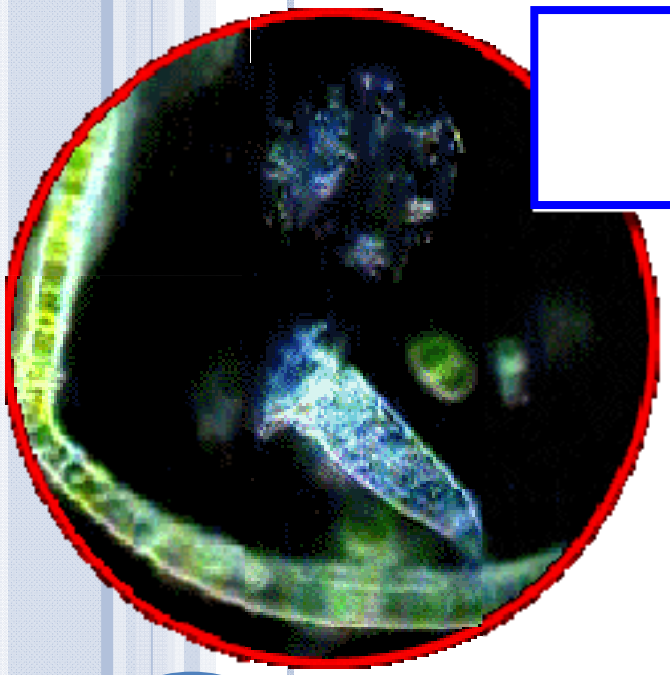


Cells

PART I: The Basic ideas of Cells

PART II: The Methods to observe Cells

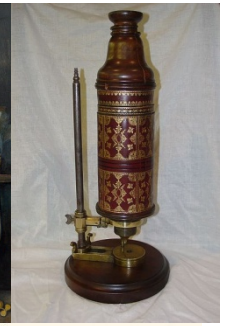
Chia-Fen Hsieh

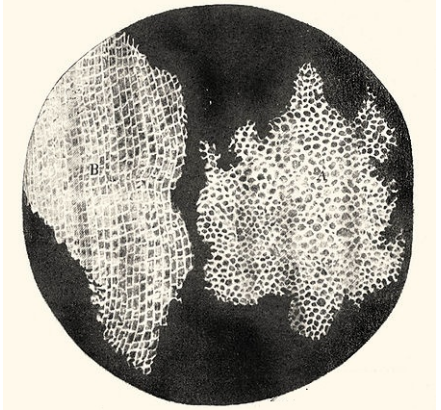
Cell (Biology)

- It comes from the Latin *cellula* (a small room)

- It was coined by Robert Hooke

  . . . I could exceedingly plainly perceive it to be all perforated and porous, much like a Honey-comb, but that the pores of it were not regular. . . these pores, or cells, . . . were indeed the first microscopical pores I ever saw
  (Micrographia, 1665)



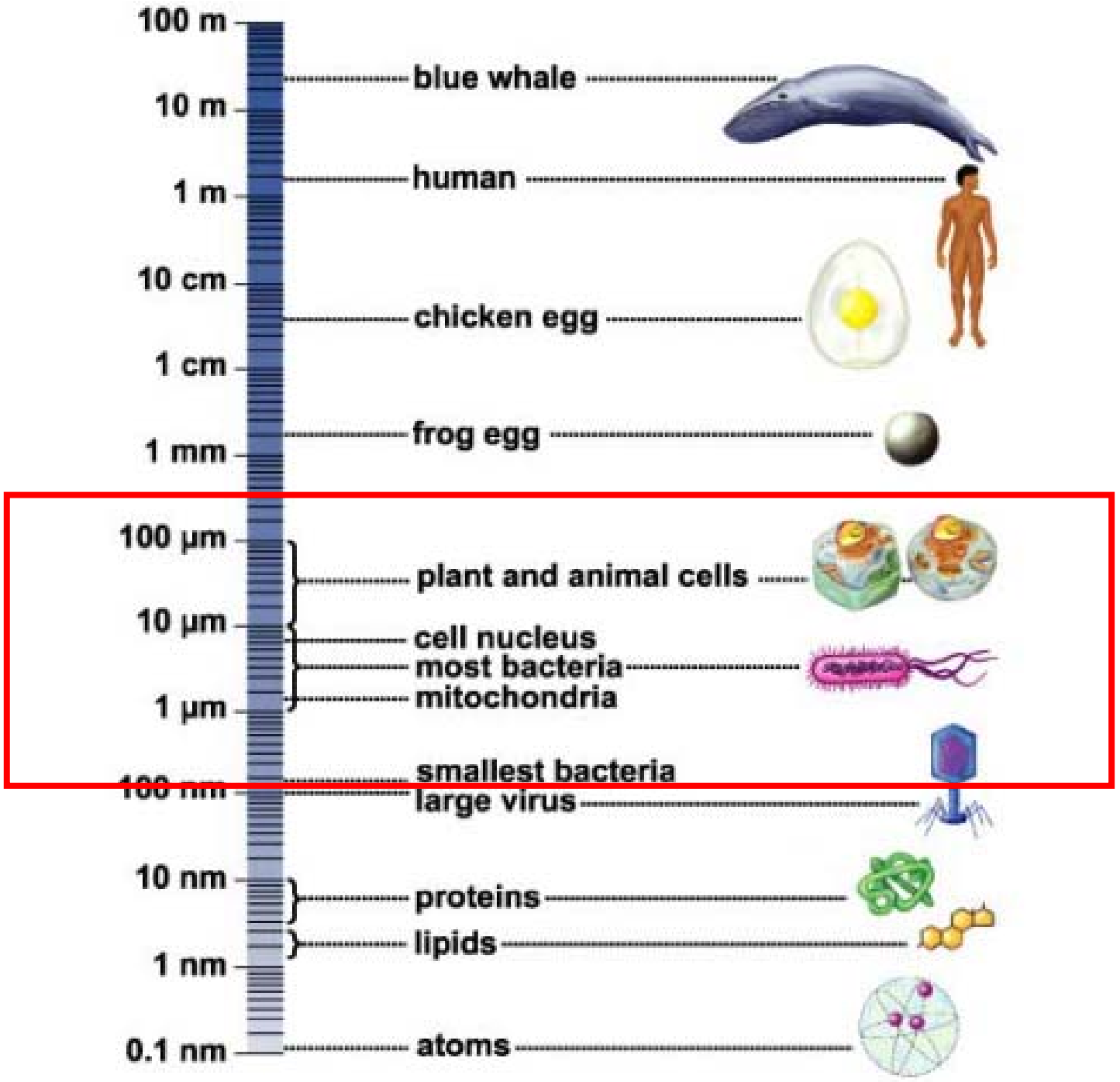


- It is the fundamental unit of life

What is the size of a cell?

plant and animal cells .....  ? ?

cell nucleus
most bacteria .....  ? ?
mitochondria

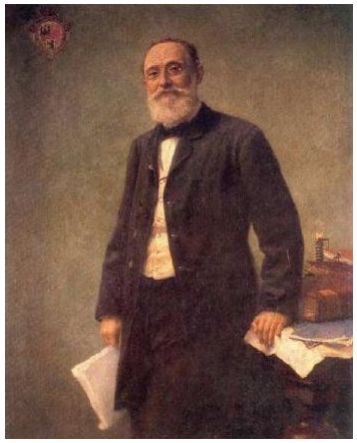

100 m
10 m
1 m
10 cm
1 cm
1 mm
100 µm
10 µm
1 µm
100 nm
10 nm
1 nm
0.1 nm
blue whale
human
chicken egg
frog egg
plant and animal cells
cell nucleus
most bacteria
mitochondria
smallest bacteria
large virus
proteins
lipids
atoms

Cell theory (1839-1858)

- Theodor Schwann, Matthias Jakob Schleiden, Rudolf Virchow

1810-1882

1804-1881



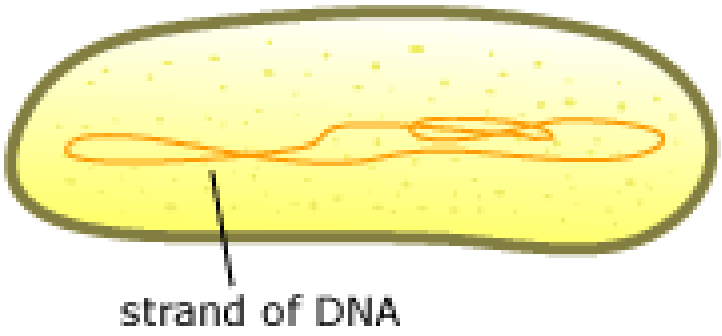
1821-1902

- Modern interpretation of cell theory:
  - All cells come from pre-existing cells by division
  - Energy flow (metabolism and biochemistry) occurs within cells
  - Cells contain hereditary information (DNA) which is passed from cell to cell during cell division

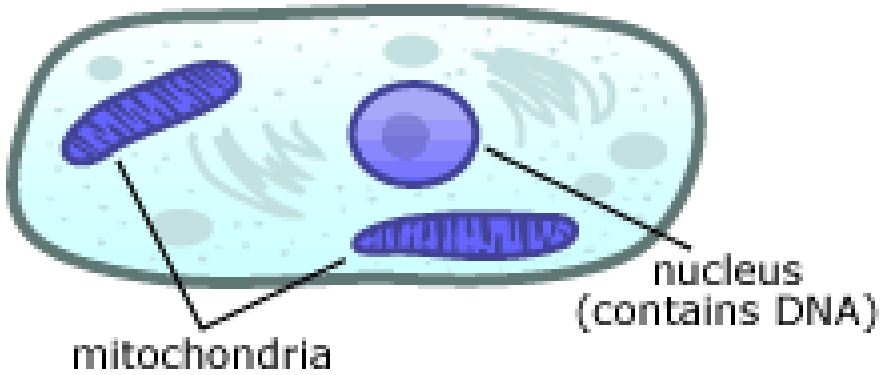
Prokaryotes vs. Eukaryotes

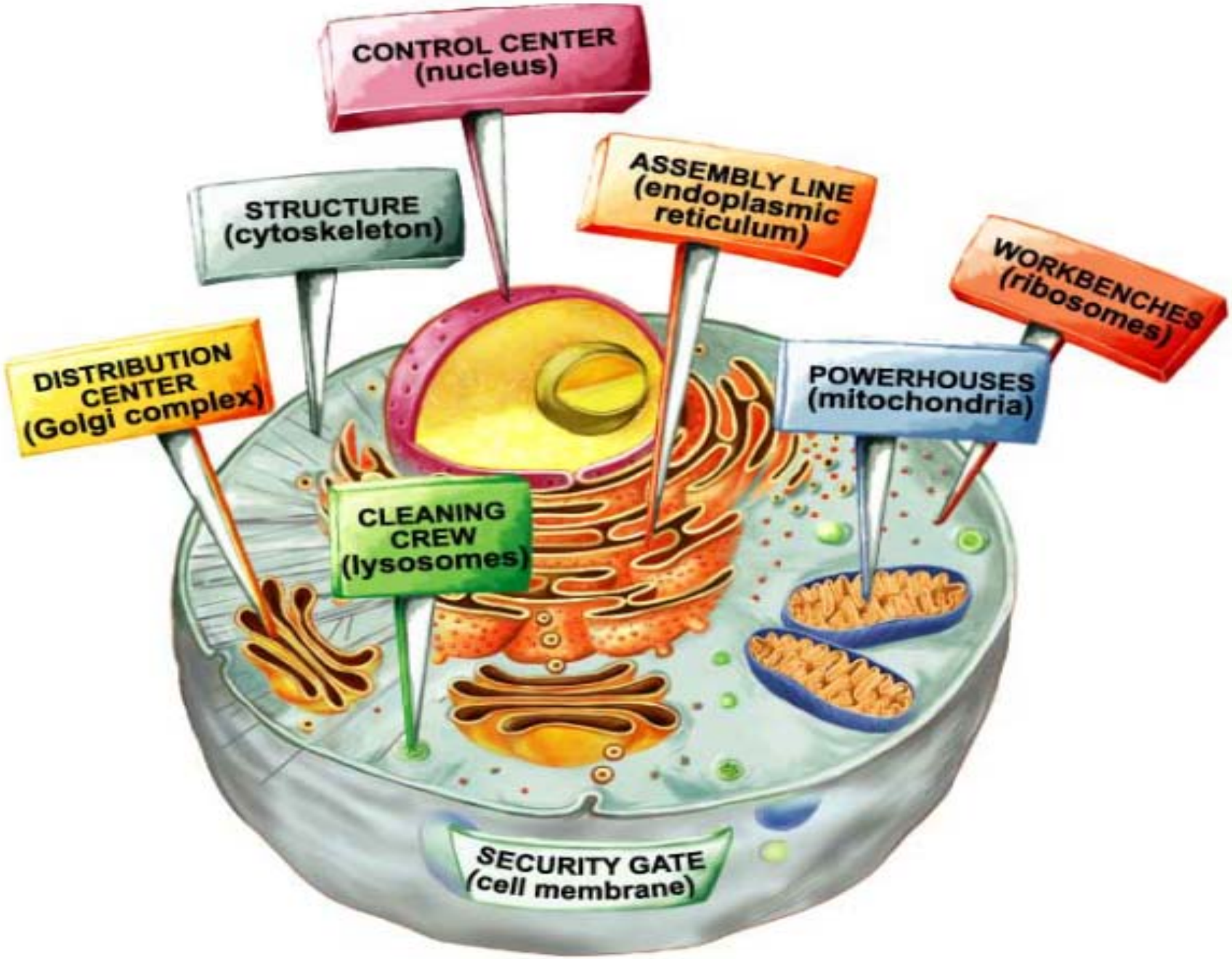
Greek derivation	“before the nucleus”	“true nucleus”
They usually are…	Single-celled organisms	Single-celled organisms or Multi-celled organisms
Including…	Bacteria and Archaea	Yeasts, animals, plants
Size	1-3 μm	10-100 μm

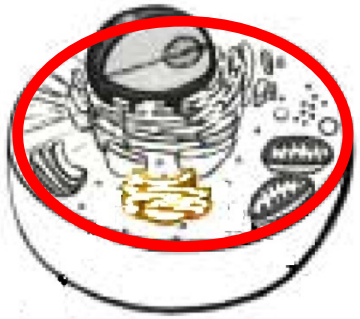
Typical prokaryote cell



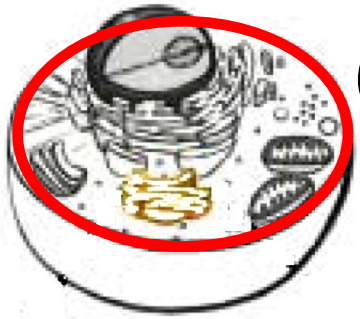
Typical eukaryote cell



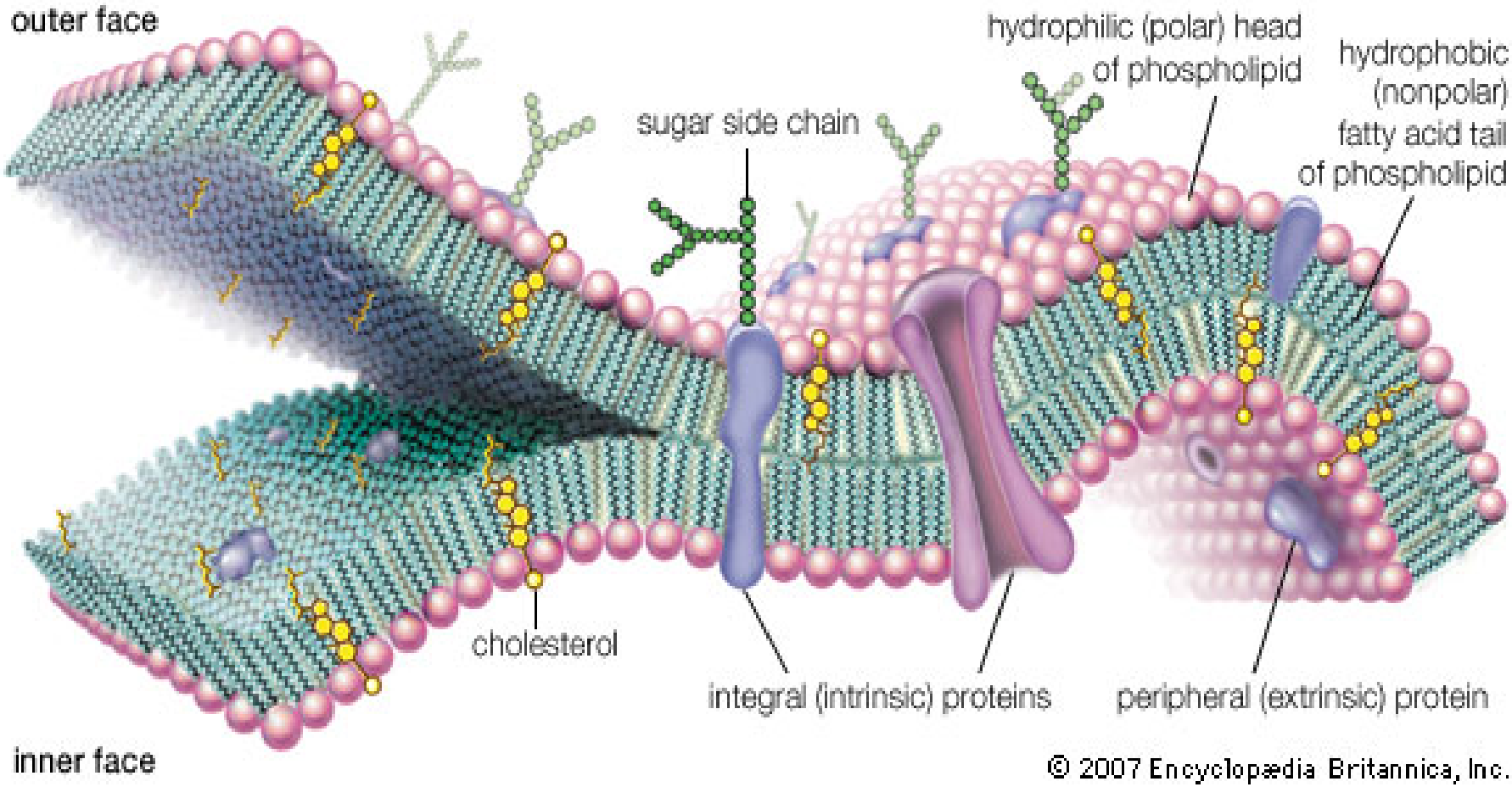

CONTROL CENTER (nucleus)
STRUCTURE (cytoskeleton)
ASSEMBLY LINE (endoplasmic reticulum)
WORKBENCHES (ribosomes)
DISTRIBUTION CENTER (Golgi complex)
POWERHOUSES (mitochondria)
CLEANING CREW (lysosomes)
SECURITY GATE (cell membrane)

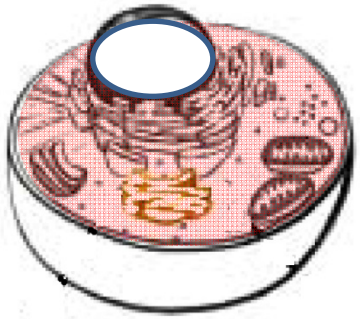


Cell membrane (Security Gate)

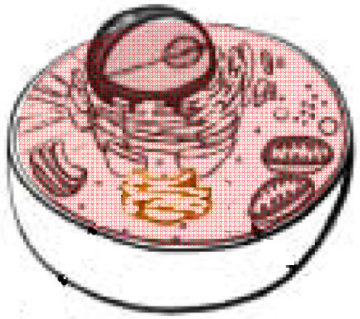


Cell membrane (Security Gate)





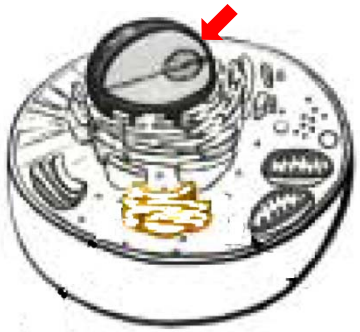
(Cytoplasm vs. Cytosol)



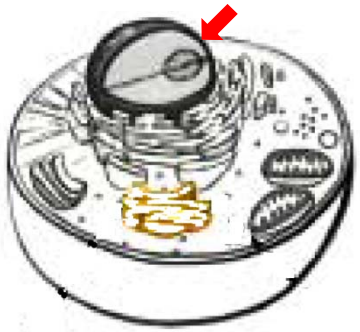
(Cytoplasm vs. Cytosol)

- Cytoplasm is the part of cell that is enclosed within the plasma membrane (except nucleus)

- Cytosol is the part of cytoplasm that is not held within organelles
  - A complex mixture of cytoskeleton filaments, dissolved molecules, and water that fills much of the volume of a cell



Nucleus (Control center)



Nucleus (Control center)

Double-layered

Nucleolus

Nuclear Envelope

rRNA → ribosomes

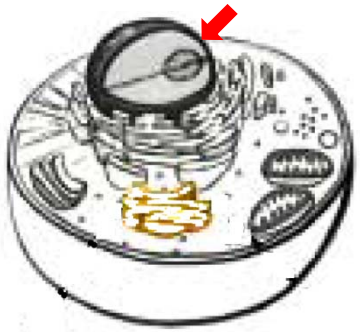
Nuclear Pores

DNA

DNA + Proteins

Chromosomes

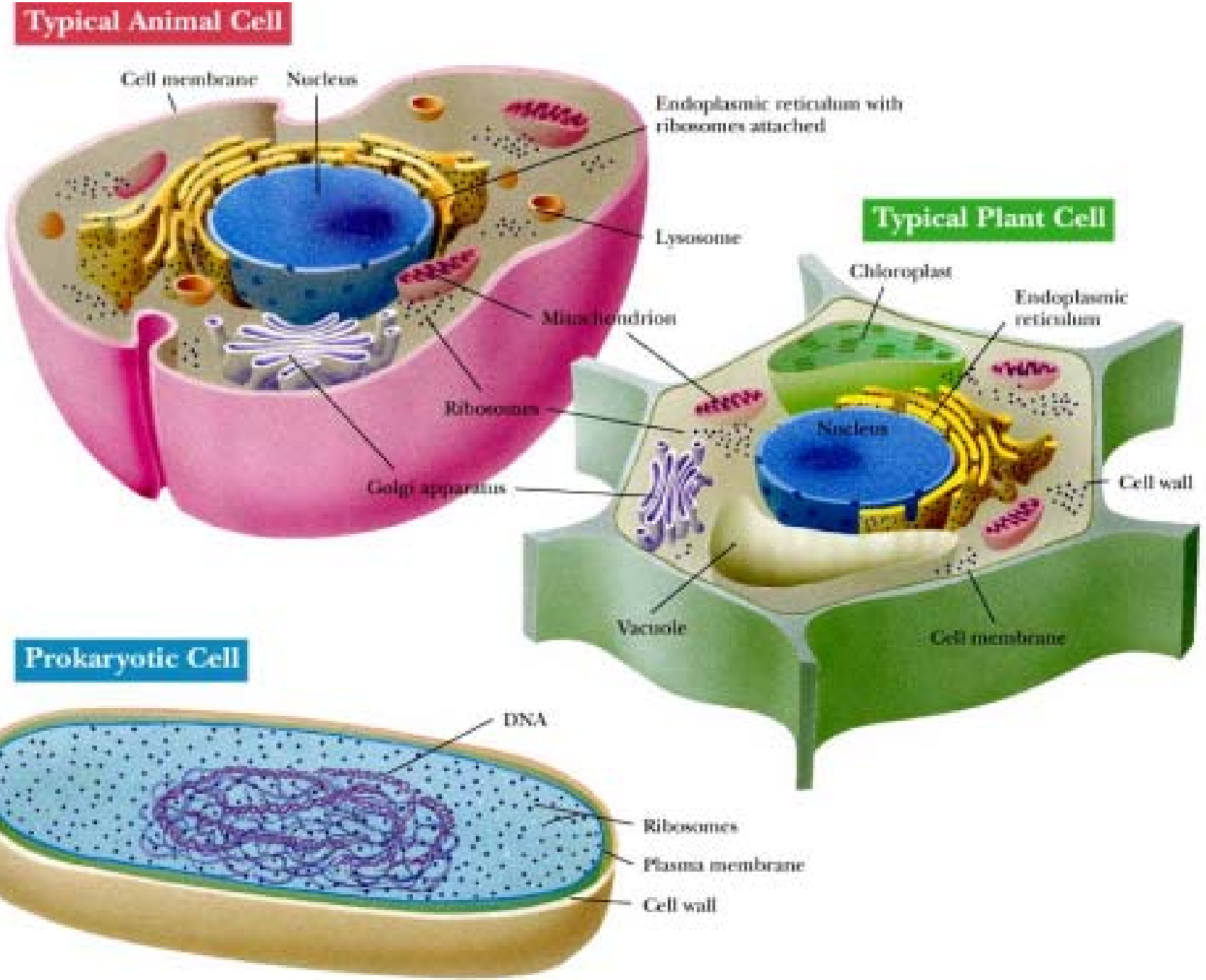
Chromatin

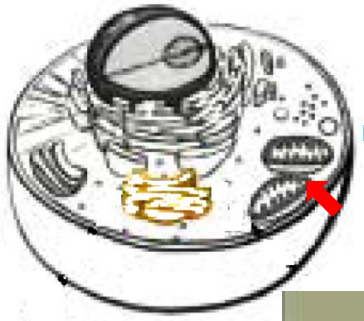


Nucleus (Control center)

- Nucleus is the ultimate control center for cell activities

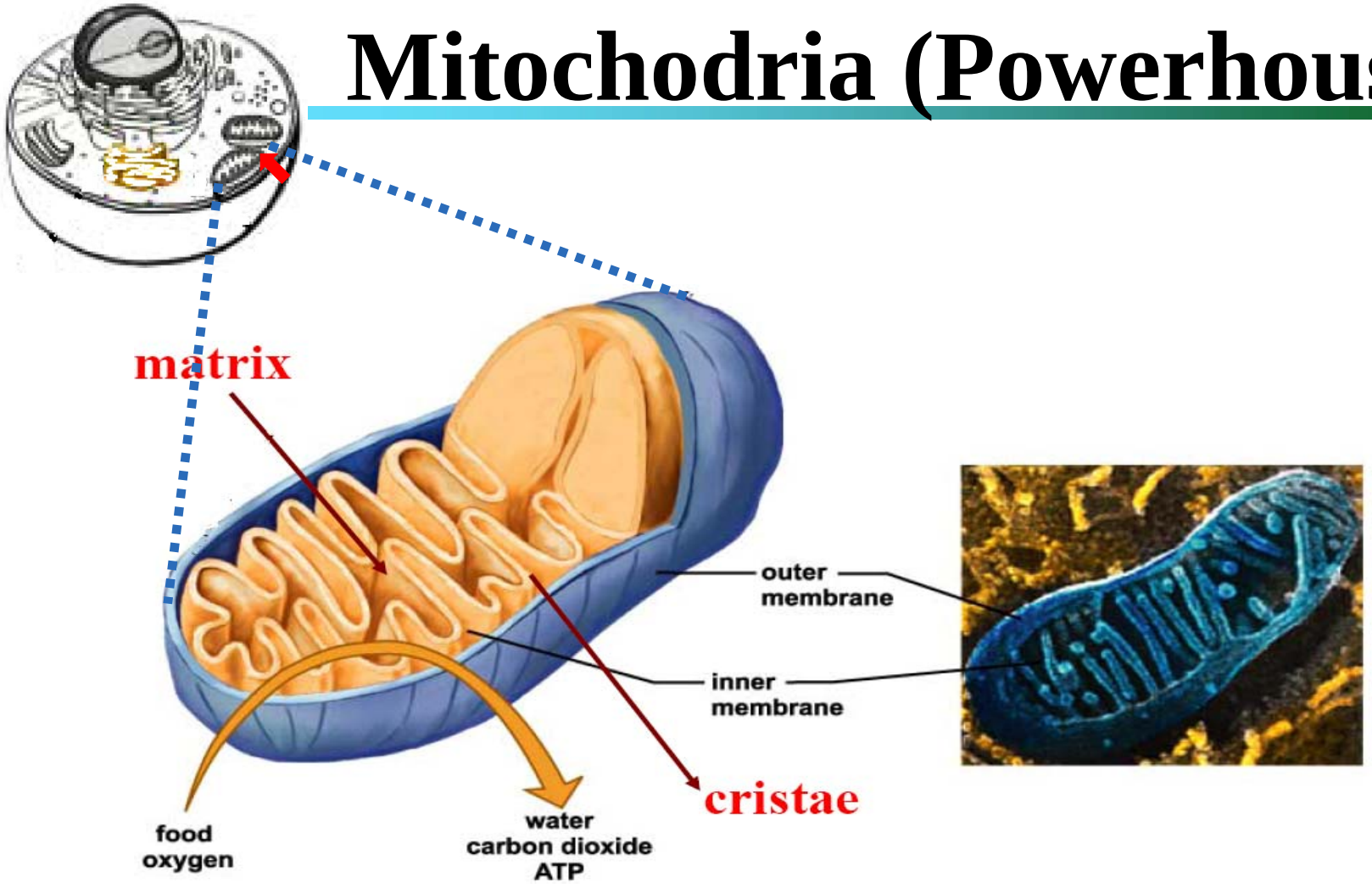
- A second major function of the nucleus involves duplication of the chromatin as a part of cell reproduction
  - When a cell is about to divide, the loosely organized strands of chromatin become tightly coiled, and the resulting chromosomes can be seen under a microscope


Typical Animal Cell
Cell membrane
Nucleus
Endoplasmic reticulum with ribosomes attached
Lysosome
Mitochondrion
Ribosomes
Golgi apparatus
Typical Plant Cell
Chloroplast
Endoplasmic reticulum
Nucleus
Cell wall
Vacuole
Cell membrane
Prokaryotic Cell
DNA
Ribosomes
Plasma membrane
Cell wall

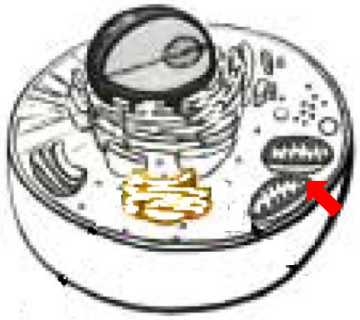


Mitochodria (Powerhouse)

Mitochodria (Powerhouse)



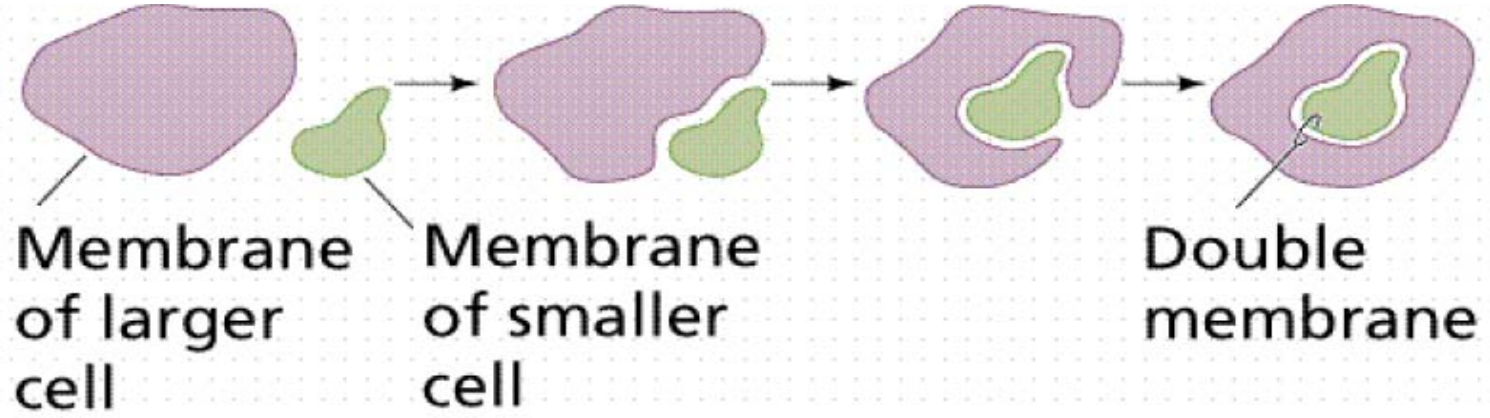
- Power plant of a cell
- Convert the energy contained in food into a useful molecular form of energy for the cell -- ATP



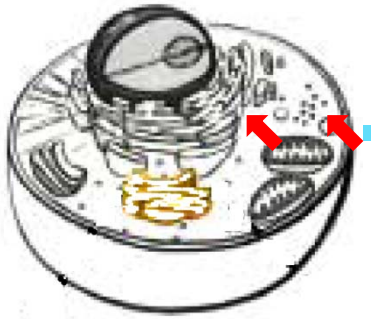
Mitochodria (Powerhouse)

- ~ 10-10,000 mitochondria in a cell

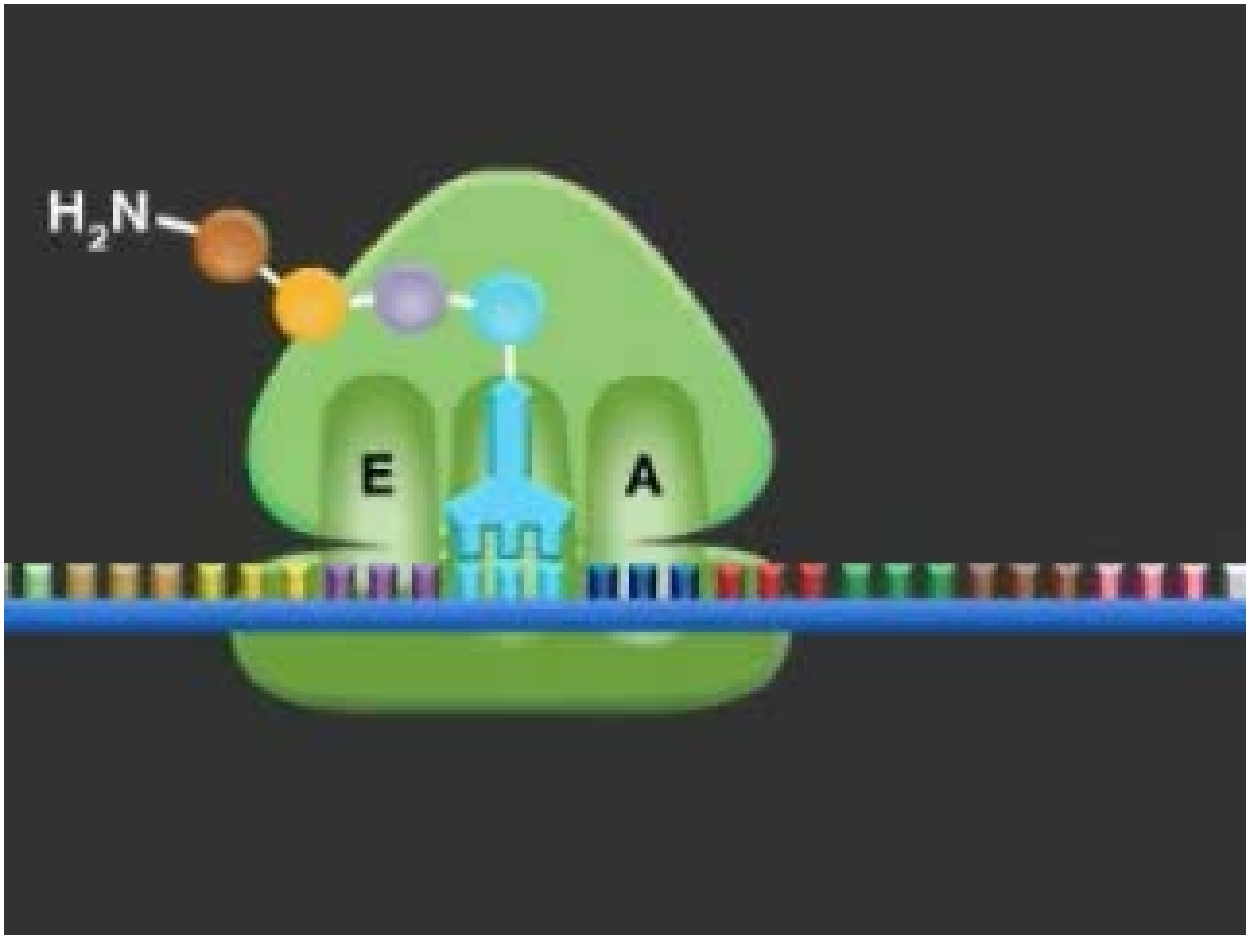
- Mitochondria may have arisen from the absorption of aerobic bacteria by larger host cells

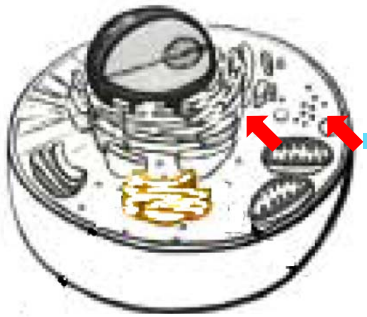


- Double membrane
- DNA and ribosomes
- 1 μm in diameter and 2-8 μm in length



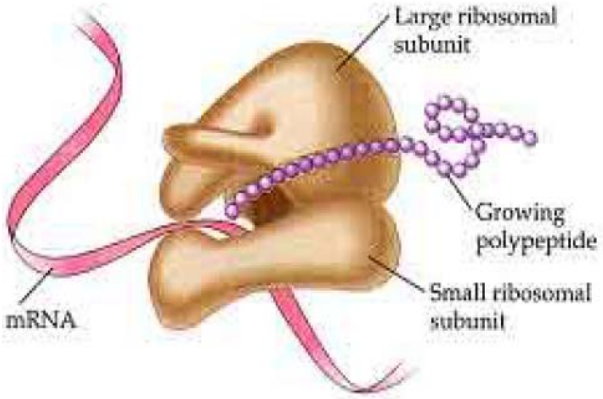
Ribosomes (Workbenches)

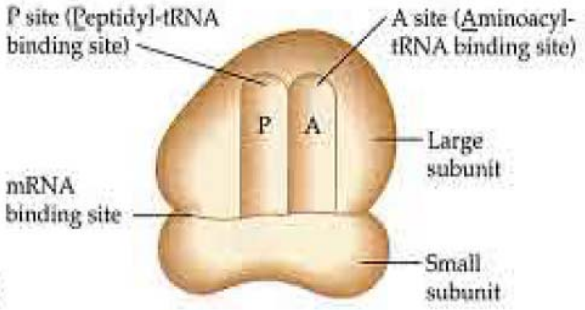


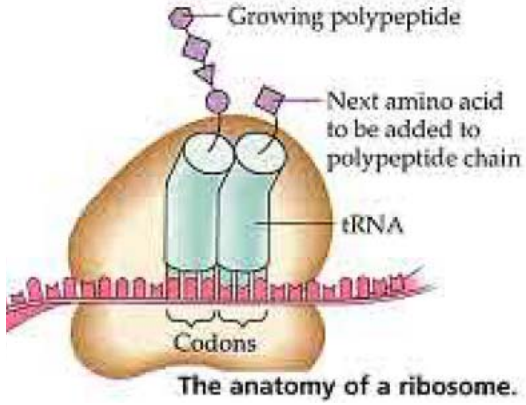


Ribosomes (Workbenches)

- Complexes of RNA and proteins (20 nm)

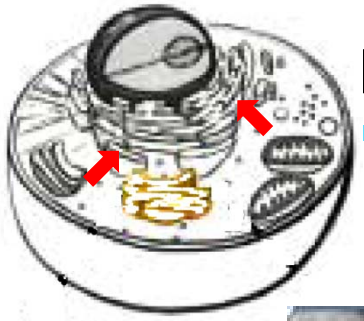




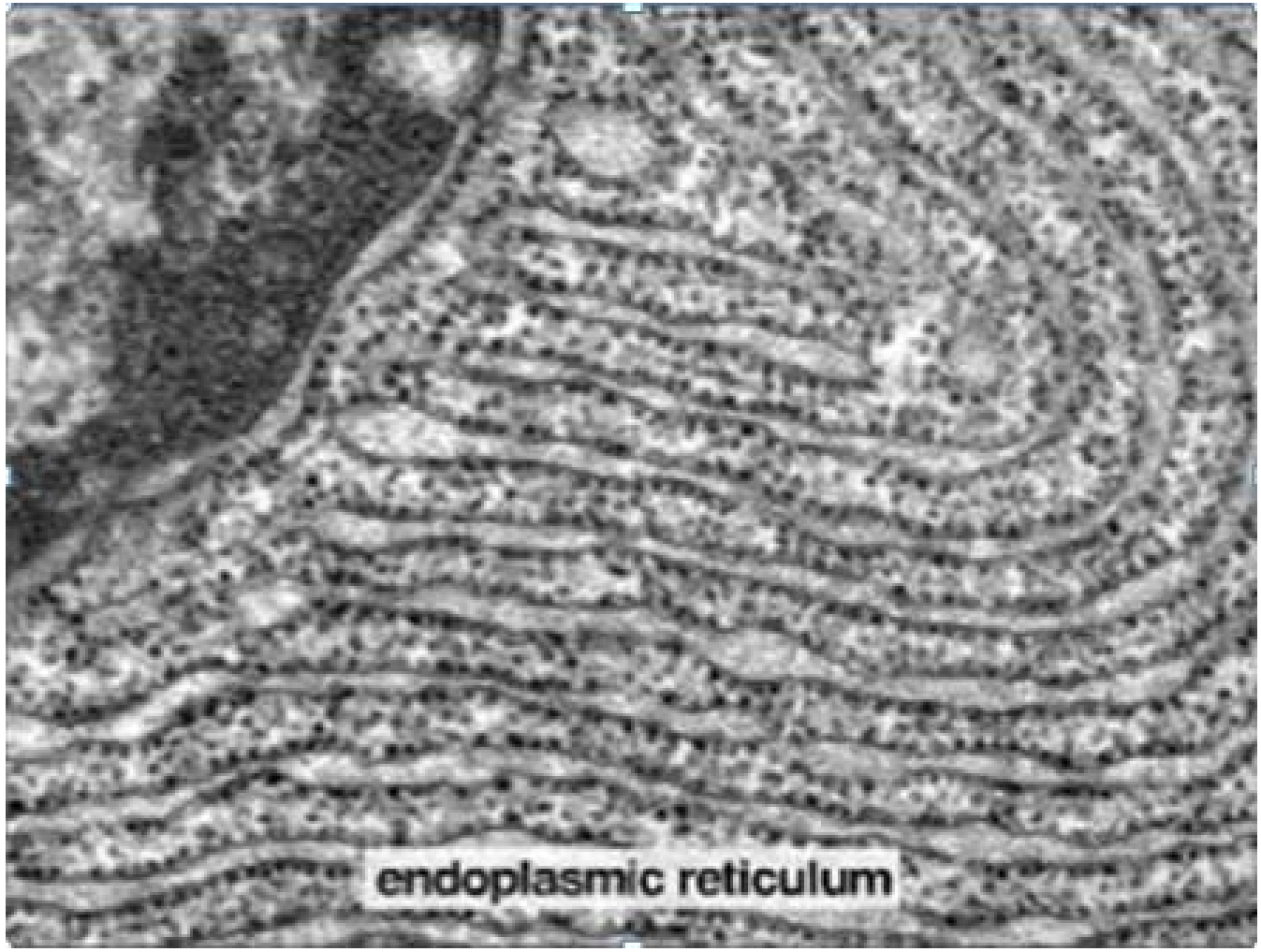


The anatomy of a ribosome.

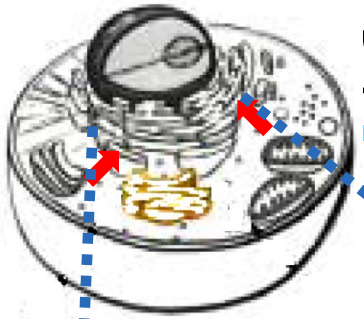
- The sites of protein synthesis from the genetic instructions held within mRNA
- Free ribosomes are suspended in the cytosol; others are bound to the rough endoplasmic reticulum (rough-ER)

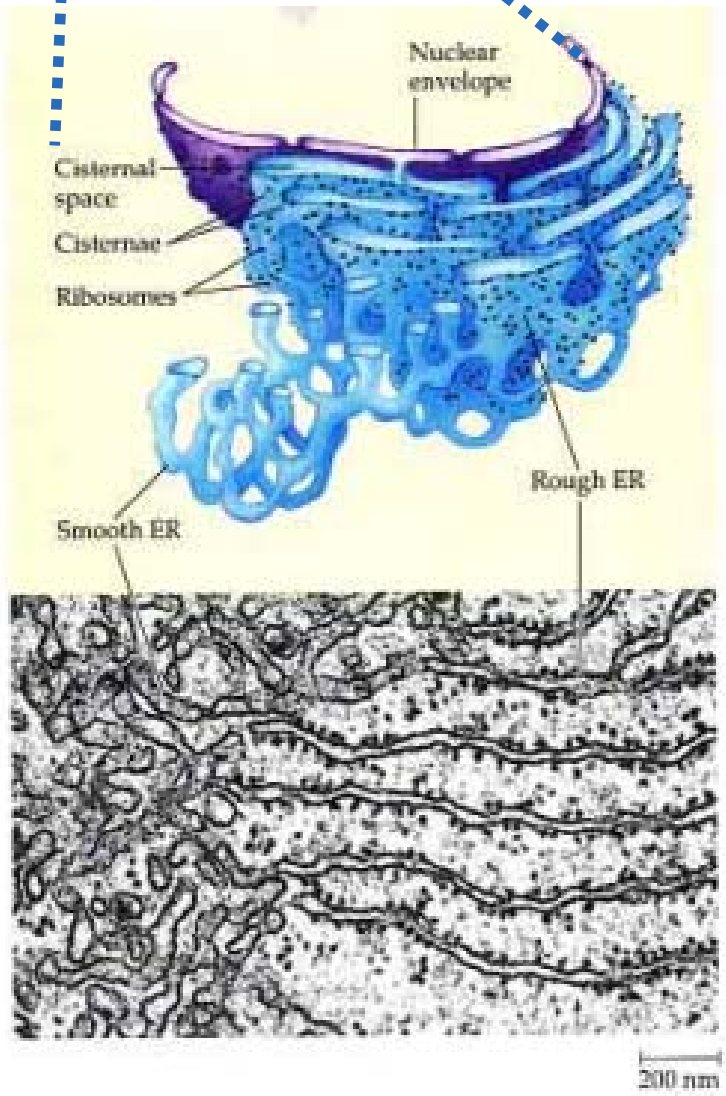


ndoplasmic reticulum (Assembly line)



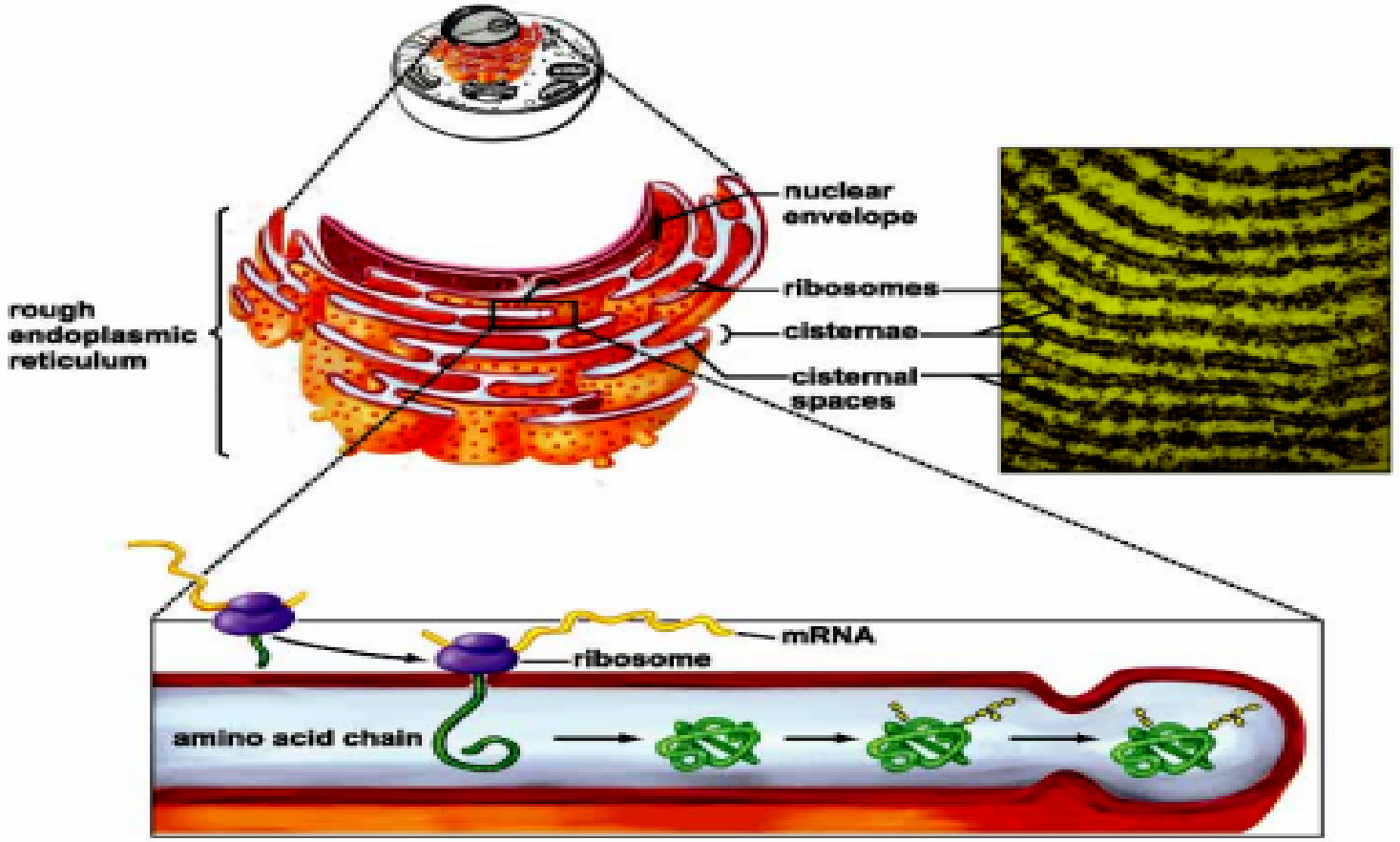
Endoplasmic reticulum (Assembly line



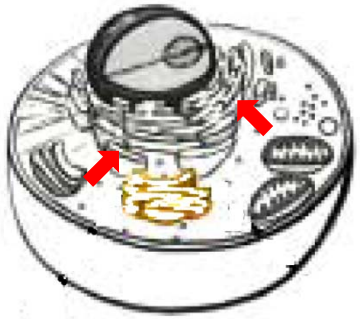


- Part of a continuous single-membrane system throughout the cell
- Two forms:
  - Rough ER – ribosomes bound to the membrane
  - Smooth ER – no ribosomes

Endoplasmic reticulum (Assembly line)



- When chain elongation resumes, polypeptide chains such as this one drop into the cisternal space of the rough ER. There they will fold up into their protein shape and undergo processing



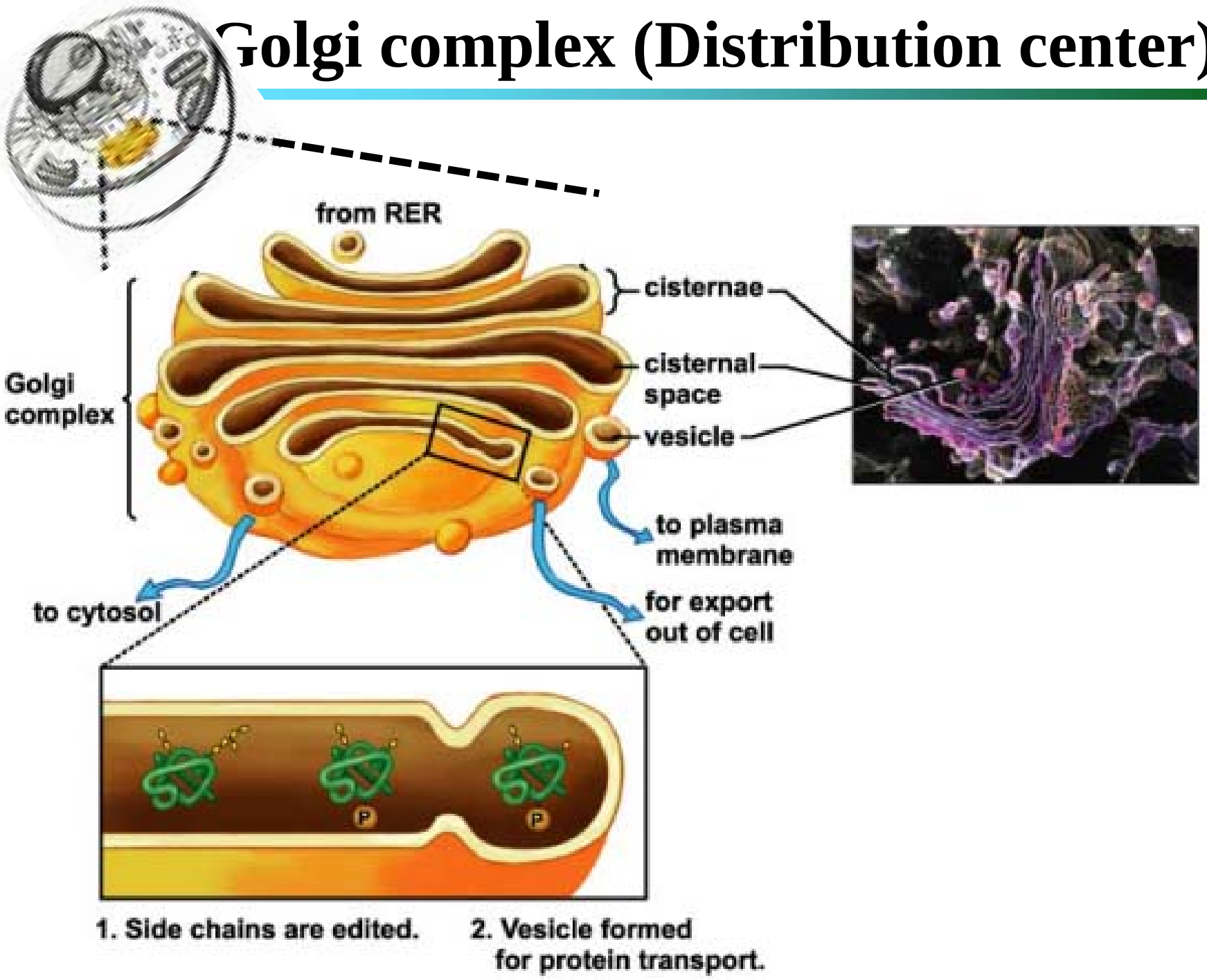
Endoplasmic reticulum (Assembly line

- The basic function of ER is transport
  - Proteins produced by the ribosomes are transported:
    - To regions of the cell where they are need
    - To the Golgi body for export from the cell

- Smooth ER is associated with regions of the cytoplasm involved in detoxification of poisons and lipid synthesis → liver cells

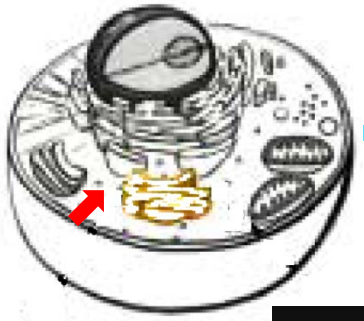
R → Golgi → Protein trafficking & modificatio

Golgi complex (Distribution center)



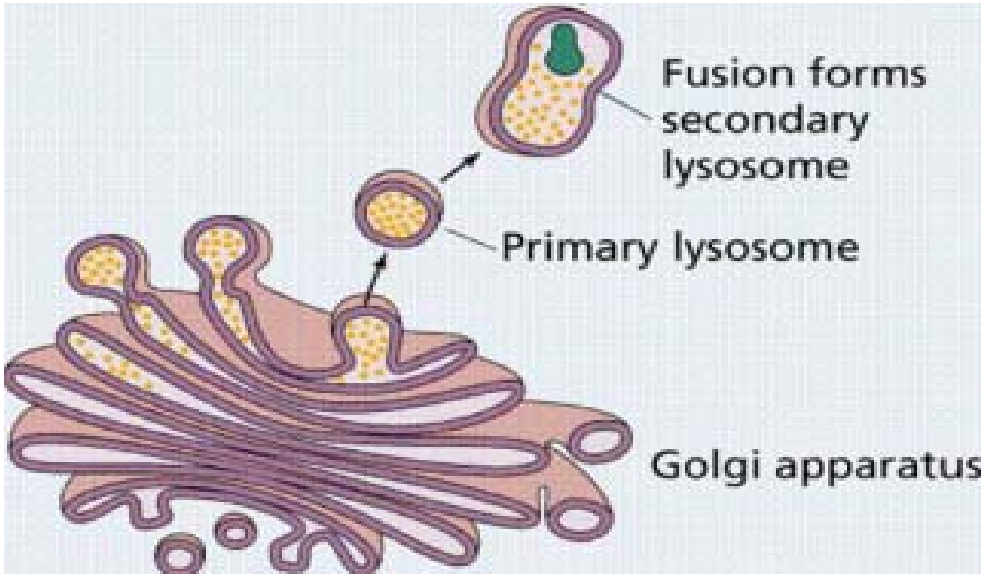
Golgi complex (Distribution center)

- Transport vesicles from the rough ER move to the Golgi complex, where they unload their protein contents by fusion with the Golgi membrane
  - A series of membranous sacs
- It is involved in secretion of proteins from the cells; sugar-linkage



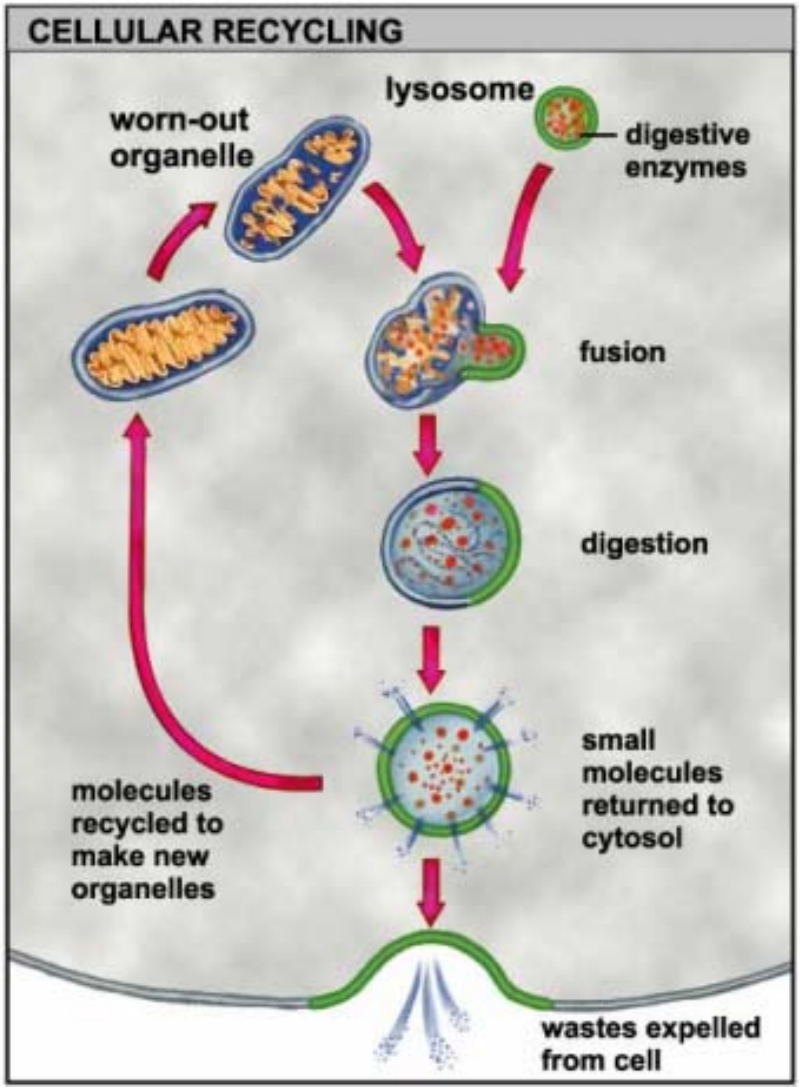
Lysosomes (Cleaning Crew)

Lysosomes (Cleaning Crew)

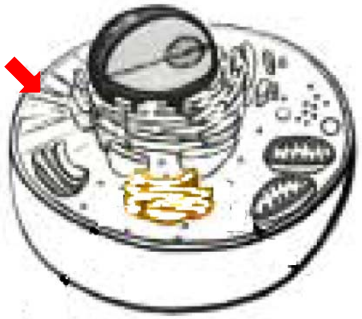


- Lysosomes fuse with vacuoles and dispense their enzymes into the vacuoles, digesting their contents
- The membrane surrounding a lysosome allows the digestive enzymes to work at pH 4.5 they require

Lysosomes (Cleaning Crew)



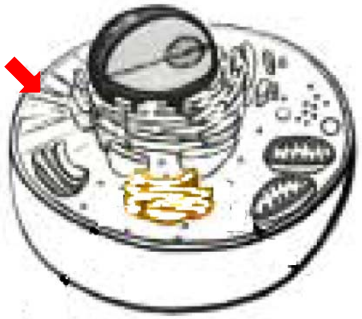
- Membrane-enclosed sacs containing hydrolytic enzymes that break down the target molecules, usually from outside sources
- They digest excess or worn-out organelles, food particles, and engulfed viruses or bacteria



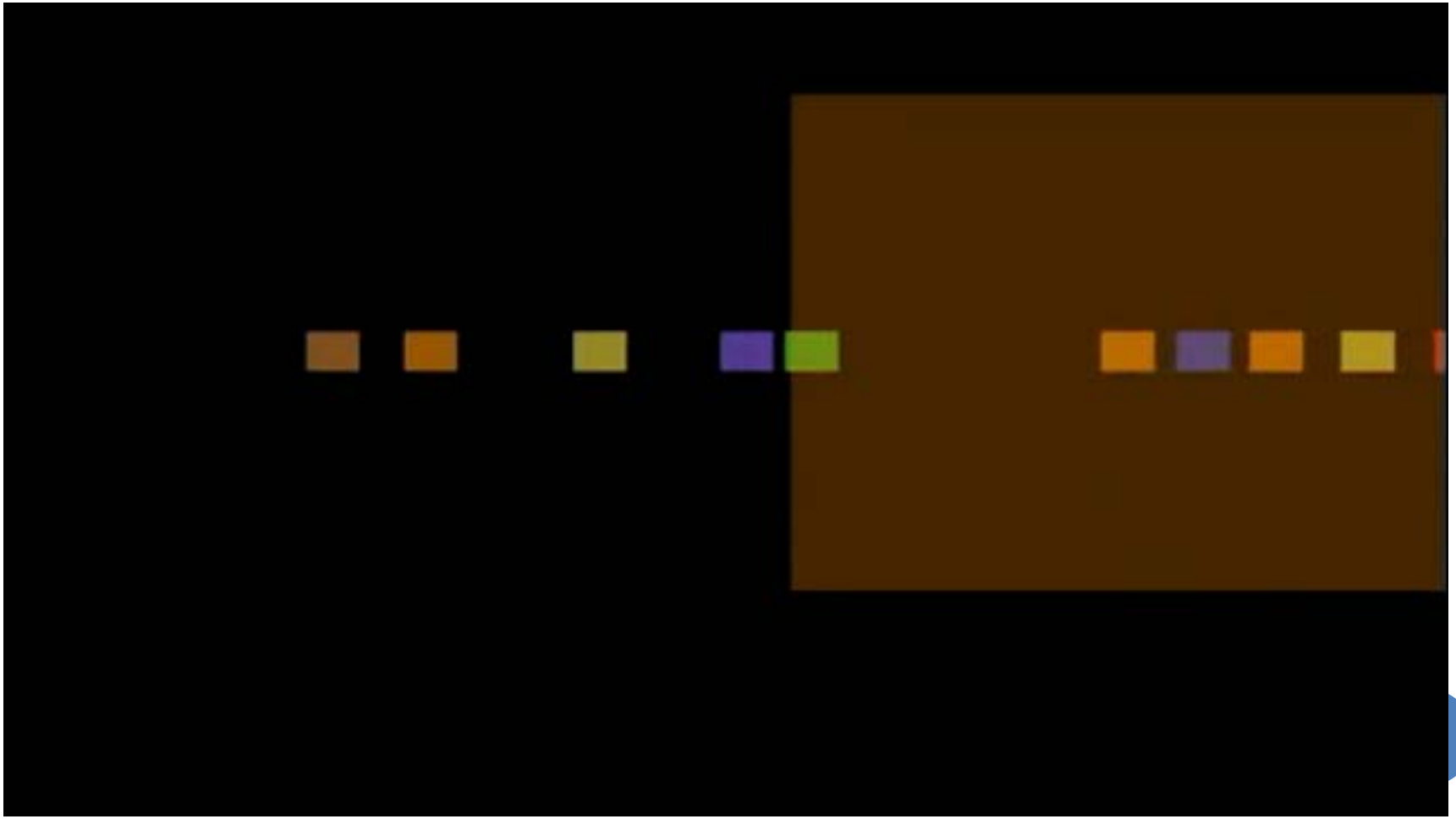
Cytoskeleton (Structure)

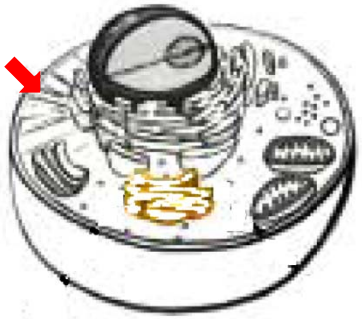
- A cellular “scaffolding” or “skeleton” contained within the cytoplasm

- It is a dynamic structure that maintains cell shape, protects the cell, enables cellular motion, and plays important roles in both intracellular transport and cellular division

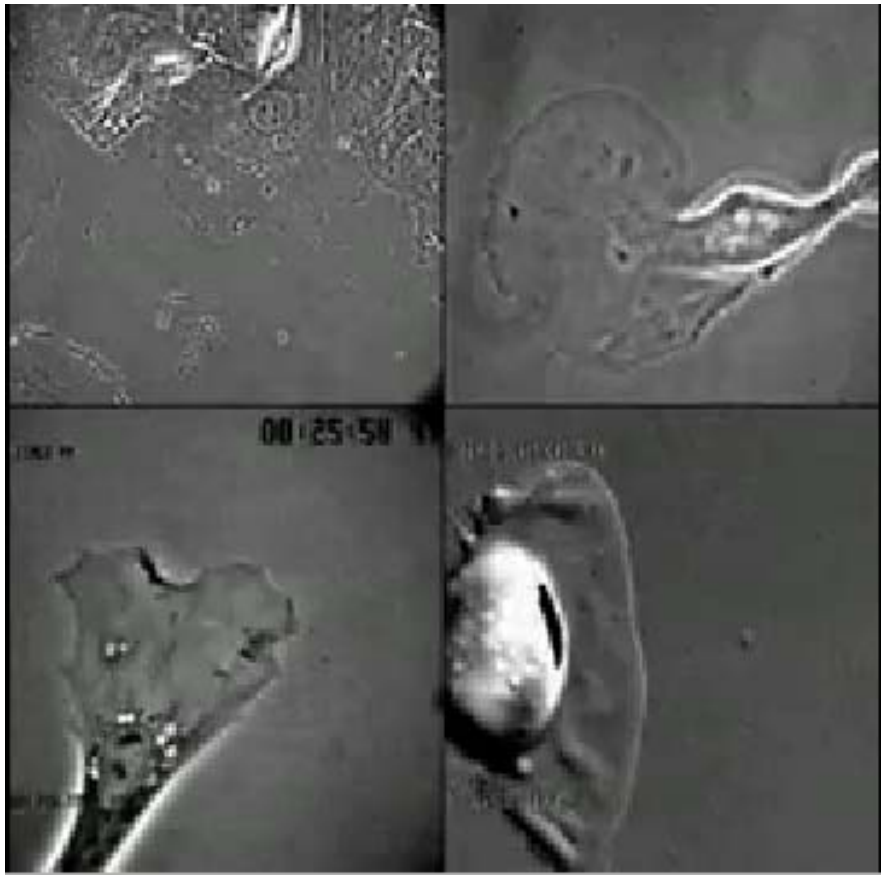


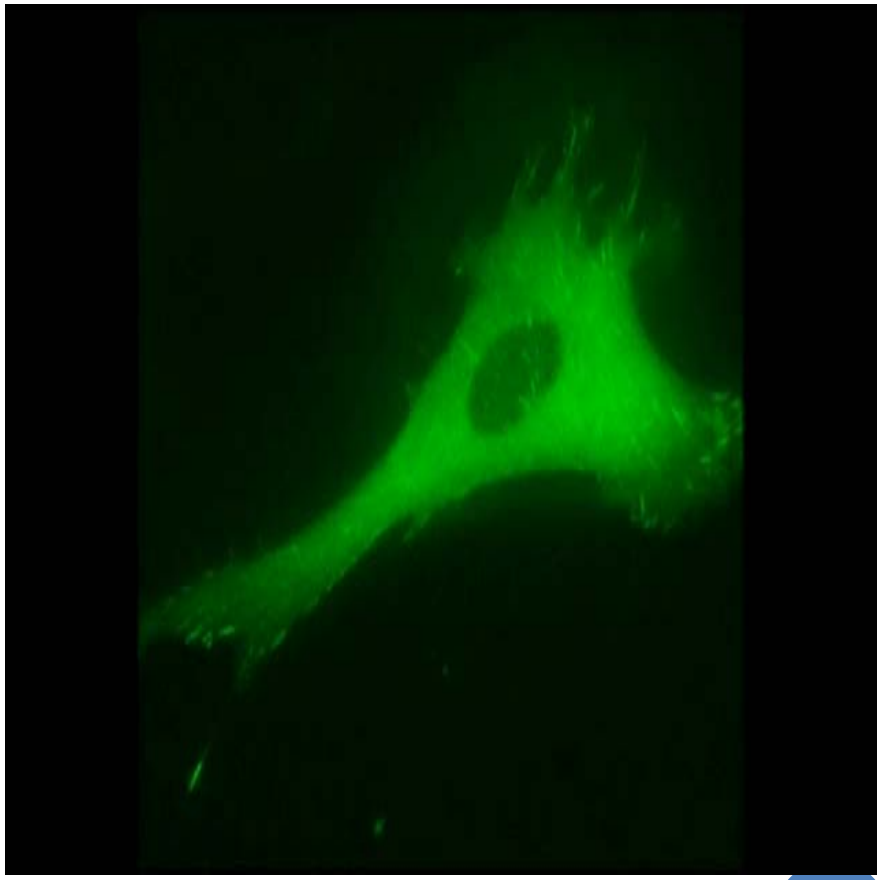
Cytoskeleton – Microtubules

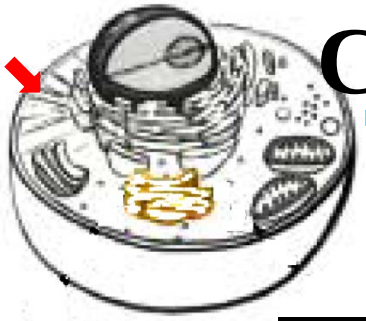




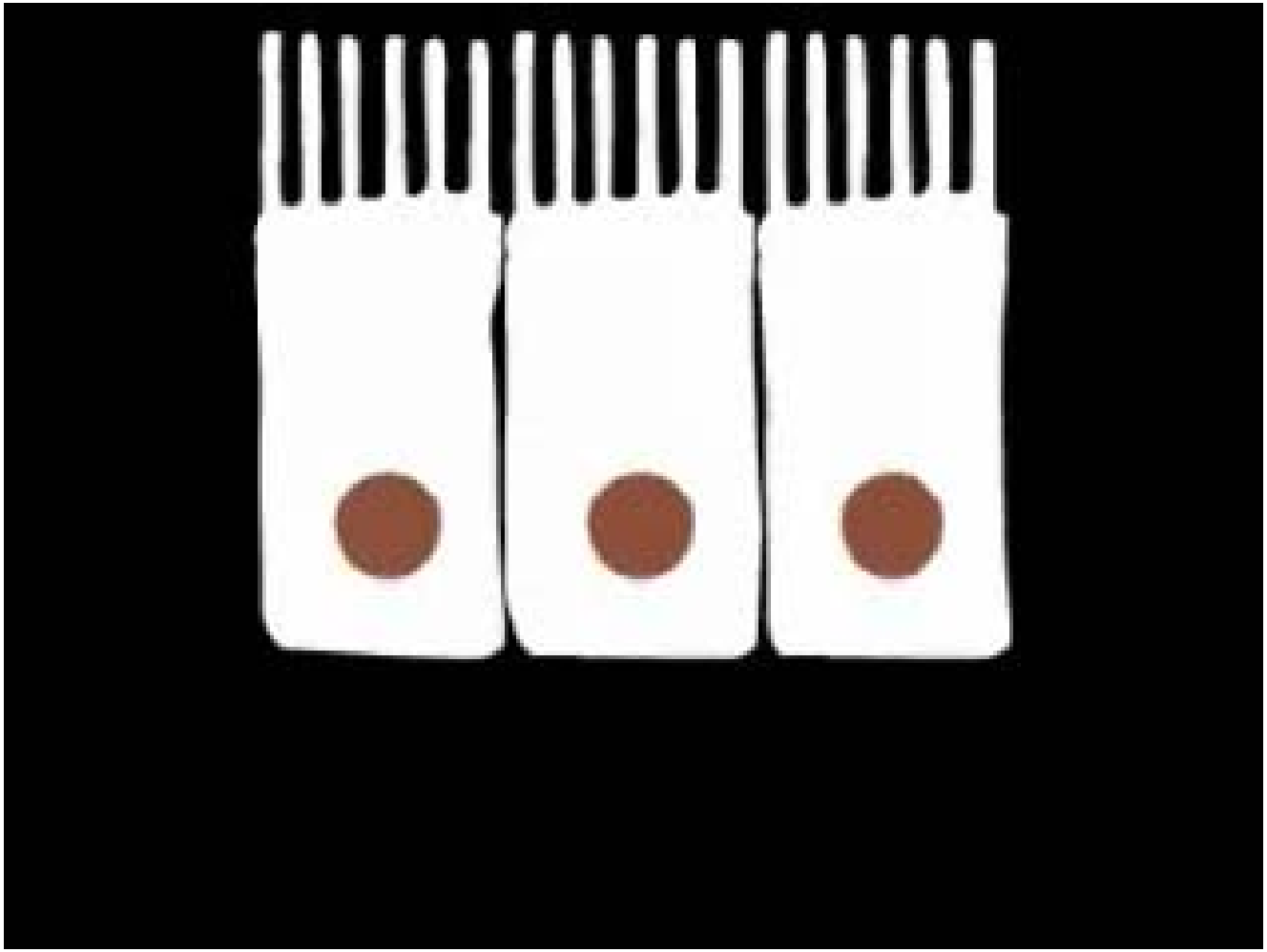
Cytoskeleton – Microfilament

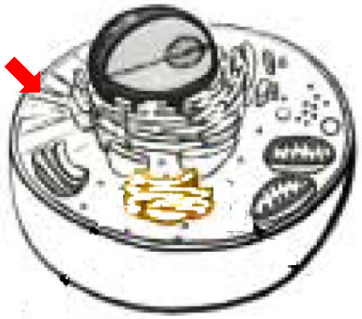






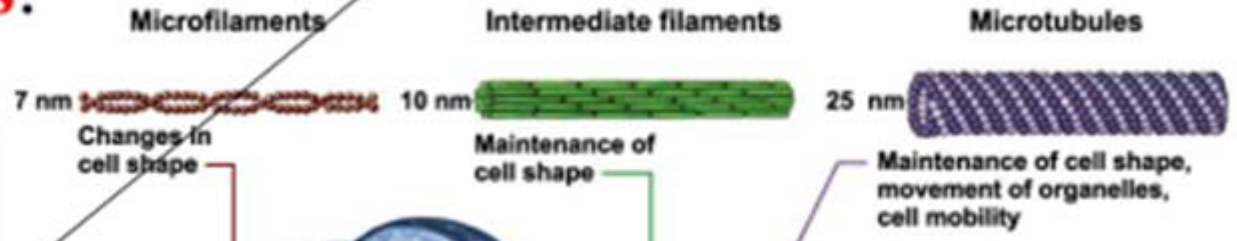
Cytoskeleton – Intermediate filaments





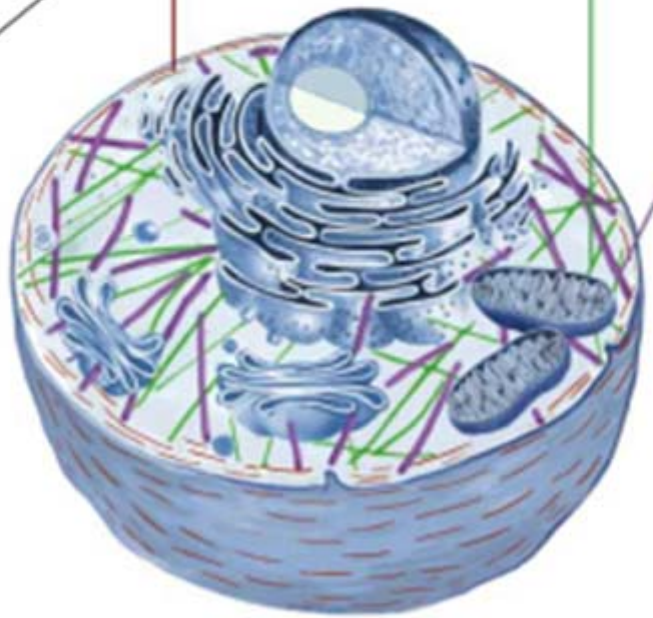
Cytoskeleton (Structure)

Three main kinds of cytoskeletal filaments: **microfilaments**, **intermediate filaments** and **microtubules**.

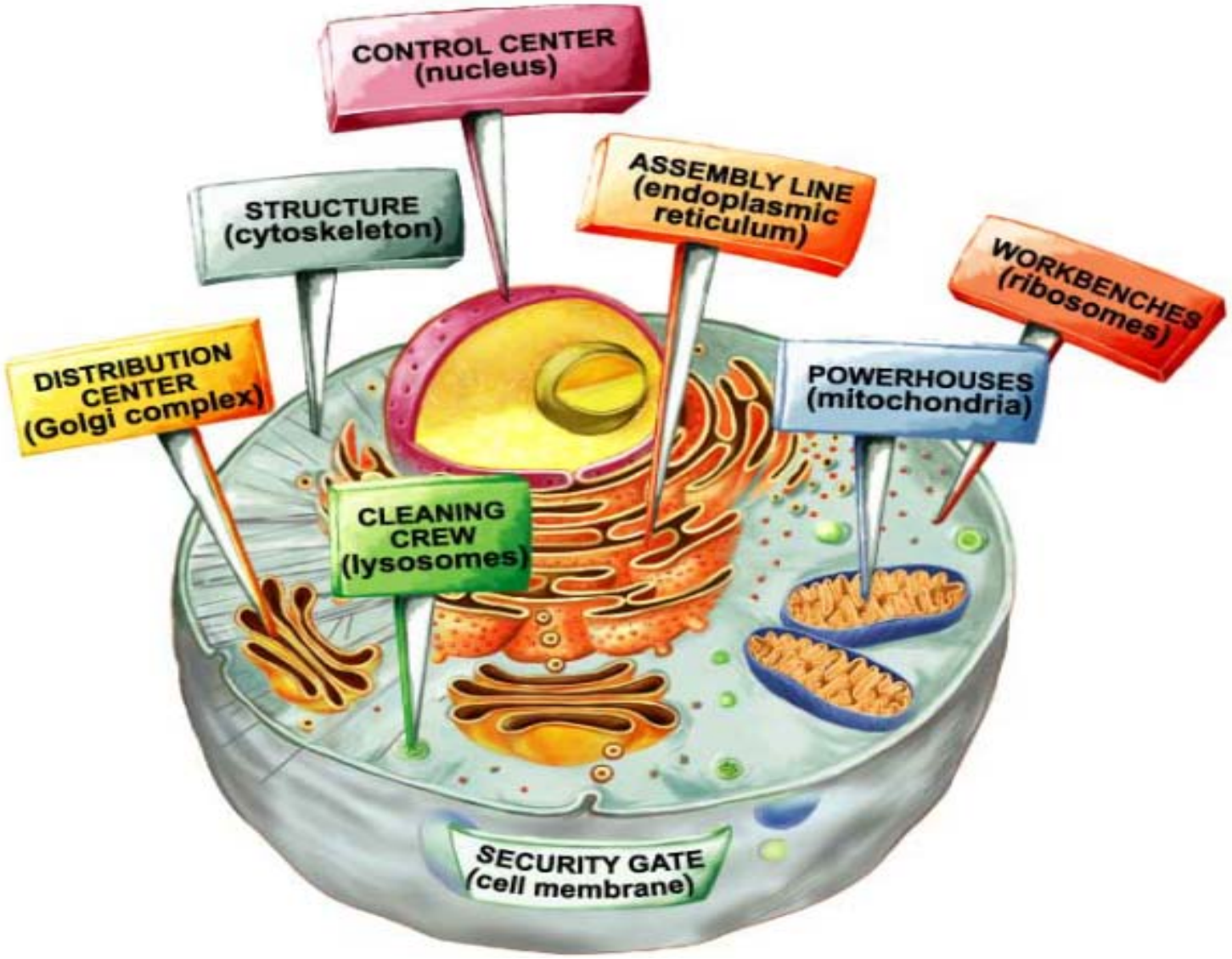


changes in cell shapes

maintenance of cell shapes

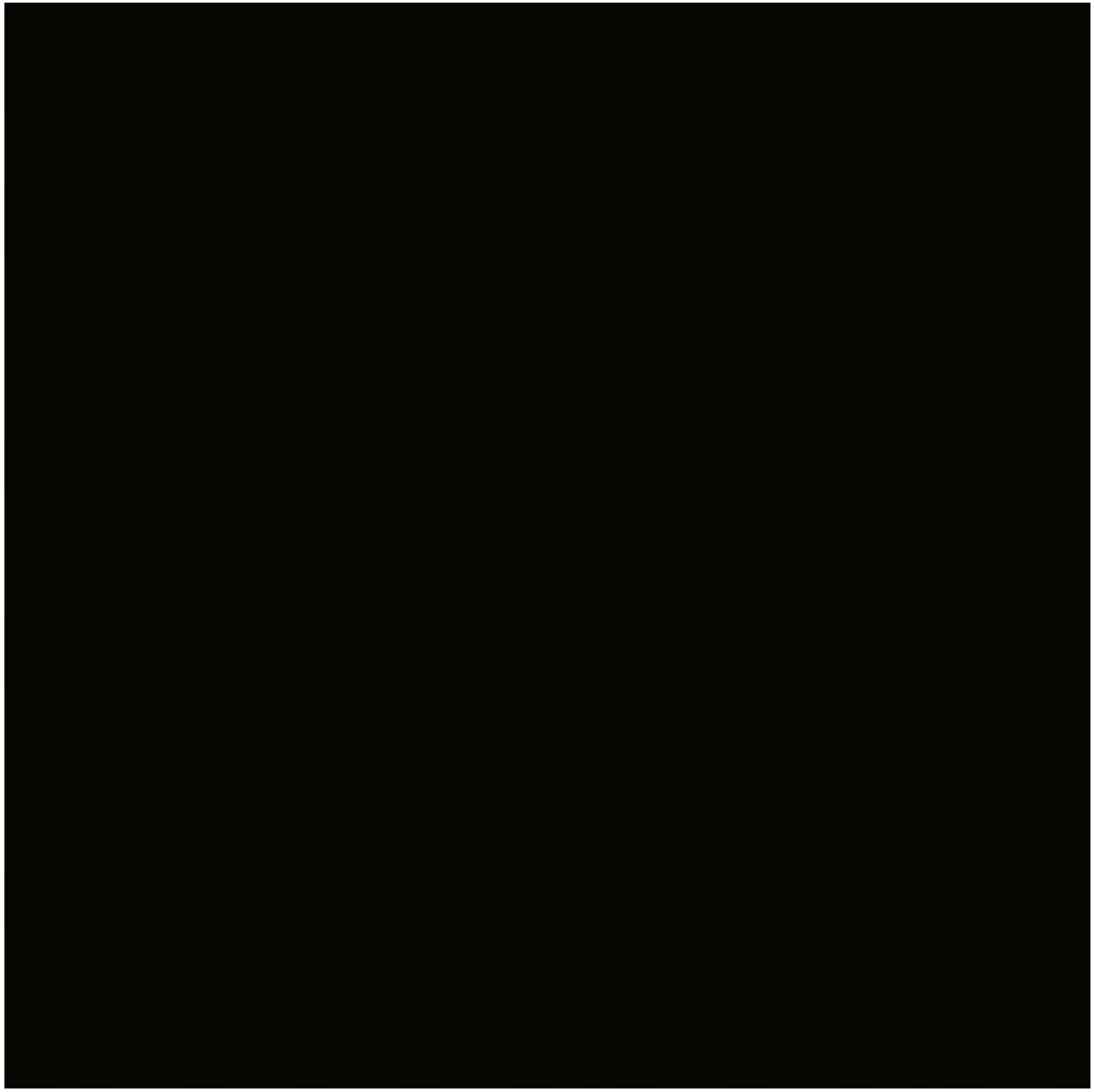


maintenance of cell shapes, movement of organelles, cell mobility



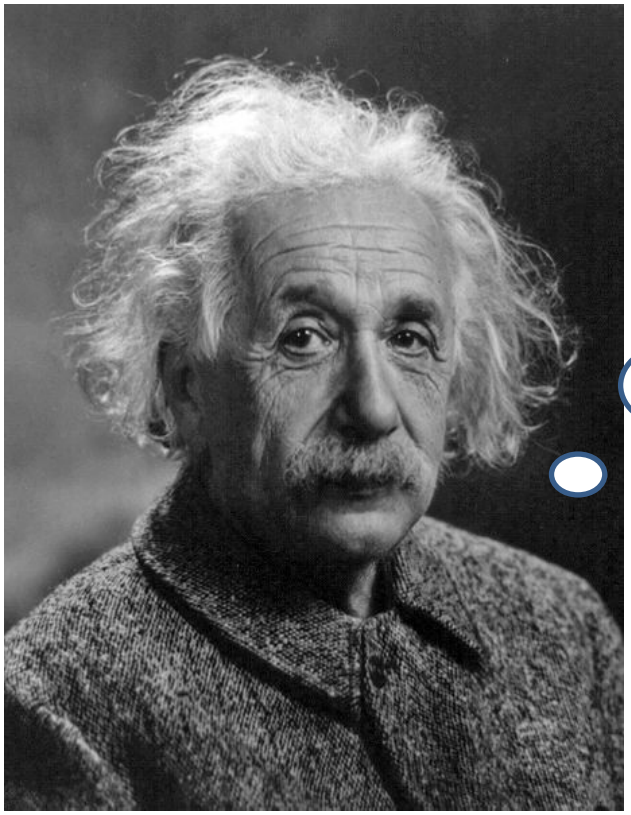
Transcription (DNA → RNA)
Translation (RNA → Protein)

The inner life of a cell” from Harvard university



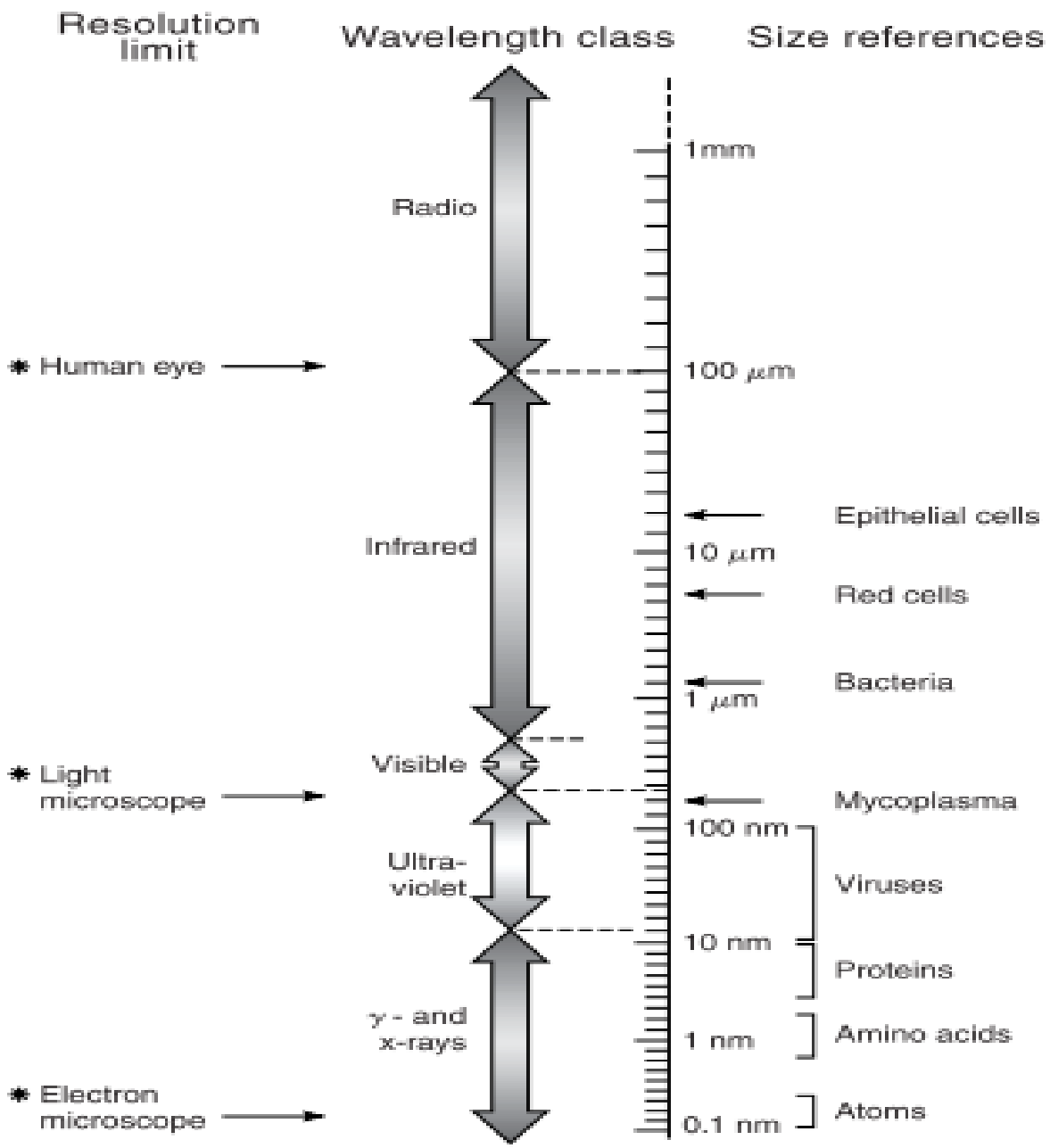
How to see?

How to study?



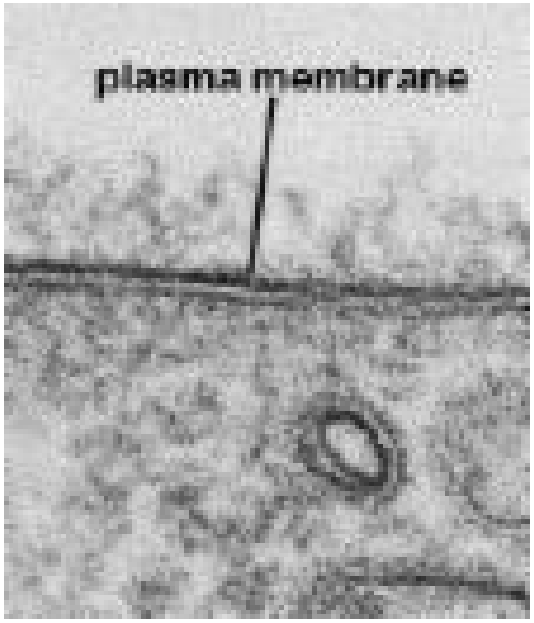
Albert Einstein

Microscopy

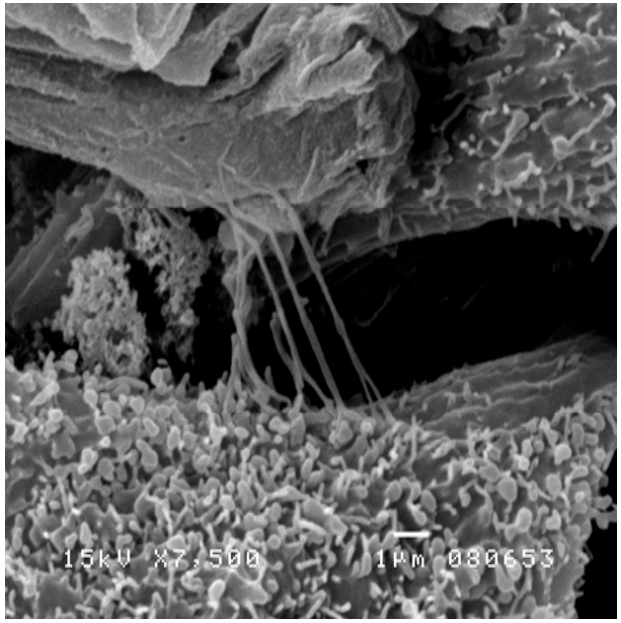

Resolution limit
Wavelength class
Size references
Radio
Infrared
Visible
Ultra-violet
γ - and x-rays
Human eye
Light microscope
Electron microscope
1mm
100 μm
10 μm
1 μm
100 nm
10 nm
1 nm
0.1 nm
Epithelial cells
Red cells
Bacteria
Mycoplasma
Viruses
Proteins
Amino acids
Atoms

Electron Microscopy

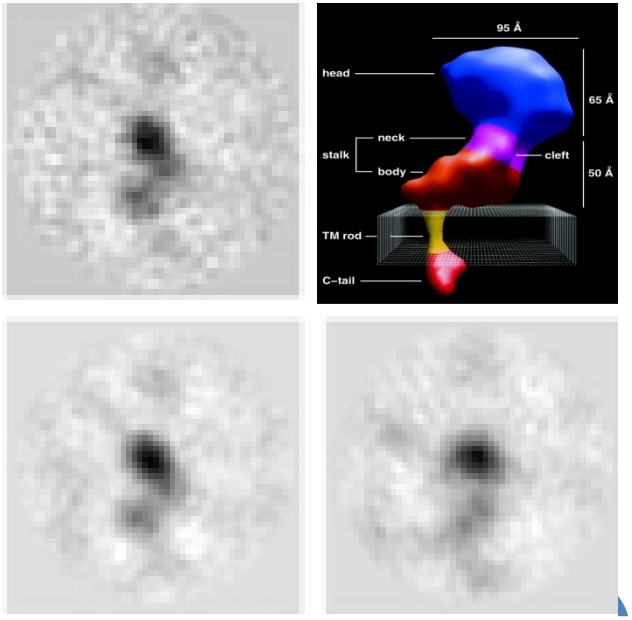
- Transmission Electron Microscope (TEM)
- Scanning Electron Microscope (SEM)
- Cryo Electron Microscope (Cryo-EM)



TEM



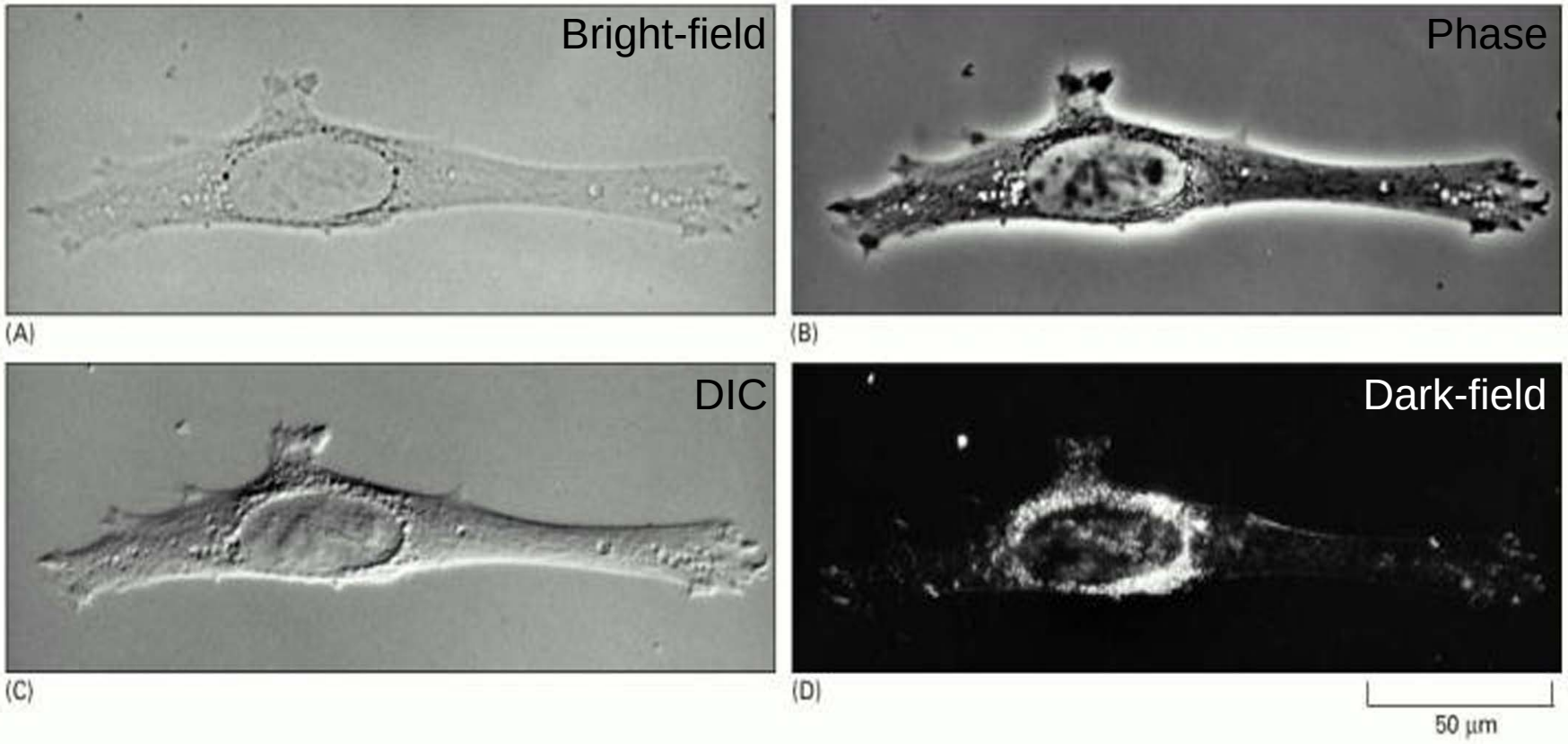
SEM



Cryo-EM

Light Microscopy

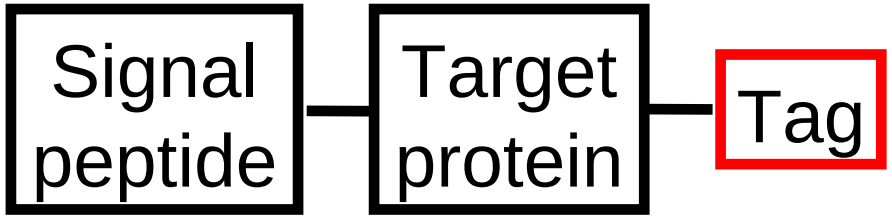
- Bright-field microscopy
- Phase-contrast microscopy
- Differential-interference-contrast (DIC) microscopy
- Dark-field microscopy



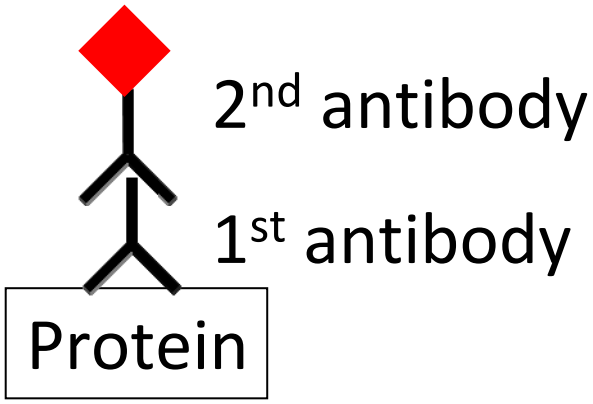
Fluorescence Microscopy

- Fusing protein tag:
  - GFP, EGFP …
  - YFP, EYFP …
  - RFP, DsRed …

One tag, one color

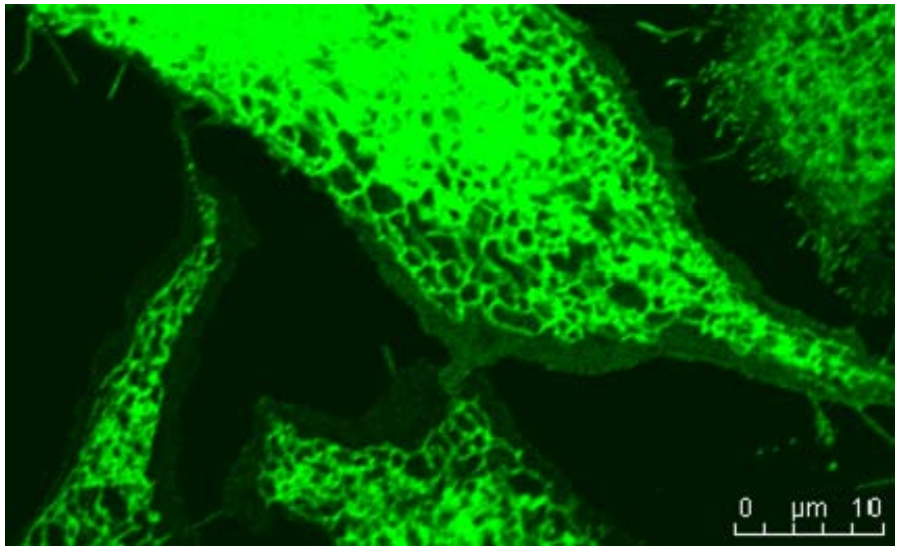


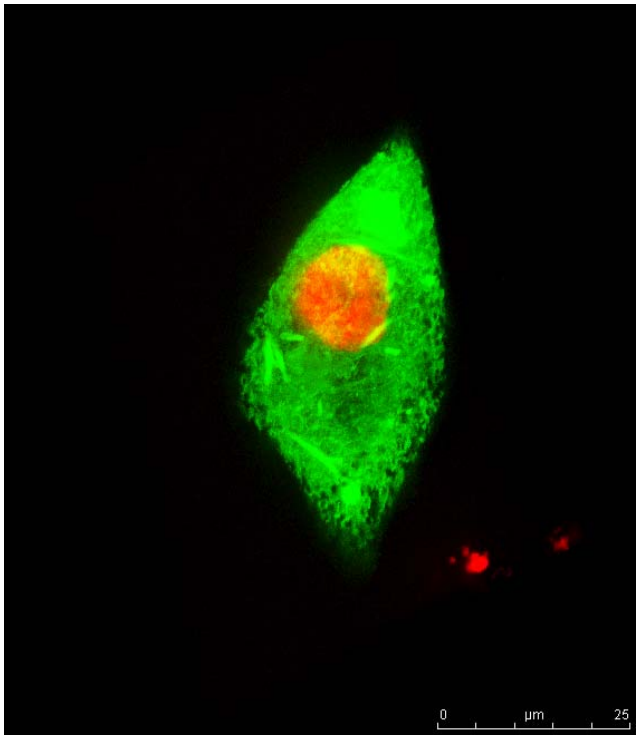
- Fluorescent labeling:
  - FITC TRITC …
  - Analog dye (membrane dye)
  - Oxidizing dye (Mitotracker…)
  - Quantum Dot
  - …
- Immuno-staining:
  - Antibody labeling

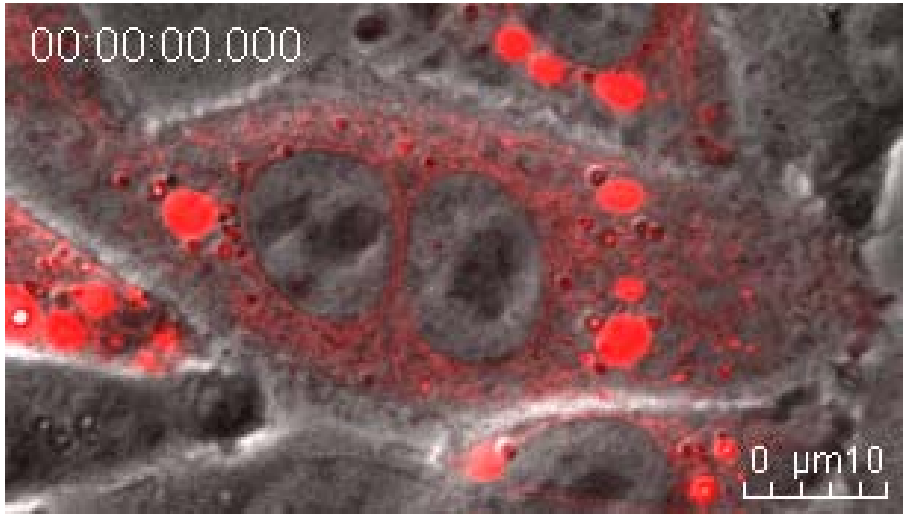


Labeling on biology

- Fusing protein tag:
  - GFP, EGFP …
  - YFP, EYFP …
  - RFP, DsRed …

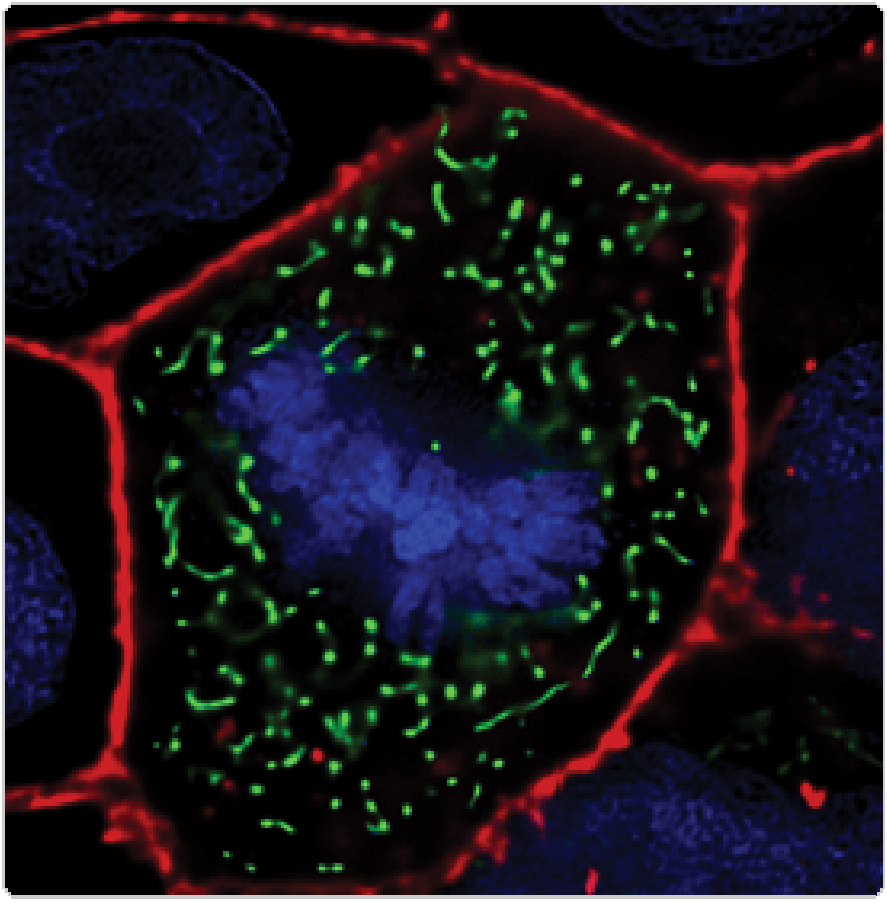






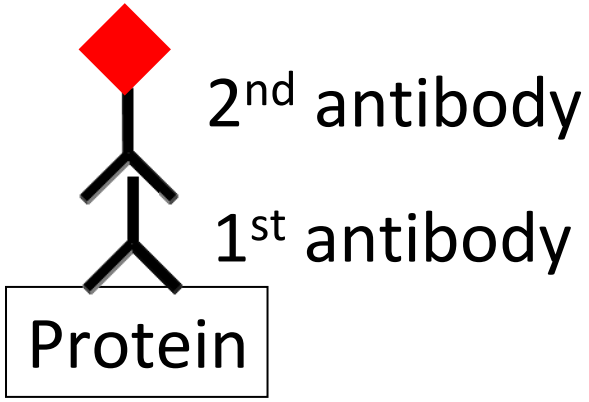
Labeling on biology

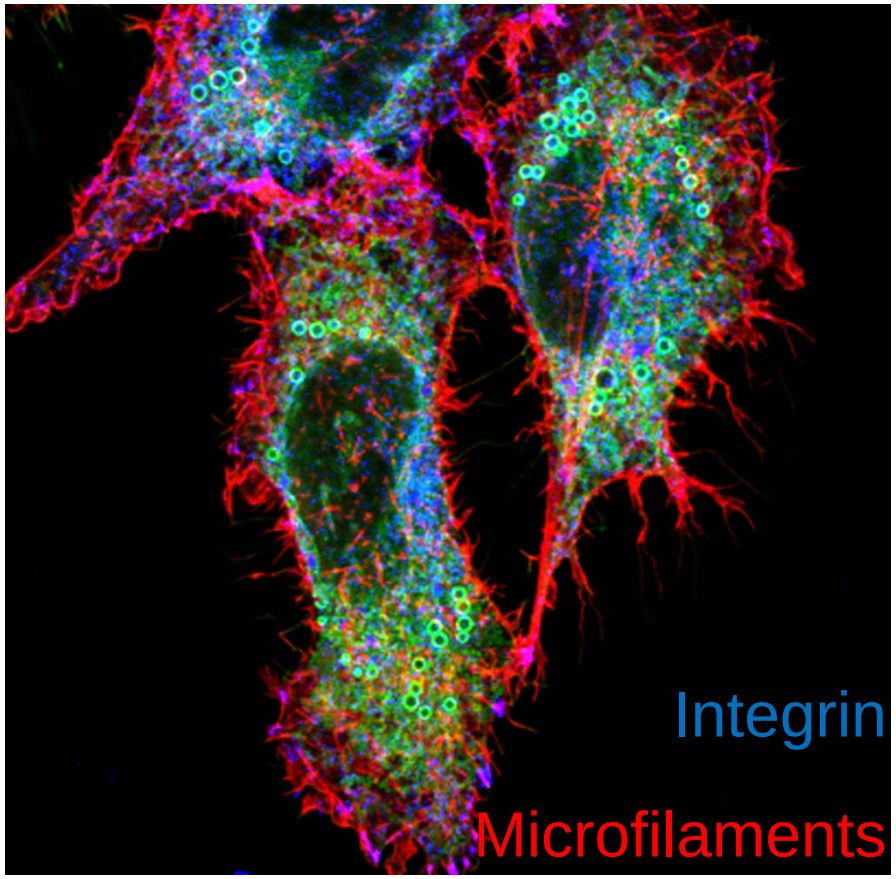
- Fluorescent labeling:
  - FITC TRITC …
  - Analog dye (membrane dye)
  - Oxidizing dye (Mitotracker…)
  - Quantum Dot
  - …

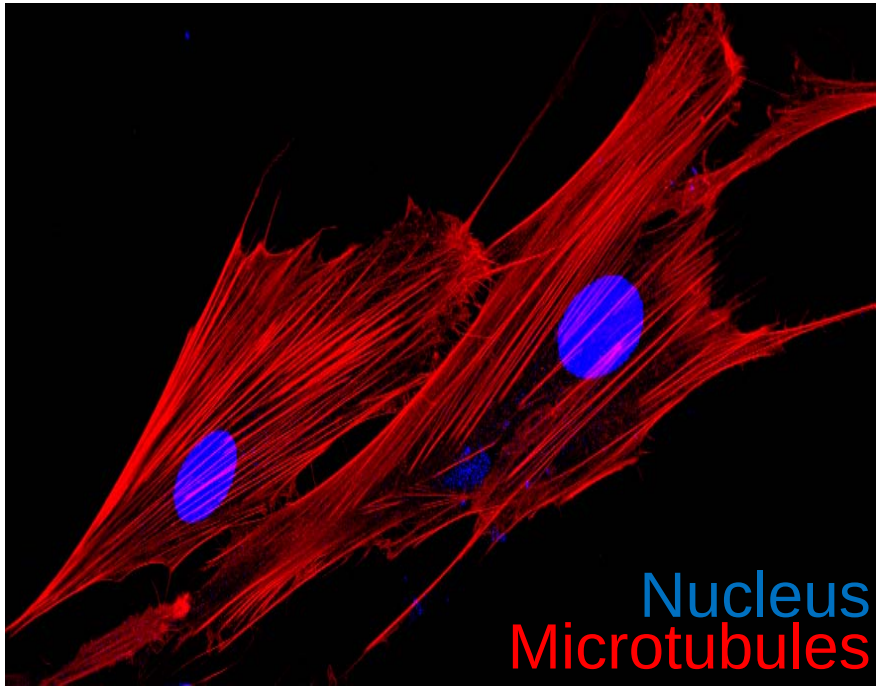


Labeling on biology

- Immuno-staining:
  - Antibody labeling

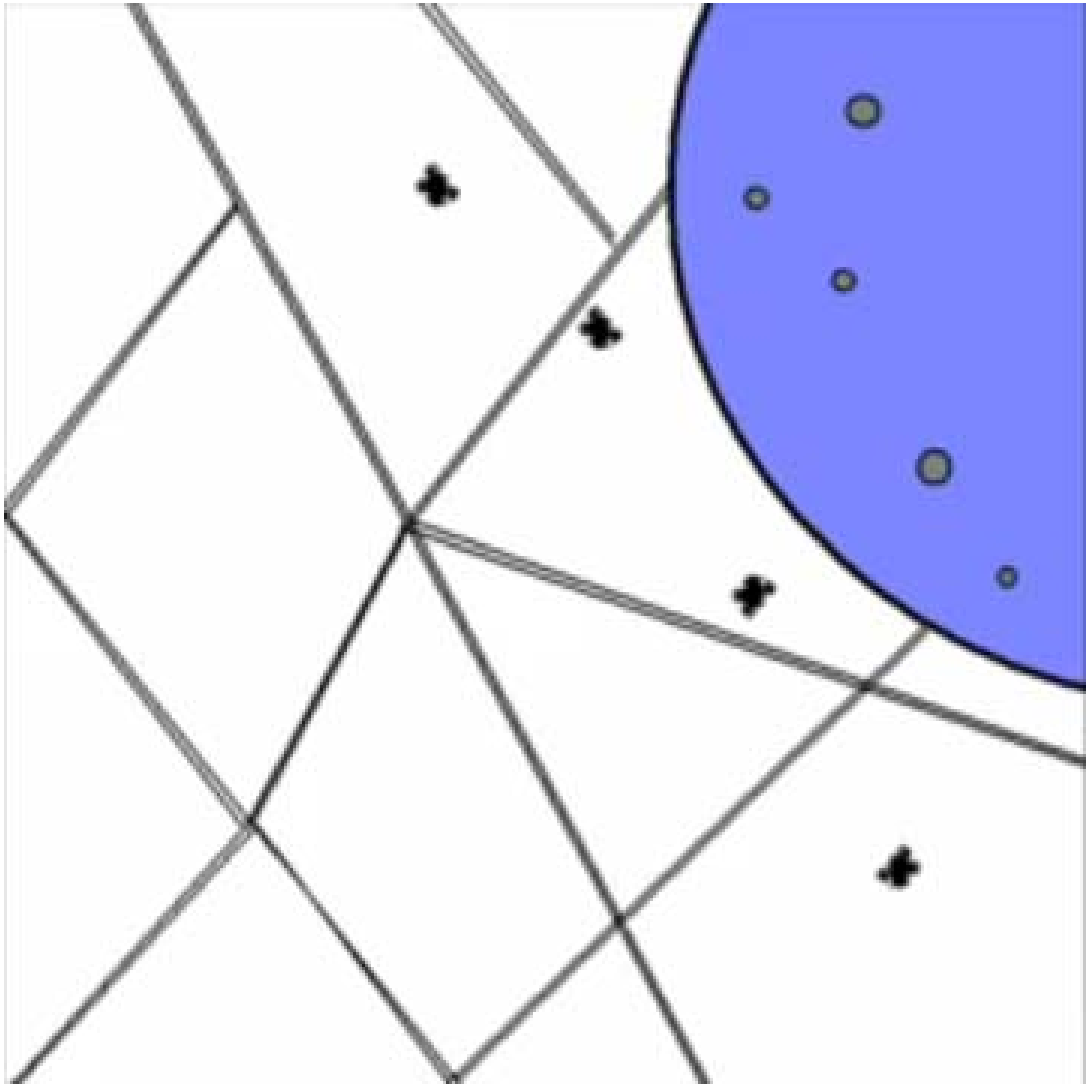






Quiz Time

Ribosome & mRNA (romantic, bloody, and violent)

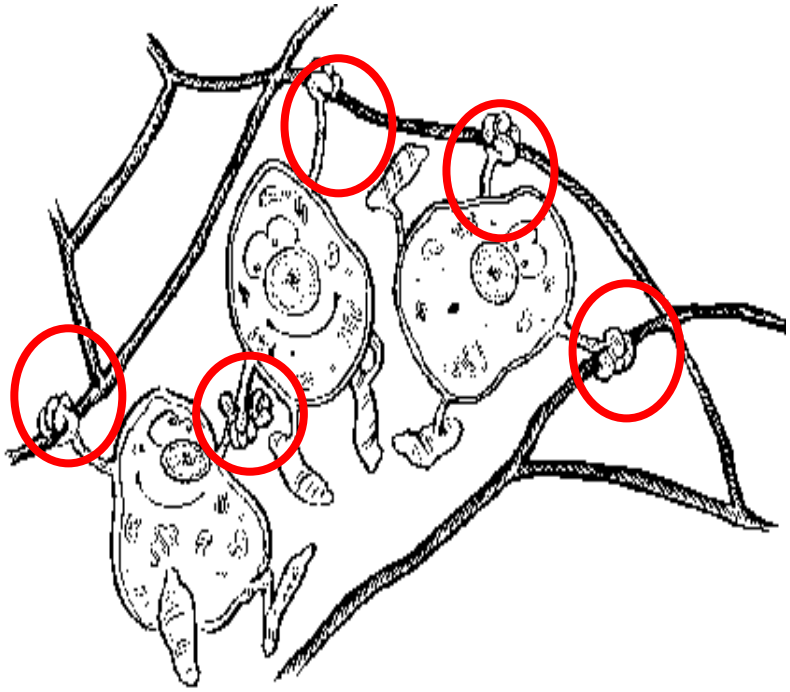


Welcome to the Biological Board!

Cells

Individual

Tissues



Together