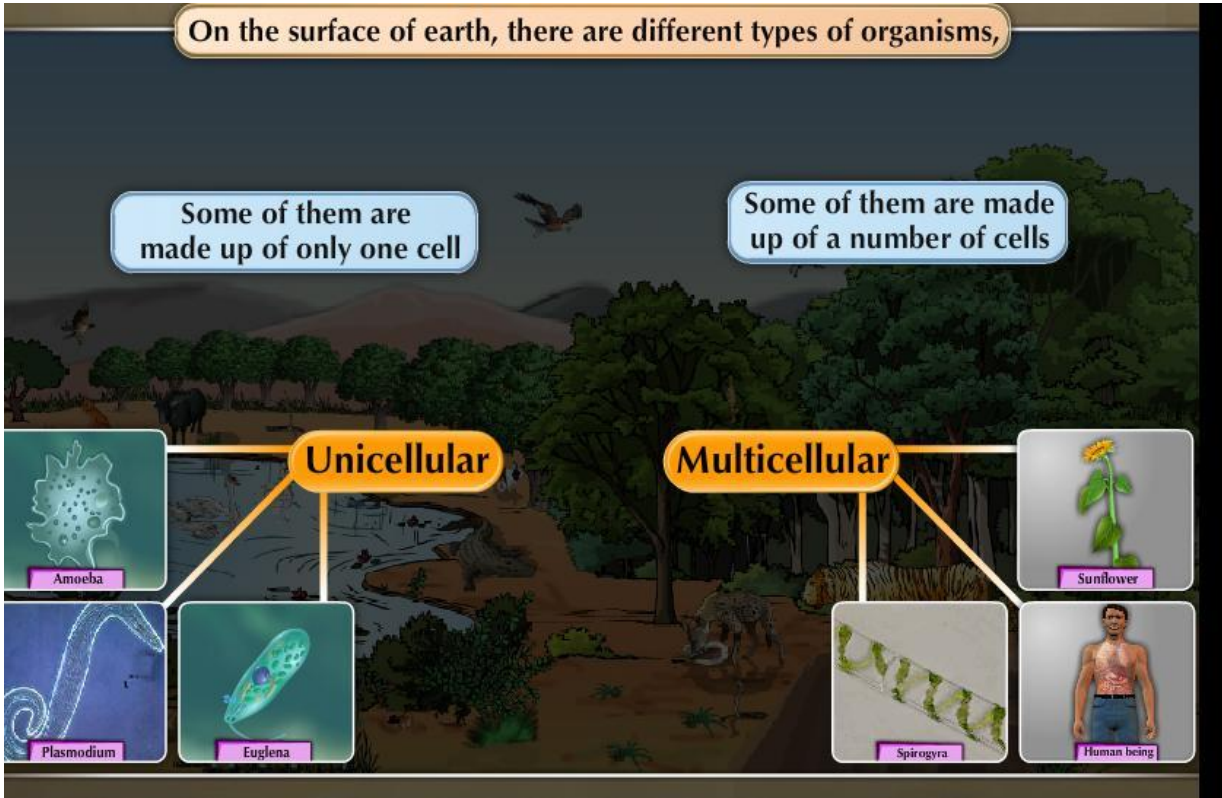
Structure of cells
Viruses, pro- and eukaryotic cells

Alexandra Stayer-Harci

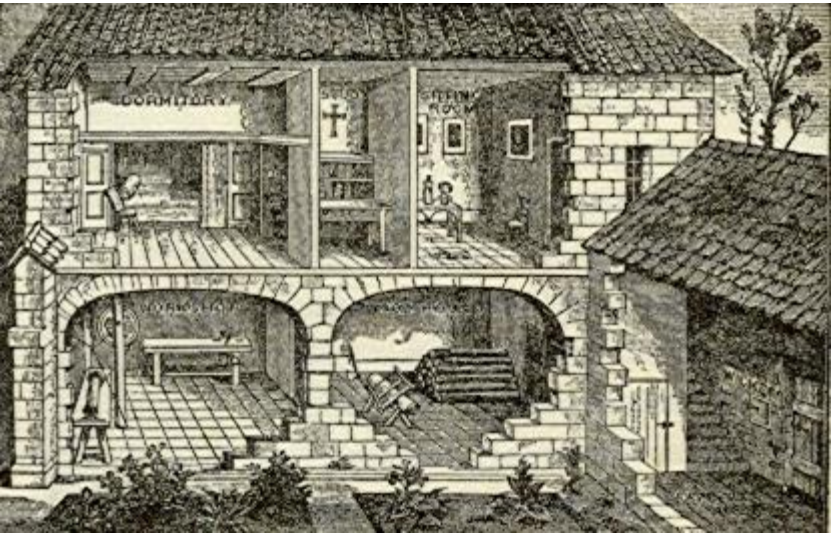
What is a cell?

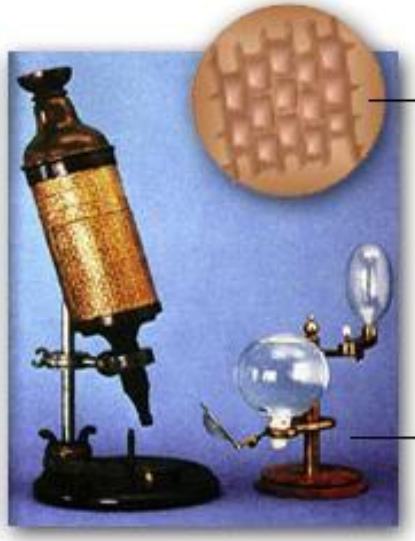
- smallest structural-, functional- and biological unit of life („building blocks of life”)
- surrounded by membrane, contains biological macromolecules
- unicellular or multicellular organisms
- appeared on Earth 3.5 billion years ago



Discovery of cell

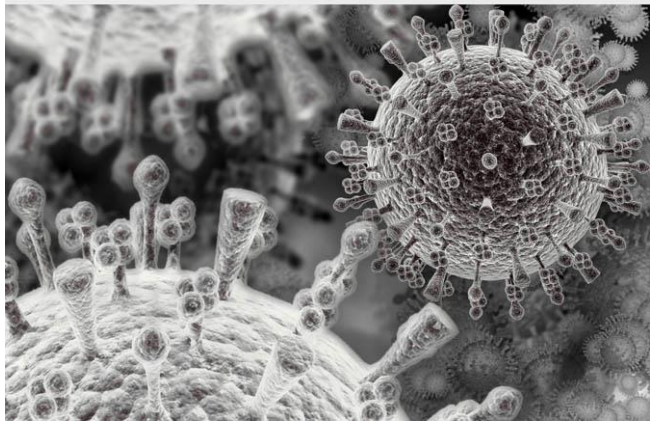
- discovered by Robert Hooke in 1665
- analyzed cork cells with his microscope → saw „small rooms” that resembles to monk’s cells
- Latin *celle* = „small room”

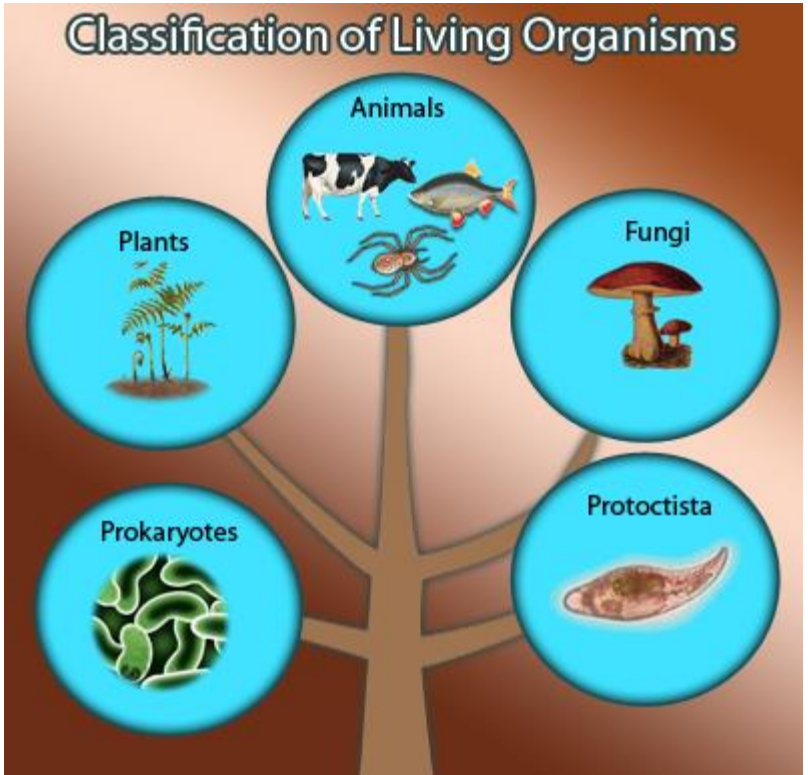




Classification of organisms

- 2 groups of living organisms on Earth:
  - prokaryotes: absence of true nucleus (bacteria)
  - eukaryotes: presence of true nucleus (protocista, fungi, plants, animals)
- Viruses (life without a cellular structure)

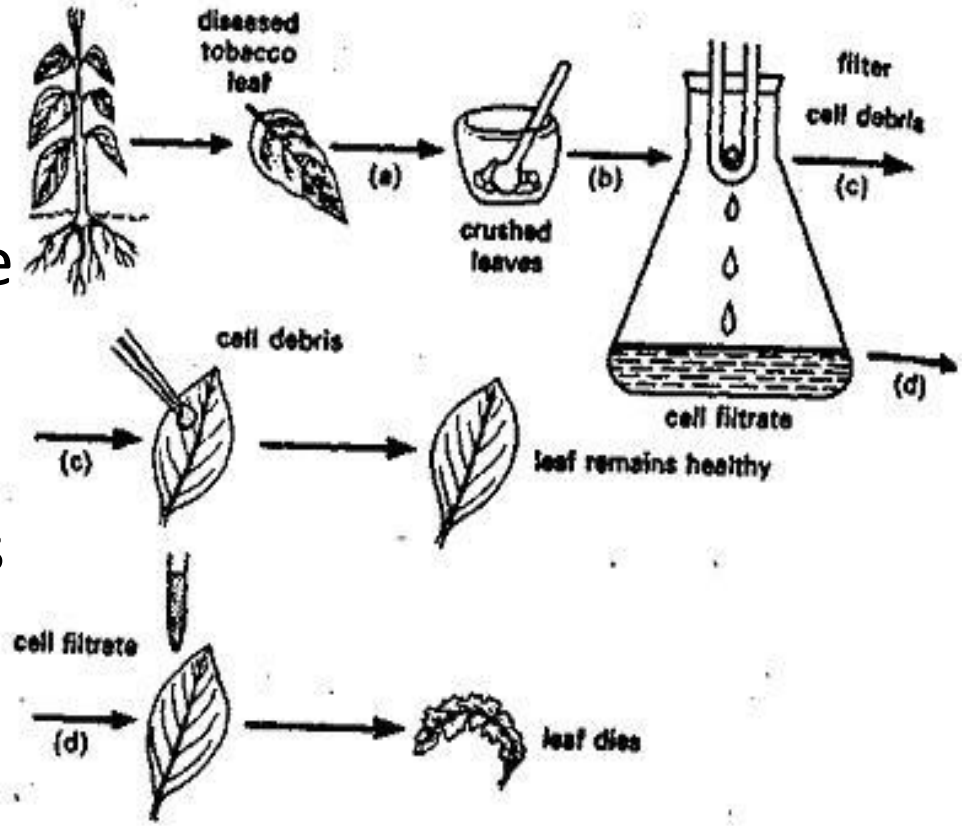




VIRUSES

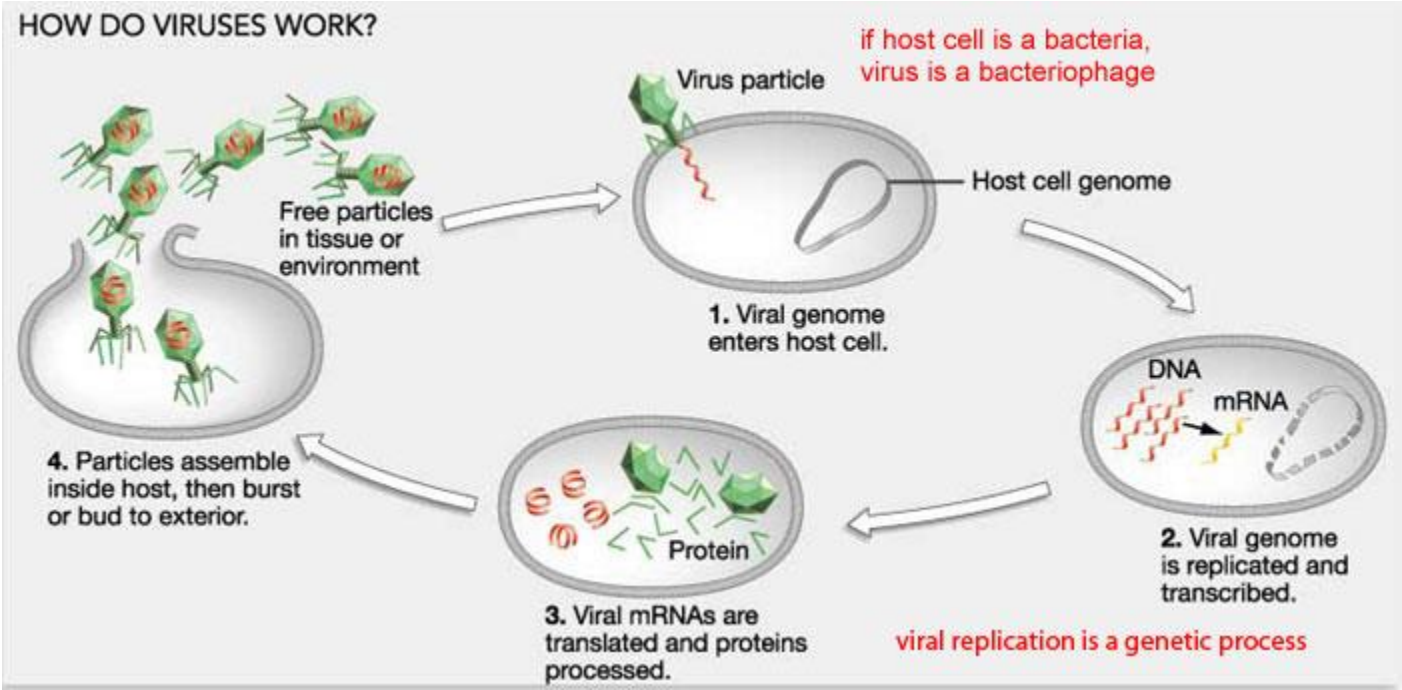
Discovery of viruses

- Dimitri Iosifovich Ivanovsky (1864-1920)
  Russian botanist
- 1892: existence of a non-bacterial infectious agent
- diseased tobacco plant → filtering the sap through a filter with small pores to retain bacteria → the filtrate remained infectious
- 1898: Martinus Beijerinck called the filtered, infectious substance a „virus“
  (Latin= poison)



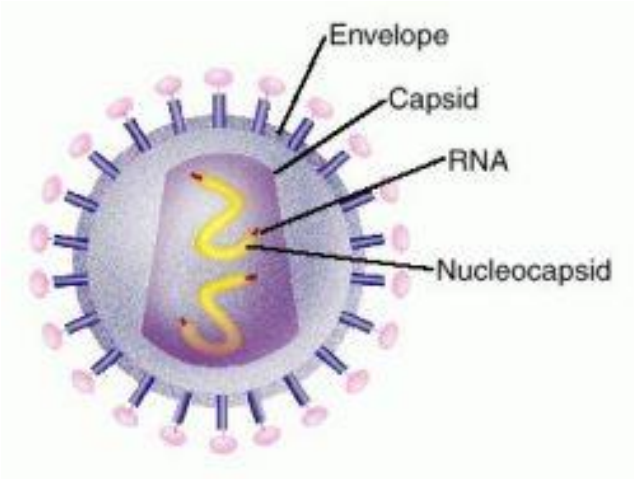
Viruses

- can replicate only inside the living cell → host cell is forced to produce many thousands of identical copies of the original virus
- can infect all types of organisms (animals, plants, bacteria)
- 20 nm to about 300 nm



Structure of viruses

- one virus particle = virion
- capsid
  - protective protein coat
  - contains many smaller, identical protein molecules = capsomers
- nucleocapsid
  - inner shell around the genetic material (DNA or RNA)
  - contains also proteins
- envelope
  - bubble of lipid around the capsid

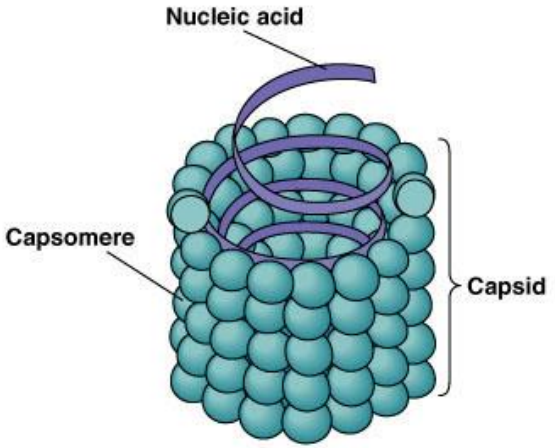


Genetic material of viruses

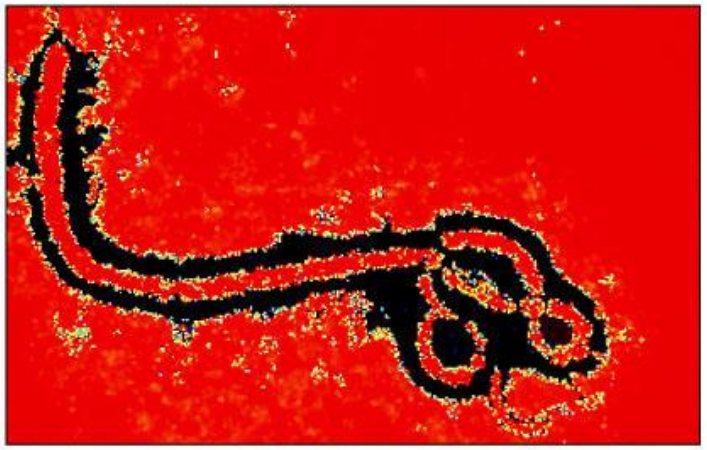
- Nucleic acid
  - DNA → DNA virus
  - RNA → RNA virus
  - Both DNA and RNA (at different stages in the life cycle)
- Shape
  - Linear
  - Circular
  - Segmented
- Strandedness
  - Single-stranded
  - Double-stranded
  - Double-stranded with regions of single-strandedness
- Size
  - smallest viral genom (Circoviruses): two kilobases, codes for only two proteins
  - the largest viral genom (Pandoraviruses): two megabases , codes for about 2500 proteins

Types of viruses (based on capsid stucture)

- Helical viruses
  - capsid forms a helical structure with a central cavity
    - e.g.: Ebola virus: causes haemorrhagic fever , mortality: 50-90%

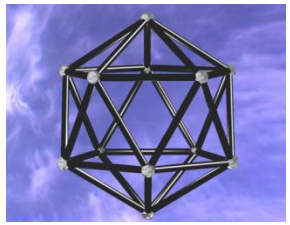


(a) A helical virus

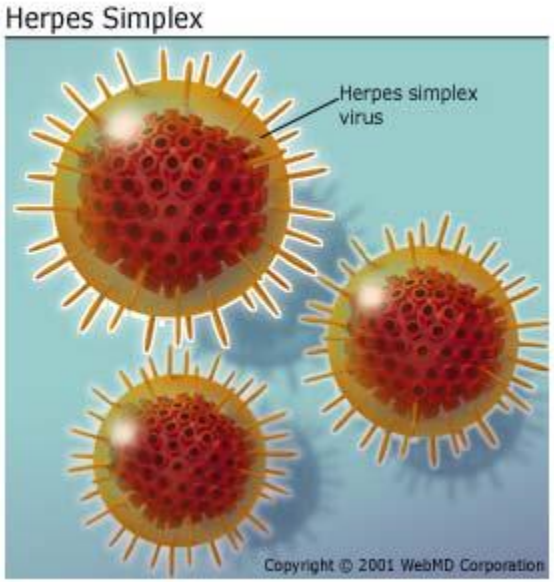


(b) Ebola virus

Types of viruses (based on capsid stucture)



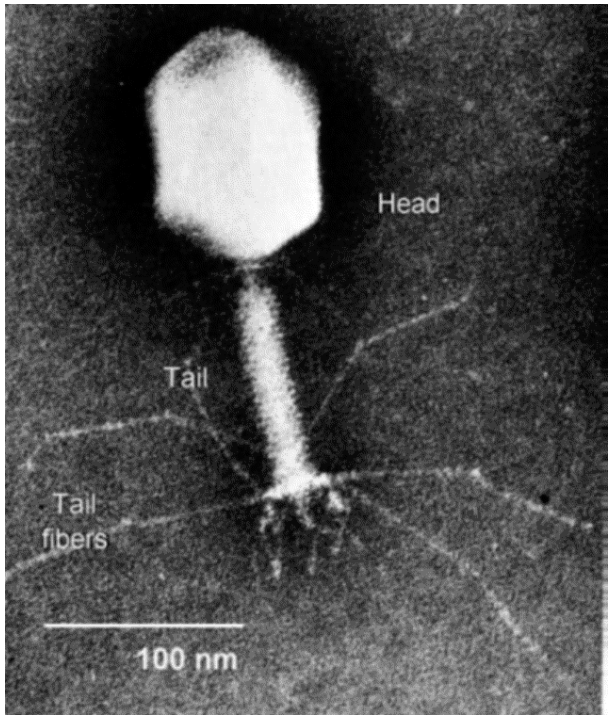
- Polyhedral viruses
  - icosahedron form (easiest shape to assemble the subunits)
    - e.g.: Herpes viruses : blisters in the skin (mouth, lips or genitals)

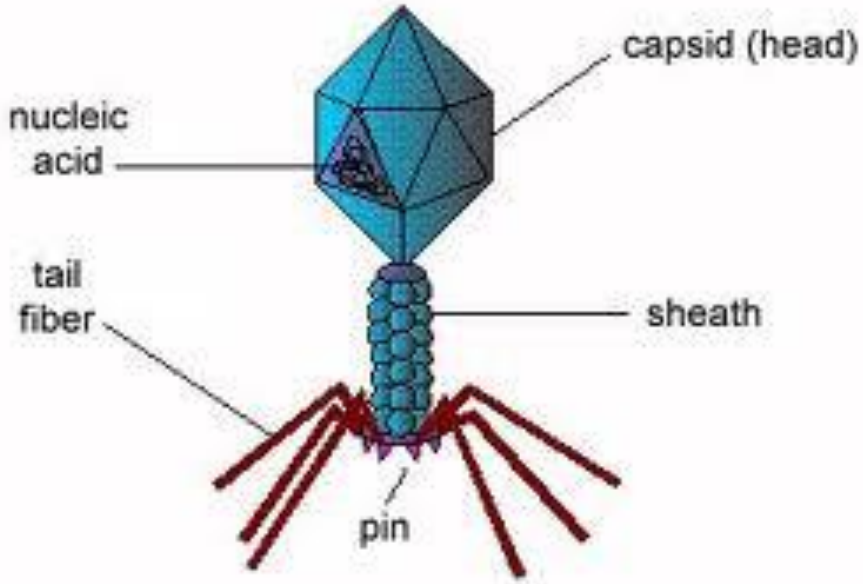


    - chicken pox virus: skin rash, fever

Types of viruses (based on capsid stucture)

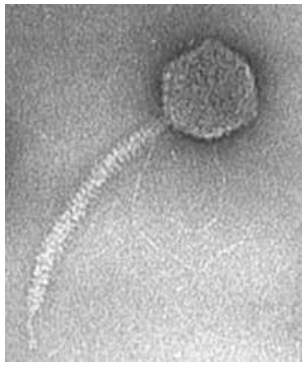
- Binal viruses
  - helical tail and polyhedral head
  - e.g.: bacteripohages





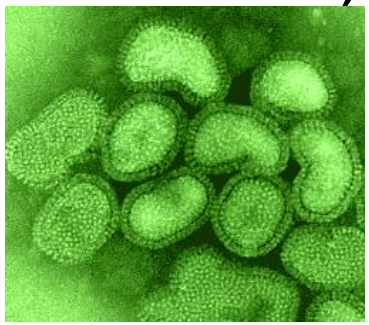
Types of viruses (based on type of host cell)

- bacteriophages
  - infect bacteria: e.g. Lambda phage ↔ E. coli



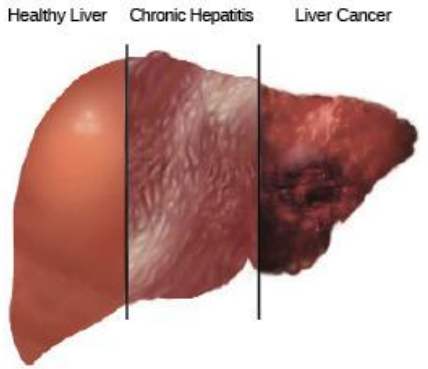
- plant viruses
  - infect plants: e.g. grape yellow vein virus

- animal viruses
  - infect animal cells: e.g. Influenza virus, Hepatitis C virus

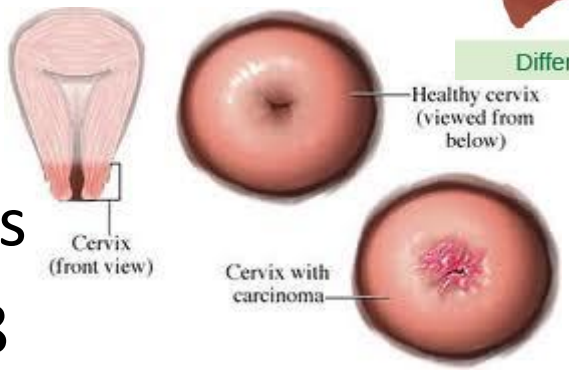


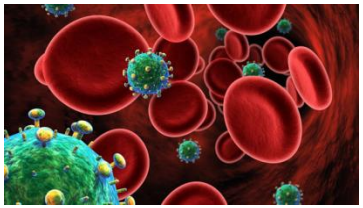
Types of viruses (based on type of genom)

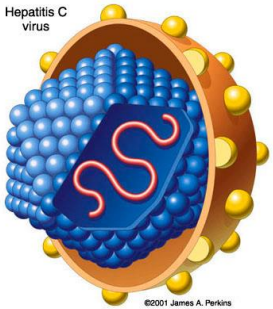
- DNA viruses
  - Hepatitis B
  - Human papillomavirus
  - Human herpes virus 8
- RNA viruses
  - HIV
  - Influenza virus
  - Hepatitis C

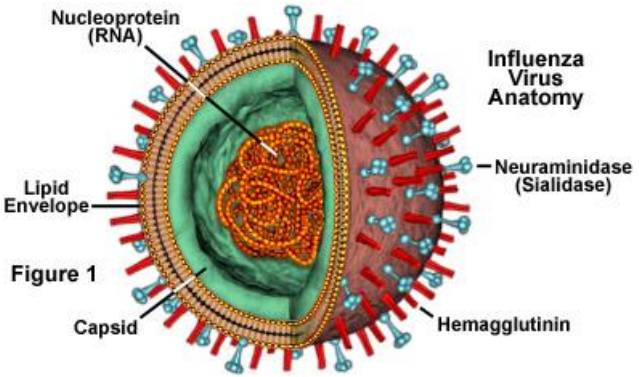


Different Types of Liver Conditions







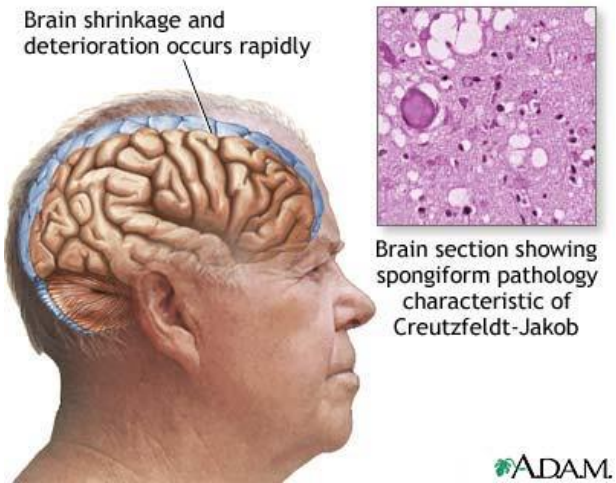


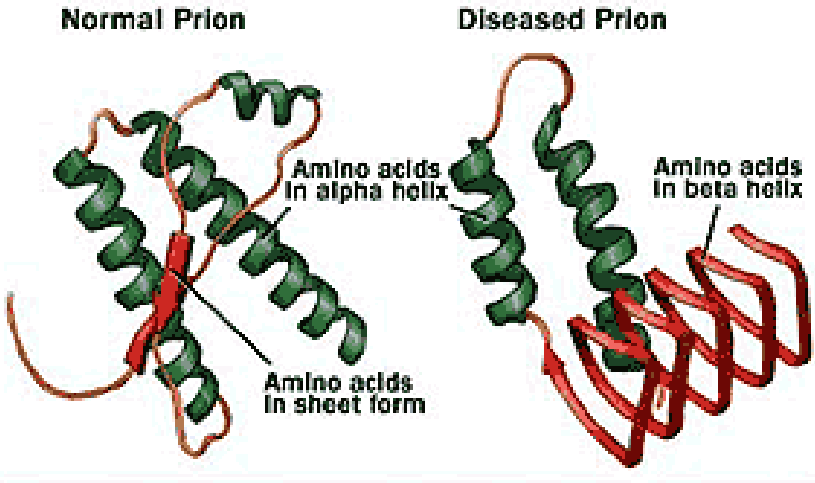
Origin of viruses

- unclear, 3 hypothesis:
  - they were small cells that parasitised larger cells → loss of genes → could reproduce only inside host cells
  - from bits of DNA or RNA that "escaped" from the genes of a larger organism
  - developed from protein and nucleic acid at the same time as cells first appeared on Earth → dependent on cellular life for billions of years

Prion

- infectious misfolded protein, doesn't contain DNA or RNA
- affect the brain and/or other neural tissues
- are currently untreatable and lethal
- "mad cow" disease
- Kuru, Creutzfeldt–Jakob disease



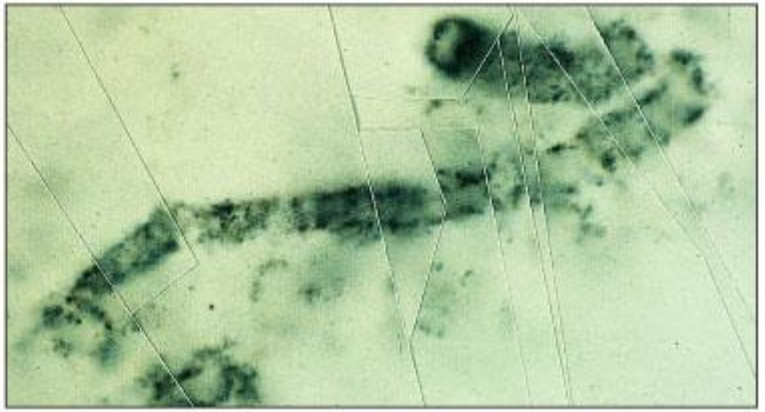


PROKARYOTES

Origin

- Greek: pro- = "before" and karyon = „nut or kernel”
- 3 hypothesises:
  - prokaryotes were the first living organisms
  - developed from more complex eukaryotic ancestors through simplification
  - developed simultaneously with eukaryotes
- The oldest known fossilized prokaryotes are 3.5 billion years old (Earth is 4,5 billion years old)

(a)



(b)

Structure of prokaryotic cells

<u>DNA</u>

- do not have a nucleus
- nucleoid region: contains the genome
- small, circular, double-stranded, mostly coding

<u>Cell organelles</u>

- no mitochondria and chloroplasts (ATP - synthesis and photosynthesis → across the prokaryotic cell membrane), ER, Golgi
- primitive prokaryotic cytoskeleton
- ribosomes
- chromosome-polysome complex

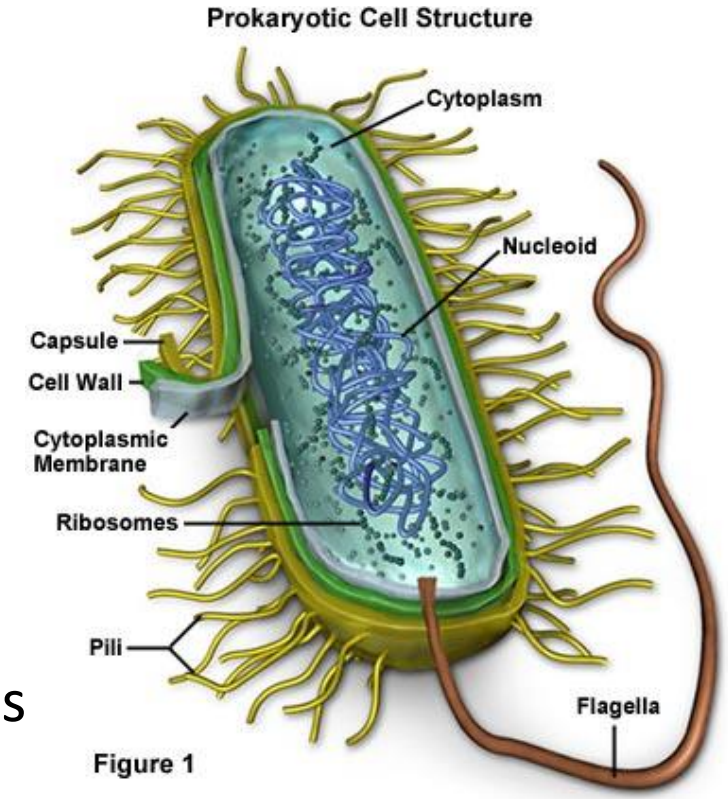
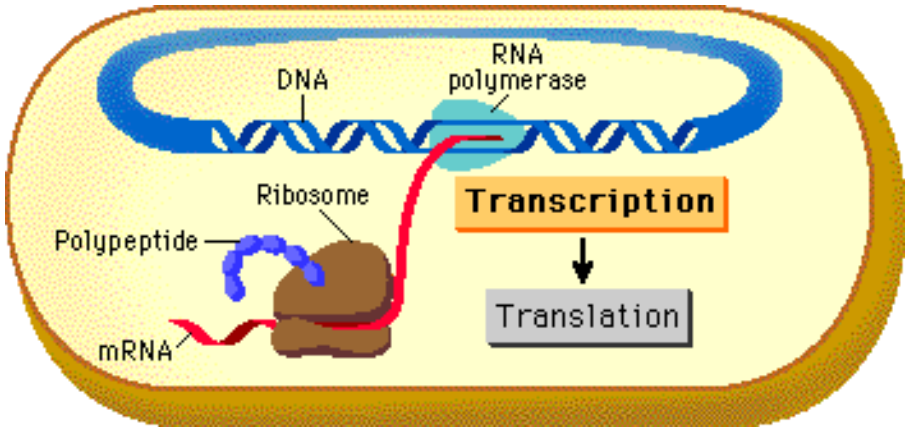
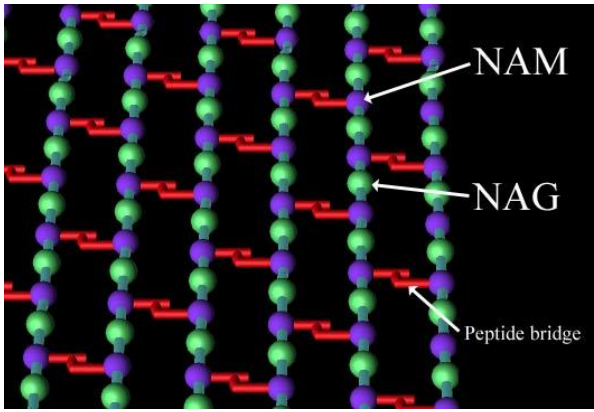


Figure 1

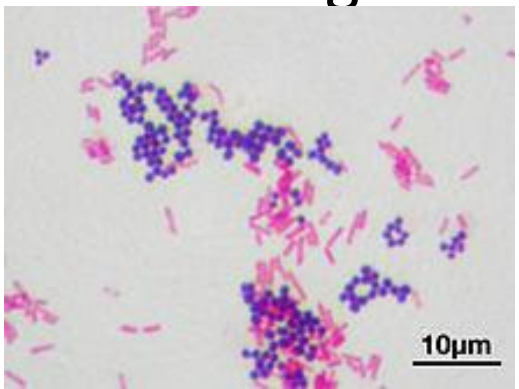


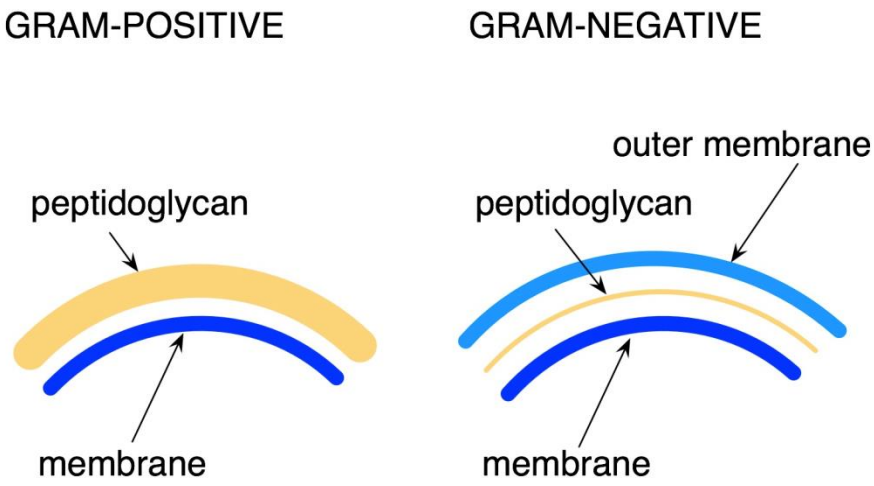
Structure of prokaryotic cells

Cell wall



- from peptidoglycan: polysaccharide chains cross-linked by peptides
- penicillin inhibits its formation
- two different types of cell wall
  - Gram-positive (purple)
  - Gram-negative (pink)

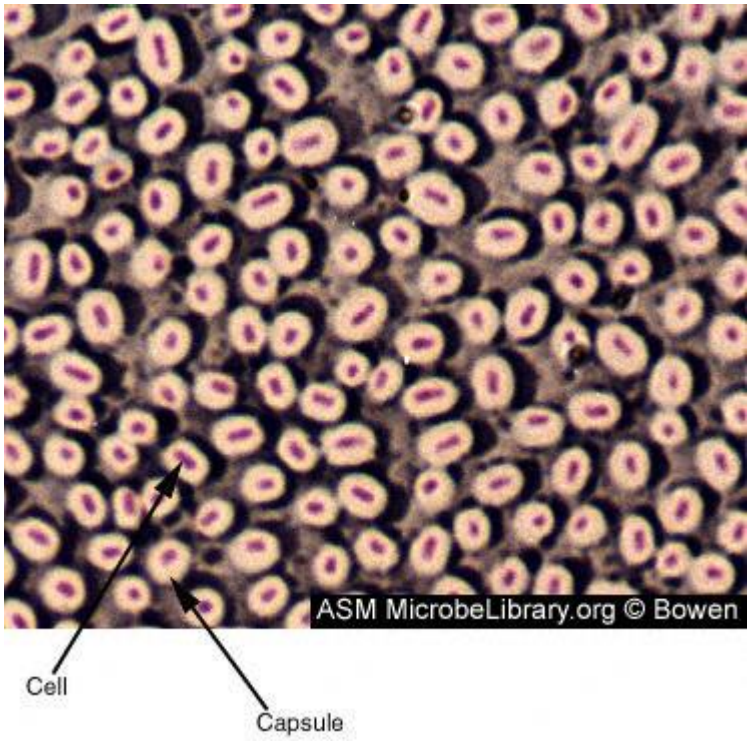




Structure of prokaryotic cells

Capsule

- outside the cell wall from polysaccharides
- protects cells from engulfment by eukaryotic cells, dehydration
- antigens → cause diseases



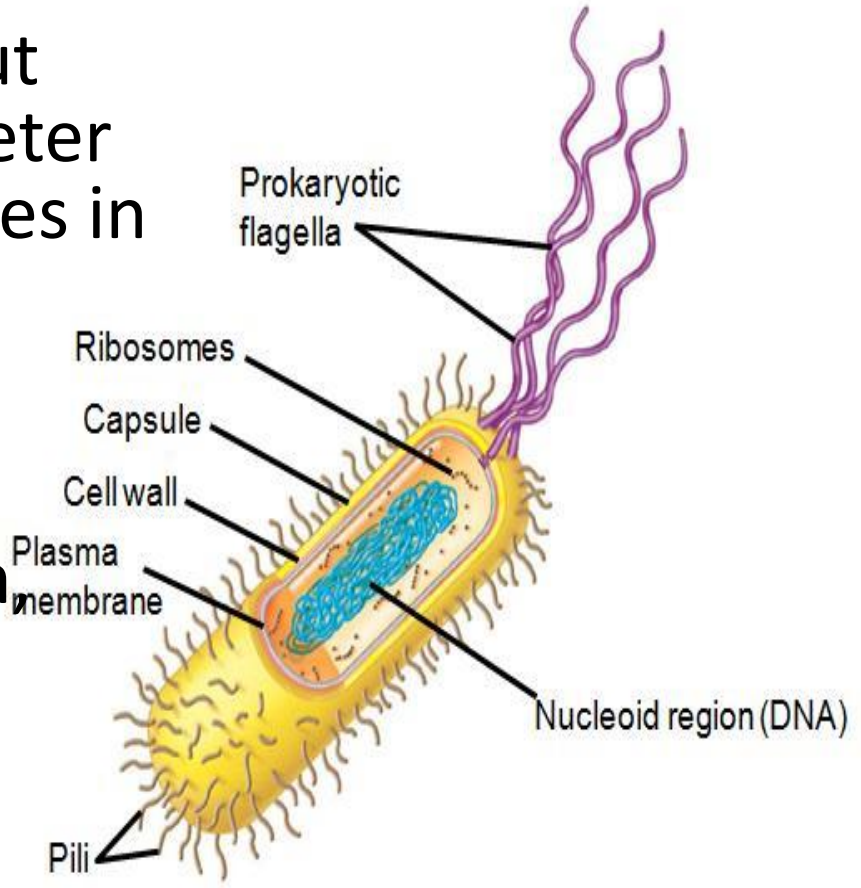
Structure of prokaryotic cells

Flagellum

- protein structures, about 20 nanometres in diameter and up to 20 micrometres in length
- movement

Pili/Fimbriae

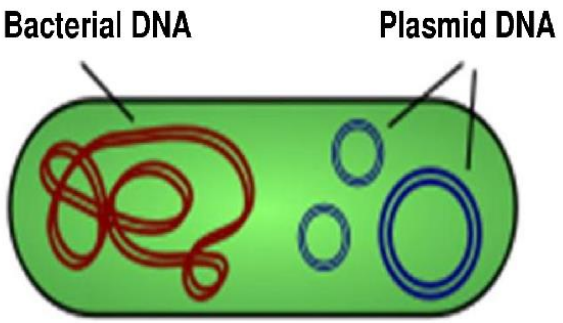
- fine filaments of protein, 2–10 nanometres in diameter and up to several micrometers in length
- attachement to host cells



Structure of prokaryotic cells

Plasmids

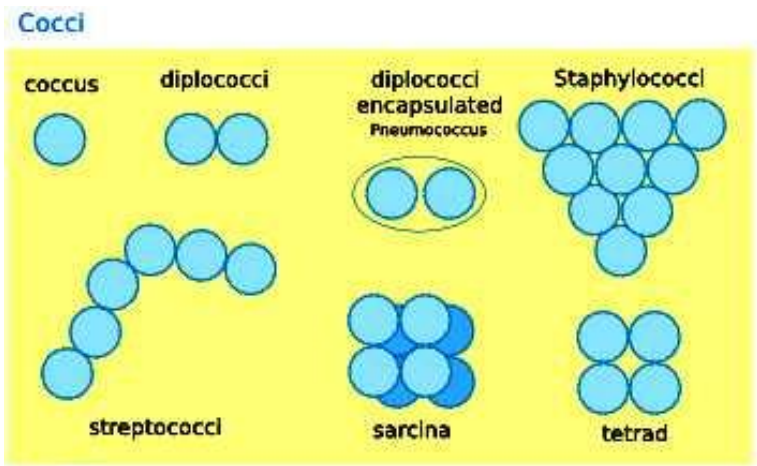
- extrachromosomal DNA
- 1-1.000/bacterium
- small, circular, double-stranded DNA, replicates independently from chromosome
- genes that may benefit survival (e.g. antibiotic resistance)
- can be transmitted from one bacterium to another

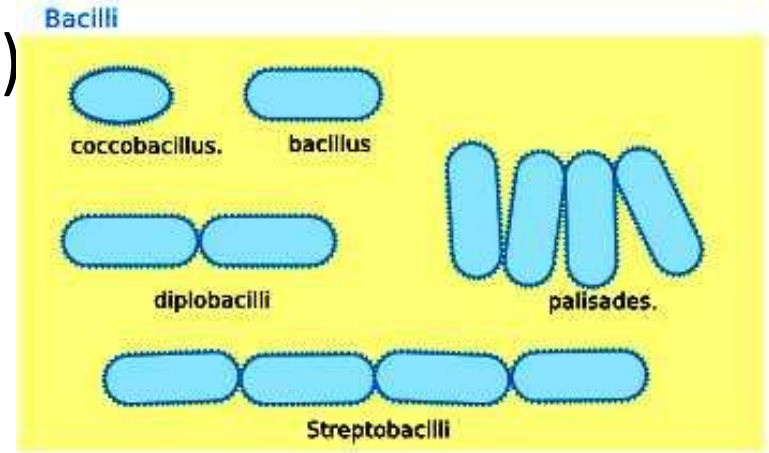


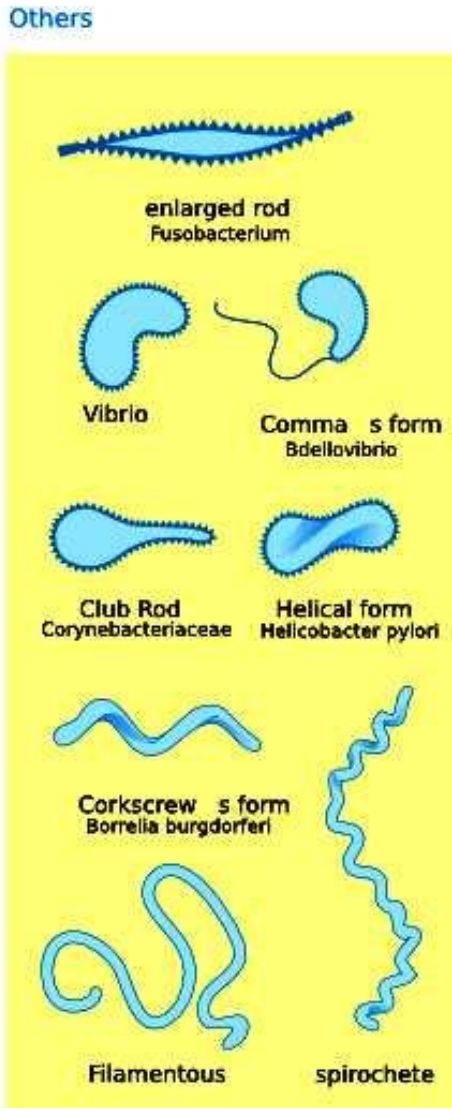
Morphology of bacteria

Wide diversity:

- 0,5-5 µm
- cocci (sing. coccus)
  → spherical
- bacilli (sing. bacillus)
  → rod-shaped
- others: vibrio, spirillum, …

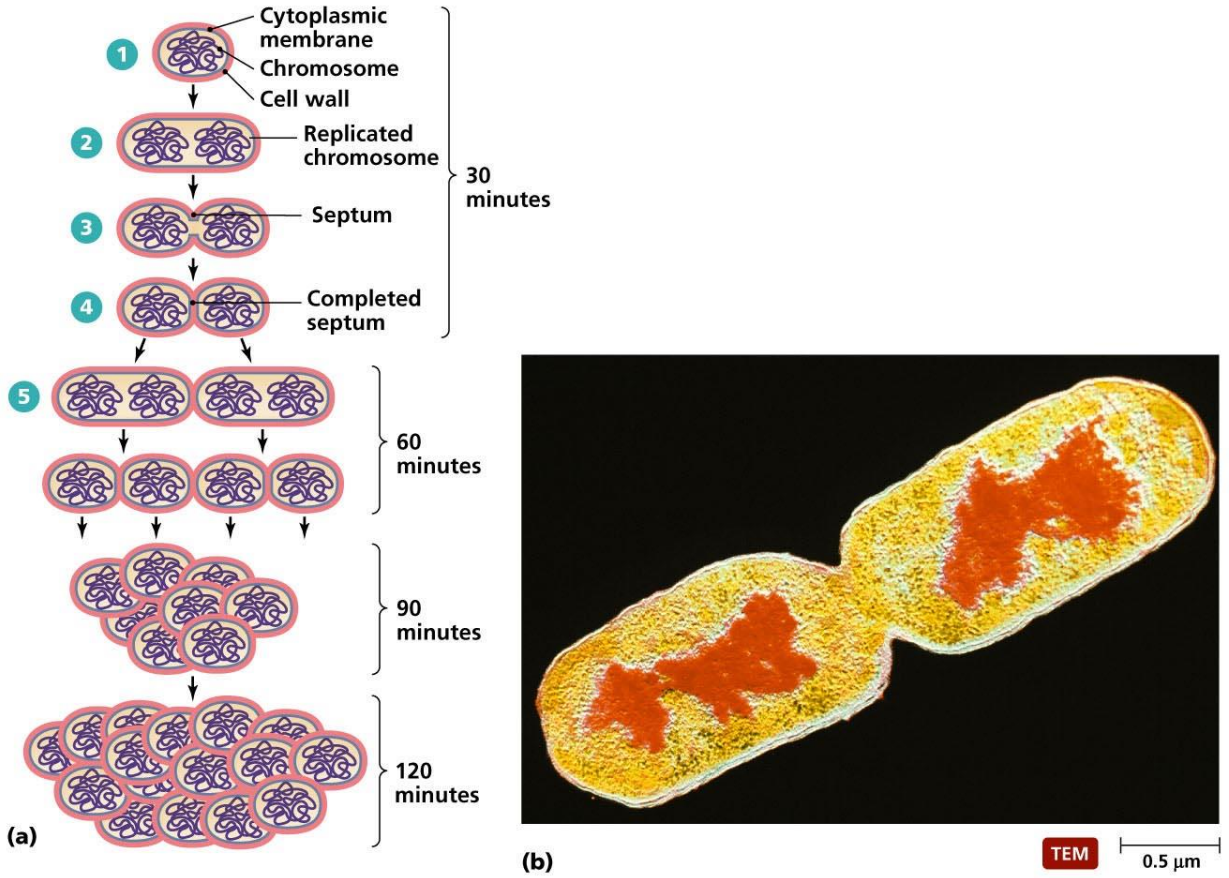






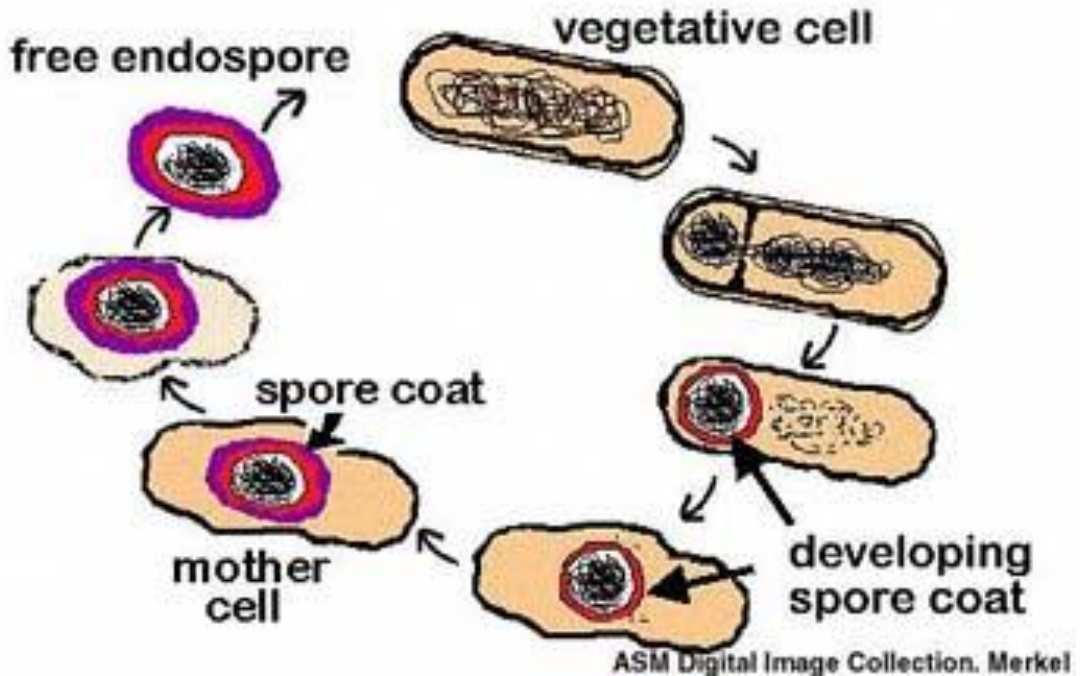
Reproduction

- Under optimal conditions: Binary fission (asexual reproduction)



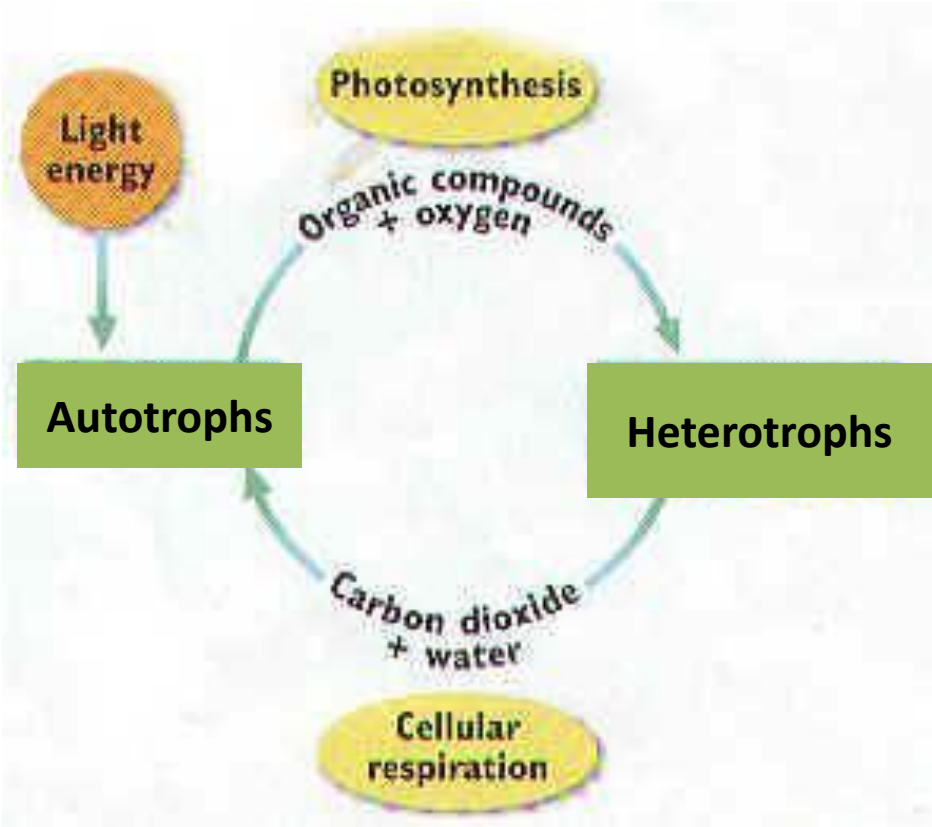
Reproduction

- Endospores: in stressful environment
  - only by some Gram + bacteria
  - lie dormant for extended periods, even centuries
  - can reactivate itself

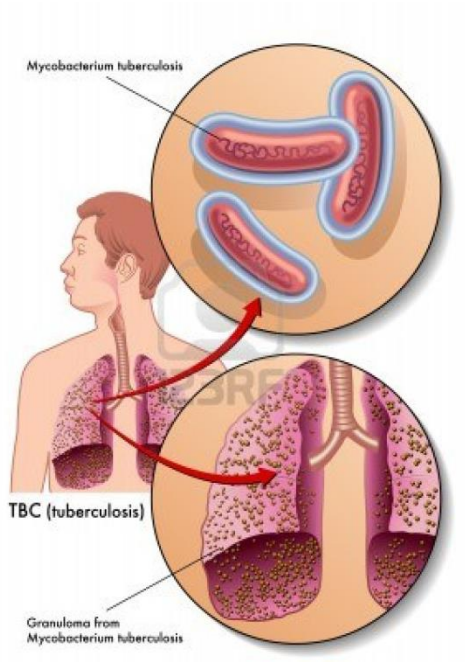


Lifestyle of bacteria

- autotrophs
  - energy from light or CO_2 (photosynthesis)
  - cyanobacteria
- heterotrophs
  - energy from organic carbon (e.g. glucose)
  - parasitic bacteria



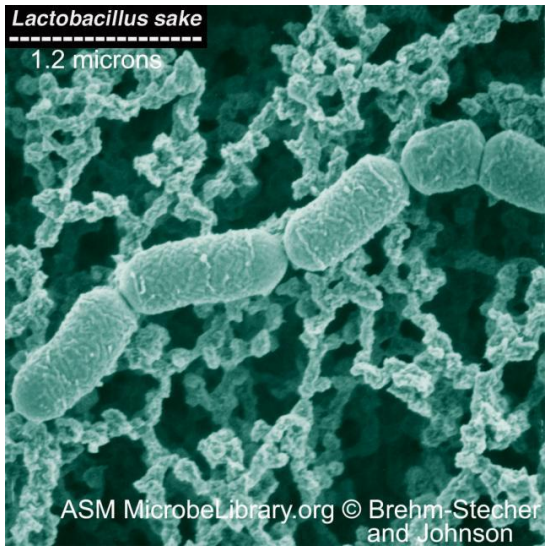
Pathogenic bacteria



- cause bacterial infection
- Tuberculosis
  - Mycobacterium tuberculosis
- Pneumonia
  - Streptococcus (50%), Legionella, Pseudomonas,…
- foodborne illnesses
  - Shigella, Campylobacter, E. coli, Salmonella,…
- Tetanus (Clostridium tetani)
- Syphilis (Treponema pallidum)
- Leprosy (Mycobacterium leprae)

The human flora

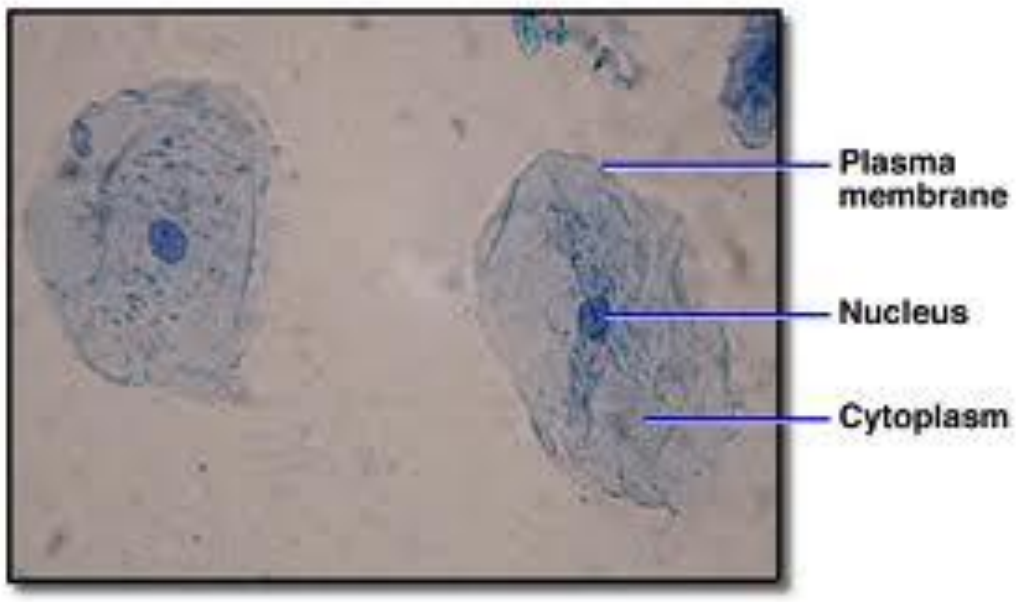
- harmless, protective function
- 1-3% of total body mass
- on and in the skin, nose, on the eye, and in the gastrointestinal tracts
- E. coli in the colon
- Lactobacillus in the vagina
- Actinomyces cause plaque in the mouth → tartar



EUKARYOTIC CELLS

Origin

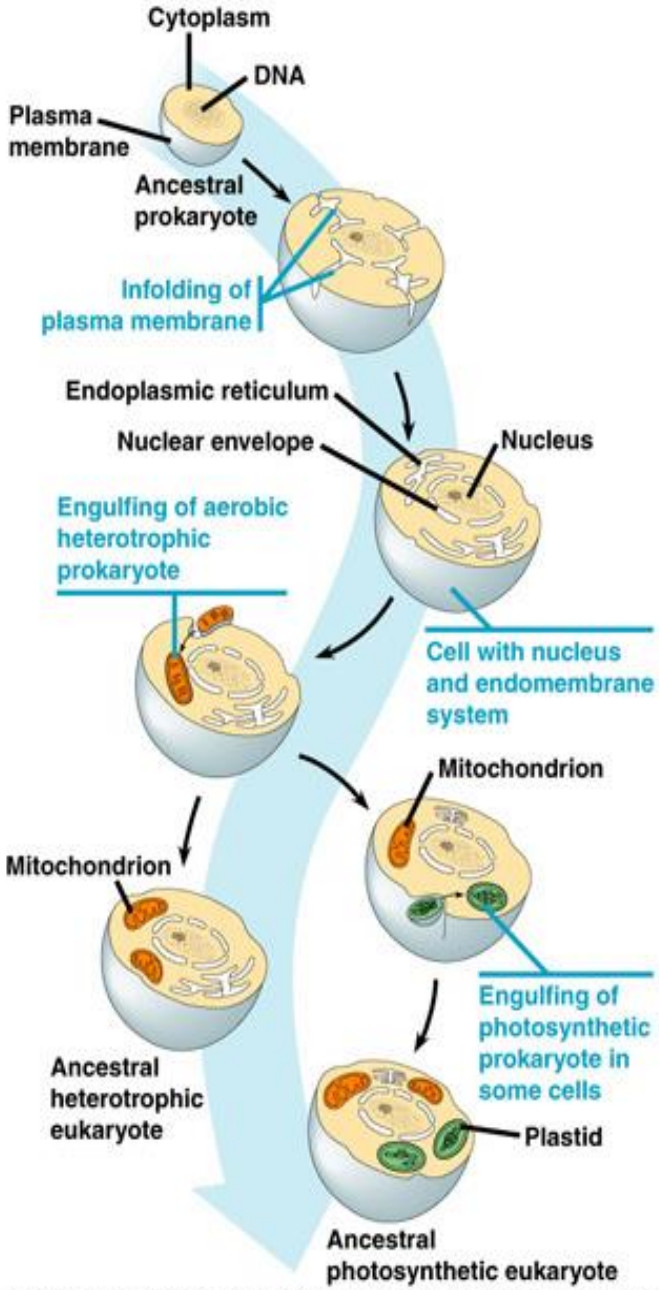
- Greek: eu = good" and karyon = "nut or kernel”
- developed approximately 1.6–2.1 billion years ago
- 10-100 µm in diameter
- Endosymbiosis theory



Endosymbiotic theory

- describes the development of eukaryotic cells
- Greek: endon = within, syn = together and biosis = living
- Konstantin Mereschkowski (1910)
- several cell organelles of eukaryotes originate from unicellular organisms

1. infolding of cell membrane → „compartments”
2. engulfing of prokaryotes → mitochondrion, plastids



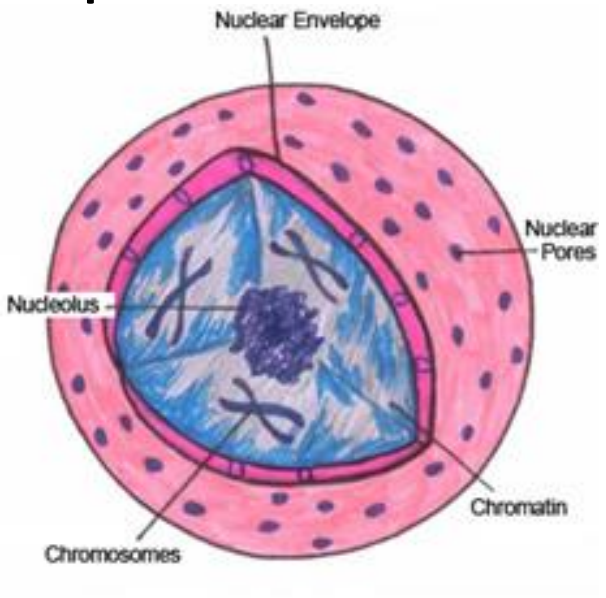
Evidences

- formation of new mitochondria and plastids through binary fission
- both mitochondria and plastids contain single circular DNA that is similar to that of bacteria (most of their genes are transferred to the host cell genome)
- ribosomes are like those found in bacteria
- comparison of the genome
- …

Structure of eukaryotic cells

<u>Nucleus and the DNA:</u>

- nuclear envelope
- DNA: linear, double stranded, mostly non-coding → forms chromatin with proteins
- nucleolus (synthesis of ribosomes)
- site of transcription

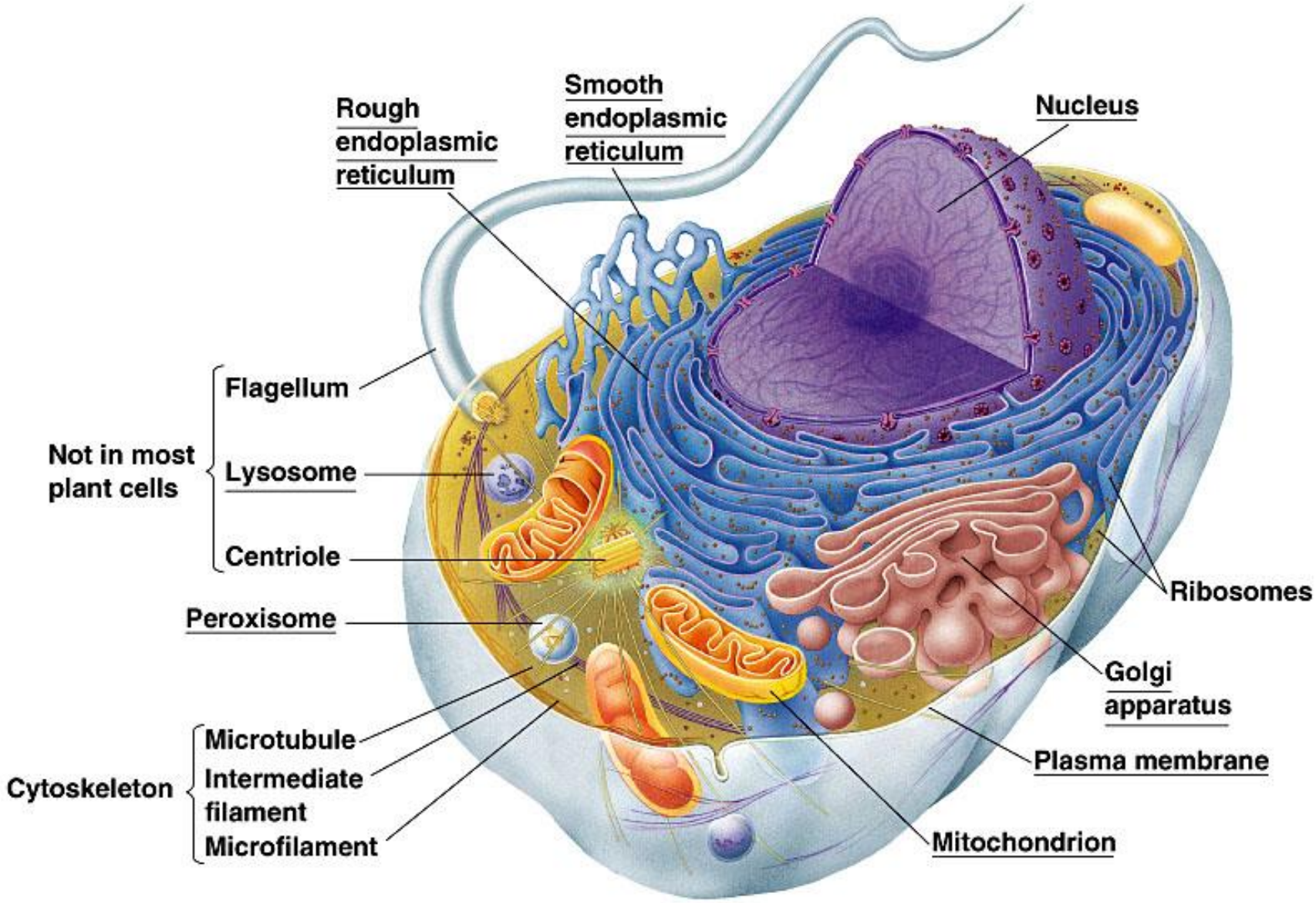


Cell Nucleus Diagram

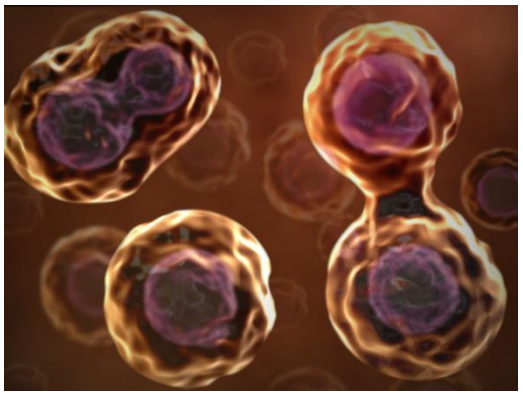
Structure of eukaryotic cells

Cytoplasm

- rough endoplasmic reticulum (synthesis of some proteins)
- smooth endoplasmic reticulum (synthesis of lipids, biotransformation)
- Golgi apparatus (maturation and sorting of proteins)
- mitochondrion (ATP synthesis)
- chloroplast (photosythesis)
- lysosome (intracellular digestion)
- ribosome (protein synthesis = translation)
- cytoskeleton (microfil., microtubules, intermediate fil.)



Structure of eukaryotic cells

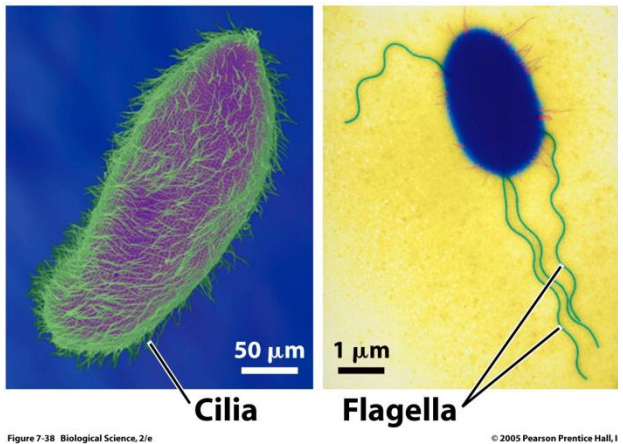


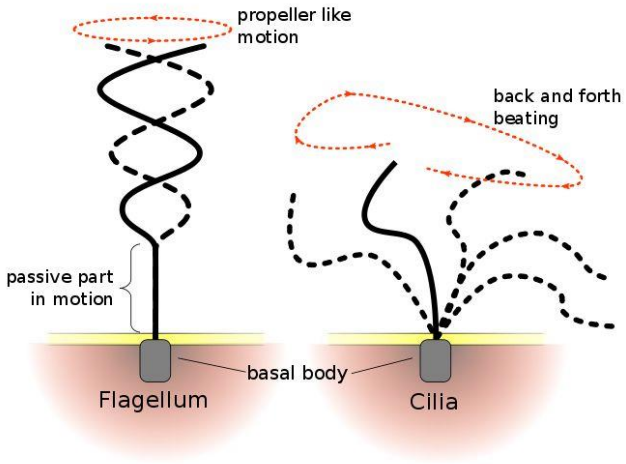
Division:

- mitosis: somatic cells
- meiosis: gametes

Movement

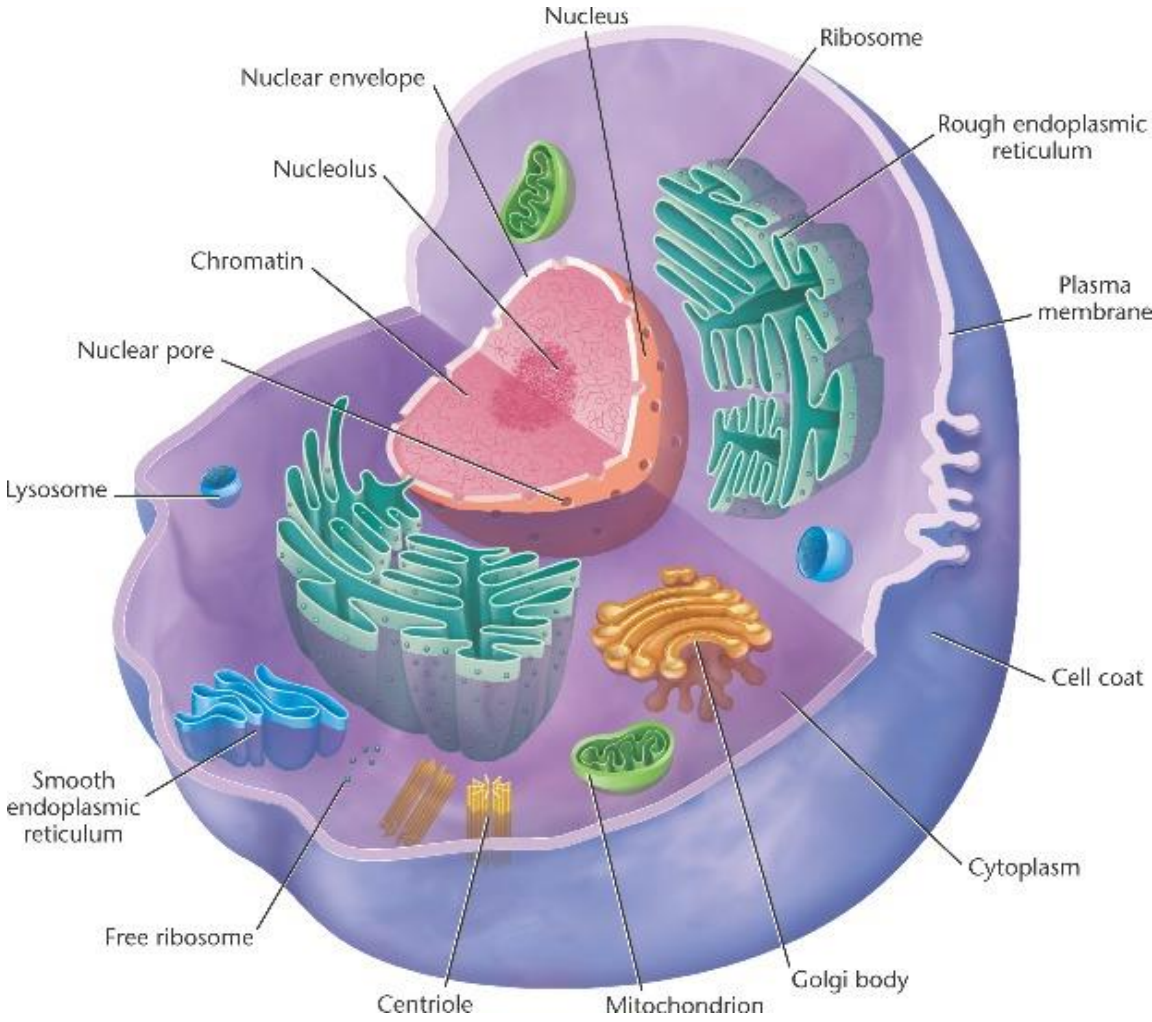
- flagella and cilia: movement, feeding, and sensation





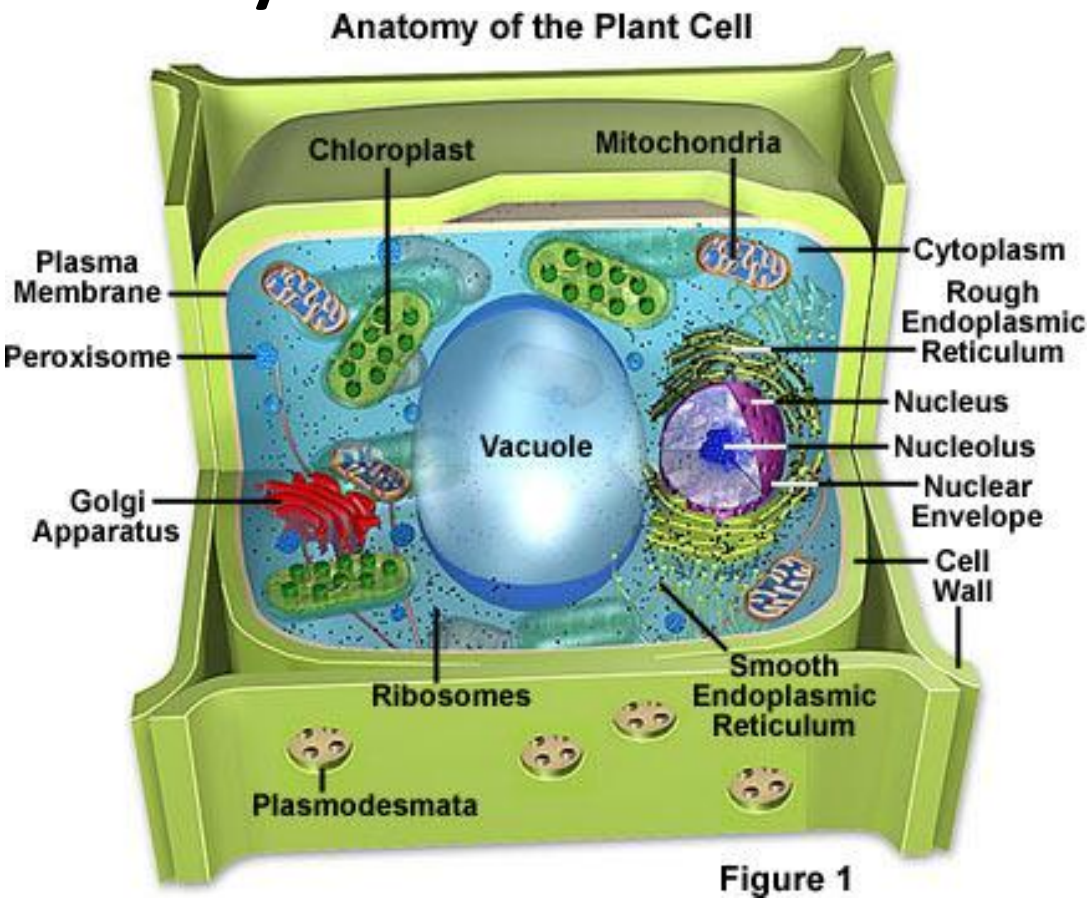
Types of eukaryotic cells

- Animal cells
  - no chloroplasts
  - no cell wall



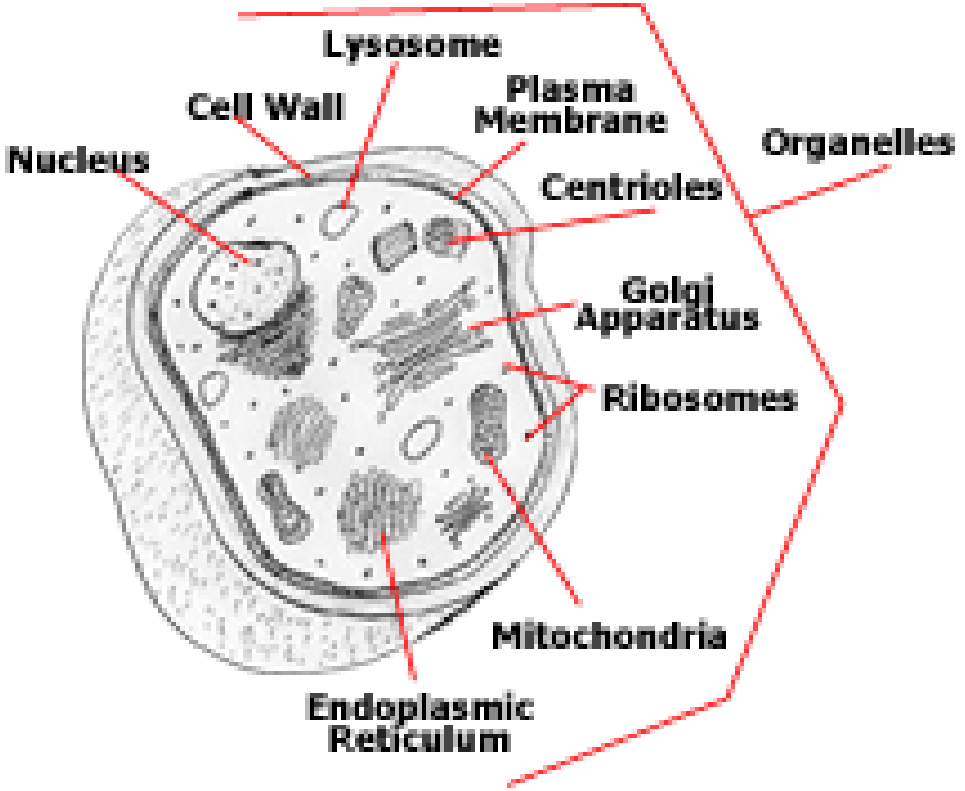
Types of eukaryotic cells

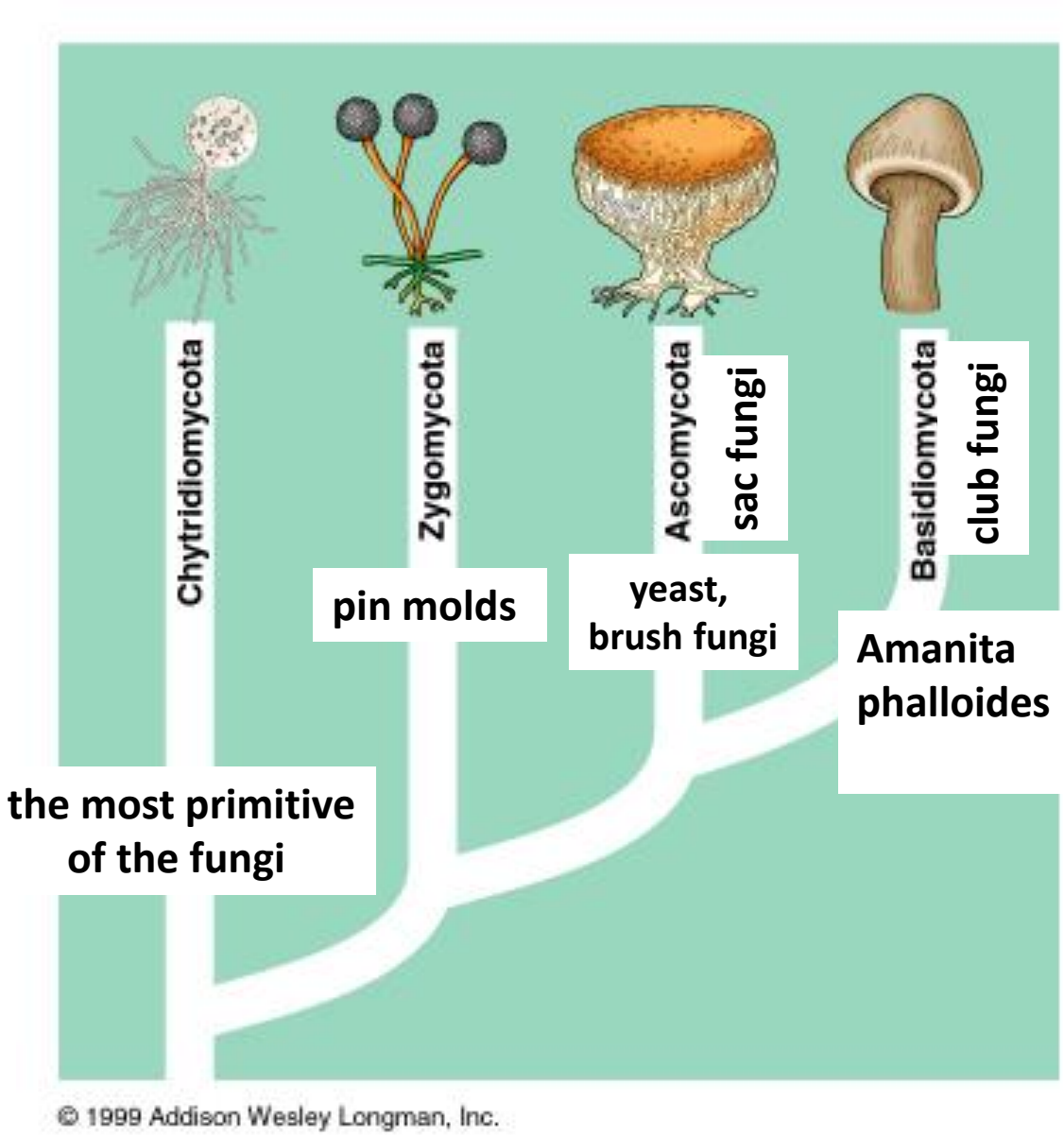
- Plant cells
  - chloroplast (photosythesis)
  - vacuoles (pressure)
  - cell wall (cellulose)
  - plasmodesmata (communication)

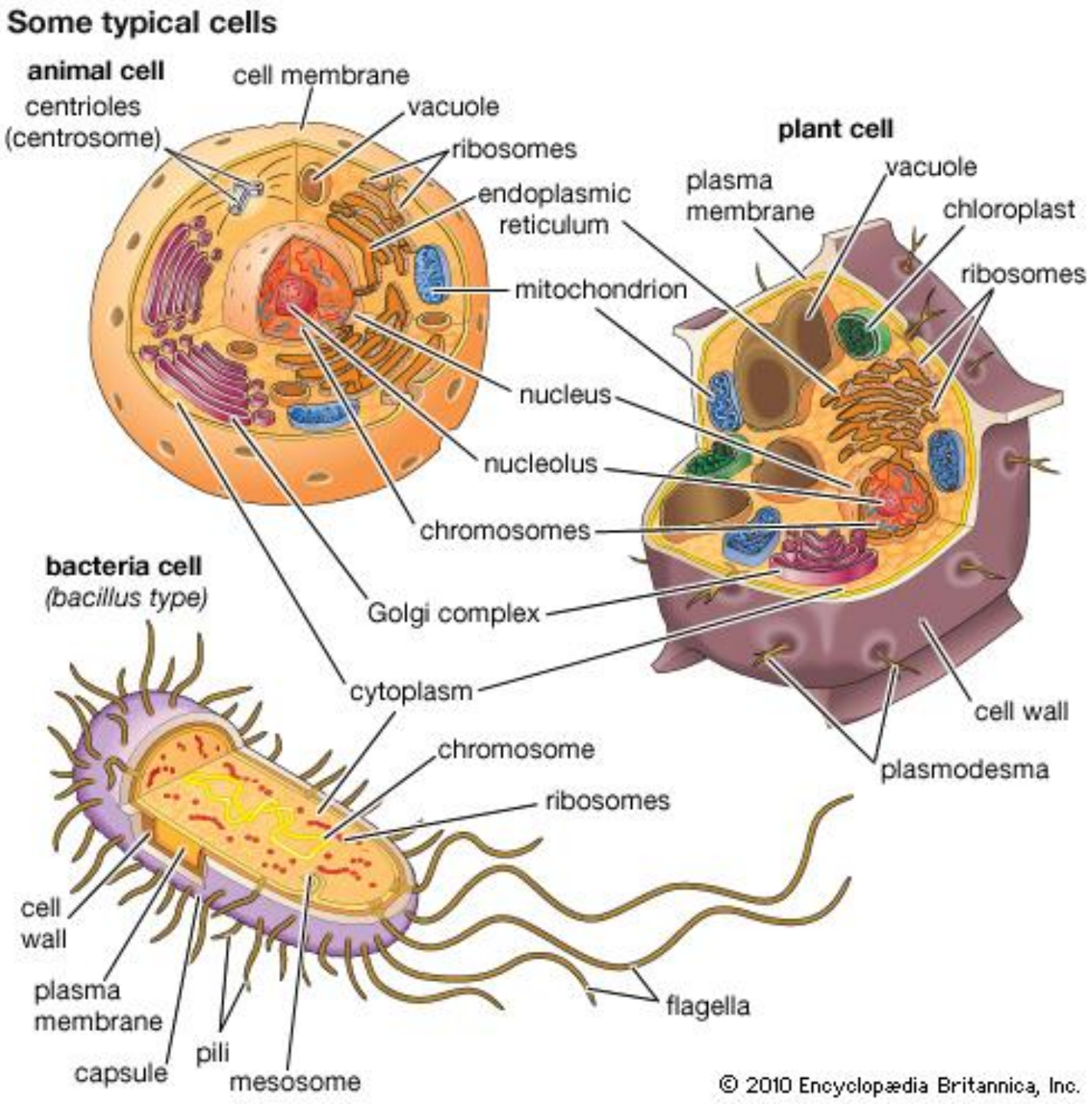


Types of eukaryotic cells

- Fungal cells
  - similar to animal cells but they have a cell wall (chitin)




Chytridiomycota
Zygomycota
Ascomycota
sac fungi
Basidiomycota
club fungi
pin molds
yeast,
brush fungi
Amanita
phalloides
the most primitive
of the fungi
© 1999 Addison Wesley Longman, Inc.


Some typical cells
animal cell
cell membrane
centrioles
(centrosome)
vacuole
ribosomes
endoplasmic
reticulum
mitochondrion
nucleus
nucleolus
chromosomes
Golgi complex
cytoplasm
plant cell
plasma
membrane
vacuole
chloroplast
ribosomes
cell wall
plasmodesma
bacteria cell
(bacillus type)
chromosome
ribosomes
cell
wall
plasma
membrane
capsule
pili
mesosome
flagella
© 2010 Encyclopædia Britannica, Inc.