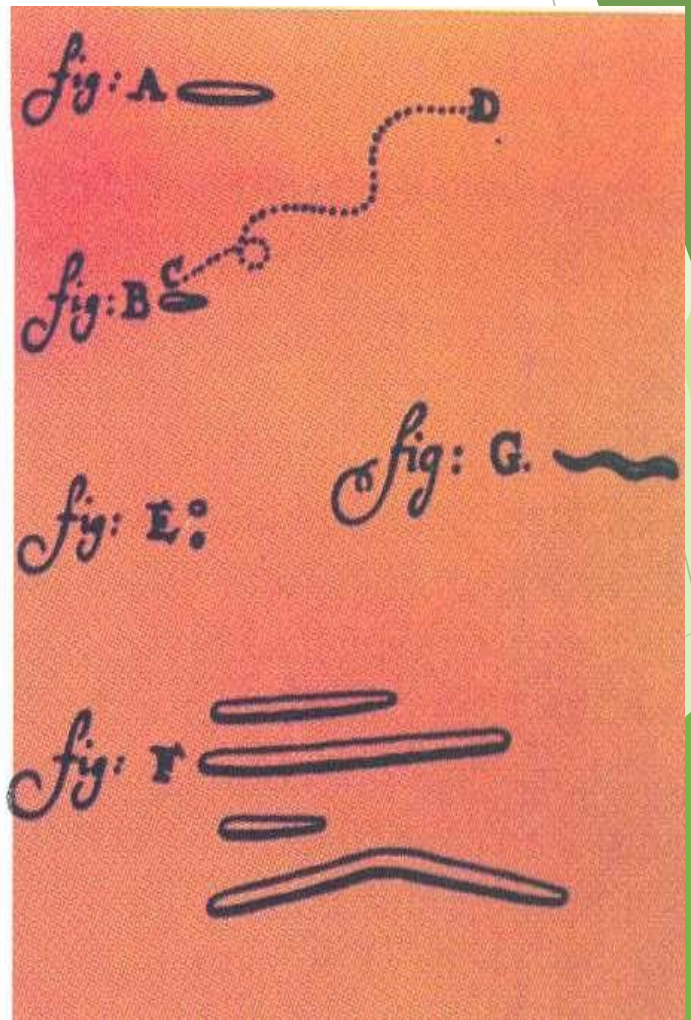
1. As a draper (merchant who sells cloth and dry goods), he used lenses to examine cloth. This probably led to his interest in lens making.
2. He assembled hundreds of microscopes, some of which magnified objects 270 times.
3. As he looked at things with his microscopes, he discovered "micro" organisms - organisms so tiny that they were invisible to the naked eye.
4. He called these tiny living organisms "animalcules". He first described bacteria, protozoans and many cells of the human body

Antonie van Leeuwenhoek

With the first microscope

On 17th of 1683 year took a smear from the tooth scurf (report in London's royal society)





Physiology period.

From mid XIX century Luis Pasteur

- **XIX-XX centuries (Robert W. Cox)**

Physiology period.
Golden age of microbiology (from XVII-XIX centuries)

GOLDEN ERA

Louis Pasteur

- Father of medical Microbiology
- In his famous experiment, he took a ***Swan Neck Flask*** and boiled nutrient rich broth inside it. He pointed that no growth took place in the flask as dust and germs had been trapped on the walls of the curved neck.

LOUIS PASTEUR

- **Louis Pasteur** was a French chemist and microbiologist who was one of the most important founders of **medical microbiology.**
- He is remembered for his remarkable breakthroughs in the causes and preventions of diseases .
- His discoveries reduced mortality from **puerperal fever**, and he created the first **vaccines** for **rabies** and **anthrax.**

** Louis Pasteur **

Louis Pasteur experience

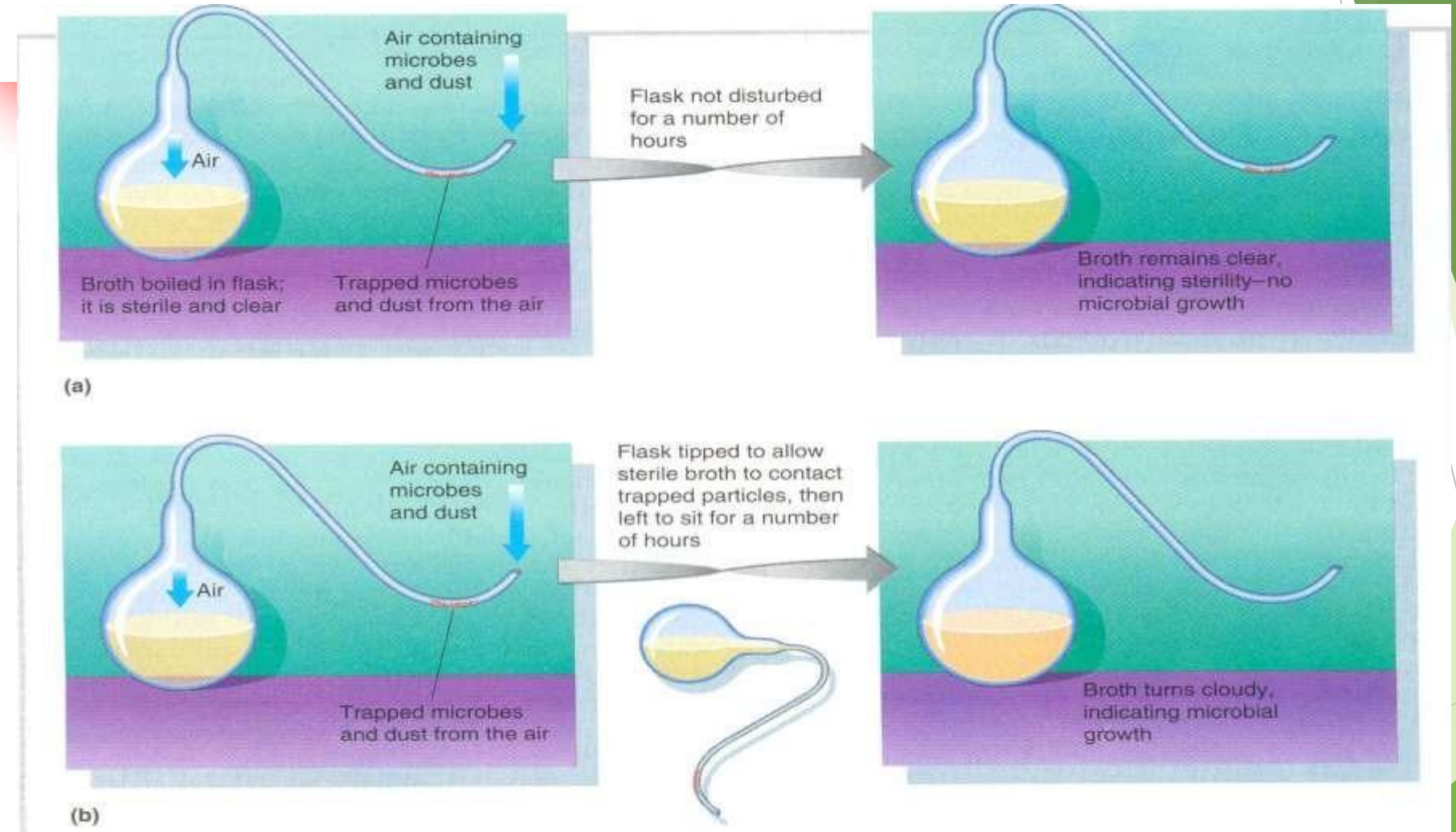
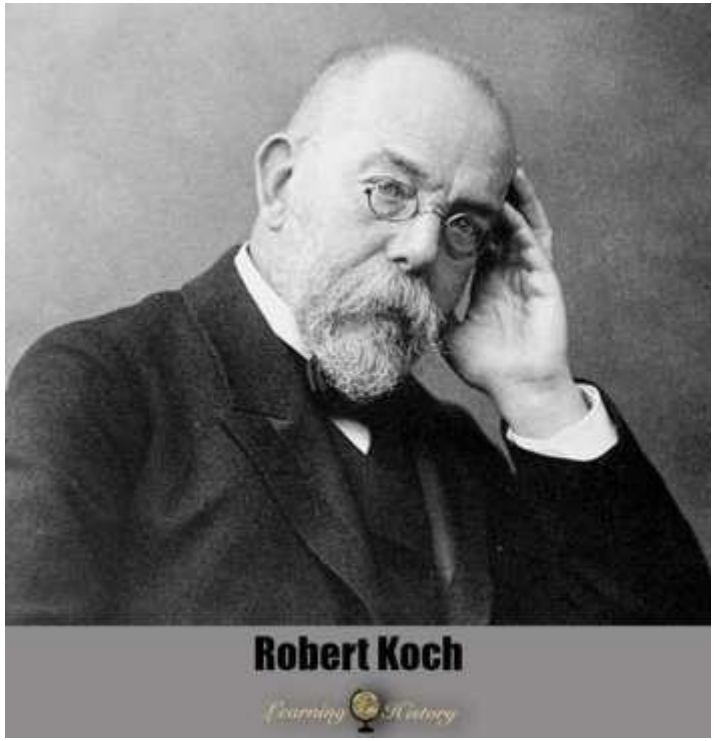


FIGURE 1-3 Swan-necked Pasteur flask. Dust settles in the neck of the flask, trapping particles and microorganisms while allowing unaltered air to reach the nutrient medium. (*a*) The broth remains clear and sterile. (*b*) If the flask is tilted so the broth flows into the neck and reaches the trapped particles, the liquid becomes cloudy within hours, indicating microbial proliferation.



Robert Koch discoveries:

•Method of stressing out of clean cultures on hard nutrition environments (included the practice of using Petri cups)

• Methods of coloring bacteria's

•Discovered pathogen of anthrax, cholera, tuberculosis

•Developed techniques of microscopy.

Got Nobel laureate for physiology and medicine in 1905 for tuberculosis research.

Robert Koch's Triad

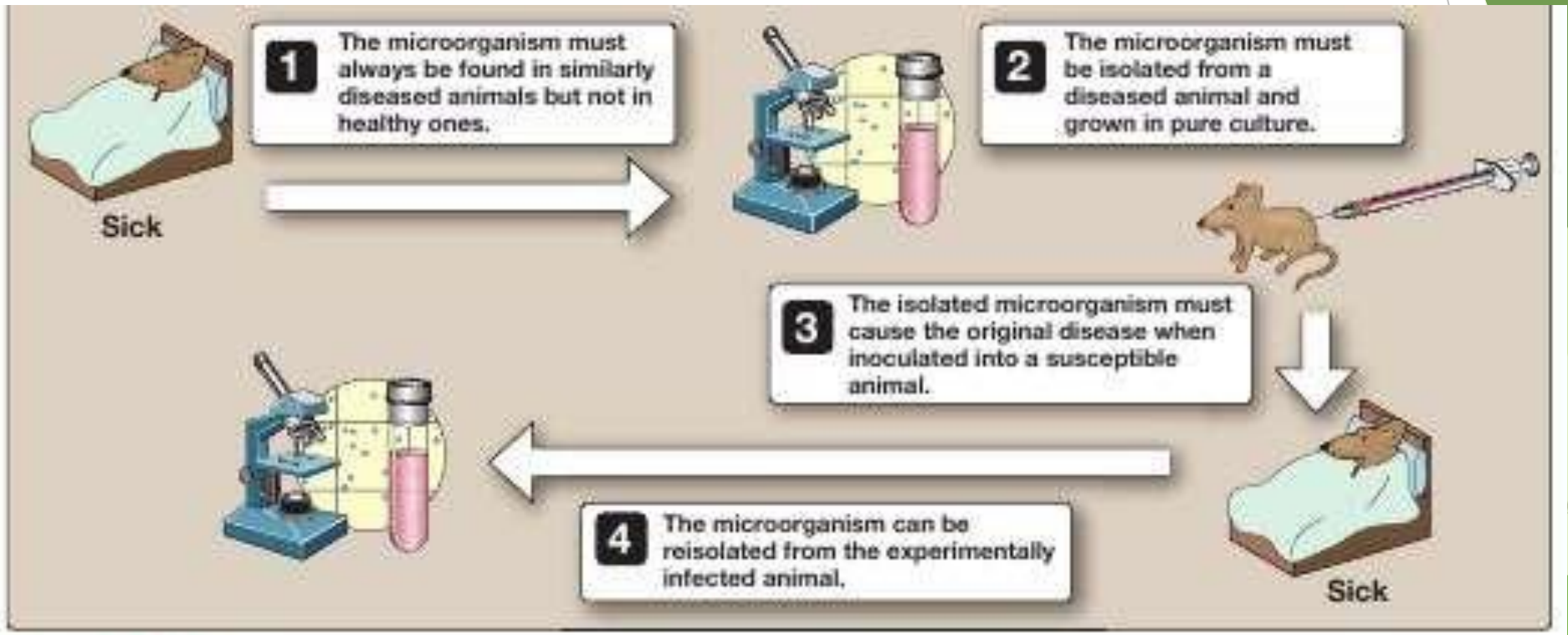


FIGURE 1-10. **Koch's Postulates: proof of the germ theory of disease.** (From Harvey RA et al. Lippincott's Illustrated Reviews, Microbiology, 2nd ed. Philadelphia: Lippincott Williams & Wilkins, 2007.)

Study of natural infectious diseases(2)

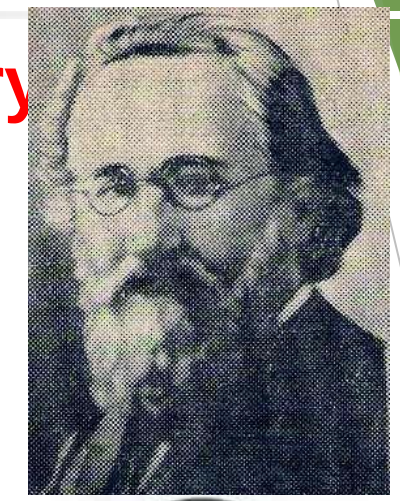
- 1839 year – I.Shenleyl set that scab (favus) causes a pathogenic fungus.
- 1843 year – D. Grubi discovered ringworm (trichophytosis)
- 1849r – A. Pollender and others discovered a pathogen of anthrax
- 1859r – D. Lambl discovered giardia.

Introduction of antiseptics rules.

Use of phenol for prevention of wound infections in the hospitals by Joseph Lister(1827-1912)

Period of Immunology

(secind half of XIX century



- Luis Pasteur (1822-1895)

  (Vaccination)

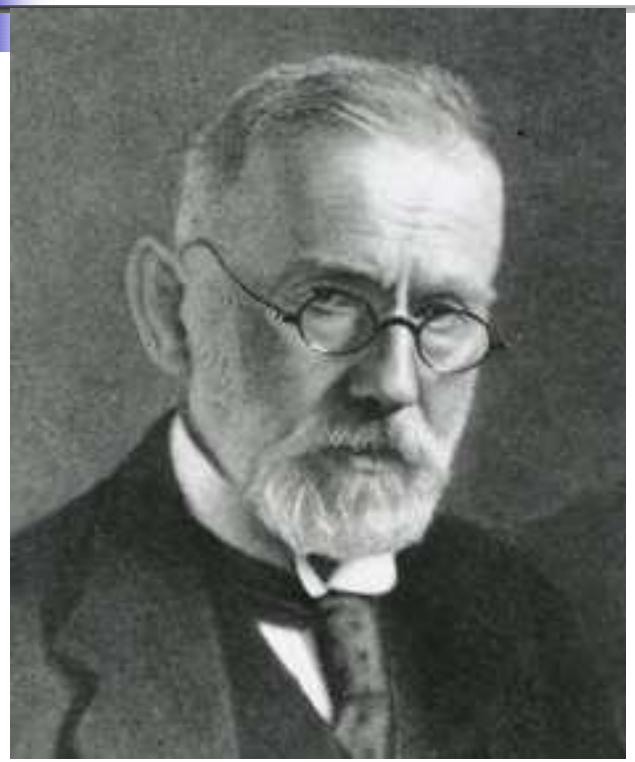
- I. I. Mechnikov (1843-1916)

  (Phagocytic theory- base of cell immunology)

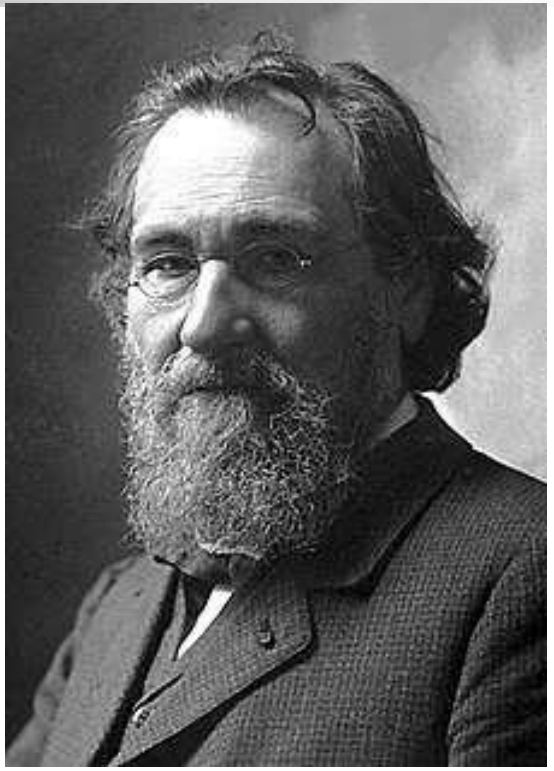
- Paul Erlich(1843-1916)

  (Antibodies – base of humoral theory of immunity)

Period of immunology.



Paul Elrich 1854-1915
Developed humoral theory of immunity.

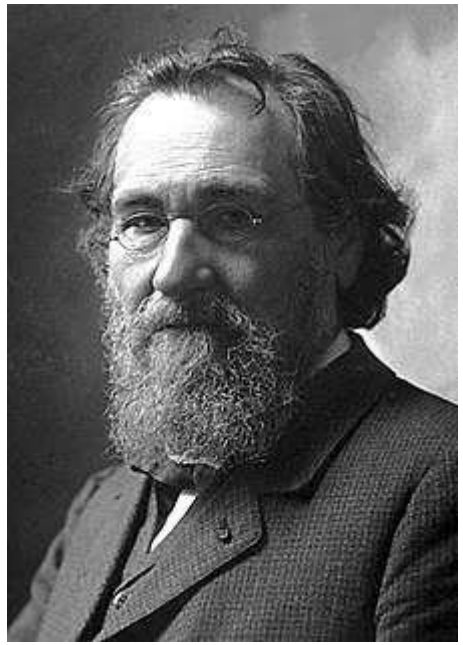


Ilya Mechnikov 1845-1916

In proceeding decades of fruitful disputes and discussions between phagocytosis and humoral theories, the mechanisms of immunity was discovered and the new science Immunology appeared.

Immunology period.

E.Jenner (1729-1723)
In 1796 year proved that vaccinating people with cow pox causes resistance to smallpox.



Ilya Mechnikov 1845-1916
“Poet of microbiology”
Developed the theory phagocytosis and cell theory of immunity.

Immunology

- Studies mechanisms and methods of protection against genetic alien substances– antigens with the aim to support and save homeostasis, structural and functional integrity of organisms and also antigen individuality of each organism and species as a whole.

Major discoveries in the field of **microbiology**

1892 year- D. I. Ivanovskiy- discovery of viruses

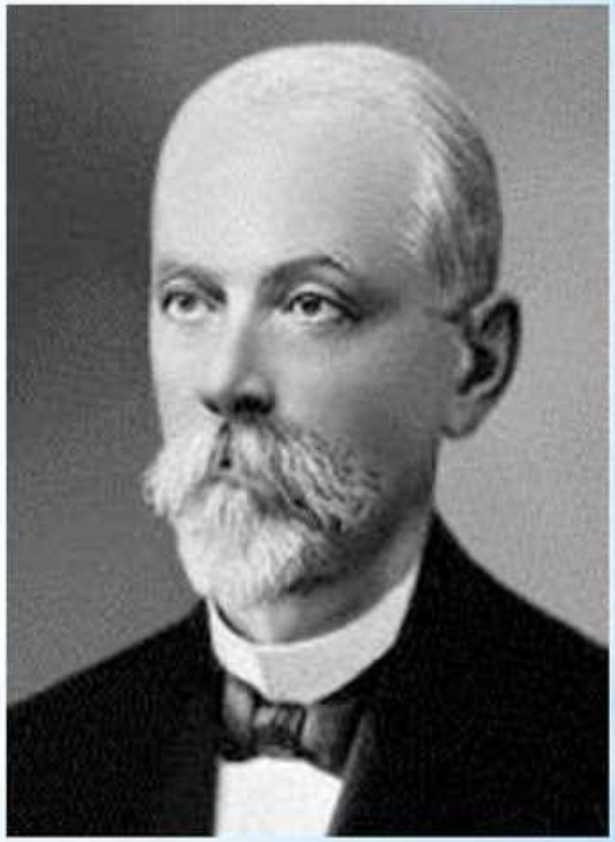
1906 year, P. Erlich – chemotherapy (salvarsan)

1928 year. – A. Fleming – penicillin

Д.И.Ивановский (1864-1920)

Dmitri Ivanovsky

Dmitri Iosifovich Ivanovsky (alternative spelling Dmitrii or Dmitry Iwanowski; Russian: Дми́трий Ио́сифович Ивано́вский; 1864–1920) was a Russian botanist, one of the discoverers of filterable nature of viruses (1892) and thus one of the founders of virology.



Penicillin (Alexander Fleming)

Sir Alexander Fleming, a Scottish biologist, pharmacologist and botanist. He wrote many articles on bacteriology, immunology, and chemotherapy. His best-known discoveries are the enzymelysozyme in 1923 and the antibiotic substance penicillin from the mould Penicillium notatum in 1928, for which he shared the Nobel Prize in Physiology or Medicine in 1945 with Howard Florey and Ernst Boris Chain.

Chain Ernst Boris (1906-1976)
English biochemical

Flory Howard Wolter
(1898-1968) Pathologist
Microbiologist

- In 1938 discovered penicillin in injection form.
- Became Nobel Laureate on physiology and medicine in 1945 along with Alexander Fleming for discovery and synthesis of penicillin.

Molecular-genetic period**(second half of XX century)**

- Using the methods of molecular biology and genetics on bacterial and viral models, the role of DNA as a substrate of heredity has been established, the genetic mechanism of protein synthesis and mutagenesis has been deciphered.
- Disclosed molecular-genetic bases of pathogenesis and immune protection ,studied system is histocompatibility.
- With the help of genetic engineering and biotechnologies we got recombinant strains of microbes produced by biologic active substances (antigens, interferon, antibodies, hormones etc.), gained by genetic- engineering and synthetic vaccines, different immunomodulators.

The modern molecular-genetic stage.

- Achievements of genetic and molecular biology
- Creation of electronic microscope.
- Evidence of the DNA role in transfer of hereditary traits.
- Usage of bacteria, viruses and plasmids as the objects of molecular- biologic and genetic researches.

Development of microbiology in Azerbaijan.

Academician P.F.Zdrodovskiy

- head of the department of microbiology of the medical faculty of ASU.
- Scientific activity - research of rickettsiosis

P.F.Zdrodovskiy

1890-1976

Development of microbiology **in Azerbaijan**

Academician L.A. Zilber, 1930-1932 - Head of the Department of Microbiology of the Medical Faculty of ASU. Scientific activity - study of the mechanism of viral carcinogenesis.

L.A. Zilber

Development of microbiology in Azerbaijan.

Associate Professor F.A. Yagubov 1933-1971 - Head of the Department of Microbiology, AMI. Scientific activities - the development of early diagnosis of syphilis, the study of the antimicrobial properties of fractions of naphthalan, the study of the epidemiology of plague in the republic.

Professor F.A. Yagubov

Кафедра медицинской микробиологии и иммунологии (2)

Профессор Н.Д.Алиев
- 1971-1988 гг – заведующий кафедрой микробиологии и вирусологии АМИ.
- Научная деятельность – изучение антимикробной активности нафталанской нефти и фитонцидов, полученных из флоры Азербайджана

Чл-корр.АМЕА, засл.деят.науки, профессор З.О. Караев
- 2004 - 2018 гг - заведующий кафедрой медицинской микробиологии и иммунологии АМУ.
- Научная деятельность – изучение микозов.

Профессор Г.Г.Ибрагимов
- 1988-2004 гг - заведующий кафедрой микробиологии и вирусологии АМУ.
- Научная деятельность - исследование антимикробной активности фитонцидов из флоры Азербайджана, изучение грибов рода Candida.

1939-2003

Профессор А.А. Кадырова
- 2019 – по наст. время - заведующая кафедрой медицинской микробиологии и иммунологии АМУ.
- Научная деятельность – изучение противовирусной активности интерферона и его индукторов, ВИЧ-инфекция, вирусные гепатиты В и С, лекарственная устойчивость микобактерий туберкулеза.

Connection of microbiology with other sciences.

What microbiology gave us?

- Principals of living organisms cultivation in artificial environment.
- Microorganisms are comfortable objects of experimental biology and medicine.
- Microorganisms are producers of different substances.
- Microorganisms –are objects for study of ecological relationships.
- Immunology, genetics, biotechnologies, cytology, pharmacy, ecology are the sciences which came from microbiology

Systematic of microbiology.

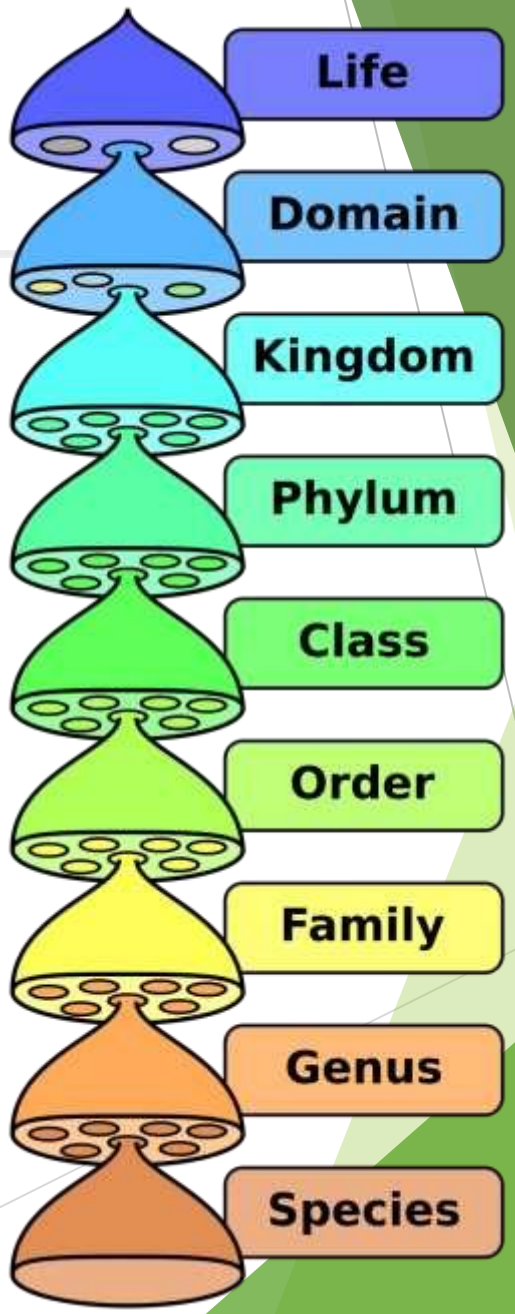
- **Systematic-** biological science, studies diversity of microorganism on the Earth and their relationships between each other.
- Systematic includes 3 parts:

- **taxonomy** – study of principles and methods of classification living creatures in the hierarchic plan.
- **classification** –process of division of many organisms on the basis of common properties to the certain taxonomy groups.
- identification –establishment of belonging of the studied organism to one or another taxon.

Taxonomic categories ,applied in classification of microbes	
Domain	Domain
Kingdom	Kingdom
Type (Phylum)	Phylum
Class	Class
Order	Order
Family	Family
Gender	Genus
Species	Species

Taxon

- The term "taxon" is used to refer to hierarchically subordinate units, the system of which makes up the classification of microorganisms.
- A taxon of the highest category of microorganisms is a domain uniting in a hierarchical order a system of taxa of a lower rank: kingdom, type, class, order, family, genus, species, subspecies.



Stages of classification of microorganisms

- The first step was the determination in the system of other organisms of the place of bacteria that became known before other microbes.
- In 1854, Kon attributed the bacteria to lower plants, and in 1957 the Negeli to schizomycetes.
- In 1866, E. Höckel, bacteria were classified as protists.
- In 1896, K. Lehman and R. Neumann compiled a classification of bacteria containing 3 families (cocci, bacteria, spirils).

Bacteria classification principles

- Basics of modern classification of bacteria's was established by David Bergey in 1923 (Bergey’s Manual of Systematic Bacteriology).
- It is built on principals of identification, based on differentiation of cell wall structure and relation to Gram strain.

David Bergey

Strain of bacteria's by Gram

- The coloring method was proposed in 1884 by the Danish scientist G.H. Gram.
- Depending on the structure of the cell wall, bacteria are divided into:
- - gram-positive (blue-violet)
- - gram-negative (red)

Hans Cristian Gram

The principals of coloring by Gram

- Gram positive-bacteria's which keeps gentian and violet in complex with iodine-violet color bacteria's

Gram negative -bacteria's after the effect of alcohol loose their color, become colorless and when treated with fussion they color become red

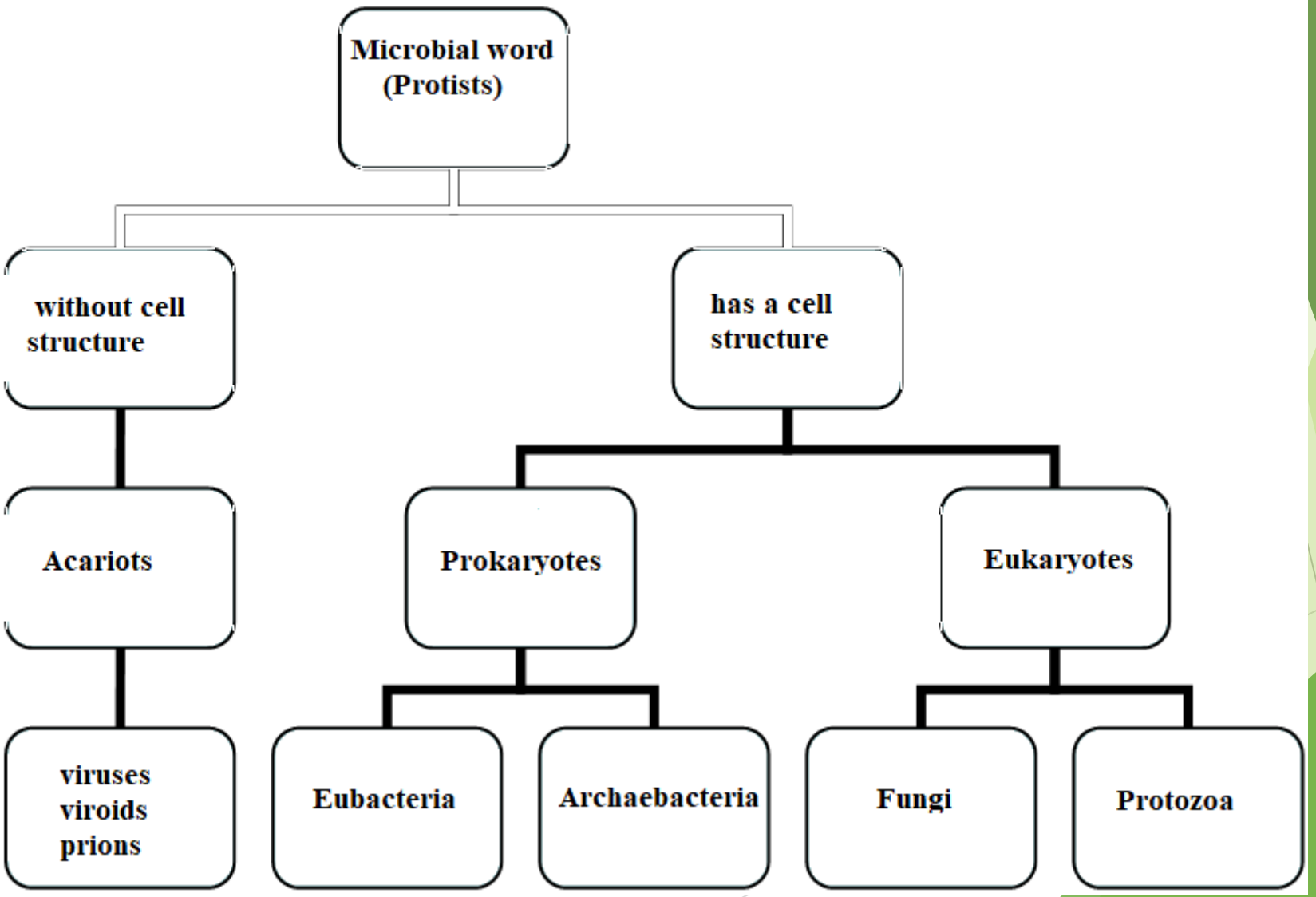
Classification of microorganisms

- In 1923 year- American society of bacteriologists published first international "Bacterium determinant" by D.Bergie
- Comity of Bergey's manual Trust:

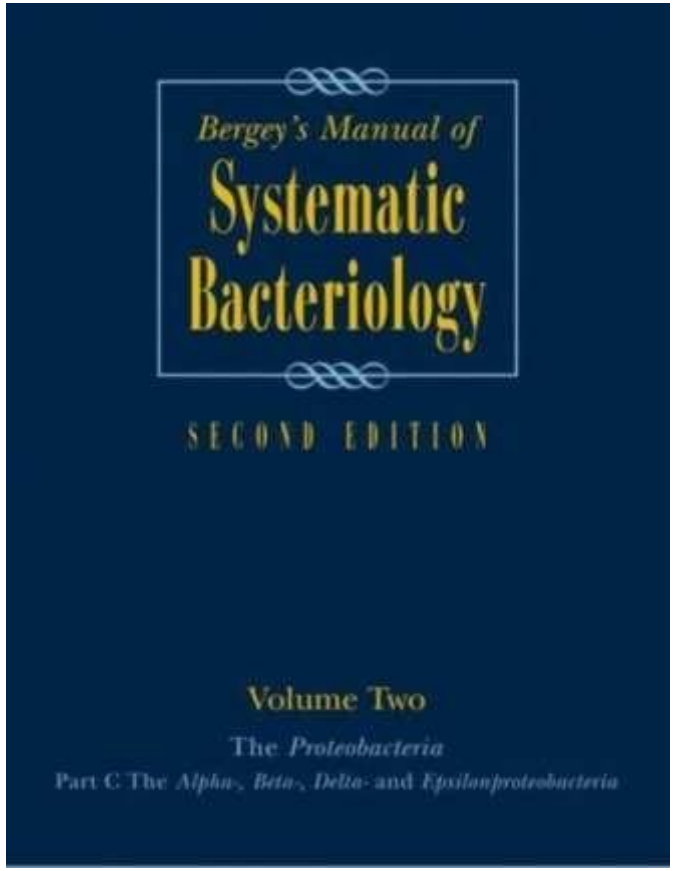
- "Bergey's Manual of Determinative Bacteriology"

-"Bergey's Manual of Systematic Bacteriology"

Classification of microbes



Qualifier of Bergie



Modern bacteria identification indicators.

- Phenotypic indicators: Gram stain, morphological and cultural properties, biochemical reactions, antigenic properties, etc.
- Genotypic indicators: the ratio of guanine + cytosine, DNA hybridization, plasmid analysis, ribotyping, etc.
- Phylogenetic indicators: rRNA sequence analysis, RNA-RNA hybridization, DNA amplification, etc.

Modern classification of microorganisms

- Microorganisms are represented by pre-cellular forms (viruses, viroids, prions) and cellular forms. Cellular forms are divided into 3 domains:
- - Bacteria - prokaryotes, true bacteria;
- - Archaea - prokaryotes, archaebacteria;
- - Eukaria - eukaryotes, which include 3 kingdoms:
- Mushrooms (Fungi) * Animals (Animalia), which include protozoa (Protozoa) * Plants (Plantae)

Comparison of prokaryotic and eukaryotic cells

Feautre	Prokaryotic cell	Eukaryotic cell
Nucleus		
Nuclear membrane	absent	presents
Nucleolus	absent	presents
Chromosome number	one	many
Mitotic division	absent	presents
DNA	circular	linear
Cytoplasm		
Cytoplasmic current	absent	presents
Ribosoms	70S	80S
Mitochondria	absent	presents
Lisosome	absent	presents
Holgi complex	absent	presents
Endoplasmic reticulum	absent	presents
Chemical components		
Sterols	absent	presents
Murein	exists	absent
Diaminopimelinic acid	may be	absent

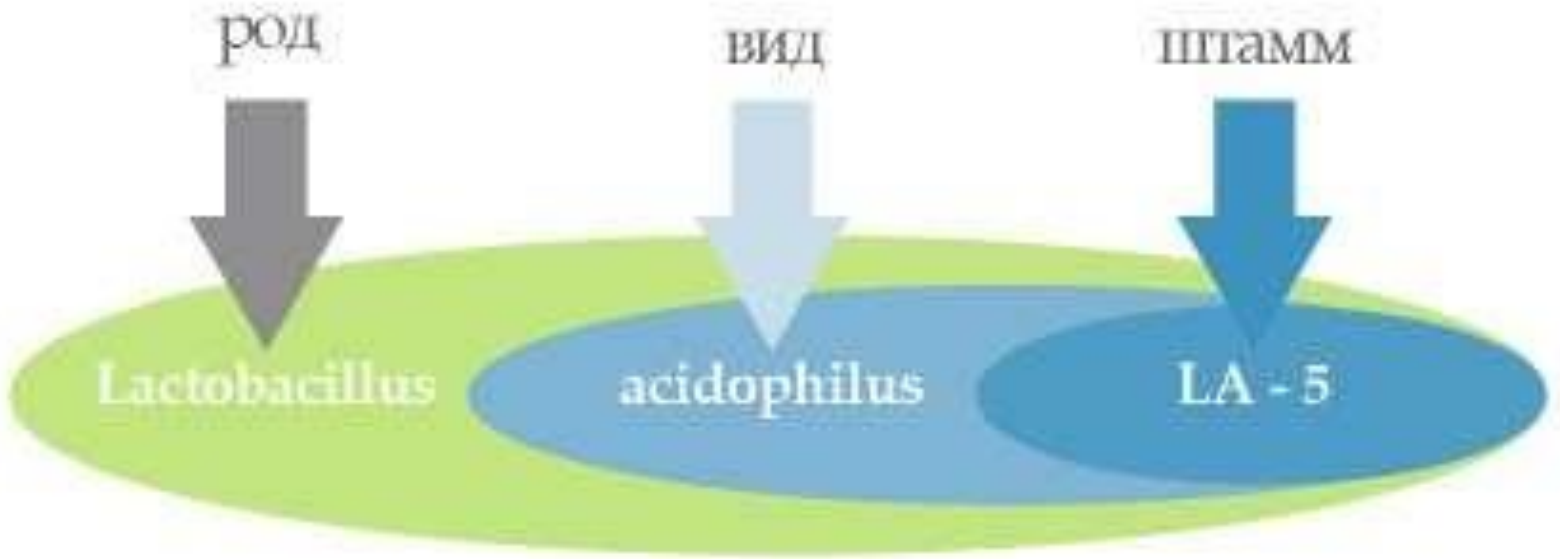
Microbe species

- Species - a collection of individuals having a common origin and genotype, similar in biological characteristics and possessing a hereditarily fixed ability to cause qualitatively defined processes under standard conditions.
- A subspecies, or variant (var) - microbes that differ in certain signs:
- - morphological - morphological,
- - serological - serovar,
- - biological - biovar,
- - biochemical - chemovar,
- - sensitivity to bacteriophages - phagovar.

Microbiological terms for microbes

- Pure culture - a collection of microbes of one species grown on a nutrient medium.
- A strain is a pure culture of microbes isolated from a specific source.
- A clone is a population of microbes derived from a single cell.
- A population is a collection of individuals of a certain type, within which there are no insulating barriers and free crossing occurs between individuals.

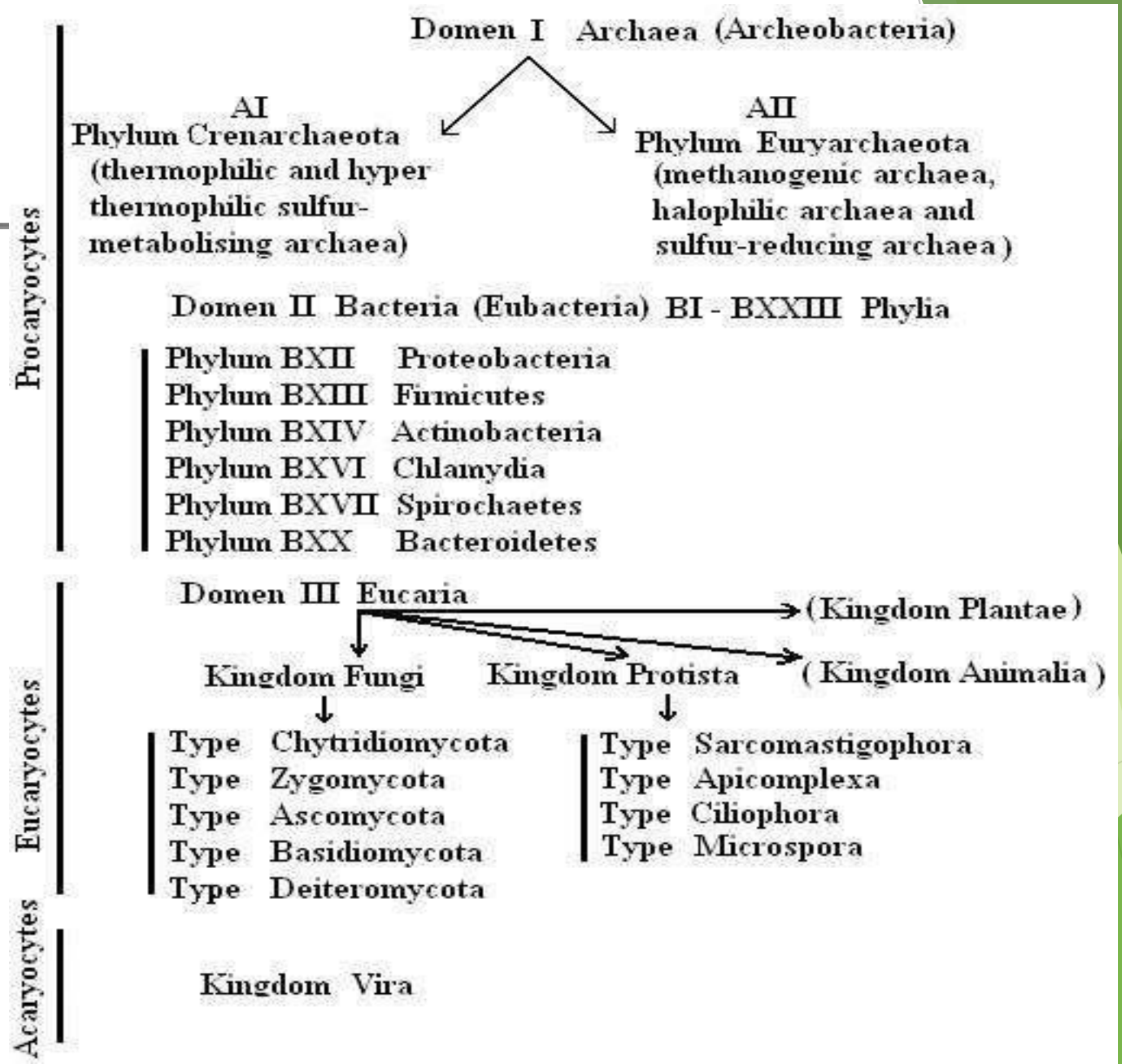
The ratio of genus, species and strain.



Modern classification of bacteria.

- According to the 2001 Bergey Manual (George M. Garrity, Julia A. Bell, Timothy G. Lilburn; Taxonomik Outline of the Prokaryotes. Bergey's Mannual of Sistematic Bacteriology, Second Edition, May, 2004), the bacteria are divided into 2 Domain: Bakteria and Archea, 26 types, 42 classes, many families and genera. The domain "Bakteria" includes 24
- The "Bakteria" domain includes 24 types and 33 classes of gram-negative bacteria with a thin cell wall (Gracilicutes), gram-positive bacteria with a thick cell wall (Firmicutes) and bacteria without a cell wall (Tenericutes). Representatives of 7 types have medical value.

Types of germs included in domains.



Methods of microbiological diagnostics.

- Microscopic method
- Microbiological method (bacterialogical)
- Biological method
- Immunological method

-serological

-allergic

- Molecular-genetic method.

Microscopic method.

- Results of microbiological researches are indicative in their nature, because many microorganisms lack morphological and tinctorial features.
- Nevertheless by microcopy of material we can define some morphological pathogen features and set a fact of presence or absence of microorganisms in given samples.

Microbiological method (bacteriological).

- "Golden Standard" of microbiological diagnostics, results of microbiological researches allow accurately establish the fact of presence of pathogen in researched material.

Biological method.

- Modeling the experimental infections in laboratory animals- major instrument research of pathogenesis diseases and characters of relationships of microorganisms and macroorganims

Immunological method.

- Identification of specific ANTIGEN OR ANTIBODY- is major instrument in diagnostics of infectious diseases. They have specific value in those cases when it is impossible to highlight the pathogen .

Immunological method.

- Antigens of microorganisms have sensitizing effects, which are used for diagnosis of infectious diseases and also in the epidemiological researches.
- The most popular probe is Mantu (PPD), used for diagnosis of tuberculosis, and also the reaction of organism to pathogen

Molecular-biological method

- One of the most modern methods of molecular biology is method of CPR-chain polymerase reaction .Research by the method of CPR have several advantages, because this method makes the field of pathogen DNA diseases more amplified.
- CPR method haves high sensitivity and absolute specifications.

Essential literature in medical microbiology and immunology.