I lecture

Medical microbiology and immunology, aims and objectives, history and development. Classification of microorganisms

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Microorganisms and their place in living world

- Microorganism (greek, *mikros* - small), or simply microbes are living organisms found in environment –soil, air, plant, animal, human organisms.

- They play important role in biogeochemical cycling being the part of biosphere.

- Some parasitic microorganisms cause diseases in plant, animal and human organisms.

Microorganisms and their place in living world

- Previously it was not possible to classify bacteria and other single cell microorganisms to plant and animal kingdoms.
- Thus, they were classified to distinct kingdom called **protists** (1866).
- Protists morphologically differ from animals and plants by their low differentiation: commonly they are unicellular microorganisms.

Microorganisms and their place in living world

- Due to cell structure protists are distinguished to 2 groups – higher and lower protists.
- ***Higher protists*** *are eukaryotes similar to plant and animal cells*. Representatives are **algae, fungi** and **protozoans**.
- ***Lower protists*** *are prokaryotes* and differ from orher organisms considerasbly. Representatives are bacteria and cyanobacteria (blue-green algae).
- Viruses which do not have cellular structure can not live free and reproduce only inside the living cells.

Prokaryotes and eukaryotes

- Due to structural features ol microorganisms can be divided to **cellular** and **acellular** organisms.

- Cellular microorganisms in turn are divided to **prokaryotes** and **eukaryotes.**

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

Prokaryotes

- **Prokaryotes (greek *karion* – nucleus) microorganisms without nucleus, the nuclear substance is located in nucleoid protoplasm.**
- **Prokaryotic microorganisms include bacteria, including spirochetes, rickettsiae, chlamydia, mycoplasmas, and actinomycetes.**

Eukaryotes

- **Eukaryotes (greek, *eu* - actual) have formed nucleus.**
- **All higher organisms (animals and plants) are eukaryotic organisms.Eukaryotic microorganisms include microscopic fungi and protozoa. Fungi aresimilar to plants microorganisms, but they do not have photosynthetic metabolism.**
- **Protozoans are microscopic single-celled organisms that are more similar to animals.**

Acellular microorganisms

- **Viruses – complex particles consisting of nucleic acids, proteins and enzymes. Their common features: have only one type of nucleic acid (RNA and DNA),obligate intracellular parazites, and grow by special mechanism called reproduction.**
- **Viroids do not have proteins consisiting of circular supercoiled RNA molecules.**
- **Prions are infectious protein agents without nucleic acid.**

Size of microorganisms

- Microorganisms are exceptionally small
- Their size varies from nanometeres (in viruses) to tens and hundreds of micrometers (protozoans)
- 1 micrometer = 10^3 millimeter
- 1 nanometre = 10^3 micrometer

Microbiology, its branches, subject, aim and objectives

- **Microbiology (greek, *mikros*-small, *life*, *loqos*-science) is a science learning life and growth of small organisms called microorganisms.**
- **This science learns features of microorganisms and processes caused in microorganism and environmental objects by microorganisms.**

General, basic microbiology

Learns morphology (form and structure), pgysiology (nutrition, metabolism,respiration, growth features), genetics (heredity and variability), and ecology of microorganisms.

«*Microflora*»,«*microbiota*», or «*microbiome*»

- **For long time microorganism were considered plants and called as microflora.**
- **However, it is known that microorganisms consist of both plant and animal representatives – bacteria, fungi, protozoans and viruses.**
- **While some representatives possess both plant and anima features (exp., bacteria and microscopic fungi), protozoans are mostly similar to animals. It is not possible to classify viruses as animals or plants.**
- **Thus, currently it is suggested to substitute “microflora” term to “microbiota” or “microbiome”.**

Special microbiology

- Learns features of distinct microorganisms and has branches:
- **bacteriology** (science about bacteria),
- **virology** (science about viruses),
- **mycology** (science about fungi),
- **protozoology** (science about fungi)

According to application fields special microbiology is divided to branches

- **Medical microbiology**
  - **Sanitary microbiology**
  - **Clinical microbiology**
- **İndustrial microbiology**
  - **biotevhnology**
- **Veterinary microbiology**
- **Agromicrobiology**
- **Cosmic microbiology**

Medical microbiology

- **Learns features of disease causing microorganisms and pathological processes developing in microorganism during diseases.**
- **Main objectives of medical microbiology aredevelopment of laboratory diagnostics, specific prevention and treatment methods of diseases caused by microorganisms.**

Sanitary microbiology

- Learns microorganism living in environment (air, water, soil etc.) and processes caused by them.
- The main aim of sanitary microbiology is to detect causative agents of infectious diseases from environment and conduct measures to prevent contamination of environment by microorganisms, thus preventing development of infectious diseases.

Clinical microbiology

- **A branch of medical microbiology learning diseases of human organ and systems caused by microbes and priciples and of microbiological diagnostics.**

Industrial microbiology

- **Studies microorganisms used in production of food, organic molecules such as antibiotics, enzymes, vitamins, alcohol etc.**
- **Industrial microbiology is in close relationship with biotechnology learning producers of biologically active substances.**
- ***Biotechnology learns living organisms especially microorganisms, animal and plant cells used in industry.***
- **Its aim is to obtain metabolic products of living cells. Sometimes it is possible through bioeffects which are usually do not exist in nature.**

Veterinary microbiology

- **Learns microorganisms causing diseases in animals and develops diagnostic, specific prevention and treatment methods used in diseases caused by them.**
- **Veterinary microbiology is related to medical microbiology- many microorganisms causing animal diseases are pathological for human as well.**

Agromicrobiology

- Studies microflora of soil, role of microorganism in plant nutrition and soil fertility,
- Studies phytopathogen microorganisms causing plant diseases and develops methods used in struggle with them.

Space microbiology

- Studies effect of Space factors on microorganisms and human microflora,
- Develops methods to prevent spread of microorganisms from Earth surface to space

Immunology

- **Immunology is a science evolved together with microbiology and developed based on microbiology. Learns structure and function of immune system- supporting inner homeostasis of organism.**
- **Immune competent cells of immune system produce protective reactions called immune reactions thus supporting inner stability of organism against genetically foreign substances called antigens by removing them from organism.**

Development of microbiology

- Stages of development.
- Theoretical
- Morphological
- Physiological
- Immunological
- Molecular genetic

C.Frakastoro
(1476-1553)

Theoretical

- **Hippocrates played an important role in formation of knowledge about infectious diseases in antic age medicine (IV-III b.c).**
- **Hippocrates thought that epidemics are caused by rotting organic matter called miasma also called night air.**
- **Hippocrates theory existed until renaissance - XIV century when a new theory of infectious diseases had emerged. In 1374 in Venice people suspected in plague were isolated for 40 days (*quarantina*).**

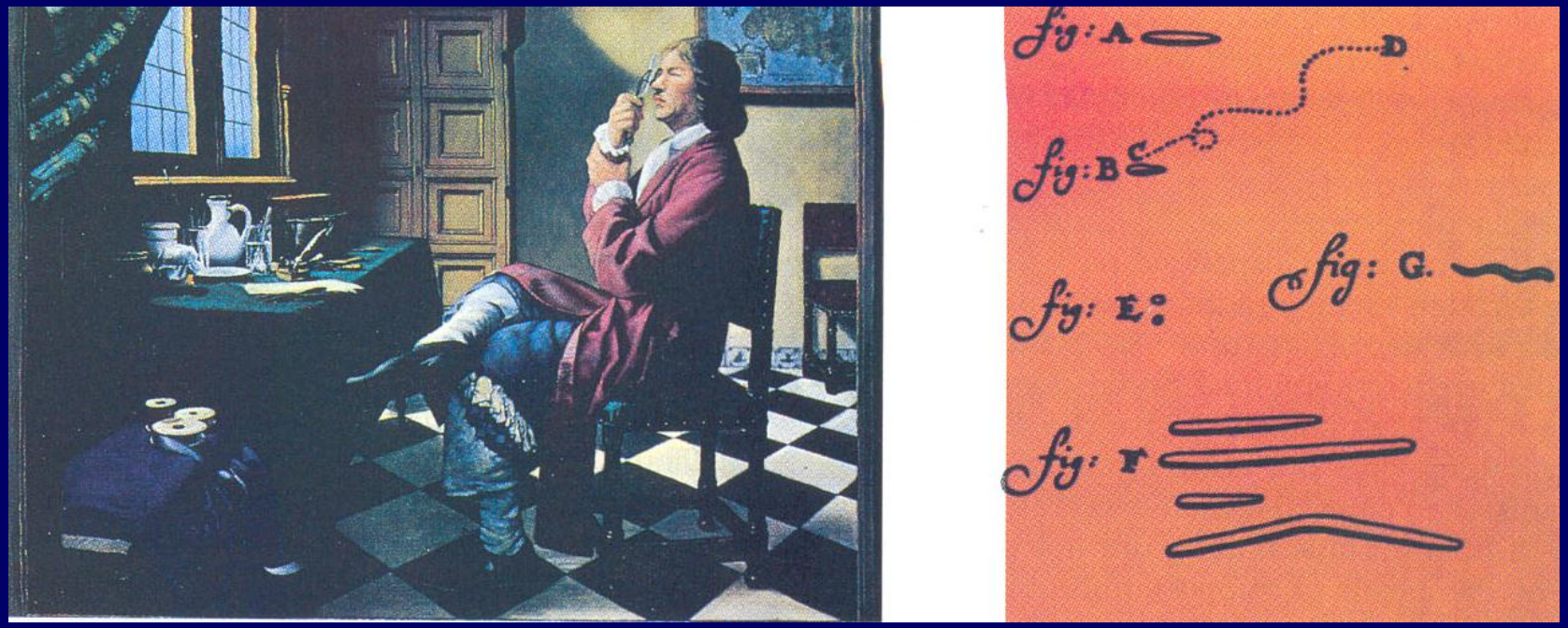
Theoretical stage

- **In XV-XVI G.Fracastoro (1476-1553) suggested that diseases are caused by «living pathogenic agents» - *contagium vivum*.**
- **He thought that these agents are nonvisible and live in environment, spread by air and environmental objects.**

Morphological stage

- **The first prove of microorganisms existence was given by datch scientist Antonie van Leeuwenhoek(1632-1723).**
- **Antonie van Leeuwenhoek produced microscope lenses. His handcrafted microscope could magnify object 160-200 times.**
- **He discovered living organisms in dental plaque, faeces and other objects and called them «wild animals» - «*animalcula viva*». He sent his observation to London Royal Society.**

Left - A.Leevenhoek with his microscope; right – first drawings of microbes revealed from dental plaque (sent to London Royal Society in 1683).



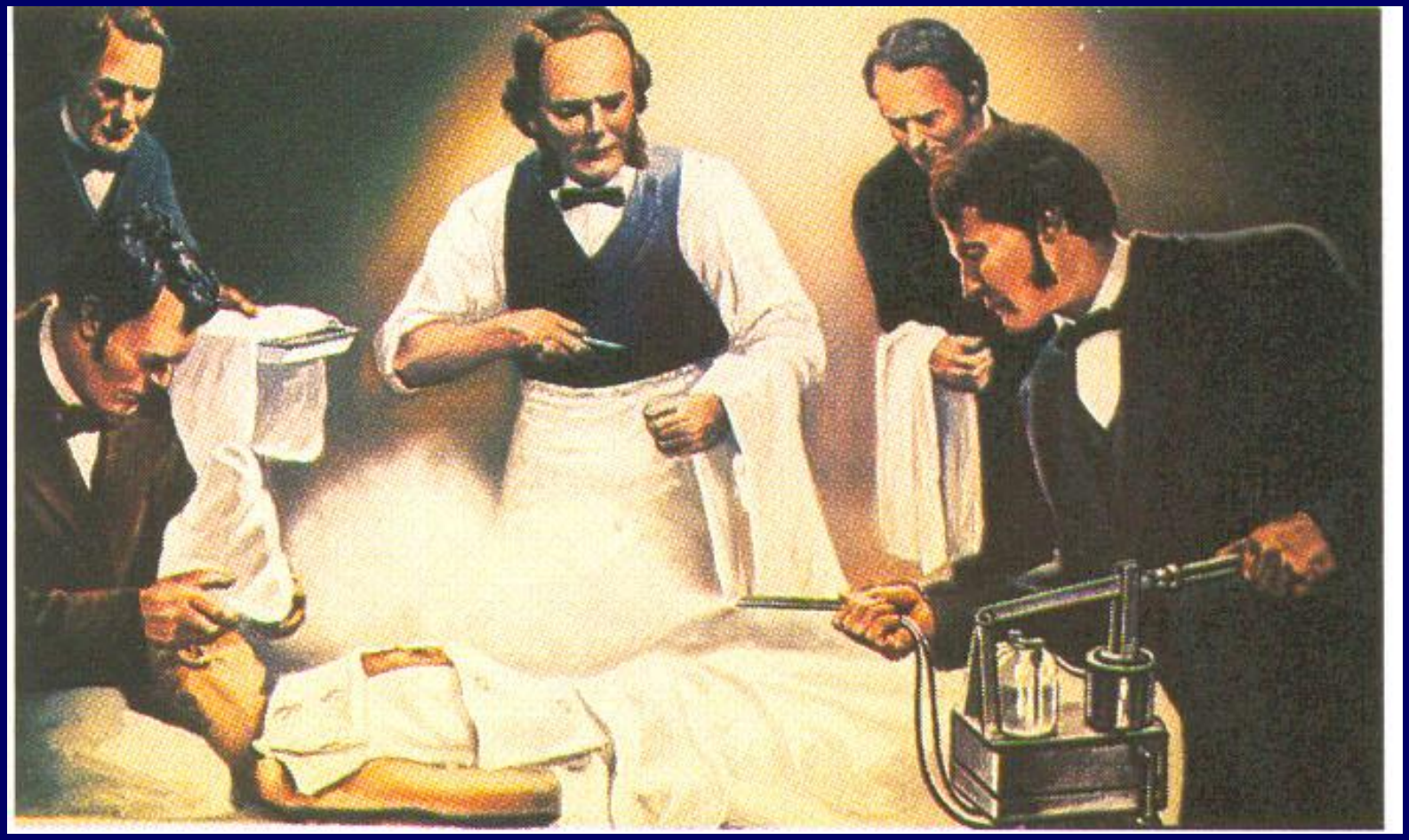
Physiological stage

- From XIX century middle scientists begun intensively learn bacterial physiology. This stage continuing to develop up to our days is called physiological stage.
- Researches of Louis Pasteur (1822-1895) played an important role in development of physiological stage.

Louis Pasteur researches

- Role of microorganisms in fermentation
- Anaerobiosis
- Pasteurization
- Proved that there is no spontaneous generation
- Vaccination principles and development of vaccines

Based on L.Pasteur researches an English surgeon J.Lister developed antiseptic principles playing an important role in prevention of postsurgical complications

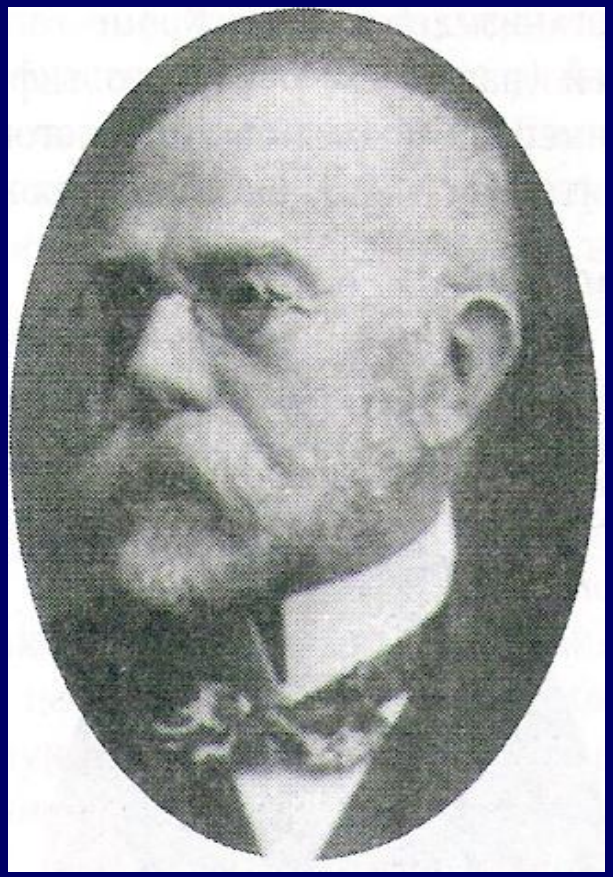


In XVIII English physician E.Jenner (1749-1823) proposed a protective vaccine against natural pox

Statue of first vaccinated boy in Paris Microbiological Institute

Robert Koch (1843-1910)

- Application of aniline dyes and immersion microscopy,
- Methods of obtaining of pure culture, application of solid nutrient media(potato and gelatin),
- Discovery of tuberculosis causative agent, Koch tuberculin (*Alt Tuberculin Koch*),
- Delayed-type of hypersensitivity reaction,
- Henle-Koch postulates

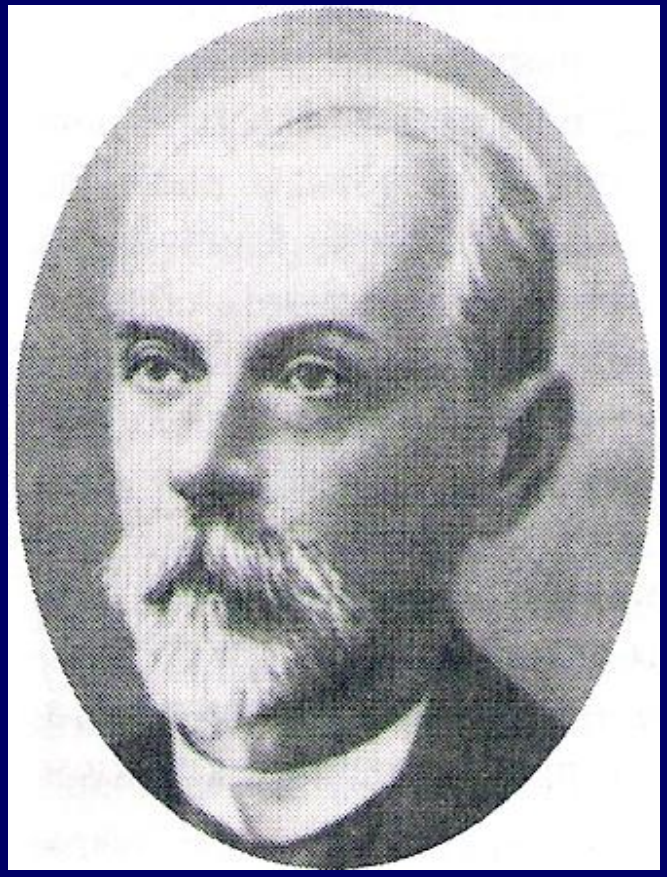


Henle-Koch triade

- This triade suggested the role of microbe in development of infection by 3 terms :
- 1) pathogen must be demonstrable in every case of disease and is not present in other diseases and healthy people;
- 2) after isolation in pure culture it can produce disease in experimental animal;
- 3) the agent can be recovered from experimental animal.

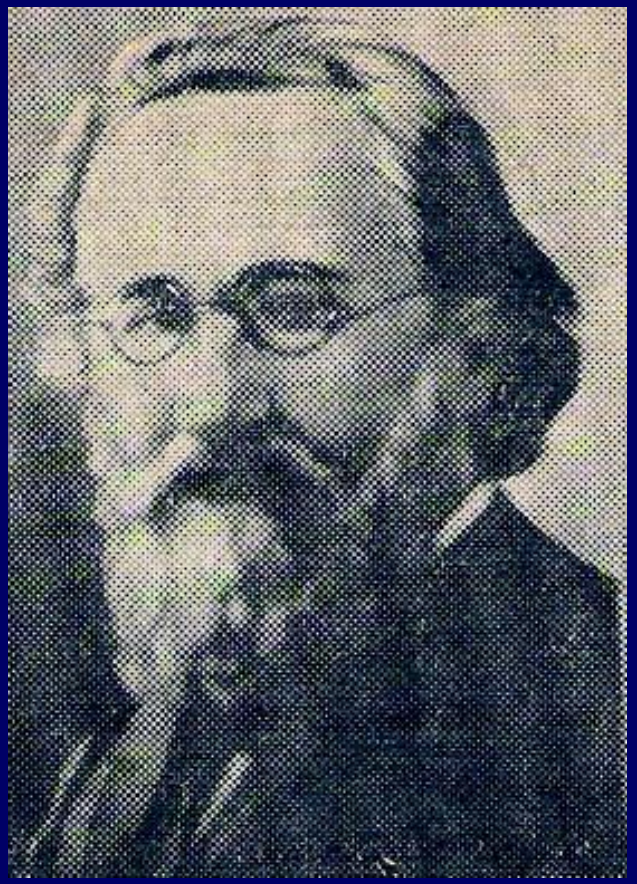
Discovery of viruses

- **In 1892 Russian scientist D.I.Ivanovski (1864-1920) learned tobacco mosaic disease discovered small microorganisms passing through bacterial filters and causing specific pathological processes – viruses.**
- **In the middle of XX century– *virology formed as a distinct independent science learning viruses.***



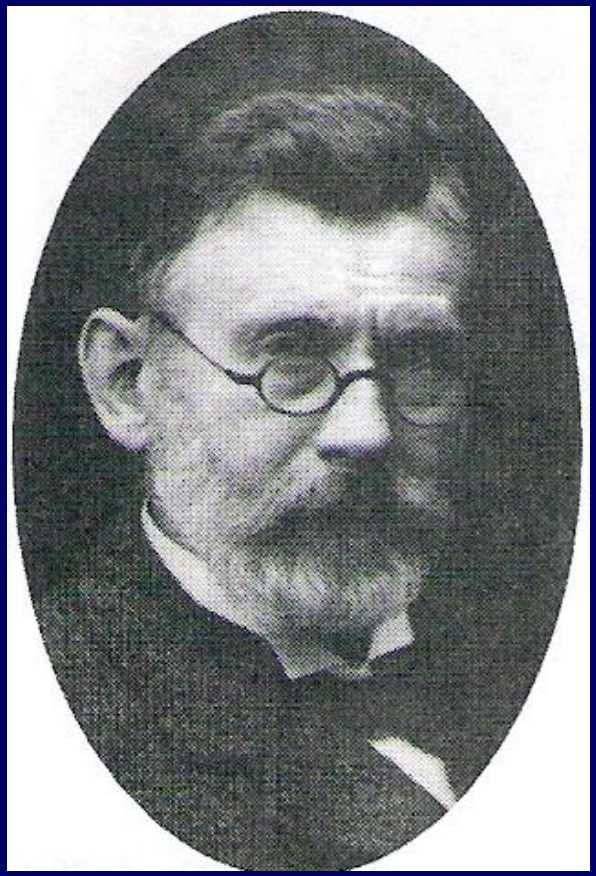
İmmunological stage

- **İ.İ.Mechnikov (1845-1916) proved that many human cells such as leukocytes, bone marrow and spleen cells can engulf and digest foreign substances including microorganisms. I. Mechnikov called these cells as phagocytes and the process as phagocytosis.**
- **In 1908 Nobel Prise**



İmmunological stage

- **Paul Erlich (1854-1915)**
- ***Humoral theory of immunity*- suggested leading role of antibodies in immunity.**
- **Theory of antibody production– «side-chain» theory**
- **In 1908 Nobel Prise**
- **Chemical therapy- synthesis of chemical drugs and *chemical therapeutic index***



İmmunological stage

- S.Richet and J.Portier – immediate type hypersensitivity reaction
- P.Medawar and M.Hasek - tolerance,
- F.Bernet et.al – immunological memory
- T- and B-lymphocites, their role in immunity, immune globulins, researches in structure of interferon and cytokines.

Molecular genetic stage

- **Discovery of DNA molecule structure by J.Watson and F.Crick in 1953 is the beginning of new stage in development of microbiology and immunology.**
- **Study of genomic and antigenic structure of microorganisms, molecular structure of immune globulins, immune response mechanism, immune system mediators, discovery of cytokines.**
- **Application of new diagnostic methods - genetic methods**
- **Genetic engineering**
- **Study of major histocompatibility complex**

Development of Medical Microbiology in Azerbaijan

- **Academic P.F.Zdrodovskı (1890-1976) the chief of Microbiology department of Medical Faculty in Baku State University**
- **Studied brucellosis and rickketsiosis.**

Development of Medical Microbiology in Azerbaijan

- In 1930-1932 academician L.A.Zilber was the chief of Microbiology department.
- Discovered the causative agent of tick encephalitis
- Learnt etiology and immunology of malignant tumors and proposed virological theory of malignant tumors development.

Development of Medical Microbiology in Azerbaijan

For long time(1933-1971) the chief of Microbiological department associate professor F.A.Yaqubov worked on development of serological methods used in infectious diseases diagnostics

Development of Medical Microbiology in Azerbaijan

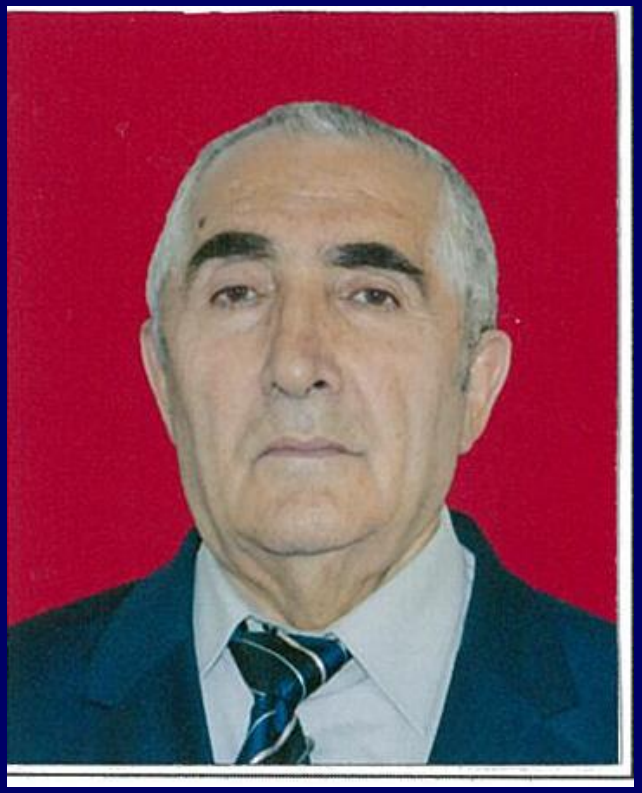
- **Professor N.C.Aliyev (1911-2004) was the chief of Microbiology department in 1971-1988.**
- **His researches were devoted to Naftalan oil, antimicrobial features of phytoncides and biuologically active substances obtained from microbes.**
- **He is the author of book written in Azerbaijani «Basics of medical microbiology» (1975).**

Development of Medical Microbiology in Azerbaijan

- **Professor H.H.İbrahimov (1939-2003) was the chief of Microbiology department in 1988-2003.**
- **His researches were devoted to antimicrobial features of phytoncides and Candida spp.**

Development of Medical Microbiology in Azerbaijan

- ANAS correspondent **Zakir Qarayev (1941-2020)** was the chief of Microbiology department in 2004-2019.
- His researches were devoted to immune deficiencies developing after antibiotic treatment and formation mechanisms, treatment and diagnostics of immune deficiency
- In 1982-1993 worked as director of Mycology and skin Mycosis Scientific Center.



Systematics of microorganisms

Although, the principles of all living organisms are similar, microbes systematics have distinctive features.

Taxonomy

- **Each microorganism in systematics has its own taxonomy (greek, *taxis* – place, row).**
- **Taxonomy learns classification, identification and nomenclature of micriirganisms.**

Classification categories

- ***Classification categories of microorganisms is the same as in other organisms*** **: domen - kingdom –class– order - family – genus – species.**
- **Some categories are changed depending on microorganism representatives.**
- **For exp., in animals «family» category is used, while in plants and microbes «order» is used.**

Taxonomic categories used in classification of microorganisms

Beynəlxalq (ingilis dilində)	Nümunə
Domain	*Bакteria*
Kingdom	*Proкariote*
Class	*Scotobacteria*
Order	*Eubacteriales*
Family	*Enterobacteriaceae*
Genus	*Escherichia*
Species	*coli*

The main classificarion category – species consists of microorganisms with the same origin and similar morpho-biological features

- **Species have:**
- **Strains with different morphological features - *morphovars*,**
- **Strains with different biological features– *biovars*,**
- **Strains with different antigenic features– *serovars*,**
- **Strains with different susceptibility to phages– *phagovars* etc.**
- **One species of microorganisms consists of manyn strains.**
- ***Strain* –microorganism related to one species obtained from different sources or from the same source in different time.**

Identification

- **Identification** is finding place of microorganism in classification by its biochemical, morphological, antigenic, genetic etc. features.
- Phenotypical, genotypical and phylogenetic features are used for identification.

Phenotypical features – morphological, tinctorlal, biochemical, antigenic etc.

- **Morphological features – shape, size, and structure of microorganism.**
- **Tinctorial features – staining ability of microorganisms**

Phenotypical features
(cultural features)

- For identification purpose **culture** of microorganism is obtained by cultivation in laboratory.
- Cultural features of different microorganism species are stabile and can be used for their identification.
- For identification **pure culture** containing only one species is used.
- Sometimes microbe **clone** containing cells emerged from one mother cell is used.

Phenotypical features
(biochemical features)

- **Biochemical features- ability of microbes to metabolize substrates or enzymatic activity of microbe.**
- **Biochemical features of different microorganism species are stabile and can be used for their identification.**

Genotypical features

- **Guanine-cytosine ratio in molecule (G+C),**
- **Nucleotide sequence detection by DNA-hybridization and sequencing,**
- **Restriction fragment length polymorphism(RFLP) detection by restriction enzymes.**
- **etc.**

Pjylogenetic features

- ***Phylogenetic features*** **ribosome-RNA and ribosome protein synthesis coding genes, 16S ribosome RNA nucleotide sequence detection, etc.**
- **It revealed that ribosome-RNA and ribosome protein synthesis coding genes are conservative and have little variation during evolution process.**

Differentiation

- **Identification ends up with detection of species and genus name of microorganism.**
- **All microorganism groups have specific identification parameters used for their differentiation from other microorganisms.**
- **Differentiation features are needed to differentiate similar microorganisms.**

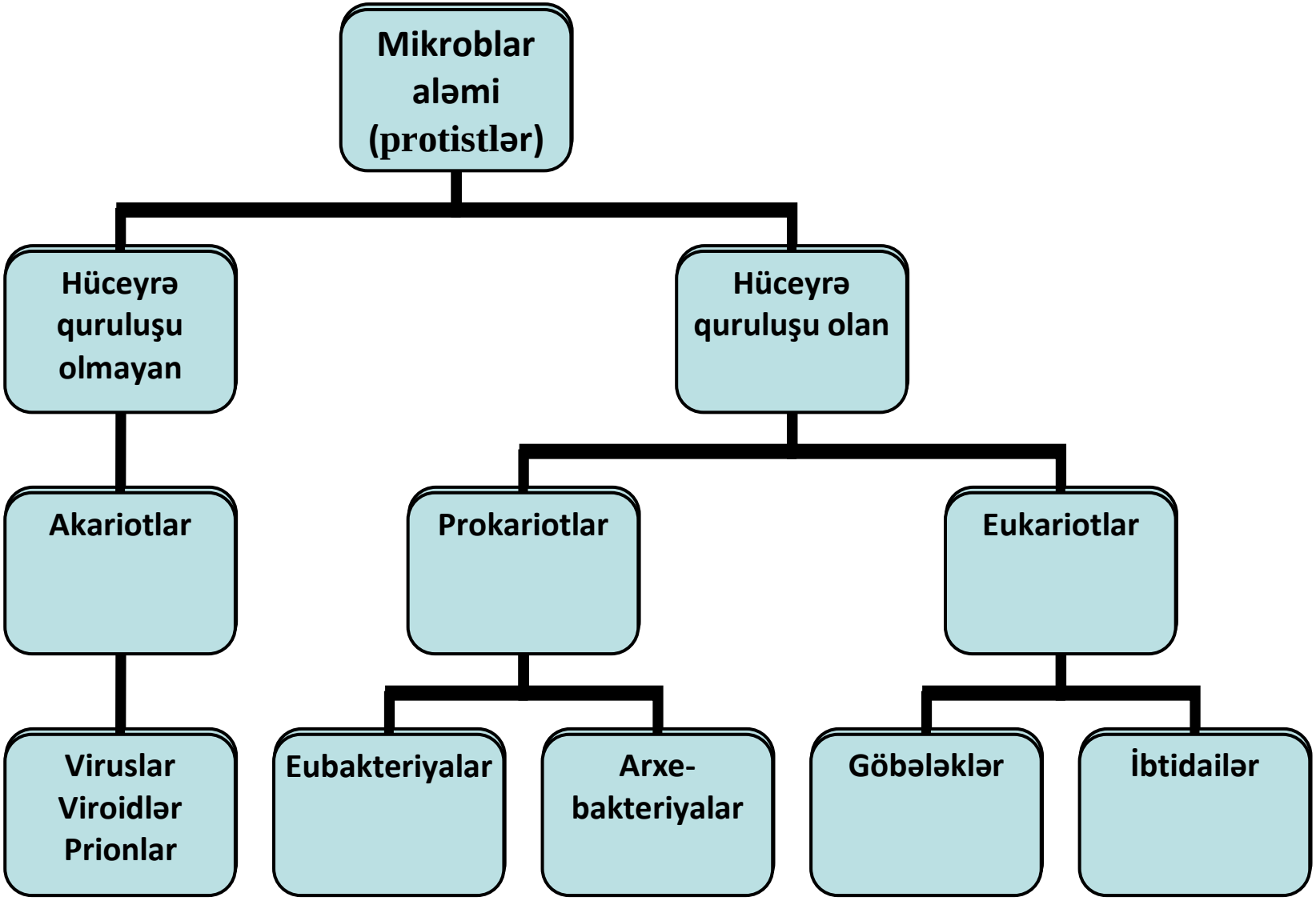
Microorganisms nomenclature

- **For naming of microorganisms binomial nomenclature (except viruses) is used (proposed by C.Linneus).**
- **It is two part naming system consisting of first part – capitalized generic and second – specific species name written with small letters. Exp., *Mycobacteium tuberculosis*.**

Modern principles of microorganism classification

- **Modern classification divides microorganisms to 2 groups: cellular and acellular.**
- **Acellular(akaryotes) microorganisms belong to a special *kingdom*.**
- **Cellular microorganisms belong to 3 domains: bacteria, archebacteria, and eukarya.**
- ***Bacteria domain consists of* true bacteria (eubacteria, greek, *eu* - true), *archebacteria domain consists archebacteria* (both domains - prokaryotes),**
- ***Domain Eukarya consists of eukaryotic microorganisms.***

Microbe kingdom classification



Acellular microorganisms(ακaryotes)

- Unlike prokaryotes and eukaryotes they do not have cellular elements – cell wall, cytoplasm, and other subcellular structures.
- Includes of viruses, viroids and prions

Cellular microorganisms

- Divided to prokaryotes and eukaryotes.
- Prokaryotes modern classification is based on Bergey classification. This classification first introduced by American bacteriologist Bergey in 1923, is annually updated by International Committee on Classification of Bacteria
- According to last update – 9th edition all prokaryotes depending on cell wall structure divided to 4 categories.
- Each category consists of many groups.

Bergey classification of prokaryotes

- Gram negative eubacteria with cell wall
- Gram positive eubacteria with cell wall
- Eubacteria lacking cell wall
- Archebacteria

Classification of Eukaryotic microorganisms

- Eukaryotic microorganism are included in «eukariya» domain.
- Unlike Prokaryotes they have formed nucleus which is separated from cytoplasm by special membrane.
- Eukaryotic microorganisms include Fungi and protozoans