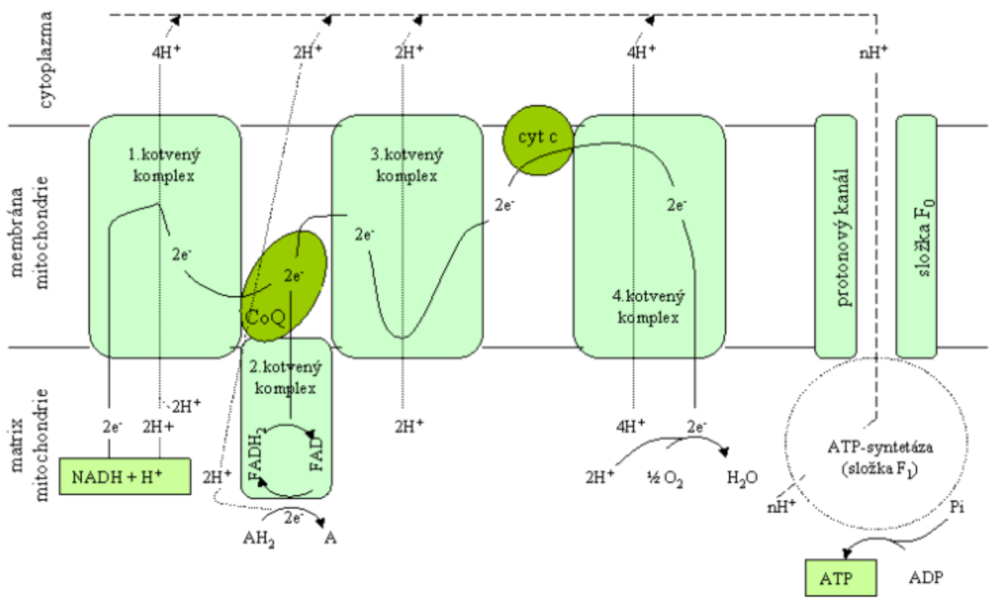
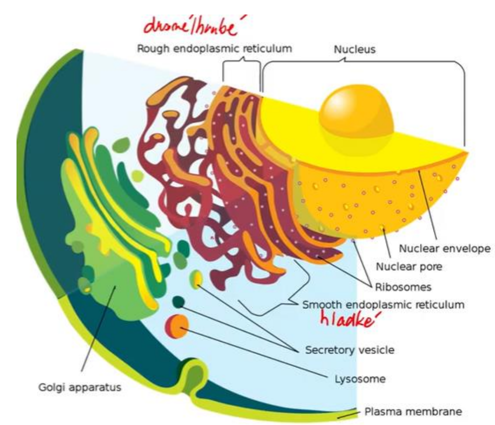
Biology2022 - FAOB1

BIOLOGY
Introduction



Obr 1. Dýchací řetězec



https://en.wikipedia.org/wiki/File:Endomembrane_system_diagram_en_(edit).svg

Josef Skopalík, Ph.D.

Short summary of BIOLOGY in next 12 weeks

September 2022 Introduction. Microscopy and another visualisation methods
Cell – definition, development of cells (bacteria, plant, animal).
Eukaroyte / Prokaryote
Basic internal structure and bioenergetics of different cells

October 2022 Structure of biological membranes - basal cell bioenergetic.
Transport of ion and another bioactive compound.
Organelles and illness connected to organelles.
Organelles and clinical target in organelless.

November 2022 Cell signaling and Cell cycle.
– clicnical aspect for Cancer and Regeneration medicine
Biologie of human immune system. Pathological state
in immune systém and basic clinical strategy.
Cell division (Types of Division in PROKARYOTE and EUKARYOTE).
Mitosis and Meiosis. Gene transcription. Genome. MENDEL genetics.
Mutation and cancer

October 2022 Modern trends in cell biology and genetics

Why medical and pharmaceutical worker need BIOLOGY a CELL BIOLOGY:

- We should take not only macroscopical experience and statistic form curative effects from set of patient in previous time

- We need also basic idea about structure of tissue and cells and about aktivity of bioactive molecules in this microstructure

- Many new pharma-compounds arte tested on cells IN VITRO (Evidence based science – before clincila tests)

Biology

/ Lecture 1 /

-Visualization technique

- Cell and tissue definiton

What is visibility?

And what visibility is needed in medicine? :

Analogy:

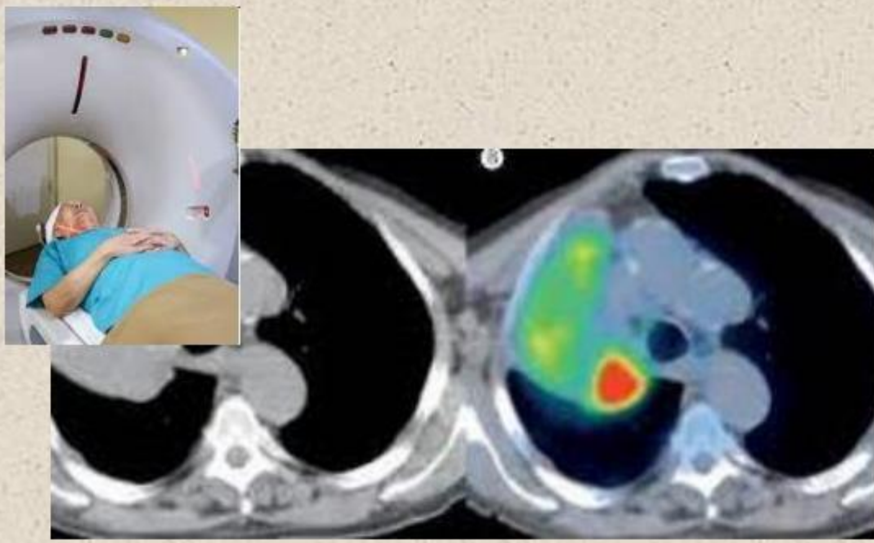
If we fight against “forest disaster“, sometimes we need technique for macroscopic visibility, sometimes for detail (microscopic) visibility

Good objective visualisation = key step for good fighting

And what visibility is needed in medicine? :

Analogy:

If we fight against “medical disaster“, sometimes we need technique for macroscopic visibility, sometimes for detail (microscopic) visibility



Good objective visualisation = key step for good fighting

*The human and animal body is not o „bag of sugar water with smal soul inside", however exact description of body and tissue structure had to wait to first „science-man" **Aristotle** (384–322 BC). Before Aristotle, many Greek philosophers had speculated copartments of body and live organims but their theorizing was unsupported by empirical investigation.*

TABLE 1–1 HISTORICAL LANDMARKS IN DETERMINING CELL STRUCTURE

1665	Hooke uses a primitive microscope to describe small chambers in sections of cork that he calls "cells."
1674	Leeuwenhoek reports his discovery of protozoa. Nine years later, he sees bacteria for the first time.
1833	Brown publishes his microscopic observations of orchids, clearly describing the cell nucleus.
1839	Schleiden and Schwann propose the cell theory, stating that the nucleated cell is the universal building block of plant and animal tissues.
1857	Kölliker describes mitochondria in muscle cells.
1879	Flemming describes with great clarity chromosome behavior during mitosis in animal cells.
1881	Cajal and other histologists develop staining methods that reveal the structure of nerve cells and the organization of neural tissue.
1898	Golgi first sees and describes the Golgi apparatus by staining cells with silver nitrate.
1902	Boveri links chromosomes and heredity by observing chromosome behavior during sexual reproduction.
1952	Palade, Porter, and Sjöstrand develop methods of electron microscopy that enable many intracellular structures to be seen for the first time. In one of the first applications of these techniques, Huxley shows that muscle contains arrays of protein filaments—the first evidence of a cytoskeleton.
1957	Robertson describes the bilayer structure of the cell membrane, seen for the first time in the electron microscope.
1960	Kendrew describes the first detailed protein structure (sperm whale myoglobin) to a resolution of 0.2 nm using X-ray crystallography. Perutz proposes a lower-resolution structure for hemoglobin.
1965	Christian de Duve and his colleagues use a cell-fractionation technique to separate peroxisomes, mitochondria, and lysosomes from a preparation of rat liver.
1968	Petran and collaborators make the first confocal microscope.
1970	Frye and Edidin use fluorescent antibodies to show that plasma membrane molecules can diffuse in the plane of the membrane, indicating that cell membranes are fluid.
1974	Lazarides and Weber use fluorescent antibodies to stain the cytoskeleton.
1994	Chalfie and collaborators introduce green fluorescent protein (GFP) as a marker to follow the behavior of proteins in living cells.

Cell definition

The cell is the structural and functional elementary unit of all living organisms,

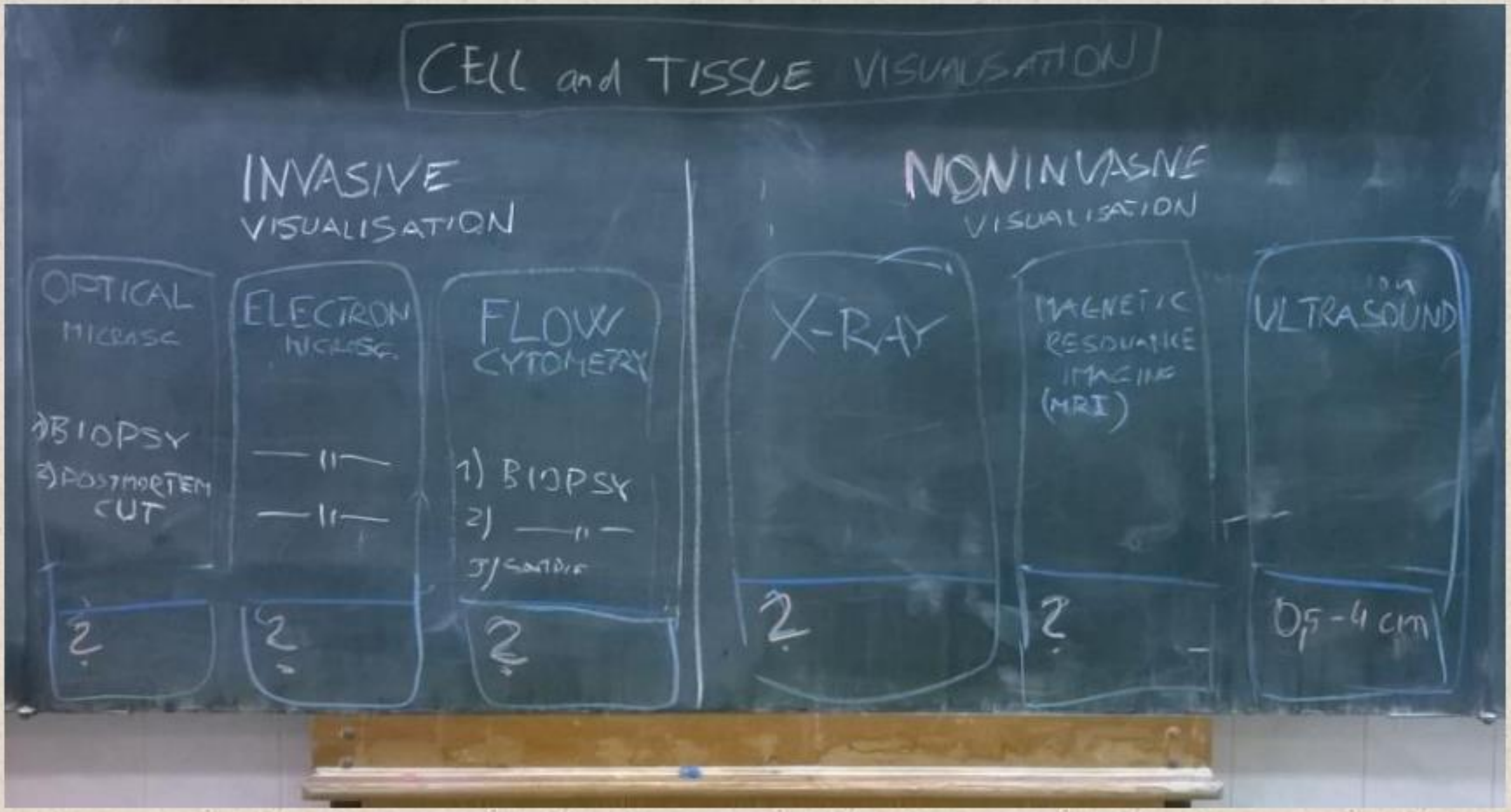
conserving the features of the organism,

having the ability of self-control, self-regulation, and self-reproduction,

being the result of a long time of evolution

In cell biology, an **organelle** is a specialized subunit, usually within a cell, that has a specific function. The name **organelle** comes from the idea that these structures are parts of cells, as **organs** are to the body, hence **organelle,** the suffix -elle being a diminutive.

We can divide the technique via the invasivity or the non-invasivity:

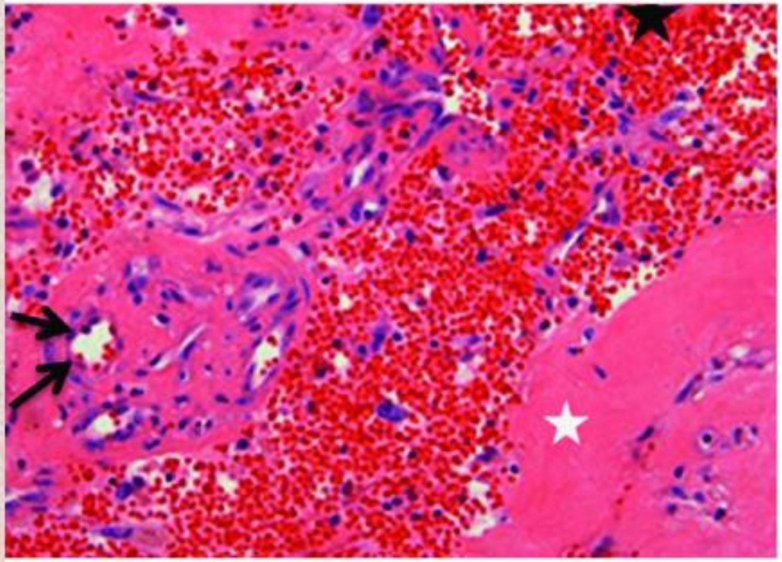


Homework: 1) ad resolution to your exercisebook (information are on folloving pages)

Each technique have some advantages and disadvantages:

For example Hematoma of leg

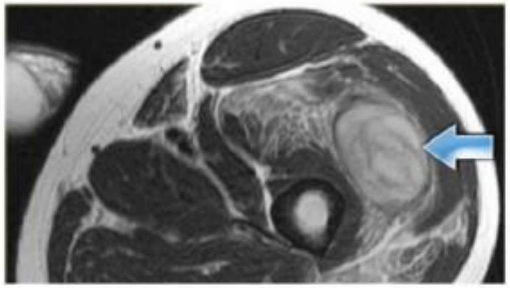
Hematoma
by microscopy
(focused inside the muscle)

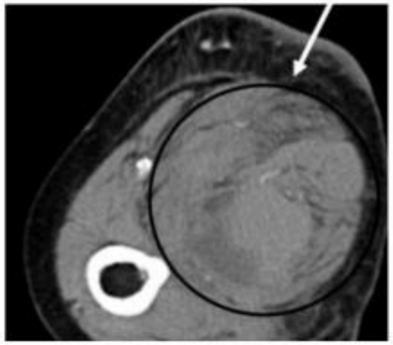


Microscopic view of organized hematoma showing angiogenesis (arrows), fibrosis (white asterisk) and extravasated red blood cells (black asterisk) (hematoxylin and eosin staining, original magnification, × 400).

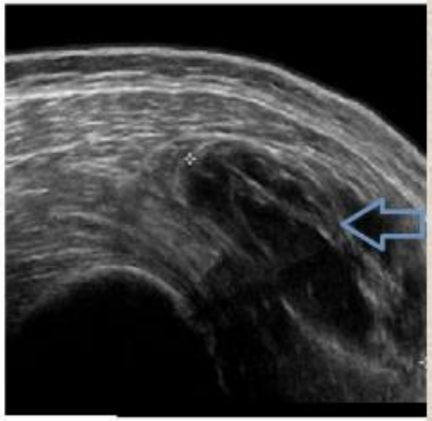
Hematoma
by X-RAY CT

Hematoma
by NMRi





Hematoma
by Ultra Sound

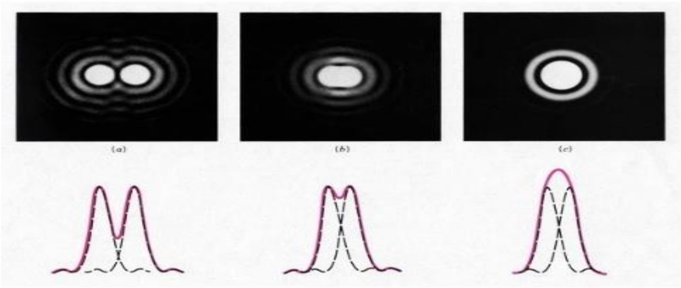


For medical and pharmacologica curative strategy we need mostly combination of all these technique.

MAGNIFICATION and RESOLUTION

of visualisation machine (microscopes, ultrasound, telescopes…)

- RESOLUTION (or sometimes RESOLVING POWERS) is defined as the ability of a microscope (or another machine) to distinguish two close together entities as being separate. An example of resolving power is how well a microcope can show two bacteria as two separated circles.



- For example school microscope : 0,1mm distance of bacterias resolve, but 0,01mm long
- bacteria which are in contact are visited as one small dot.

- RESOLUTIO of microscope - similar to screen defintion of resolution in home TV or PC)

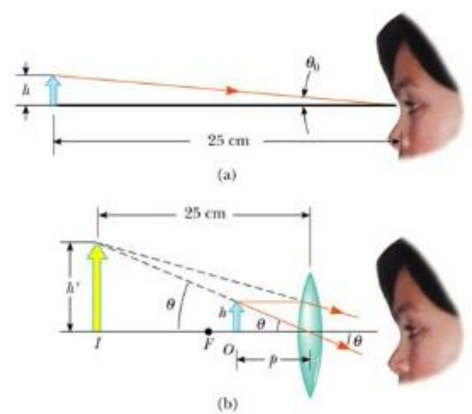
- MAGNIFICATION of any optical machine can be defined by two ways:

- Standart magnification

$$M = \frac{L \text{ of visualised object}}{L \text{ of real object}} = \frac{50}{5} = 10$$

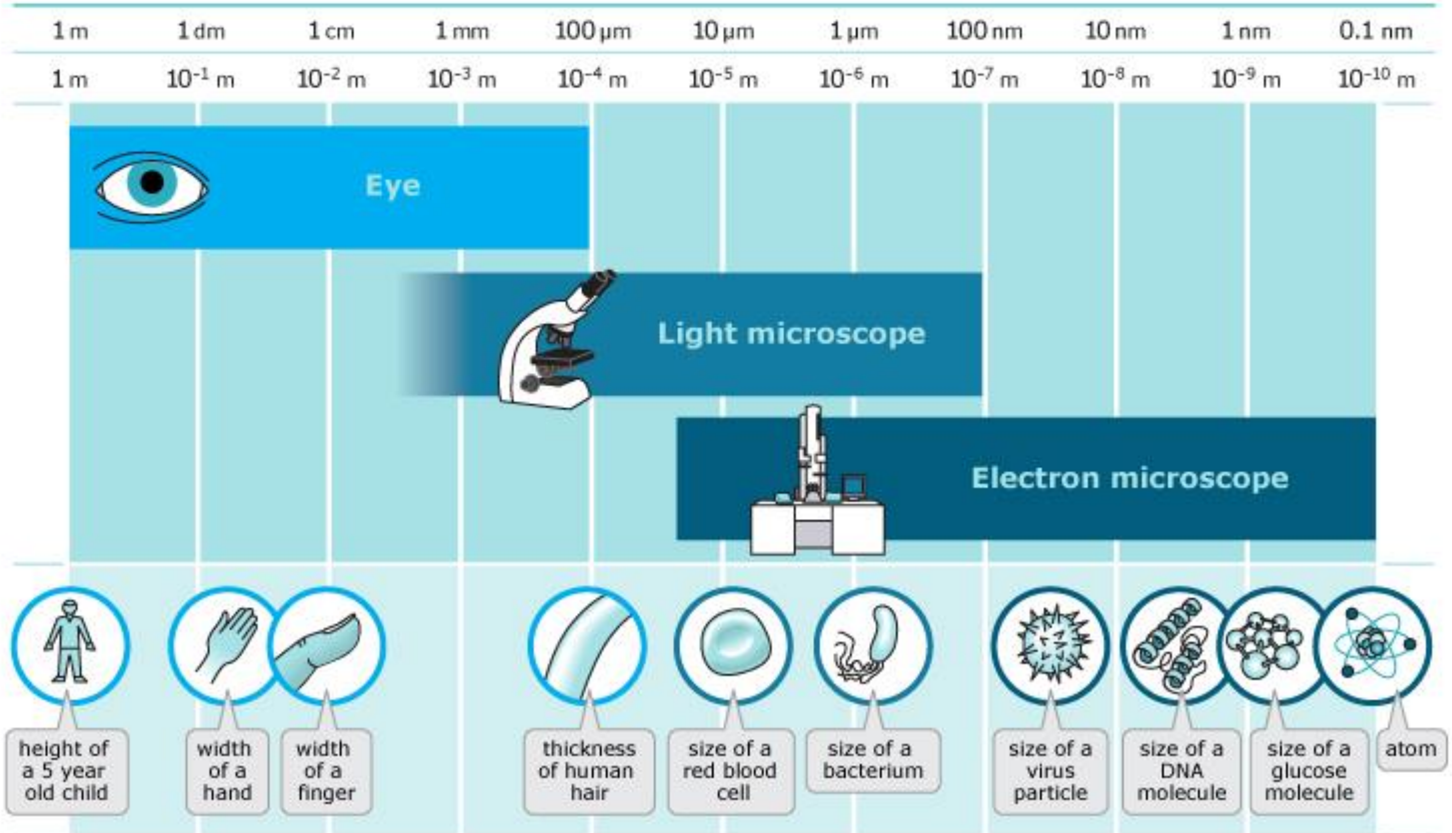
Anglular magnification (mostly for LENS)

$$m \equiv \frac{\theta}{\theta_0} = \frac{\text{angle with lens}}{\text{angle without lens}}$$

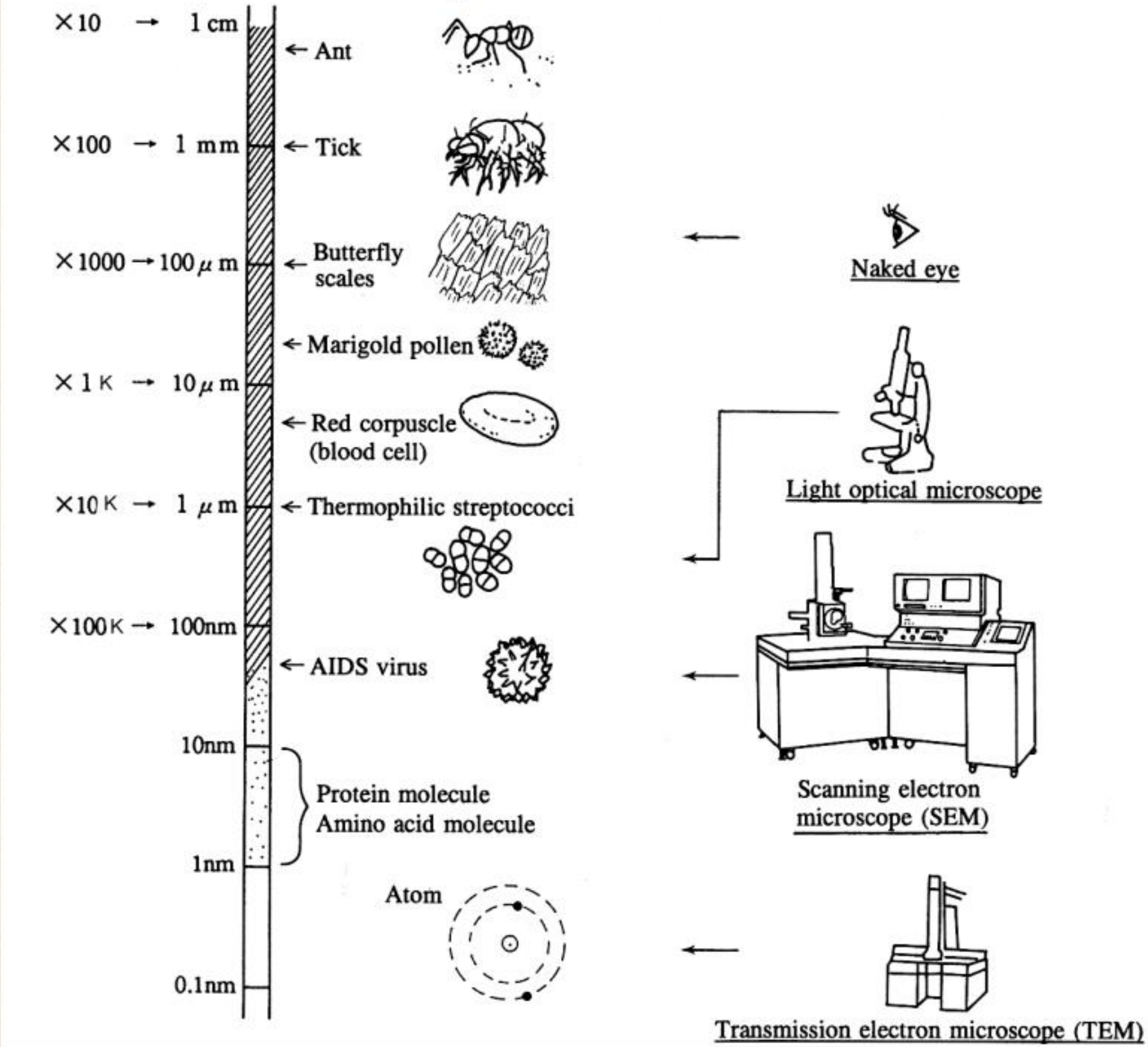


Both of them are comparable and recomputable

Typical resolution of traditional microscopes

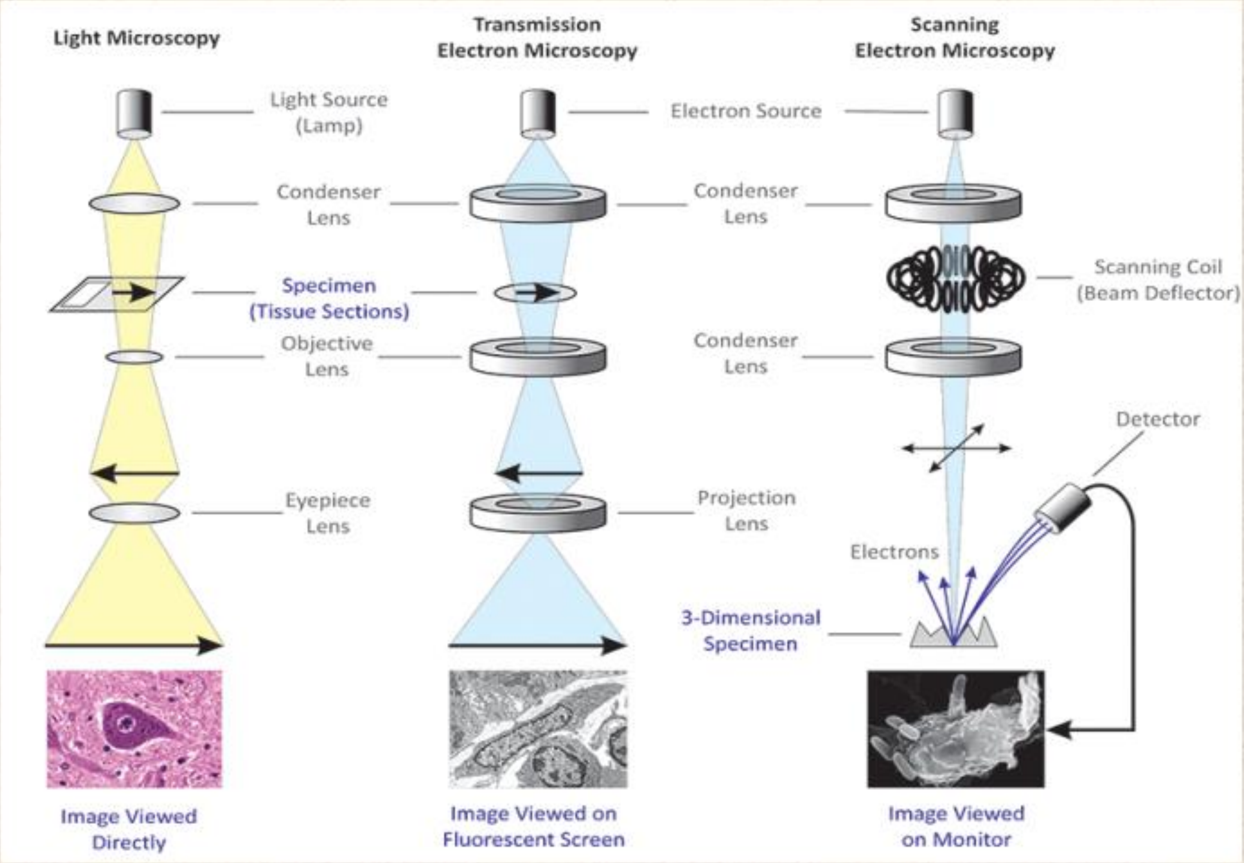


MAGNIFICATION Object RESOLUTION



Basic construction of microscopies: Learn!! Will be also in final test !

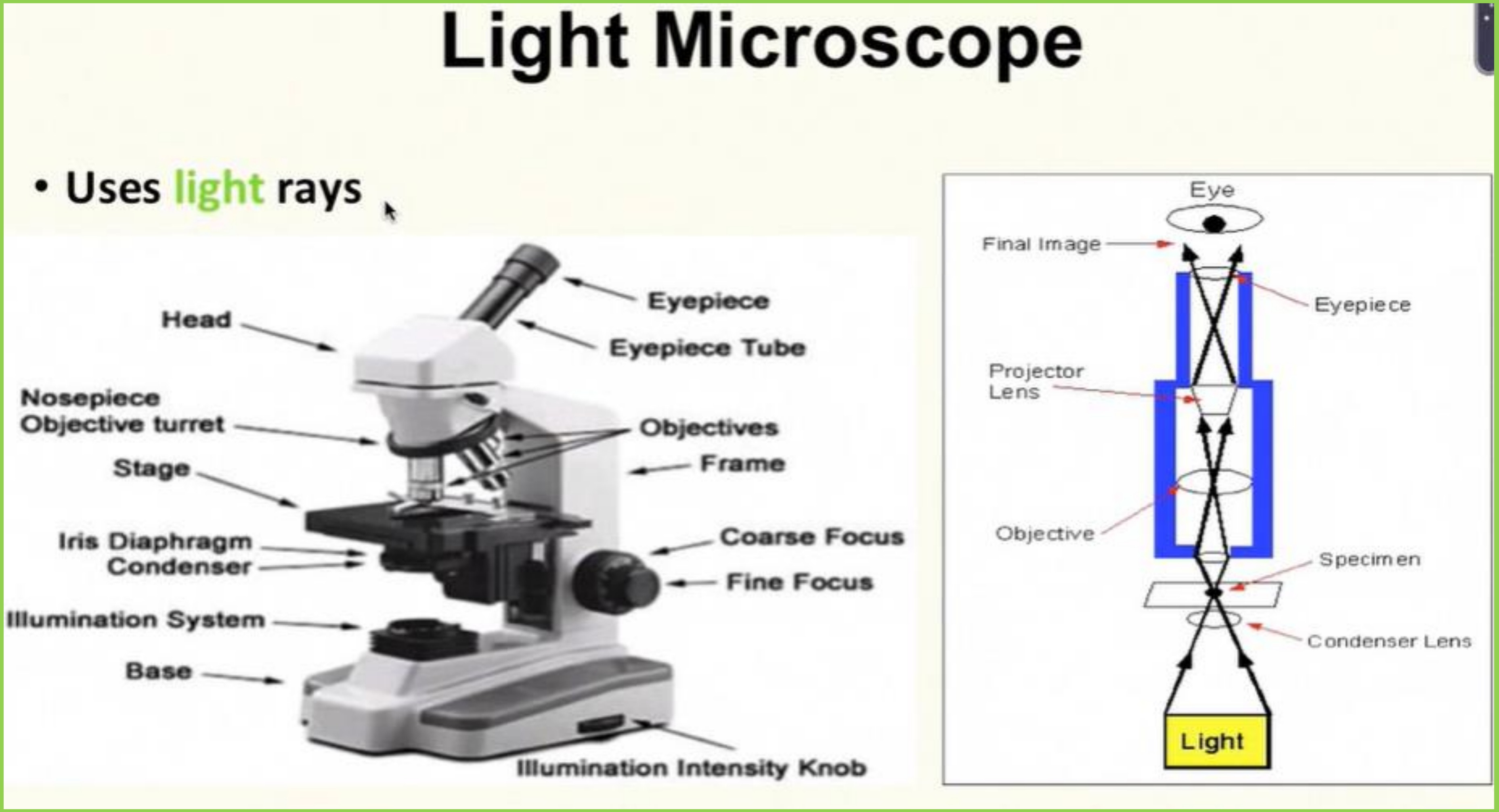
OPTICAL and ELECTRON



	Light Microscopy	Transmission Electron Microscopy	Scanning Electron Microscopy
Resolution	200 nm	0.1 nm	0.5 nm
Magnific.	~×2000	×50~×1,500,000	×10~×1,000,000

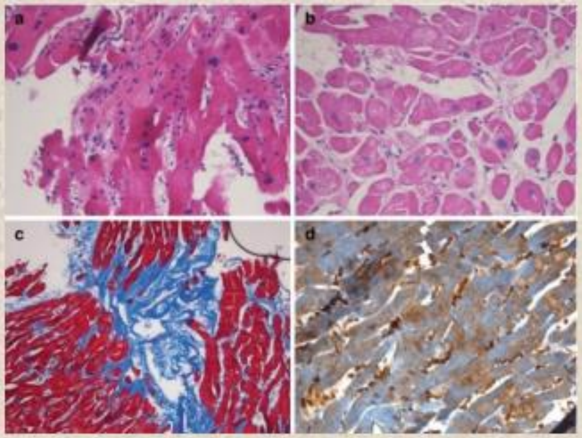
!! IMPORTANT VOCABULARY

of microscope comopnents (will be used in 3 excersise at october !!!) and will be also in final test

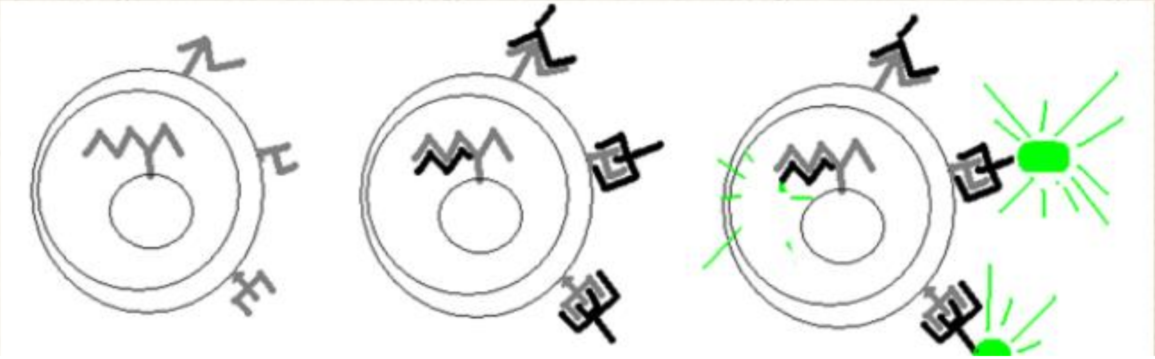


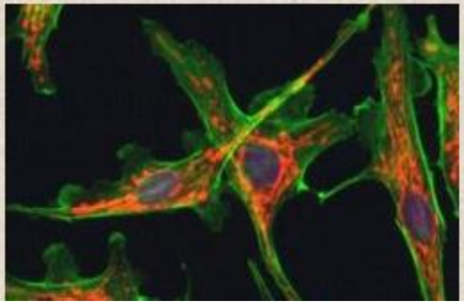
How we can upgrade some structure of cells for better contrast ?
Use staining.

1) **Traditional Histochemistry Staining** (used chemicals which have specific afinity to some part of cell or tissue, for example DNA, collagen etc.



2) **Anitibody staining** (best way: rimary and secondar antibody which makes some structure fluorescent)





Practical excersise 1 MICROSCOPE

Basic aims:

1) Be friendly with school optical microscope.
2) Be prepared to read magnification of objectives
3) Be prepared to focuse the microscope and draw the cell structure vhich is visble in mircroscope

For basic bacrkoudn vocabulary:

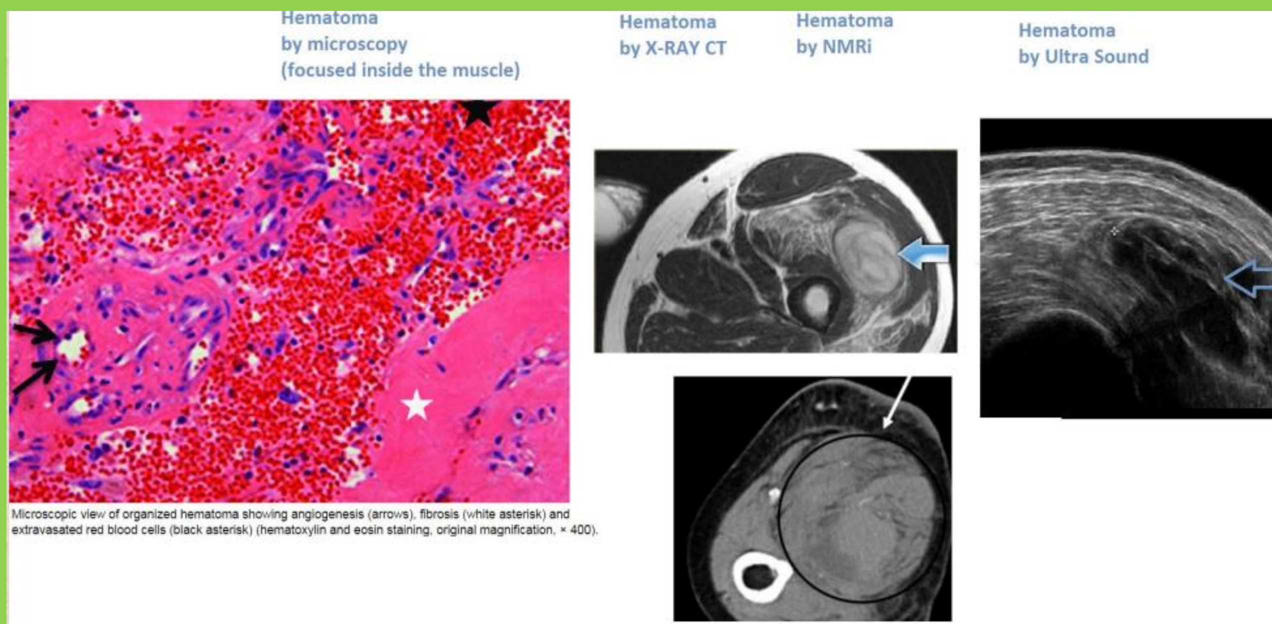
Practical excersise 1 MICROSCOPE

Basic aims:

4) Be friendly with recomputing of

mm …… um ….. nm (mili … micro … nano meter)

5) Be prepared to tip, which visualization machine produce this scans:



Microscopic view of organized hematoma showing angiogenesis (arrows), fibrosis (white asterisk) and extravasated red blood cells (black asterisk) (hematoxylin and eosin staining, original magnification, × 400).

6) Have a idea about resolution of machines

Additional very good short movie about tomography:

CT and MRI are very sofistic technical aparature, where geat physical theoretic backround is neded from quantm physics and nuclear physics theory. Very ilustrative videos for medical and biological worker is here:

CT image quality and

https://www.youtube.com/watch?v=qsHTrQ0lb2s

MRI basic principles and resolution

https://www.youtube.com/watch?v=Ok9ILIYzmaY

https://www.youtube.com/watch?v=aQZ8tTZnQ8A

https://www.youtube.com/watch?v=VnpqylFYtqI

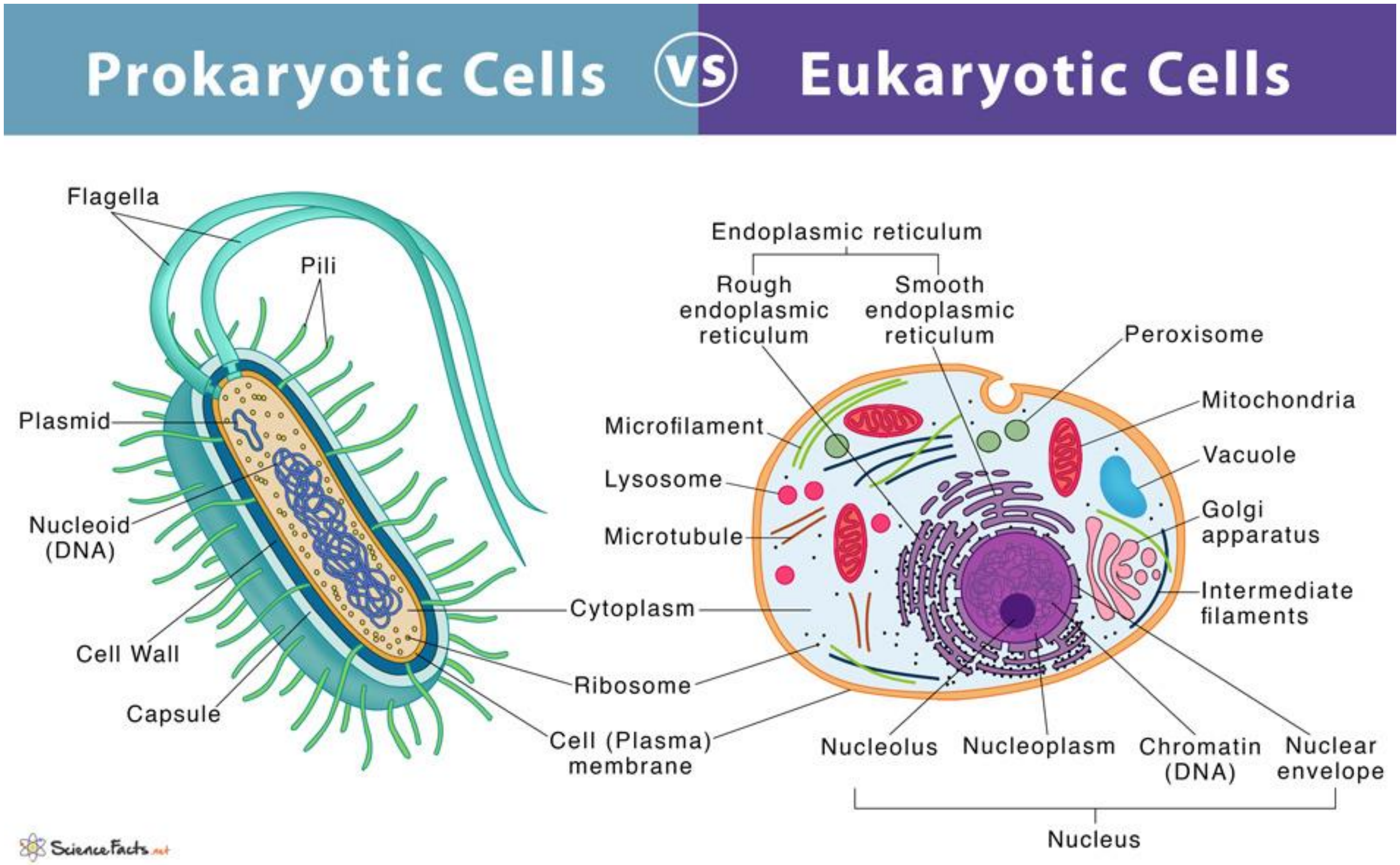
Biology

LECTURE 2

Cell and the subcellular structures
Prokaryota / Eukaryota
Cells from Animal / Human / Bacteria

- Medicinal experts should have good overview not only about human cells, but also about another historical cells (bacteria + archaea = PROKARYOTA) and viruses because their interaction with human body is critical for development of many pathologies (flu, diabetic wound, pathology of intestine microorganism, …aerobic or anearobic environment could induce different bacterial activity etc)

PROKAROYTE vs. EUKAROYTES



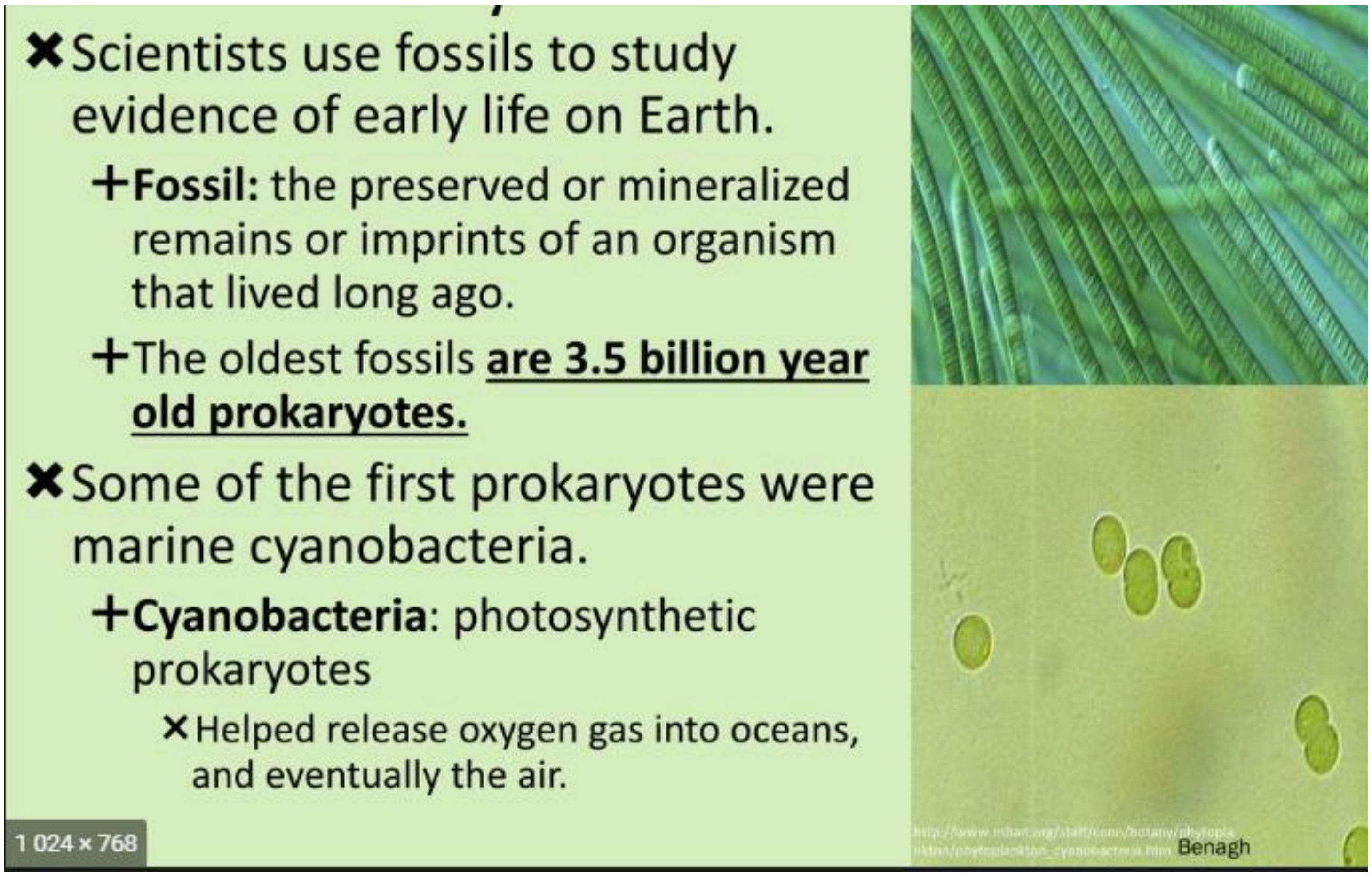
The Prokaryotic Cell

Of all the types of cells revealed by the microscope, *bacteria* have the simplest structure and come closest to showing us life stripped down to its essentials. Indeed, a bacterium contains essentially no organelles—not even a nucleus to hold its DNA. This property—the presence or absence of a nucleus—is used as the basis for a simple but fundamental classification of all living things. Organisms whose cells have a nucleus are called eukaryotes (from the Greek words *eu*, meaning "well" or "truly," and *karyon*, a "kernel" or "nucleus"). Organisms whose cells do not have a nucleus are called prokaryotes (from *pro*, meaning "before").

The Eukaryotic Cell

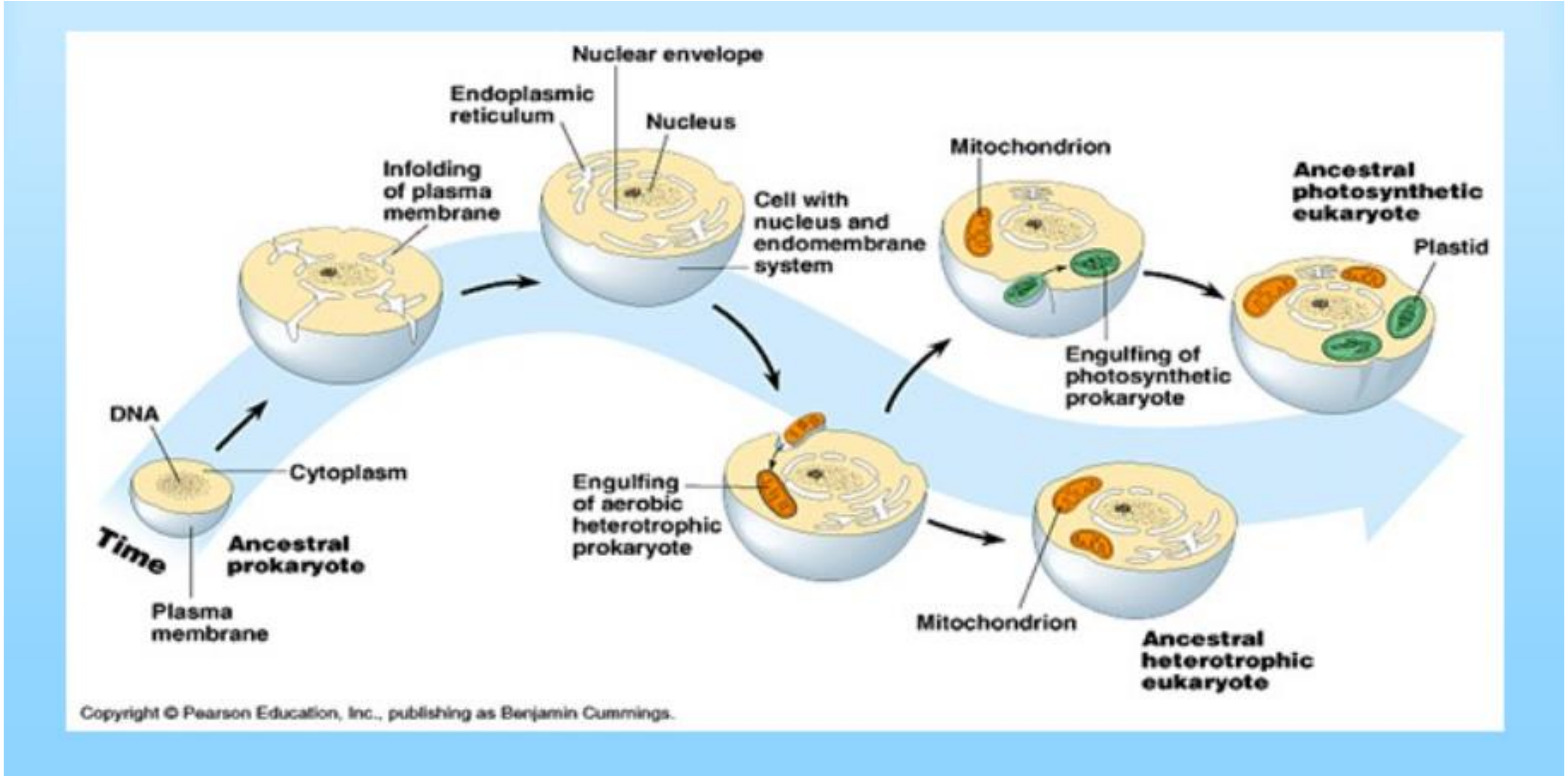
Eukaryotic cells, in general, are bigger and more elaborate than bacteria and archaea. Some live independent lives as single-celled organisms, such as amoebae and yeasts (Figure 1–13); others live in multicellular assemblies. All of the more complex multicellular organisms—including plants, animals, and fungi—are formed from eukaryotic cells.
By definition, all eukaryotic cells have a nucleus. But possession of a nucleus goes hand-in-hand with possession of a variety of other organelles,

Prokaryota role in evolution



Eukaryota

- developing organels via historical ages



Date (million years ago)	Organisms	Events	Atmospheric oxygen (~%)
3800	Prokaryote chemoautotrophs	Origin of life	0
3500–3000	Prokaryote heterotrophs; precursors of cyanobacteria. Stromatolites. Sulfur bacteria	Beginning of photosynthesis	Traces
2100	Filamentous spirally curled organisms, (Grypania)	Major land masses; shallow seas, Iron deposits, BIFs	0.1%
2000	Cyanobacteria tolerant to O_2	Sterols in bitumen (fossil organisms)	0.2%
1700	Spheromorph Acritarchs, primitive unicellular eukaryotes	Atmosphere oxidising Endosymbiosis. Aerobic respiration	0.3%
1200	Red algae and metaphytes	Large cells. Endosymbiosis. Aerobic respiration. Meiosis. Genetic recombination	0.5%
1000–550	Various primitive multi-cellular eukaryotes in precambrian fossils, some mineralized. Green algae dominant. Early land plants	Fossils and tracks. Oxygen and ozone accumulating	1–4%
450–present	Full flourishing multicellular eukaryotes; land living organisms	Ozone layer completed. Crust movements more pronounced. Super continents formed. Ocean basins altered	10–21%

Cells vary enormously in appearance and Function

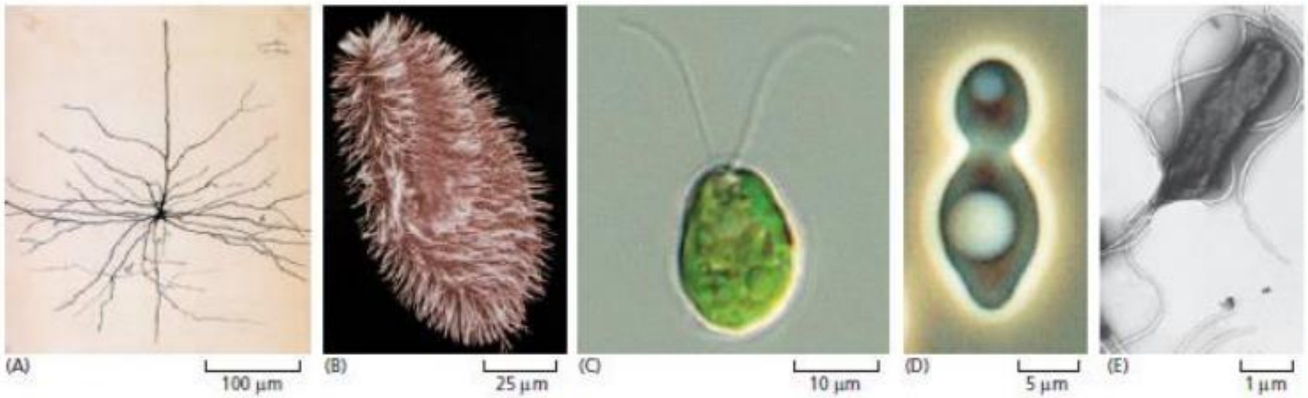
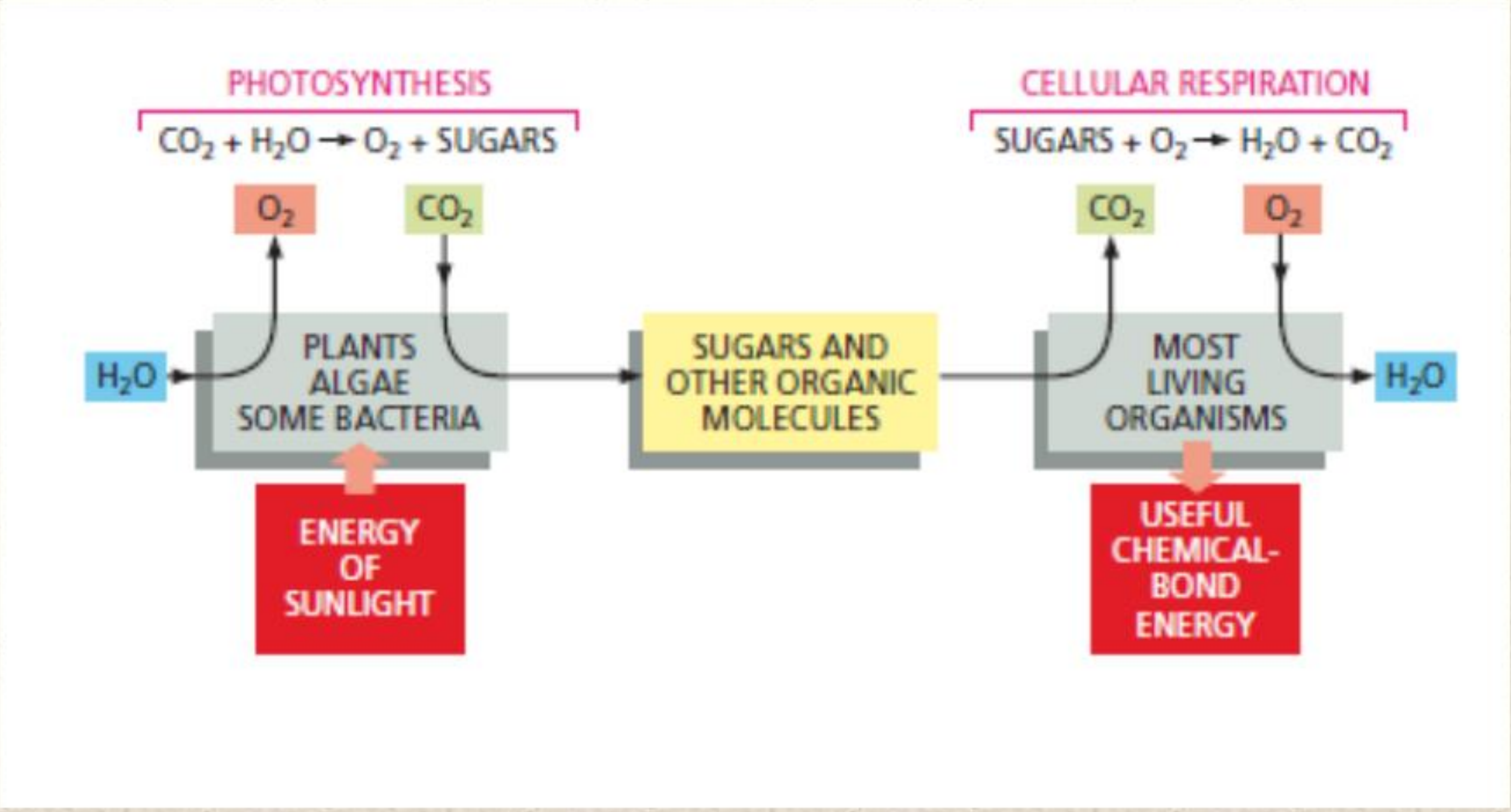


Figure 1–1 Cells come in a variety of shapes and sizes. Note the very different scales of these micrographs. (A) Drawing of a single nerve cell from a mammalian brain. This cell has a huge branching tree of processes, through which it receives signals from as many as 100,000 other nerve cells. (B) *Paramecium*. This protozoan—a single giant cell—swims by means of the beating cilia that cover its surface. (C) *Chlamydomonas*. This type of single-celled green algae is found all over the world—in soil, fresh water, oceans, and even in the snow at the top of mountains. The cell makes its food like plants do—via photosynthesis—and it pulls itself through the water using its paired flagella to do the breaststroke. (D) *Saccharomyces cerevisiae*. This yeast cell, used in baking bread, reproduces itself by a process called budding. (E) *Helicobacter pylori*. This bacterium—a causative agent of stomach ulcers—uses a handful of whiplike flagella to propel itself through the stomach lining. (A, copyright Herederos de Santiago Ramón y Cajal, 1899; B, courtesy of Anne

However biologist during centruries of modern science made basic identification of basal cell principles:

Fundamental principles of all known cells are:
(A) CEHMICAL MACROMOLECULES and STRUCTURE
(B) BIOENERGETIC



Essential Concepts

- Cells are the fundamental units of life. All present-day cells are believed to have evolved from an ancestral cell that existed more than 3 billion years ago.
- All cells are enclosed by a plasma membrane, which separates the inside of the cell from its environment.
- All cells contain DNA as a store of genetic information and use it to guide the synthesis of RNA molecules and proteins.
- Cells in a multicellular organism, though they all contain the same DNA, can be very different. They turn on different sets of genes according to their developmental history and to signals they receive from their environment.
- Animal and plant cells are typically 5–20 μm in diameter and can be seen with a light microscope, which also reveals some of their internal components, including the larger organelles.c

The electron microscope reveals even the smallest organelles, but specimens require elaborate preparation and cannot be viewed whilealive.

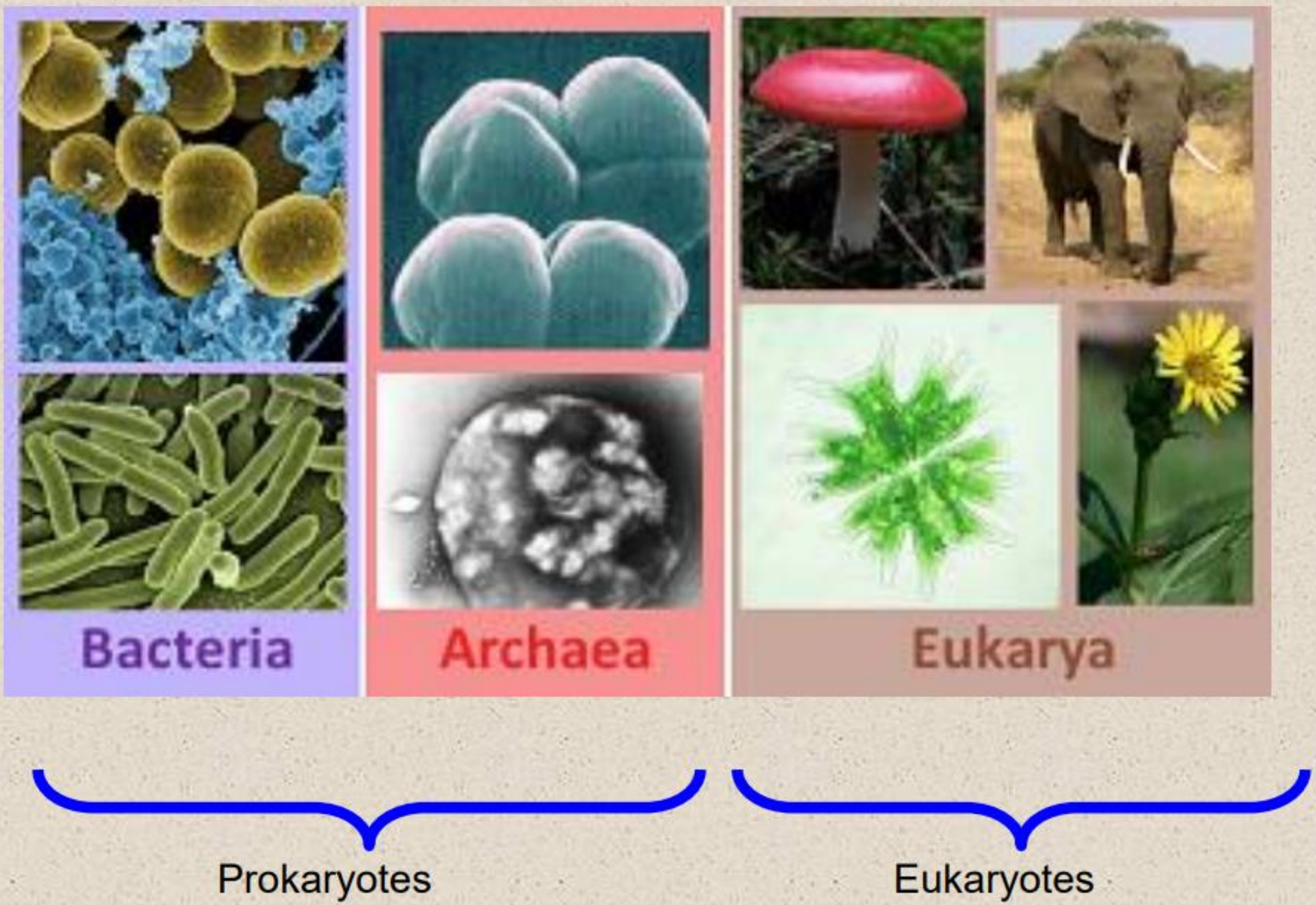
• Specific large molecules can be located in fixed or living cells with a fluorescence microscope.

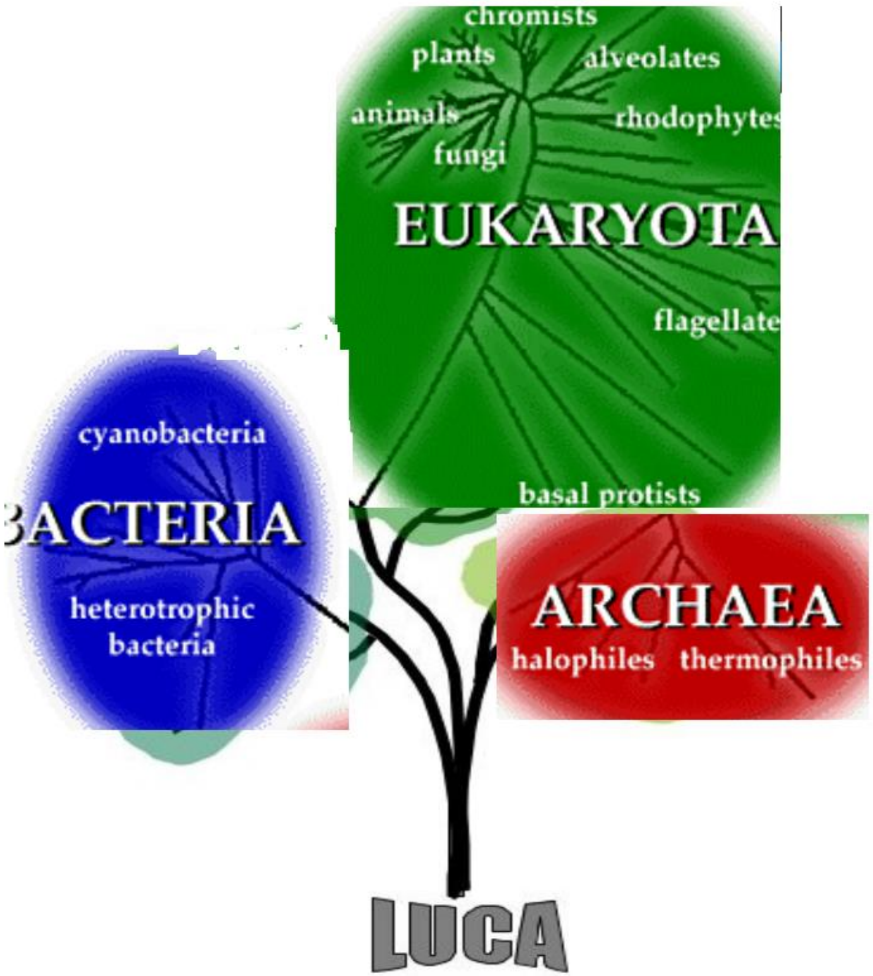
• The simplest of present-day living cells are prokaryotes: although they contain DNA, they lack a nucleus and other organelles and probably
resemble most closely the ancestral cell.

• Different species of prokaryotes are diverse in their chemical capabilities and inhabit an amazingly wide range of habitats. Two fundamental evolutionary subdivisions are recognized: bacteria and archaea.

• Eukaryotic cells possess a nucleus and other organelles not found in prokaryotes. They probably evolved in a series of stages, including the acquisition of mitochondria by engulfment of aerobic bacteria and (for plant cells) the acquisition of chloroplasts by engulfment of photosynthetic bacteria.

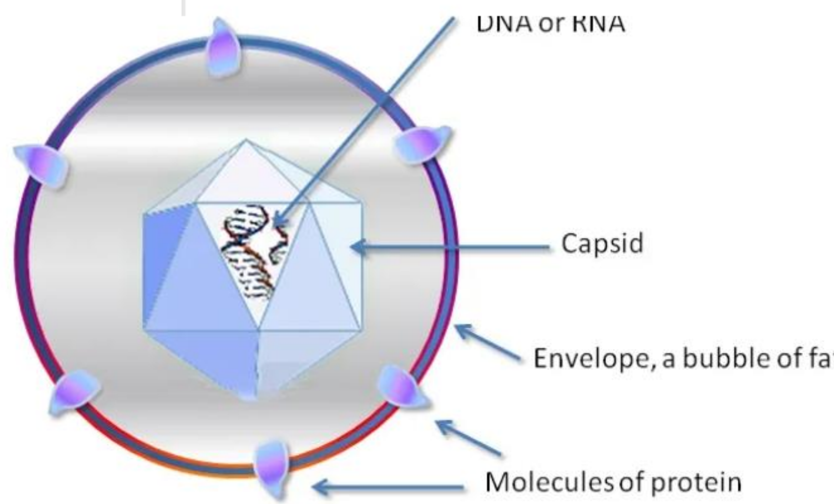
• The nucleus contains the genetic information of the eukaryotic organism, stored in DNA molecules.


Bacteria
Archaea
Eukarya
Prokaryotes
Eukaryotes

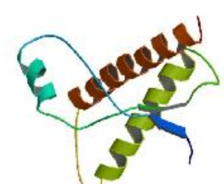


(LUCA = Last Universal Common Ancestor)

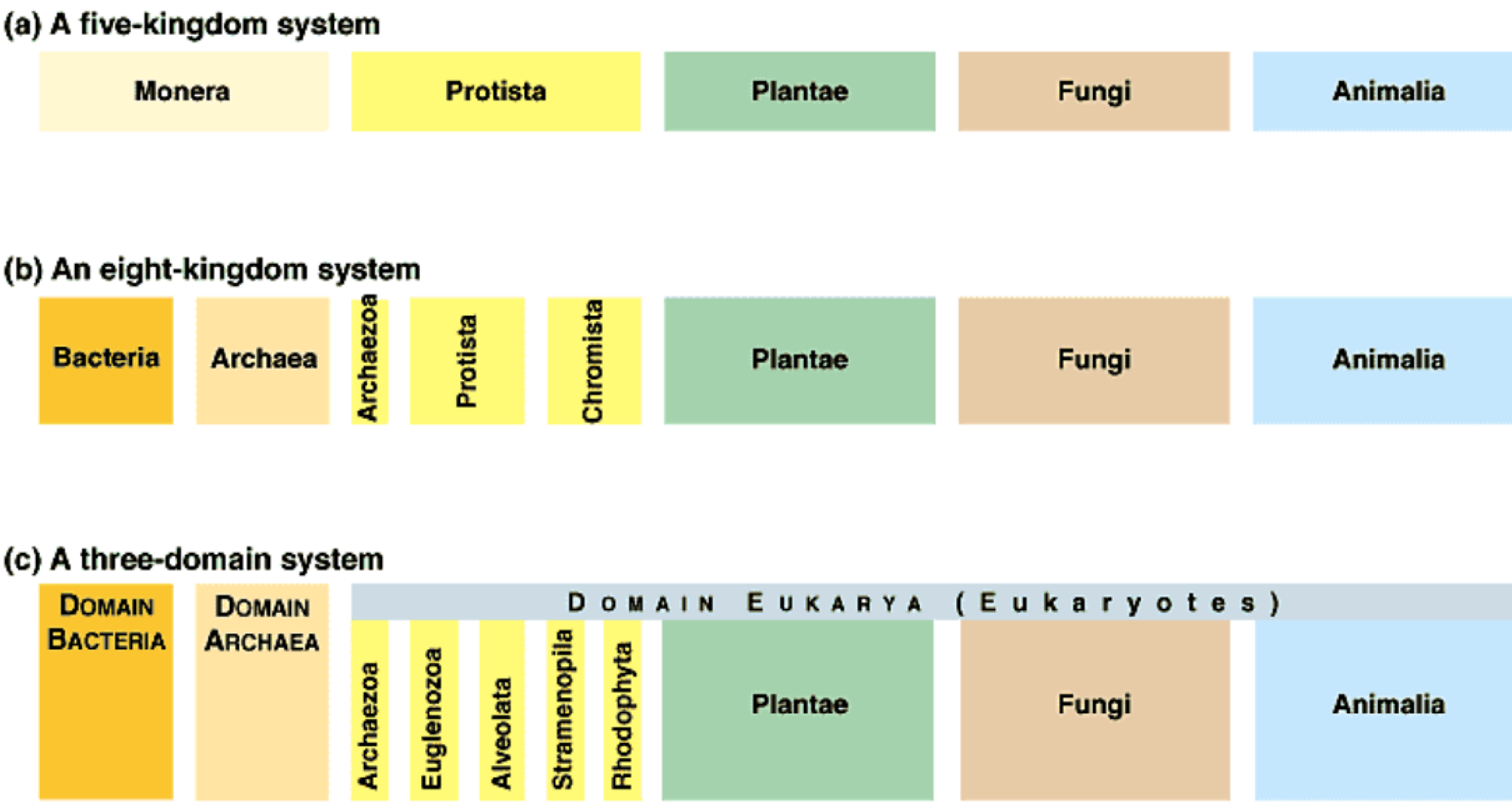
Virus



Prions

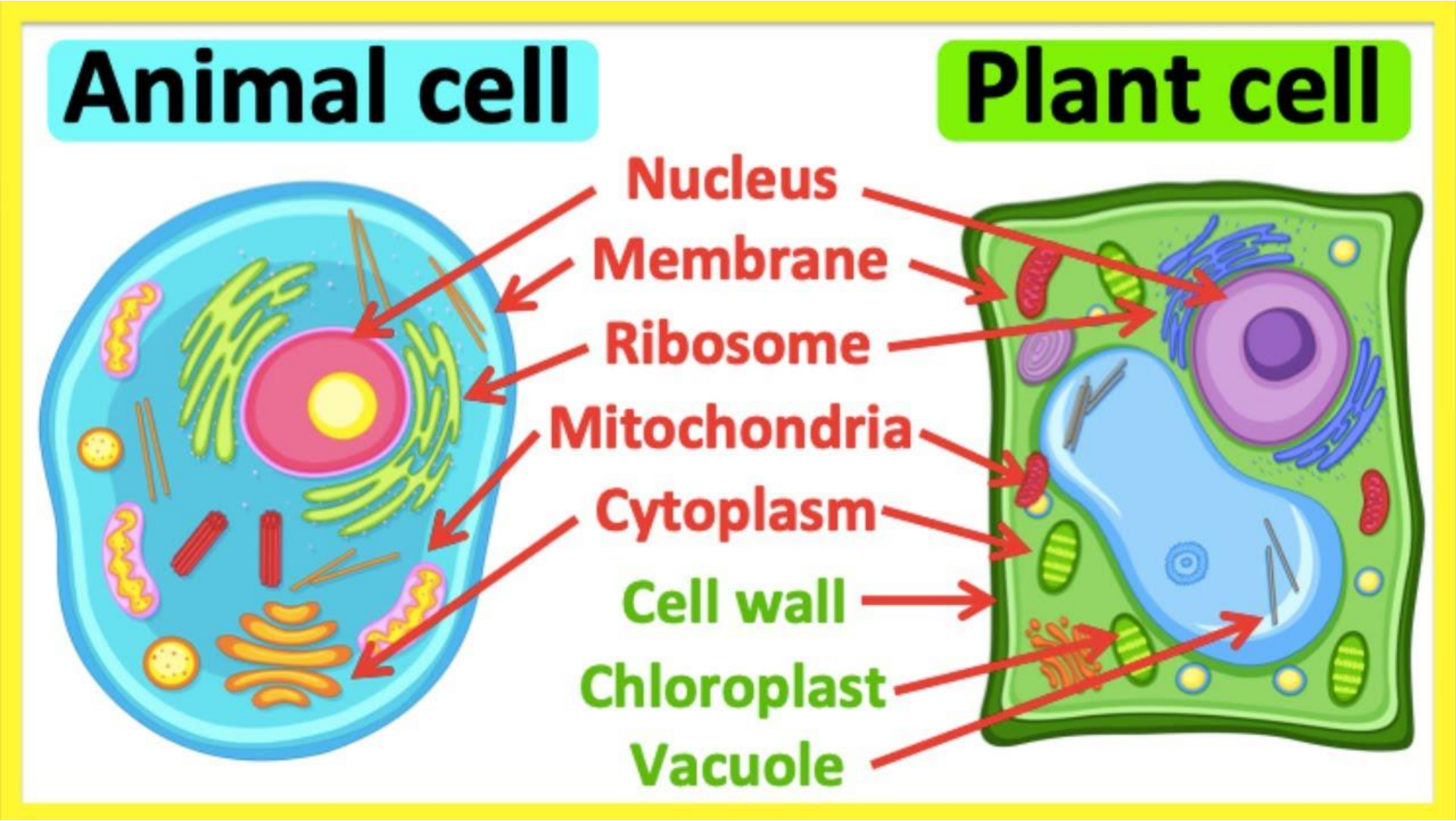


Domain Systems
(the historical concept of systematic BIOLOGY)

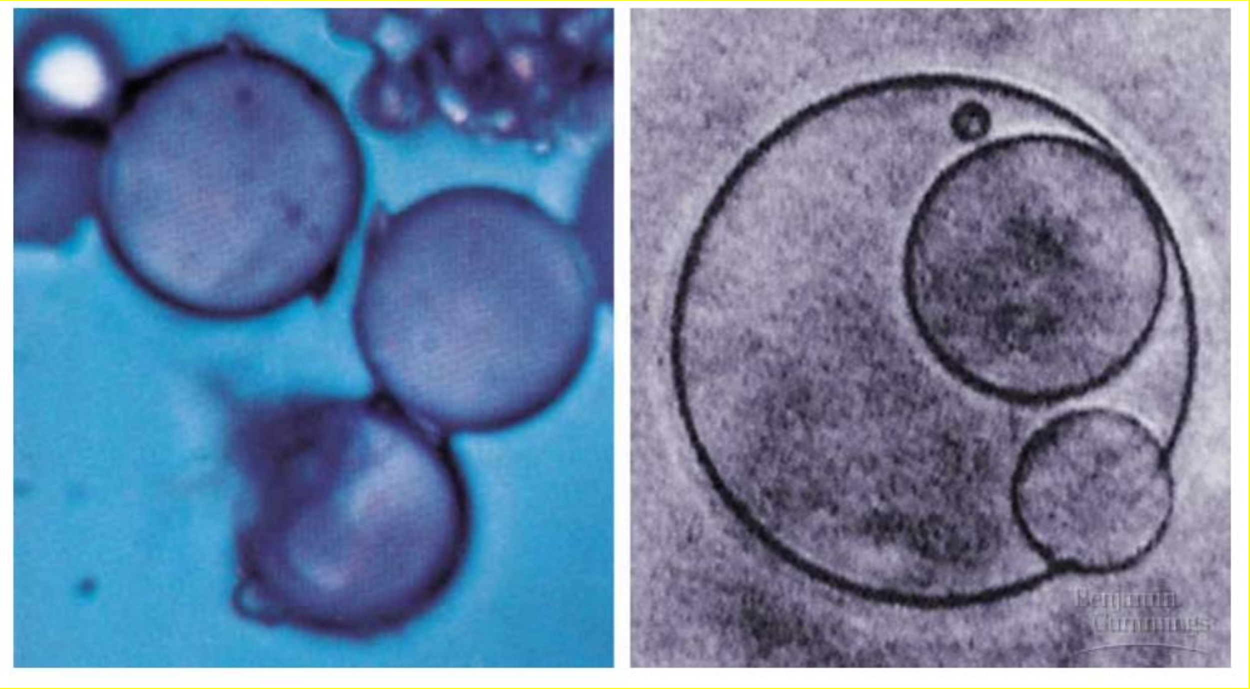


Only this tree-domain systém is used in modern BIOLOGY

EUKAROYTE:
two main group of cells

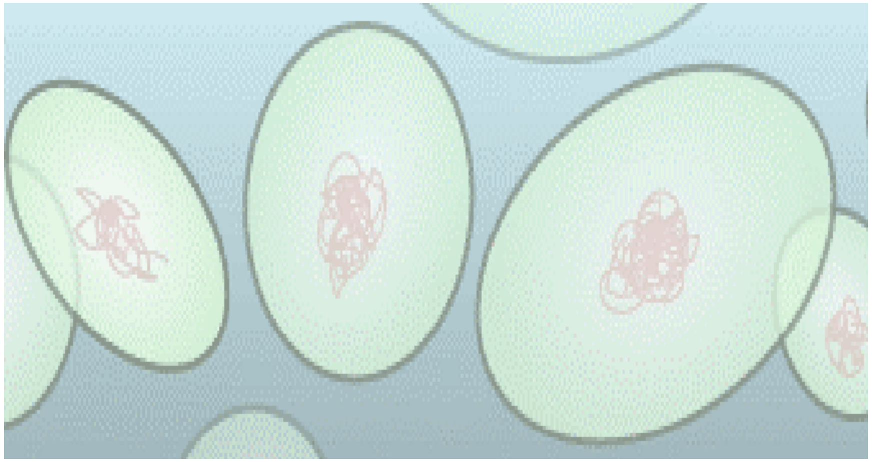


MEMBRANE and DIFUSION

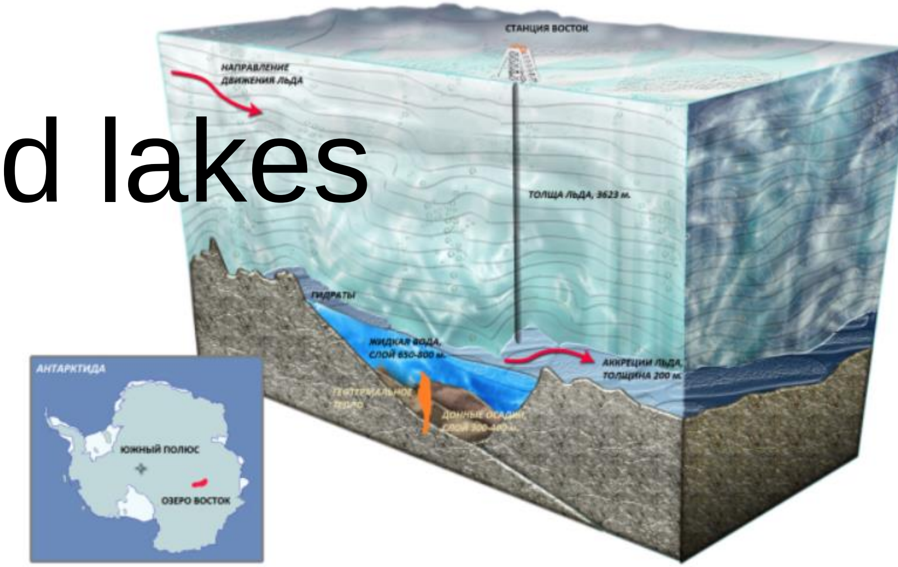


Primitive Border structure

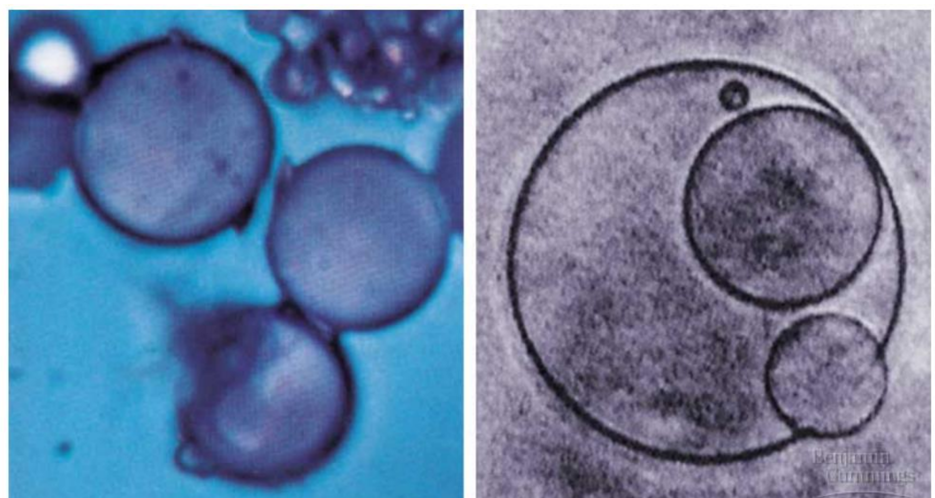
…space IN and space OUT



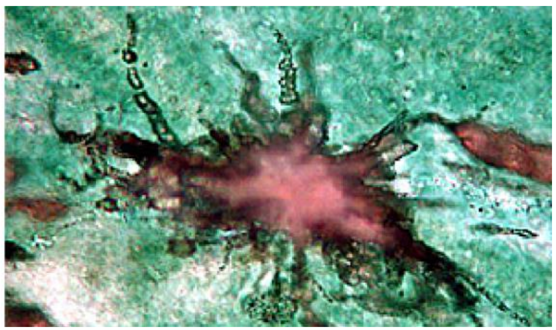
Archaic sea and lakes

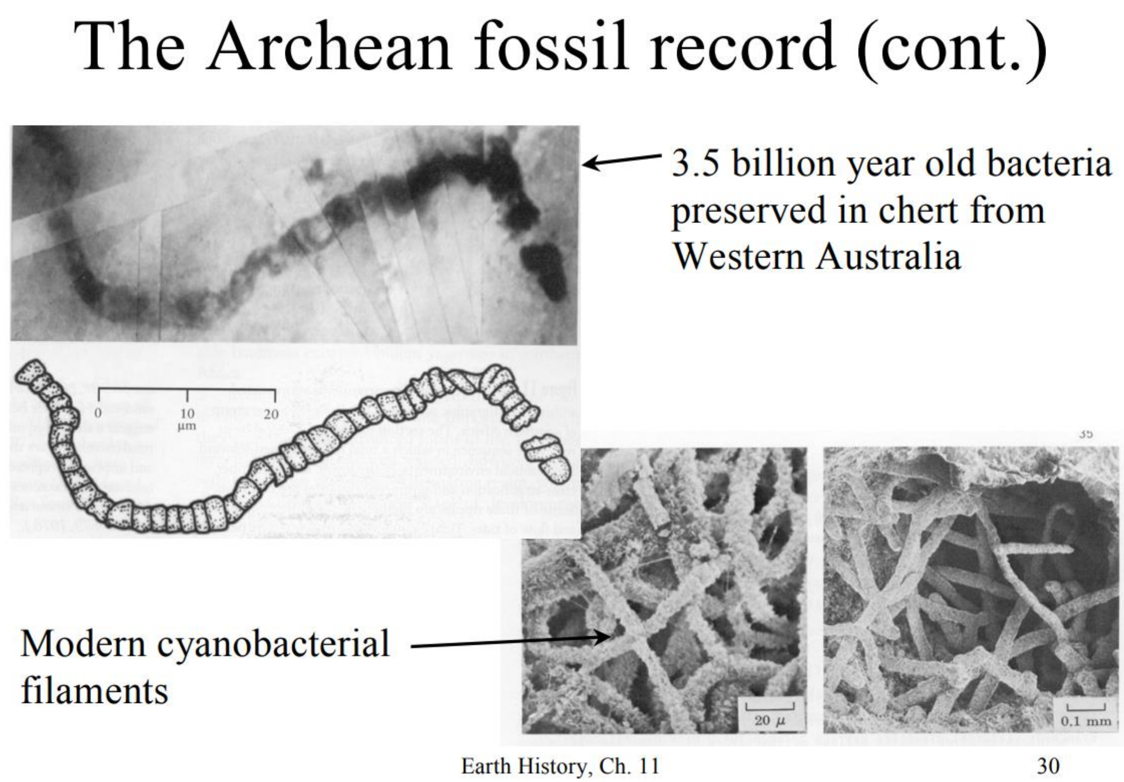


- Protobionta / Liposomes



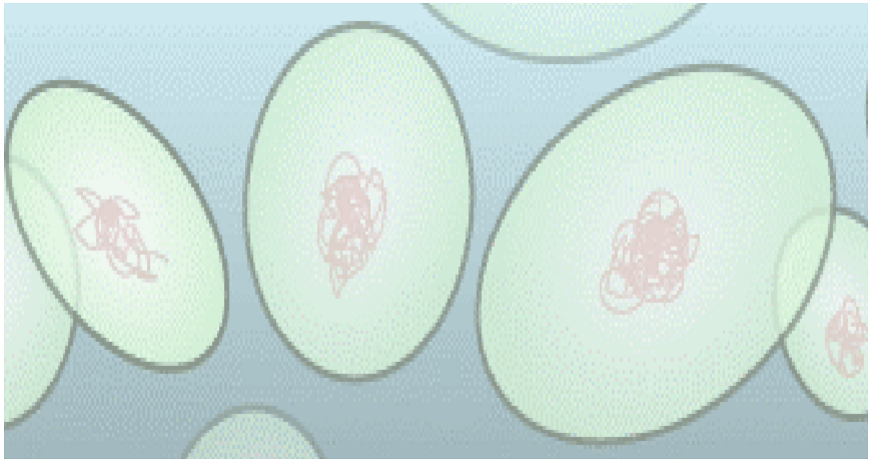
- Exact fossil arguments:

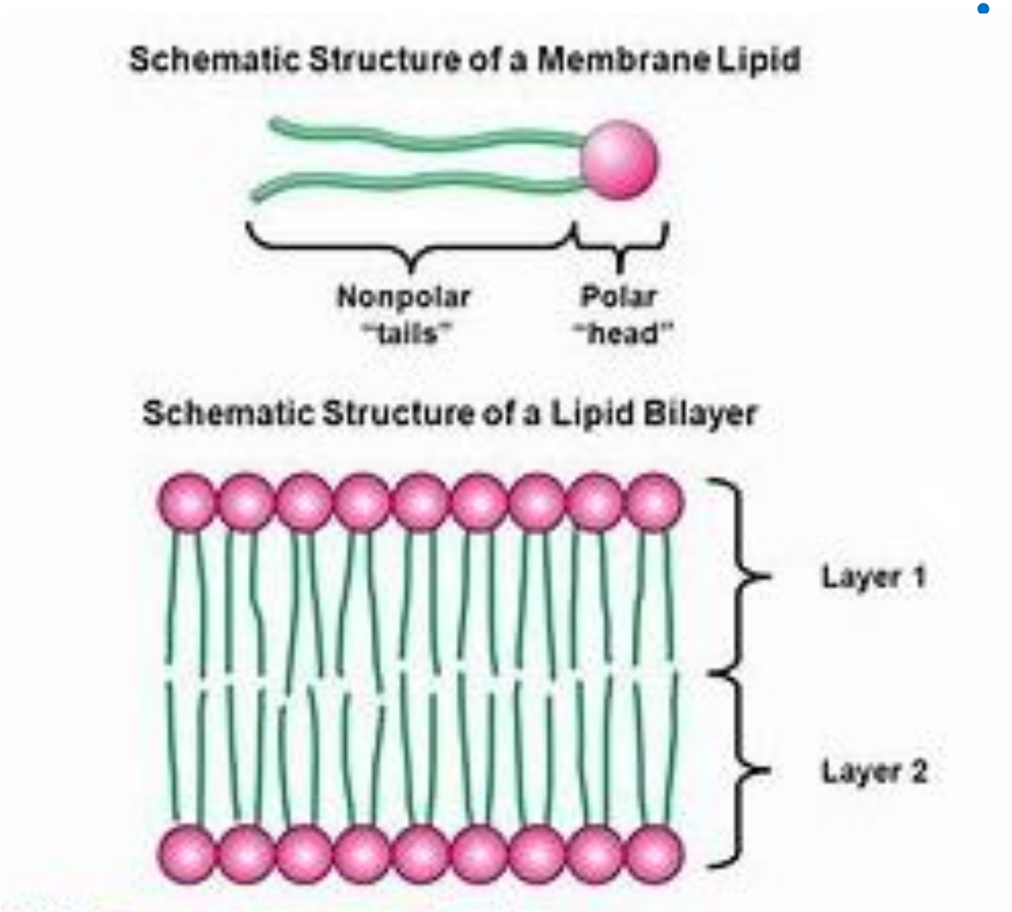




Primitive Border structure

…space IN and space OUT



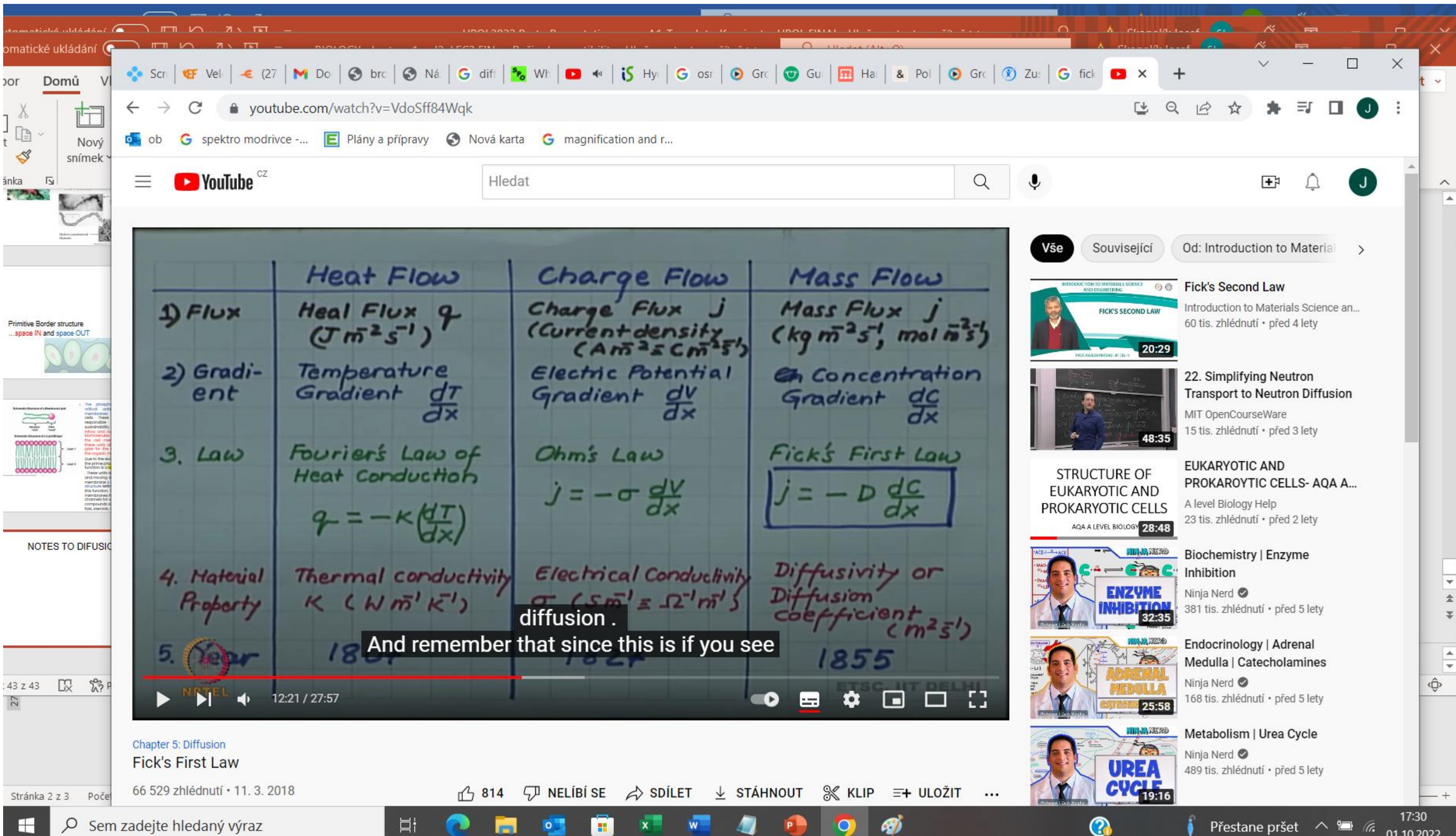


- The phospholipids are the critical units of the cell membranes protecting the cells. These units are also responsible for the sustainability of the cells. The inflow and outflow of different biomolecules are controlled by the cell membrane. In fact, these units also host a flexible gate for the entry and exit of the organic molecules.

Due to the excellent structure, the prime phospholipid function is a selective passage.

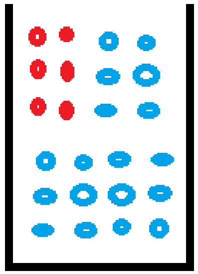
. These units are also floating and moving. It gives the cell membrane a quasi-fluid structure letting them execute this function. The cell membranes have specific channels for various organic compounds such as proteins, fats, steroids, carbohydrates,

NOTES TO DIFUSION

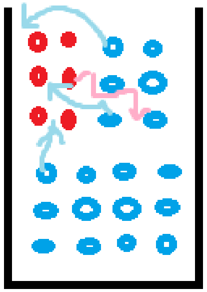


DIFUSION in simple basin (without any membrane)

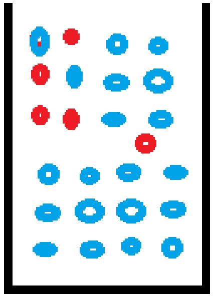
- Red molecules are droped to water.



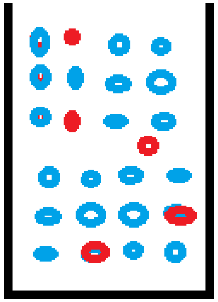
What will be happen?



later



and finaly

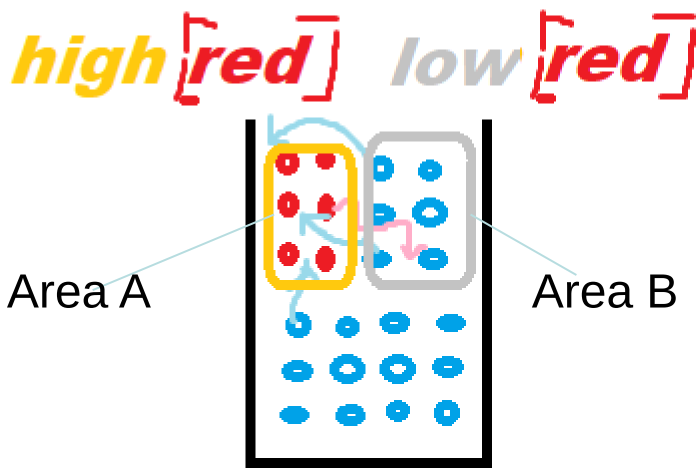


concentration of RED and WATER are finaly homogenous

- Why RED and WATER molecule diffuse?

there exist place with high concetration and

near place with low concentration .   This gradient of concentation caused the molecule movement



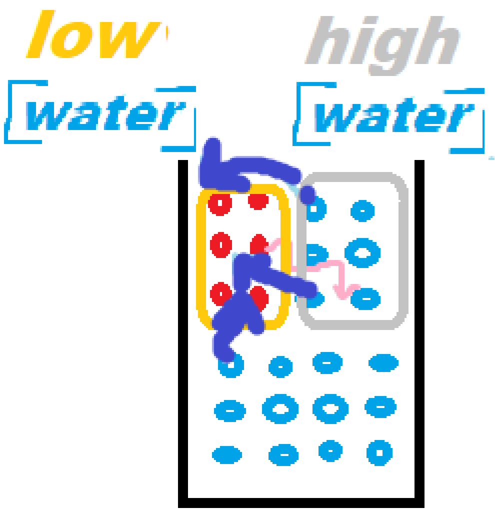
This movement is quantified by FICK LAW

$$J = S \cdot D \cdot grad[red]$$

where S is the “contacting area of drop (area with red molecules)“
D is special physical constant for this type of molecules (will be shown in next pages)
grad [red] is gradient of concentration in place A and place B
(if concentration is the same, there is gradient = 0 and no movement of molecules)

- However the same situation can be seen also from oposite site of view:

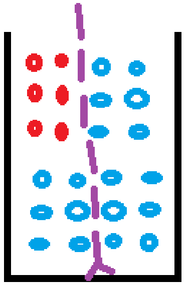
ALSO WATER MOLECUELS are driven from place B (high concentration of WATER to A (low concentration of water)

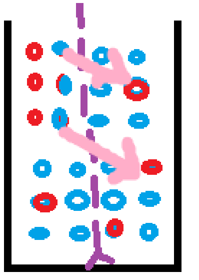


$$J = S \cdot D \cdot grad[w]$$

DIFUSION in basin with the membrane

Variant 1: Membrane is permeable only for RED

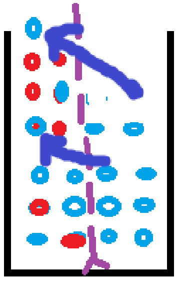




THE PHYSICAL FORCE FOR MOVEMENT OF RED MOLECULES are the same like in basin withou membrane.

Concentration of RED and WATER will be finaly homogenous in both compartments.

Variant 2: Membrane is permeable only for WATER



Water is moving through the membrane and „wants to made“ oncentration of „RED so much low as possible“ (idealy press to zero = total water).

In some time it is stoped in ekvilibrium (becaouse of extarnal presure)