CONTENTS

Part I

THEORETICAL FOUNDATIONS OF BIOLOGY

Chapter 1

BIOLOGY AS A SCIENCE ABOUT NATURE. MAN IS AT THE CENTER OF MODERN BIOLOGY AND MEDICINE. LIFE AND ITS PROPERTIES. LEVELS OF LIFE ORGANIZATION

Biology (greek., bios — life, logos — word, study) — science about life as a special phenomenon in all its spatial-temporal manifestations. The term was coined in 1809 by G.B. Lamarck and G. Treviranus.

***Biology of human*. Object of study:**

1) the life of man as a biological object is studied by anthropology — biological mechanisms of development and human life support;
2) a specific feature of human life is that a man is born with the ability to learn the program of cultural (social) inheritance, i.e., readily become public, a working, thinking being.

The life of humans as a biological object is studied by the complex of natural-scientific disciplines, or biomedicine, which combines the efforts of fundamental science and medicine representatives to solve specific tasks of practical health care.

Subject of research in biomedicine: biomedicine studies the life of biotechnology systems: genes, tissues, organs.

Methods of research in biology:

1) observation:
   - by the naked eye or with the use of optical and other equipment (loupe, microscope, an electron microscope, the differential centrifugation, X-ray analysis);
   - visualization of the living structures and processes (methods of radiology diagnostics — X-ray, ultrasound, CT scan);
2) experiment:
   - *in vivo* — uses a living creature. (Feature — ethical problems);
   - *in vitro* using living biological objects (cell, tissue, organ structure), grown outside the body. (Feature — problems of interpretation);

- natural «experiments» — mutations (the law of homologous series by N.I. Vavilov), and malformation;

3) modeling:
- mathematical;
- computer (design of medicines);
- biological (creation of living forms (cells, organisms) with set properties — knock-in, knock-out technology and others.

The basic properties that allow the existence of life:
- adaptation: individual, population, species, ecosystem, mechanisms and factors of evolution and co-evolution, adaptation;
- progress: biological, morpho-physiological, biotechnological (but biological regress);
- existence within the community.

In the process of development biology as a science, emerged a number of general ideas that characterize life:
- evolutionary doctrine (involvement of living forms in the process of historical development of the earth);
- cell theory (cell — elementary unit of life);
- the principle of ecosystems (life — there is always the community of organisms of different species);
- self-regulation of living systems;
- theory of ontogenesis (genetic bioinformation implemented in phenotype in the process of ontogenesis).

Cell theory. It has been proven that the cell is the basic unit of all living things, because it has all the properties of living organisms: structure, receiving energy from the outside and its use for work and consistency, metabolism, an active response to irritation, growth, development, reproduction, duplication and transfer of biological information to descendants, regeneration and adaptation to environment.

The main provisions of the cellular theory:

a) the cell is the elementary structural and functional unit of the living; there is no life outside the cell;
b) cell is an integrated system, which includes many interconnected elements — organelles, representing an integral functional unit;
c) all the cells are homologous by their structure, chemical composition and the basic properties;
d) new cells are formed by dividing the original cell after doubling its genetic material (DNA): the cell from the cell;
e) a multicellular organism is a new system composed of many cells integrated into the tissues and organs, connected with each other by chemical factors of humoral and nervous regulation;

f) cells of multicellular organisms have the genetic potential of the organism, the equivalent genetic information, but they differ in gene activity, leading to their varying differentiation.

The basic properties of the living:

a) unity of chemical composition (98% carbon, oxygen, nitrogen, and hydrogen);
b) metabolism is the process of synthesizing and breaking down substances in the body;
c) similar structure: all living organisms have a cell structure. Outside the cell there is no life;
d) reproduction is the body's ability to reproduce their own kind. This ensures the preservation of the species;
e) heredity is the ability of organisms to transfer their characteristics and properties;
f) variability is the ability to change its characteristics and properties;
g) irritability is the body's ability to respond to external influences;
h) homeostasis is the ability of organisms to maintain the constancy of the composition and physiological processes;
i) development and death.

Structural and functional levels of living units organization:

a) molecular-genetic. The gene is the basic unit controlling life. It is studied by genetics;
b) cellular level of life is studied by Cytology. At this level the structure of cells and cell components is studied;
c) tissue level (histology) — unites cells similar in structure and origin. The tissue cells of a multicellular organism are characterized by a high degree of differentiation, and adapted to perform certain functions;
d) organ level (anatomy) is characteristic only of multicellular organisms whose cells and parts of the body formed by them achieved a high degree of structural and functional specialization;
e) organismic level. The basic unit of life is an individual. At this level they study the morphology of the body, the physiological processes occurring in the organism of individuals since its inception and until death (anatomy, physiology, autecology);
f) population-species level — they study all the laws of formation of populations studied by classical ecology;
g) biospheric — studies the circulation of substances and energy conversion related to the functioning of all living organisms on Earth (global ecology).

Hierarchical organization of natural biological systems: biopolymers–organelles–cells–tissues–organs–organisms–population–species.

Complex of life properties:

1) Metabolism (anabolism, assimilation and catabolism, dissimilation);
2) ATP is an intermediate level between catabolism and anabolism;

3) Living systems are open for energy and substance exchange;
4) Order of processes in time and in space;
5) The presence of genotype and phenotype;
6) The presence of ontogenesis (individual development);
7) Living forms are self-regulating systems;
8) The ability of protoplasm to carry out various functions (mechanical, chemical, osmotic, regulatory);
9) Existence in the form of communities;
10) Evolution of living forms.

What are the forms of life on Earth (Fig. 1)?

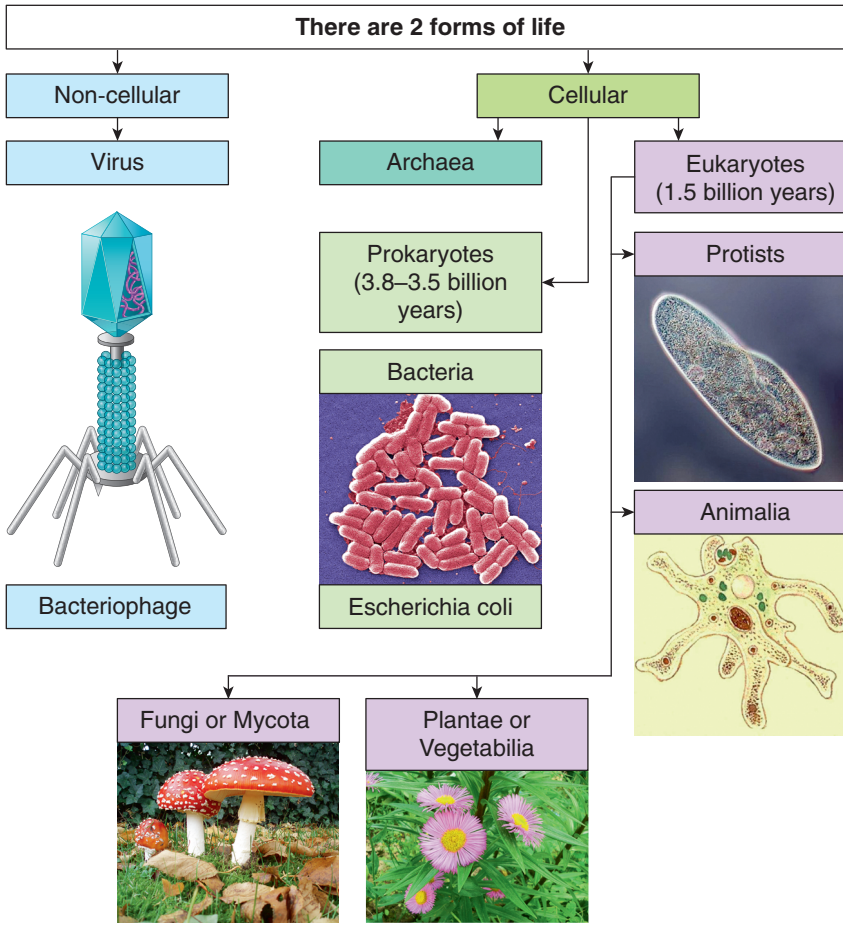

Fig. 1. The forms of life

What are the differences between prokaryotes and eukaryotes (table 1)?

Table 1. Comparative table

	Eukaryotic Cell	Prokaryotic Cell
Nucleus	Present	Absent
Number of chromosomes	More than one	One
Cell type	Usually multicellular	Usually unicellular (some cyanobacteria may be multicellular)
True membrane bound nucleus	Present	Absent
Example	Animals and Plants	Bacteria and Archaea
Genetic Recombination	Meiosis and fusion of gametes	Partial, unidirectional transfers DNA
Lysosomes and peroxisomes	Present	Absent
Microtubules	Present	Absent or rare
Endoplasmic reticulum	Present	Absent
Mitochondria	Present	Absent
Cytoskeleton	Present	May be absent
DNA wrapping on proteins	**Eukaryotes wrap their DNA around proteins called histones**	**Multiple proteins act together to fold and condense prokaryotic DNA. Folded DNA is then organized into a variety of conformations that are supercoiled and wound around tetramers of the HU protein**
Ribosomes	Larger (80S)	Smaller (70S)
Vesicles	Present	Present
Golgi bodies	Present	Absent
Chloroplasts	Present (in plants)	Absent; chlorophyll scattered in the cytoplasm

End of table 1

	Eukaryotic Cell	Prokaryotic Cell
Flagella	Microscopic in size; membrane bound; usually arranged as nine doublets surrounding two singlets	Submicroscopic in size, composed of only one fiber
Permeability of nuclear membrane	Selective	Not present
Plasma membrane with steroid	Yes	Usually no
Cell wall	Only in plant cells and fungi (chemically simpler)	Usually chemically complexed
Vacuoles	Present	Present
Cell size	10–100 um	1–10 um

Differences between prokaryotes and eukaryotes

The most important difference between prokaryotes and eukaryotes is that eukaryotes have a Nucleus (Fig. 2, 3).

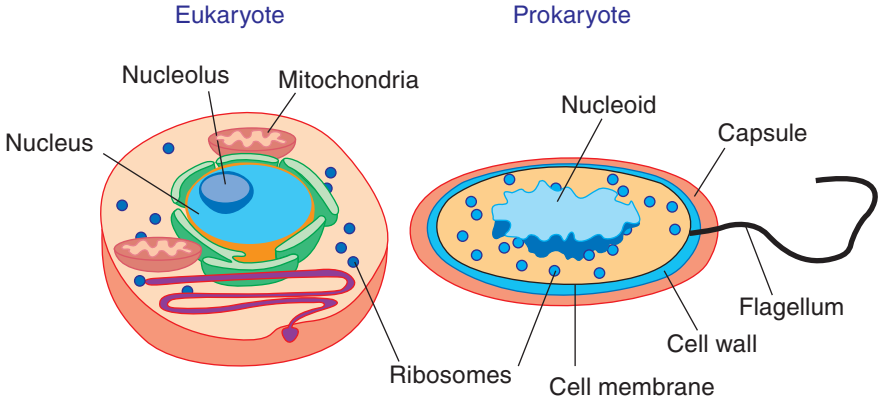

Fig. 2. Prokaryotic and Eukaryotic cells. (Differences between prokaryotic and eukaryotic cells. URL.: https://www.starlanguageblog.com/5-differences-between-prokaryotic-and-eukaryotic-cells/)

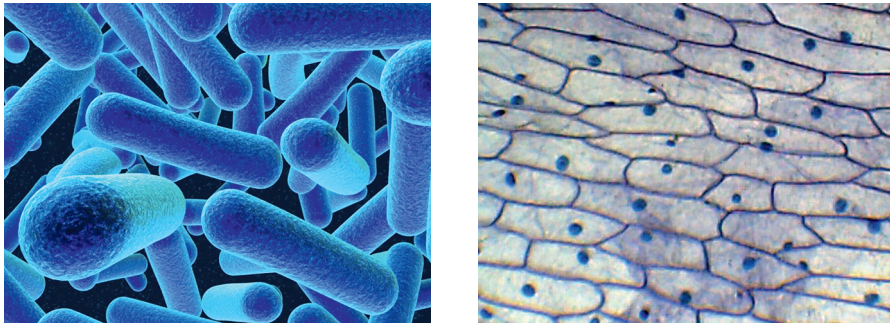

Fig. 3. Prokaryotic and Eukaryotic cells. (Brian Thomas, 2010; Educational portal for works preparation Biology for grade 6)

What do Prokaryotic and Eukaryotic Cells Have in Common?

1. Both have DNA as their genetic material.
2. Both are covered by a cell membrane.
3. Both contain RNA.
4. Both are made of the same basic chemicals: carbohydrates, proteins, nucleic acid, minerals, fats and vitamins.
5. Both have ribosomes (the structures proteins are made on).
6. Both have similar basic metabolism (life processes) like photosynthesis and reproduction.
7. Both require a supply of energy.

Features of Prokaryotic Cells (Fig. 4).

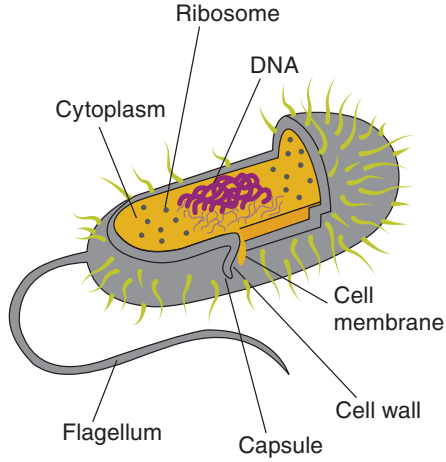

Fig. 4. Prokaryotic Cells. (Prokaryotic Cell. Educational website Quizlet. URL.: https://quizlet.com/418033241/prokaryotic-cell-labeling-diagram)

1. Capsule — outer sticky protective layer.
2. Cell wall — rigid structure, which helps the bacterium to maintain its shape.
   a. This is in NO way the same as the cell wall of a plant cell.
   b. It is made from peptidoglycan (called «murein» in older sources).
3. Plasma membrane — separates the cell from the environment.
4. Mesosome — infolding of plasma membrane to aid in compartmentalization.
5. Nucleoid — region where naked DNA is found Cytoplasm.
   a. Semi-fluid cell interior.
   b. No membrane-bound organelles.
   c. Location for metabolic enzymes.
   d. Location of ribosomes for protein synthesis.

Theory of eukaryotes origin:

1. symbiotic (Fig. 5);
2. invagination;
3. *evidence:* circular DNA, ribosomes 70S, mitochondria and plastids have two membranes.

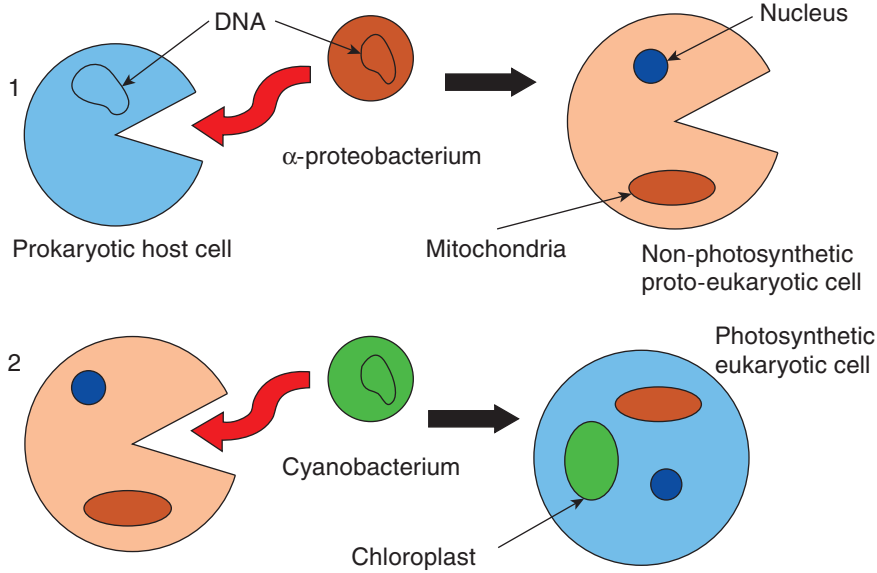

Fig. 5. Two endosymbiotic events. (Endosymbiosis and horizontal gene transfer. URL.: https://www.gesundheitsindustrie-bw.de/en/article/news/endosymbiosis-and-horizontal-gene-transfer)

Differences between eukaryotic cell and prokaryotic cell in the table 1.