Cells

structure and function

Introduction

- cell theory (1838)
  - all organisms composed of cells
  - cell is basic living unit
  - all cells from preexisting cells
- functions
  - protection, storage, secretion, support, communication, sensing, movement
- forms
  - many functions = many forms

red blood cells

digestive tract

nerve cells

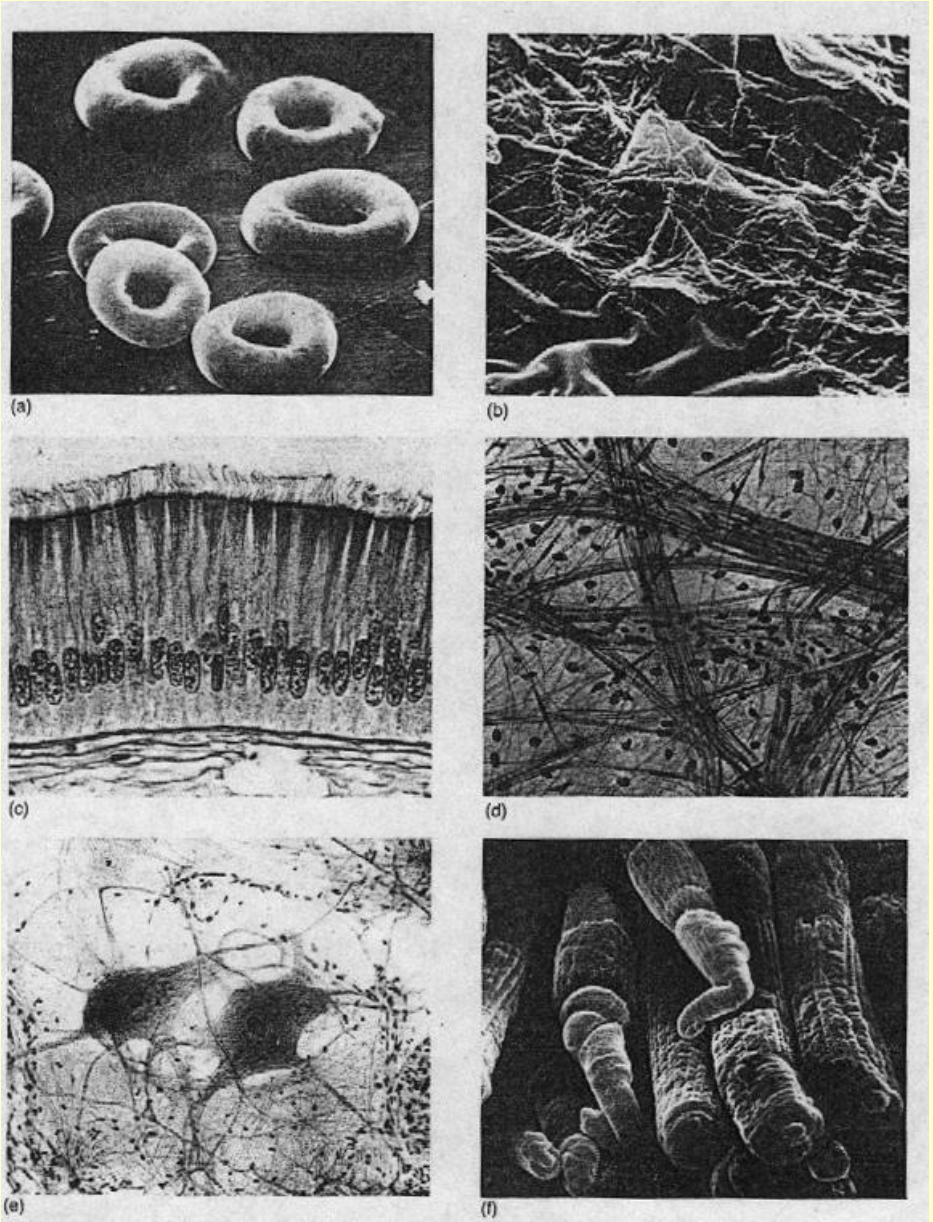


FIGURE 1.3 Micrographs showing a few of the many shapes that eucaryotic cells display. (*a*) Human red blood cells. (*b*) Human surface skin cells. (*c*) Ciliated columnar epithelium from the gut of a mussel. (*d*) Smooth muscle cells from a urinary bladder. (*e*) Spinal nerve cells. (*f*). Rods and cones in the retina of a mud puppy. (Micrographs courtesy of F. Morel, R. Baker & H. Wayland, *a*; David N. Menton, *b*; Don W. Fawcett, *c*; Manfred Kage and Peter Arnold, *d*; Carolina Biological Supply Company, *e*; Edwin R. Lewis, *f*.)

skin cells

muscle cells

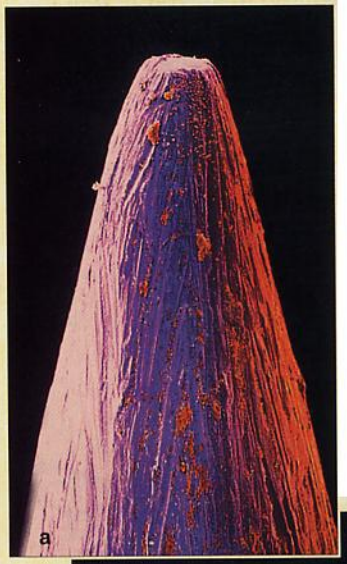
rods & cones

cell size

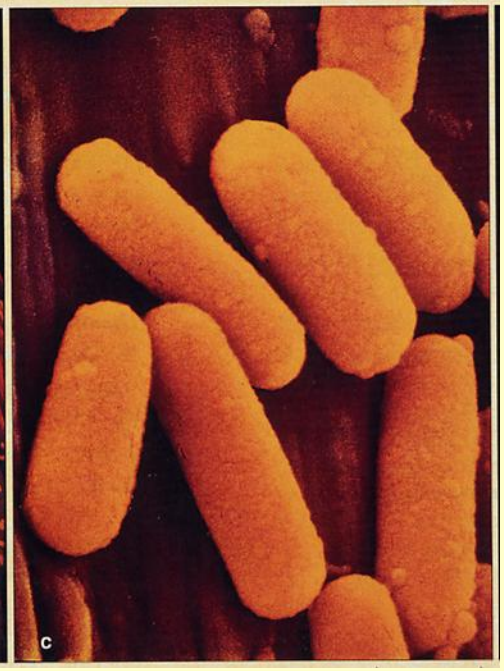
- cells are small
  - typical size 10 to 100 microns
    - micron = 1/1000th of a mm
  - few can be seen with naked eye
- size limited by:

  1) nutrient absorption

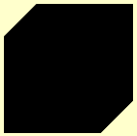
  2) waste removal



Bacteria on the head of a pin
Photo C 14,000x

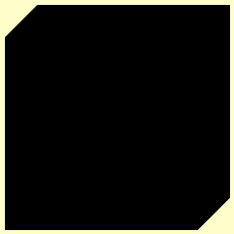


surface to volume ratio



$6 \times 0.5 \times 0.5 = 1.25\ cm^2$

$0.5 \times 0.5 \times 0.5 = 0.125\ cm^3$ (10:1)



$6 \times 1.0 \times 1.0 = 6.0\ cm^2$

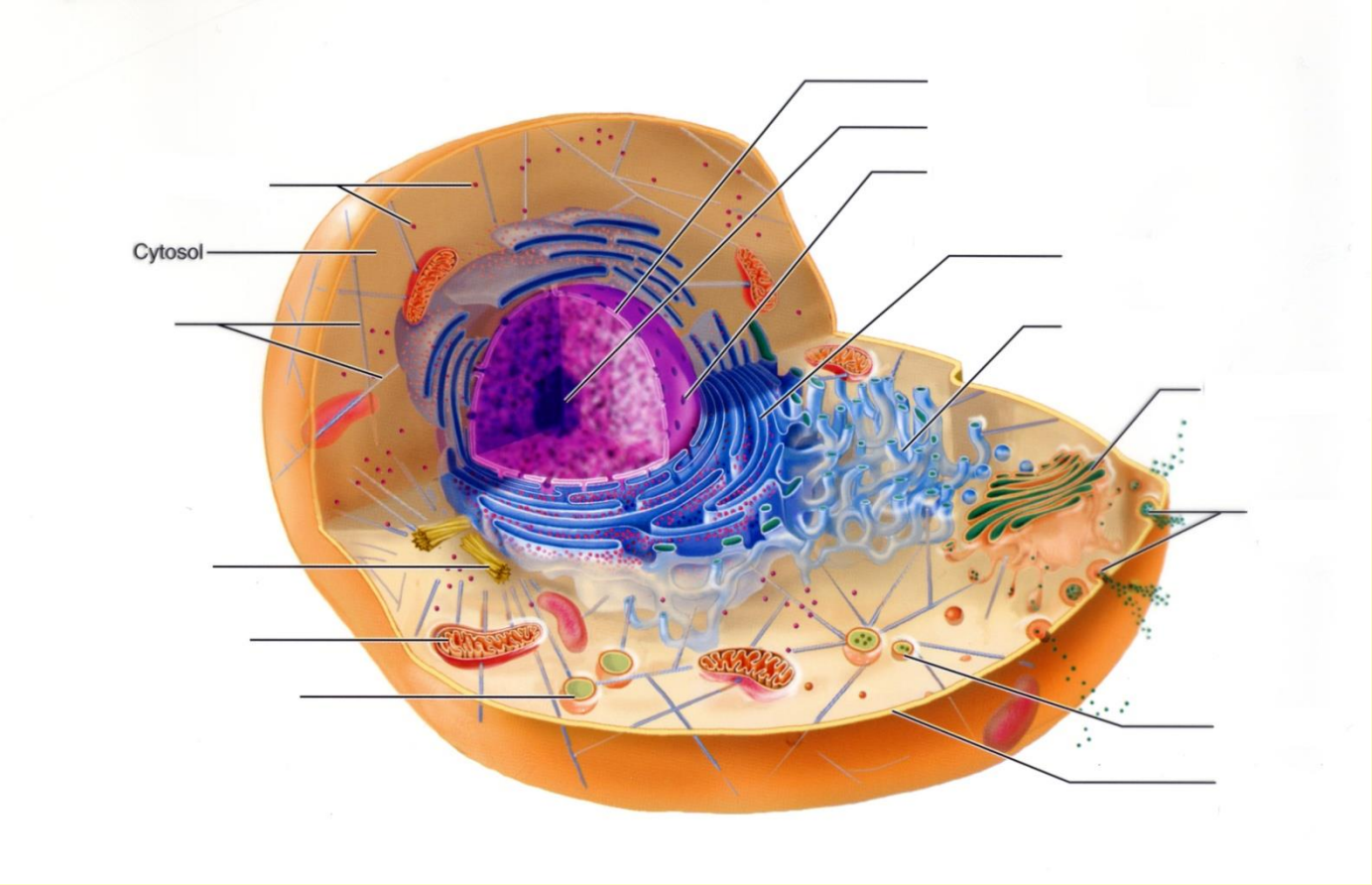
$1.0 \times 1.0 \times 1.0 = 1.0\ cm^3$ (6:1)

$6 \times 1.5 \times 1.5 = 13.5\ cm^2$

$1.5 \times 1.5 \times 1.5 = 3.38\ cm^3$ (4:1)

Major parts of cell

- Cytoplasm (jelly-like structure where all chemical reactions take place)
- plasma membrane (also called cell membrane)
- nucleus
- organelles
- cytoskeleton



A watery solution of minerals, gases, and organic molecules that is found between the cell membrane and the nucleus. It is the site of chemical reactions.

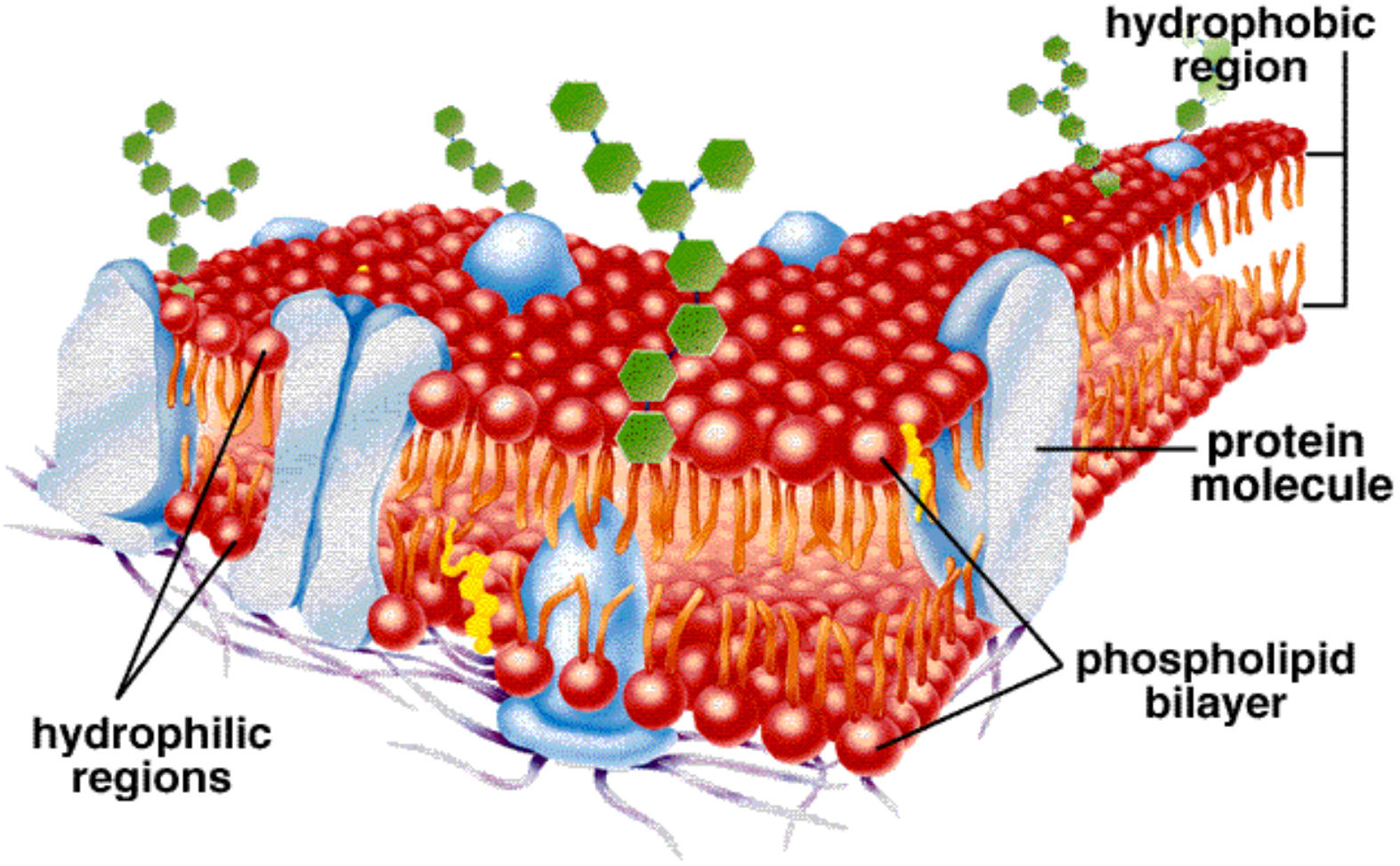
Major parts of cell

- cytoplasm
- plasma membrane
- nucleus
- organelles
- cytoskeleton

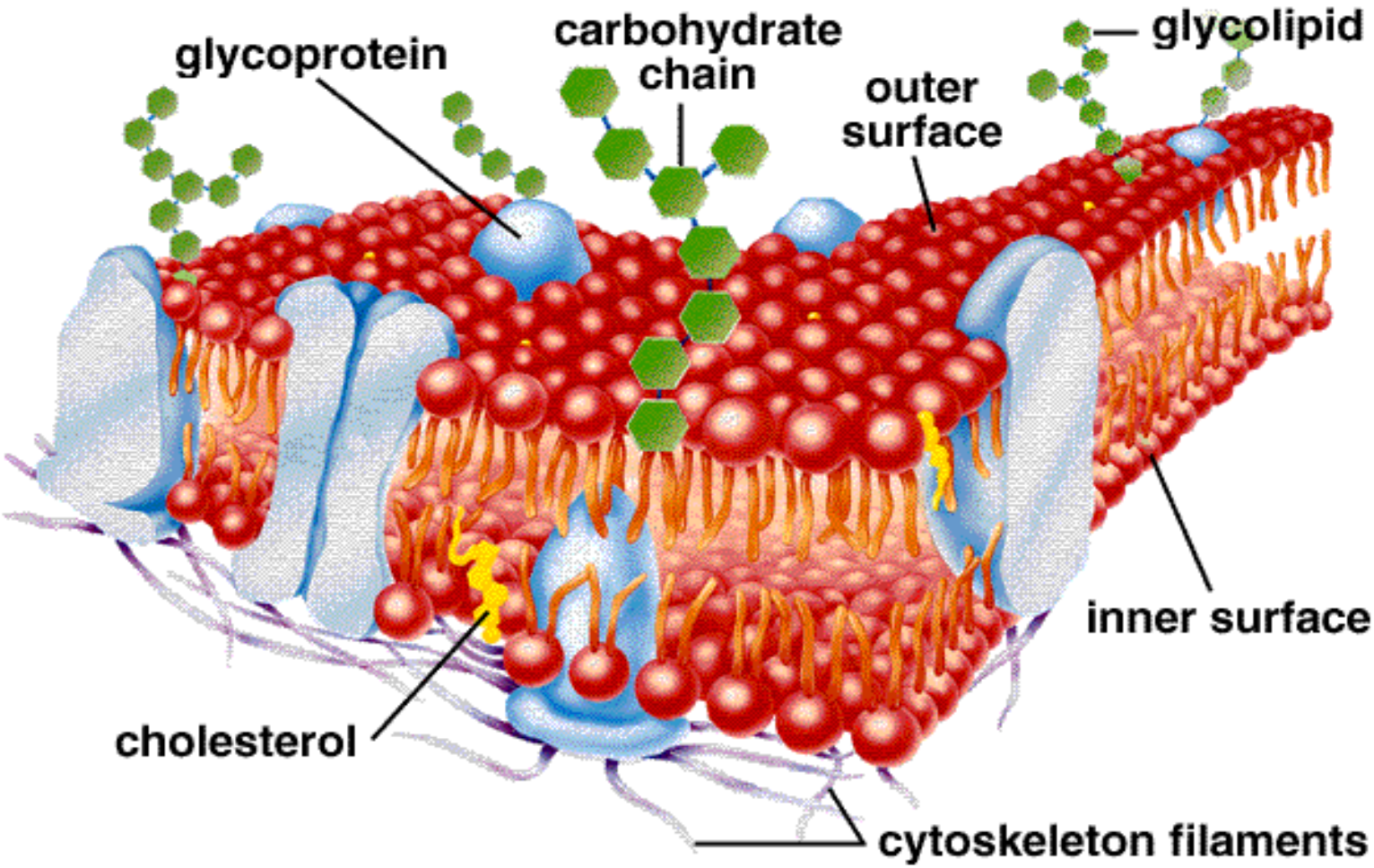
Plasma membrane

- lipid bilayer
  - two layers of fat
- maintains cell integrity
  - keeps insides inside
- surface proteins
  - cell recognition
  - ingestion
  - cytoskeleton attachment
  - receptor sites

Plasma Membrane Structure (1)



Plasma Membrane Structure (2)

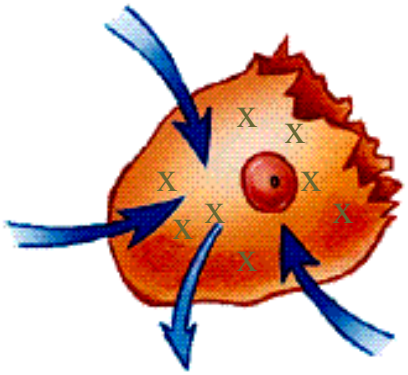


cell entry/exit

- regulates entry and exit of many molecules
  - selectively permeable
- mechanisms
  - diffusion
    - CO_2, O_2
  - osmosis
    - water

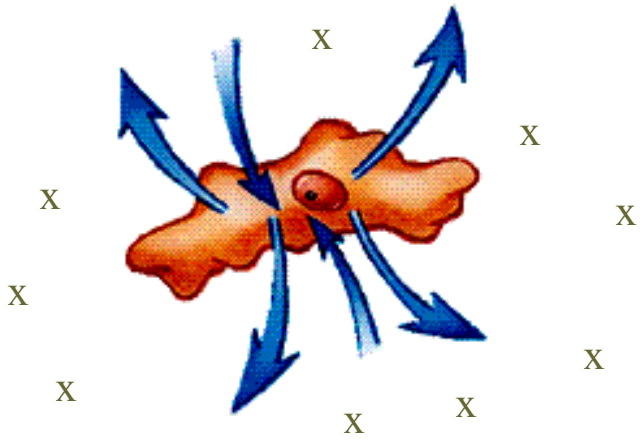
    - http://www.phschool.com/science/biology_place/biocoach/biomembrane1/intro.html

Hypotonic Conditions



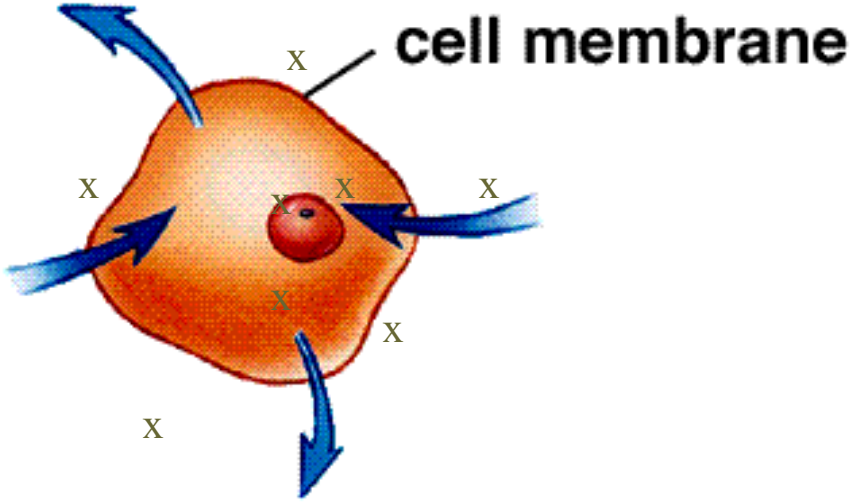
In a hypotonic environment, water enters the cell, which may burst due to osmotic pressure.

Hypertonic Conditions



In a hypertonic environment, water leaves the cell, which shrivels.

Isotonic Conditions



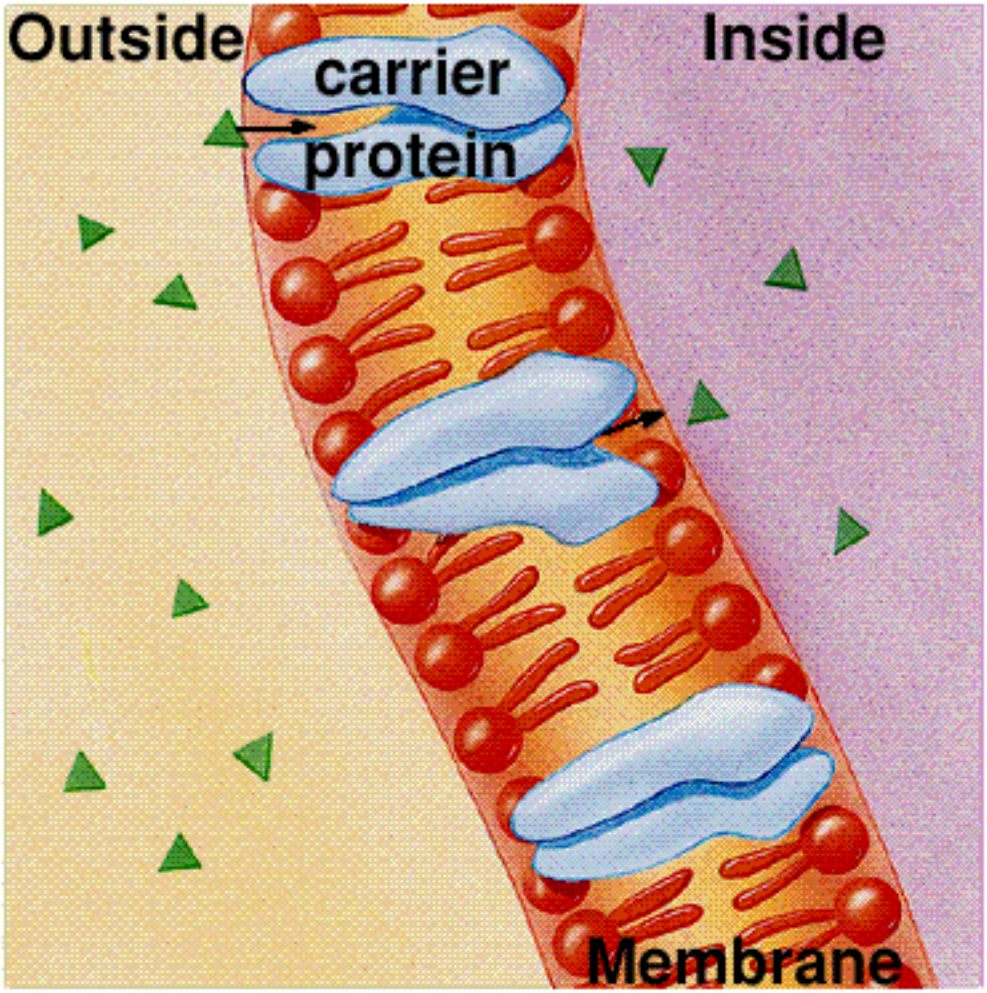
Under isotonic conditions, there is no net movement of water.

How diffusion works

cell entry/exit

- mechanisms
  - diffusion
    - CO_2, O_2
  - osmosis
    - water
  - facilitated transport
    - glucose

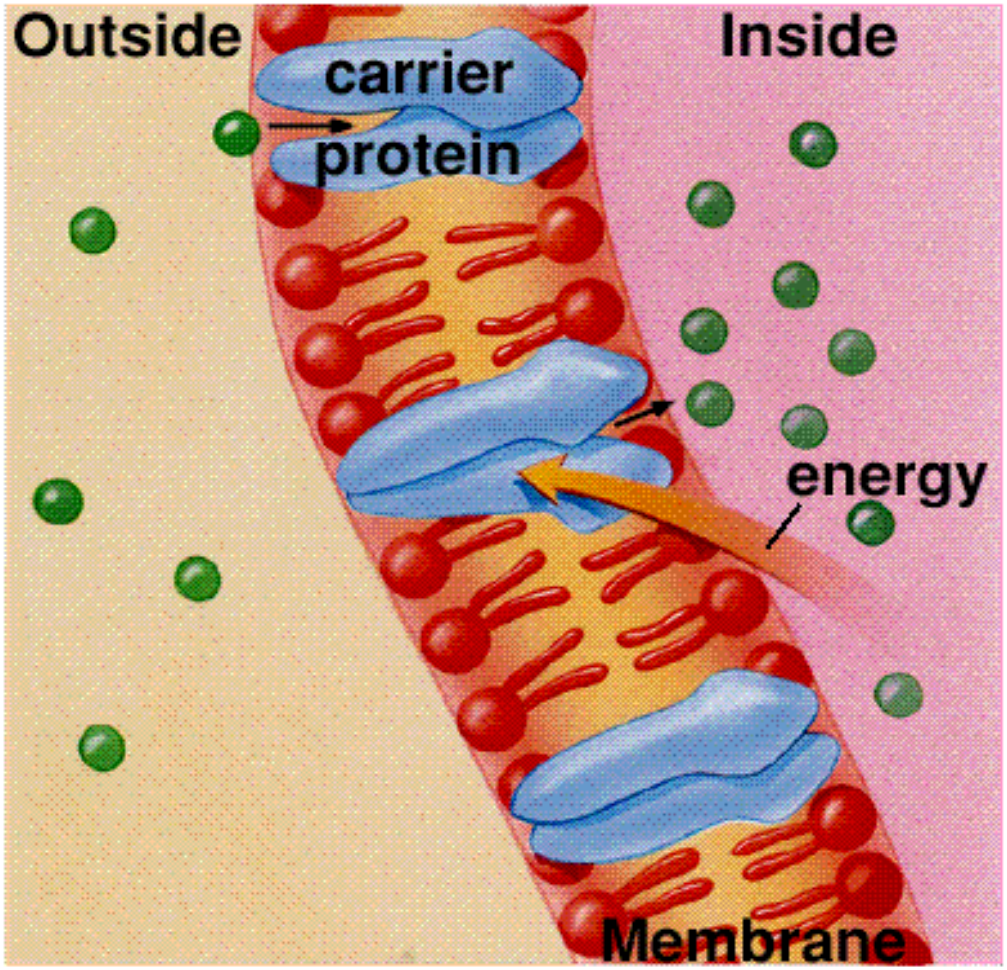
Facilitated Transport



cell entry/exit

- mechanisms
  - diffusion
    - CO_2, O_2
  - osmosis
    - water
  - facilitated transport
    - glucose
  - active transport
    - Na^+, K^+

Active Transport

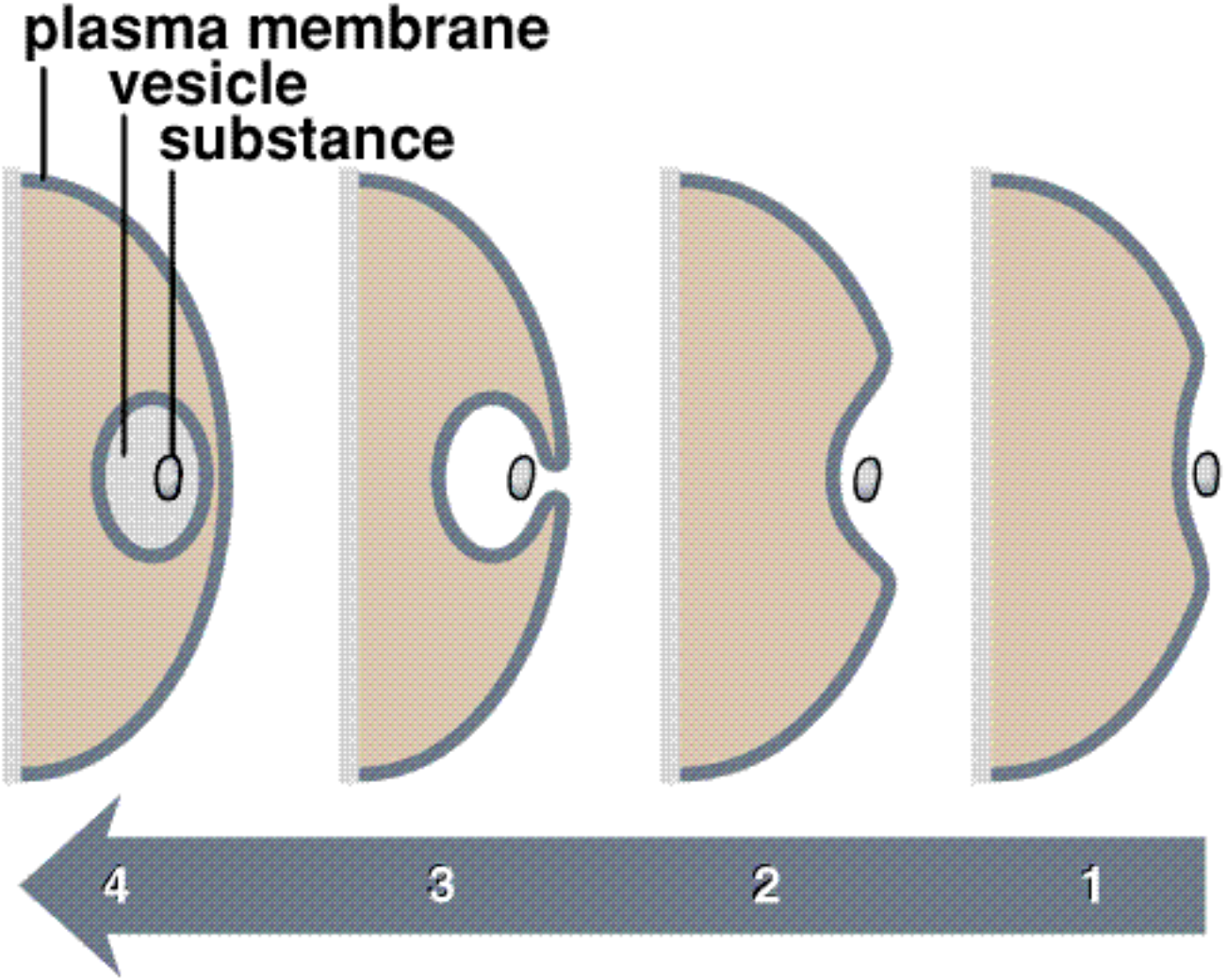


http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_the_sodium_potassium_pump_works.html

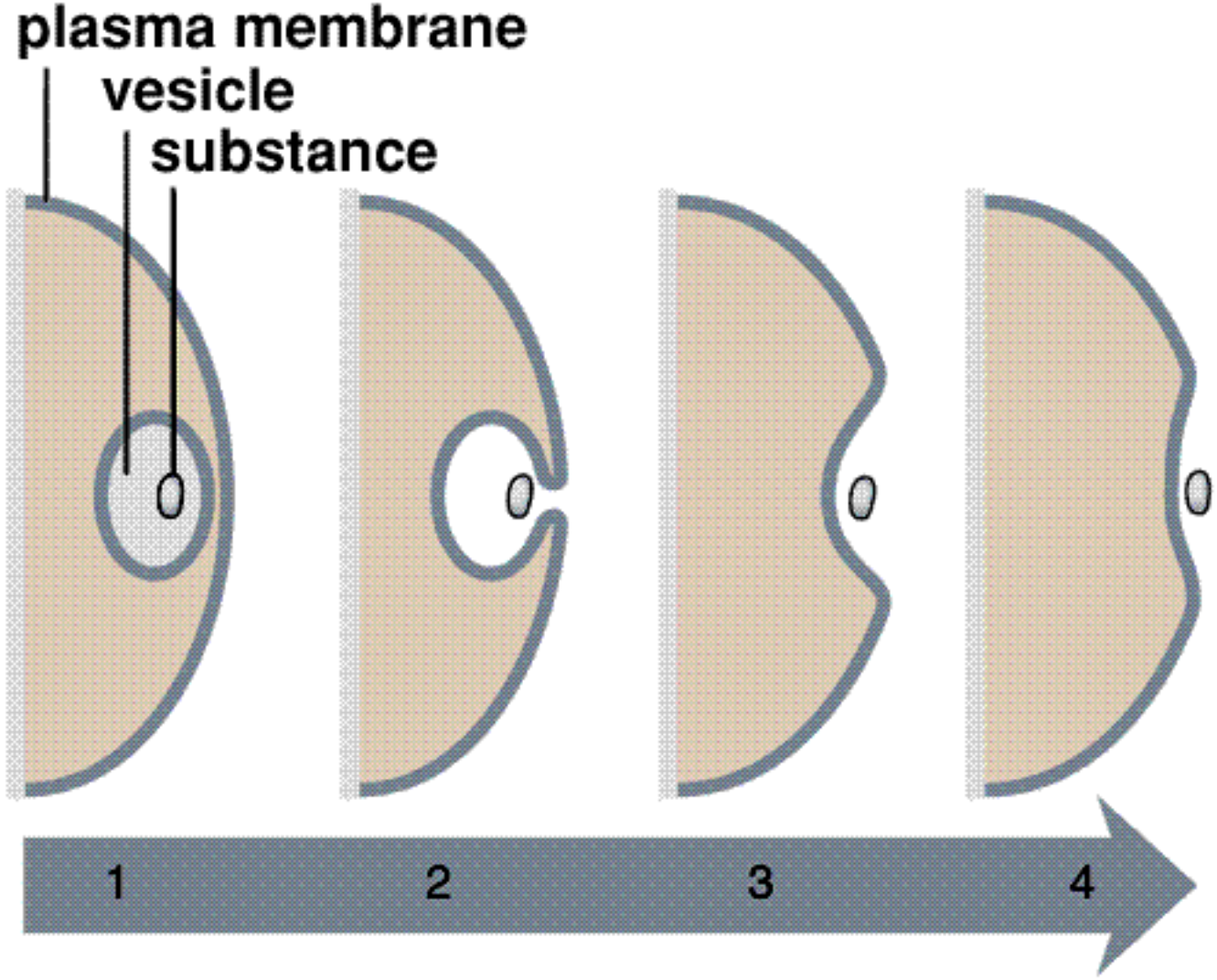
cell entry/exit

- mechanisms
  - diffusion
    - CO_2, O_2
  - osmosis
    - water
  - facilitated transport
    - glucose
  - active transport
    - Na^+, K^+
  - endocytosis, exocytosis
    - particles

Endocytosis (Right to Left)



Exocytosis (Left to Right)



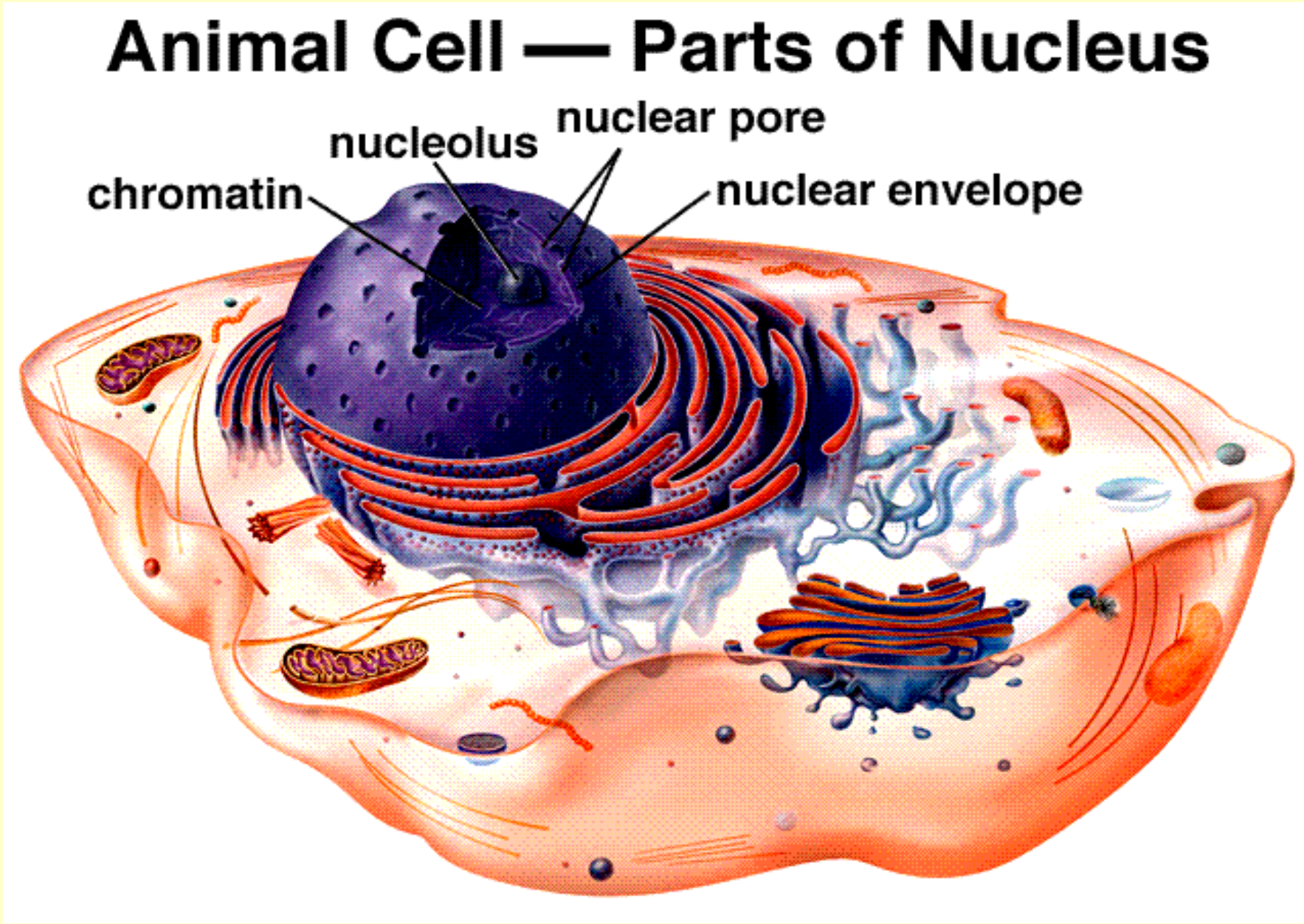
Major parts of cell

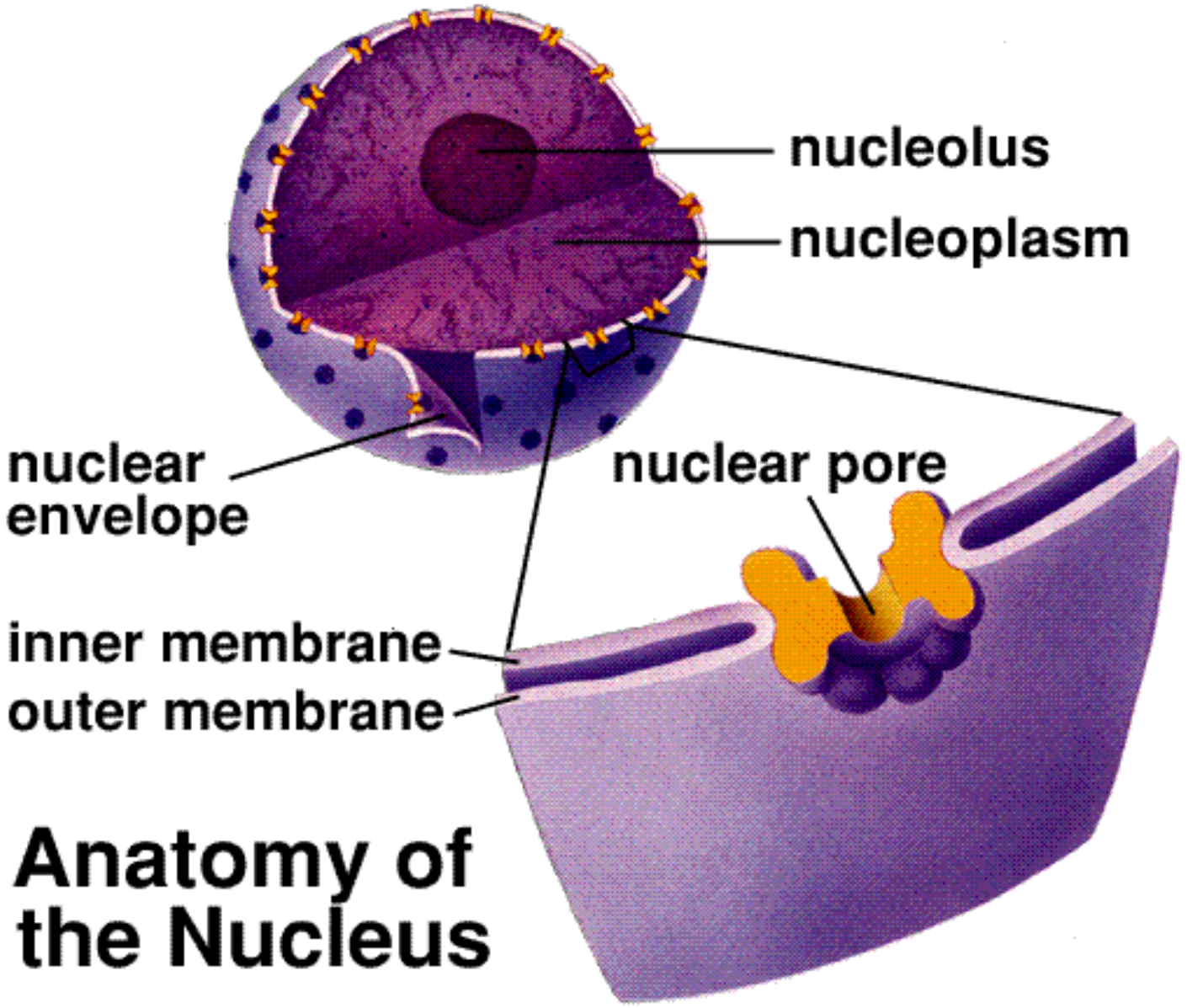
- cytoplasm
- plasma membrane
- nucleus
- organelles
- cytoskeleton

Nucleus

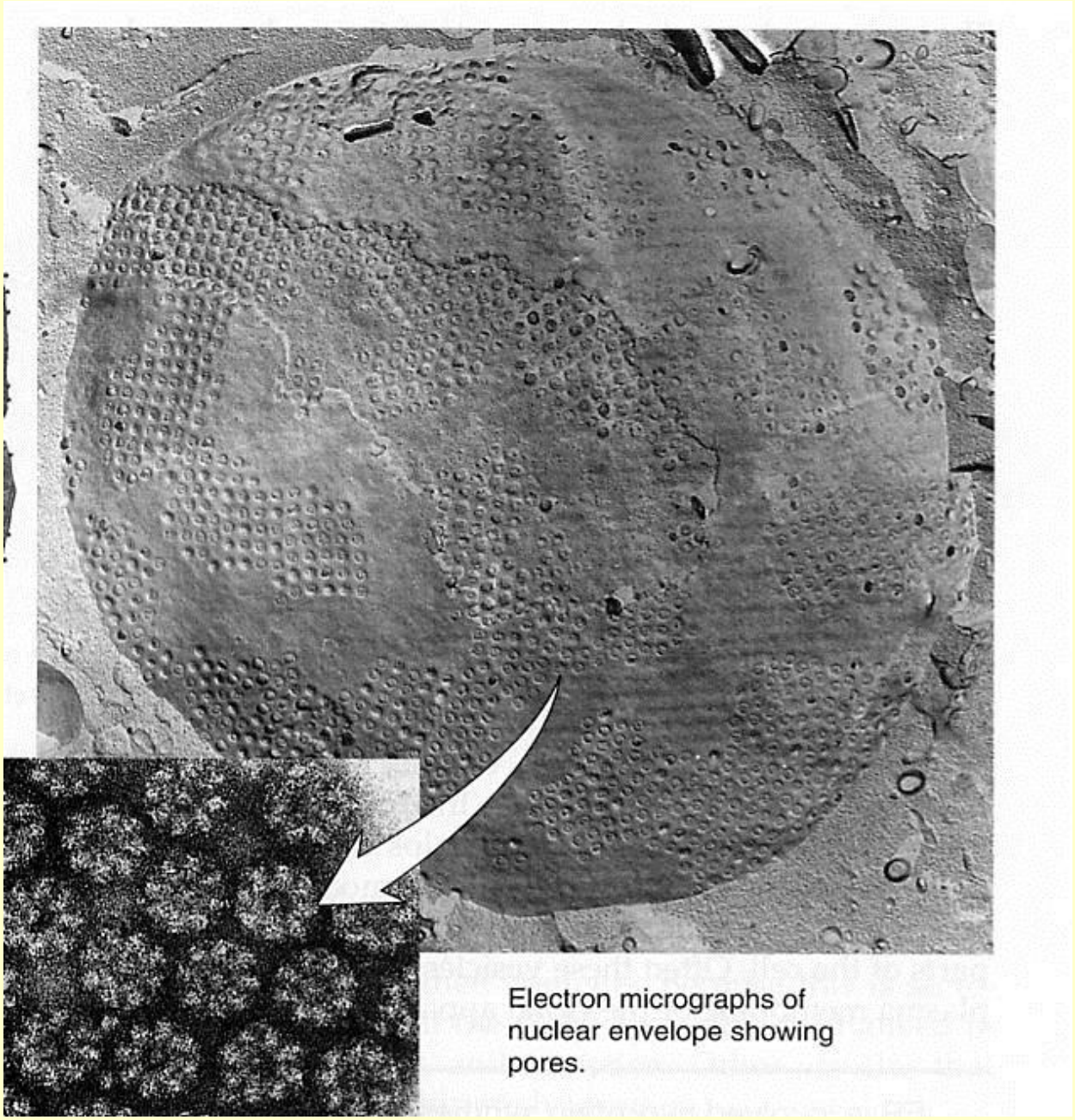
- nerve center of cell
  - chromatin directs activity of cell
- nucleoplasm
  - nucleus' cytoplasm
- nucleolus
  - dense region of nucleus
  - manufactures ribosomal components
- nuclear membrane
  - riddled with pores

Animal Cell — Parts of Nucleus





Anatomy of the Nucleus



Electron micrographs of nuclear envelope showing pores.

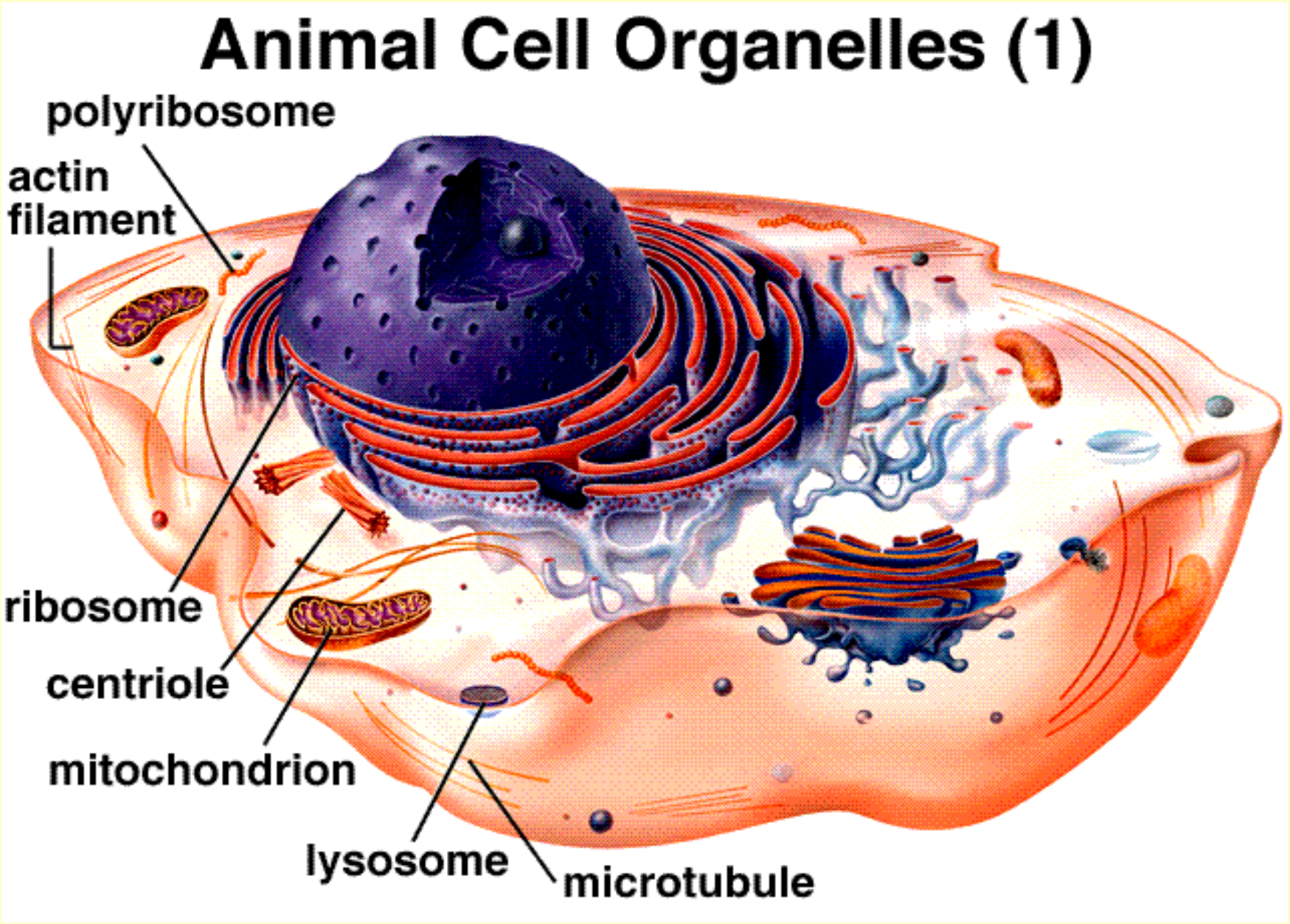
Major parts of cell

- cytoplasm
- plasma membrane
- nucleus
- organelles
- cytoskeleton

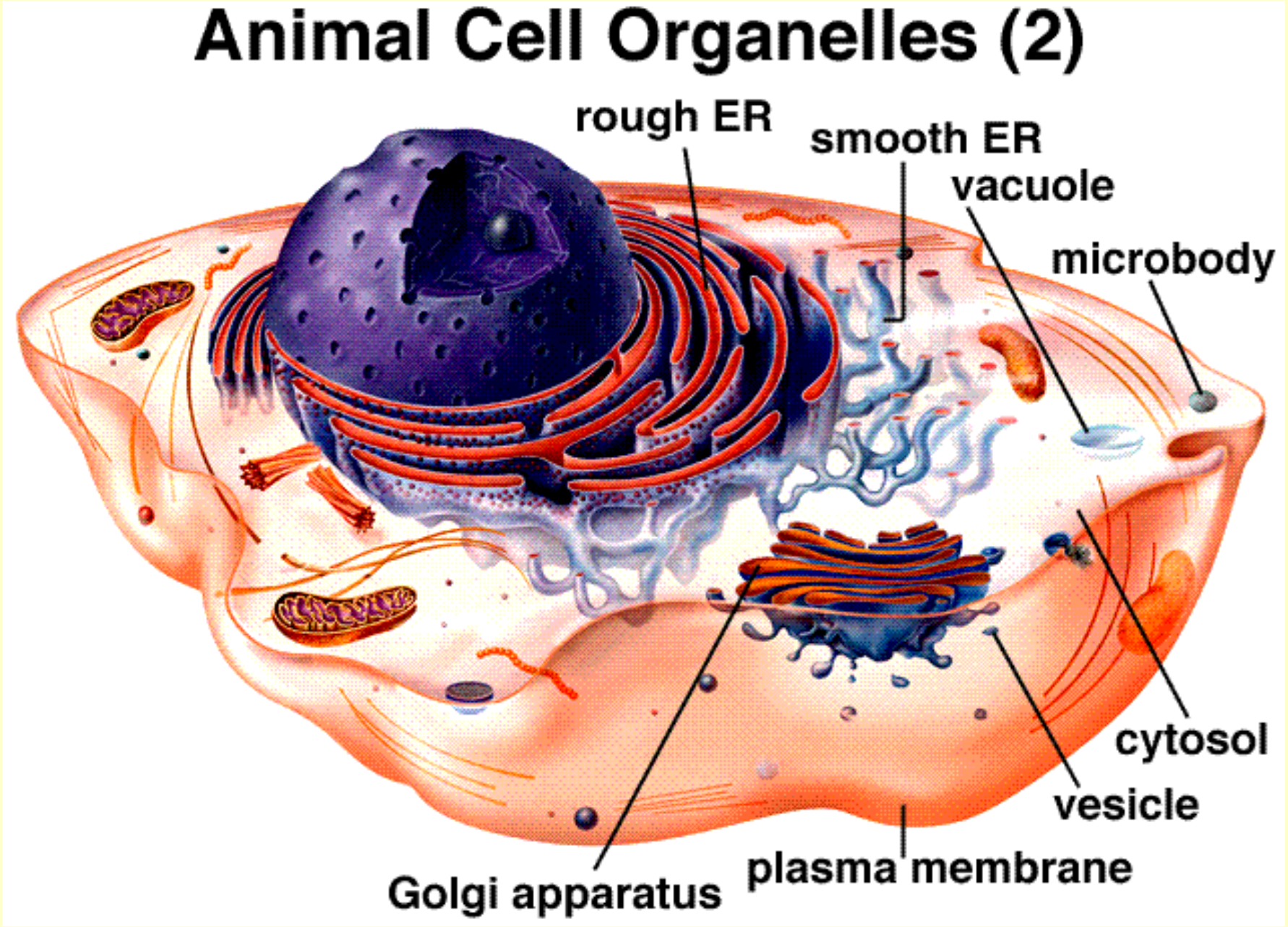
Cell Organelles

- little organs
  - compartmented portions of cell
    - membrane bound
  - many reactions incompatible
- chemical factories
  - many different products
  - many different types
  - 1 to hundreds per cell

Animal Cell Organelles (1)



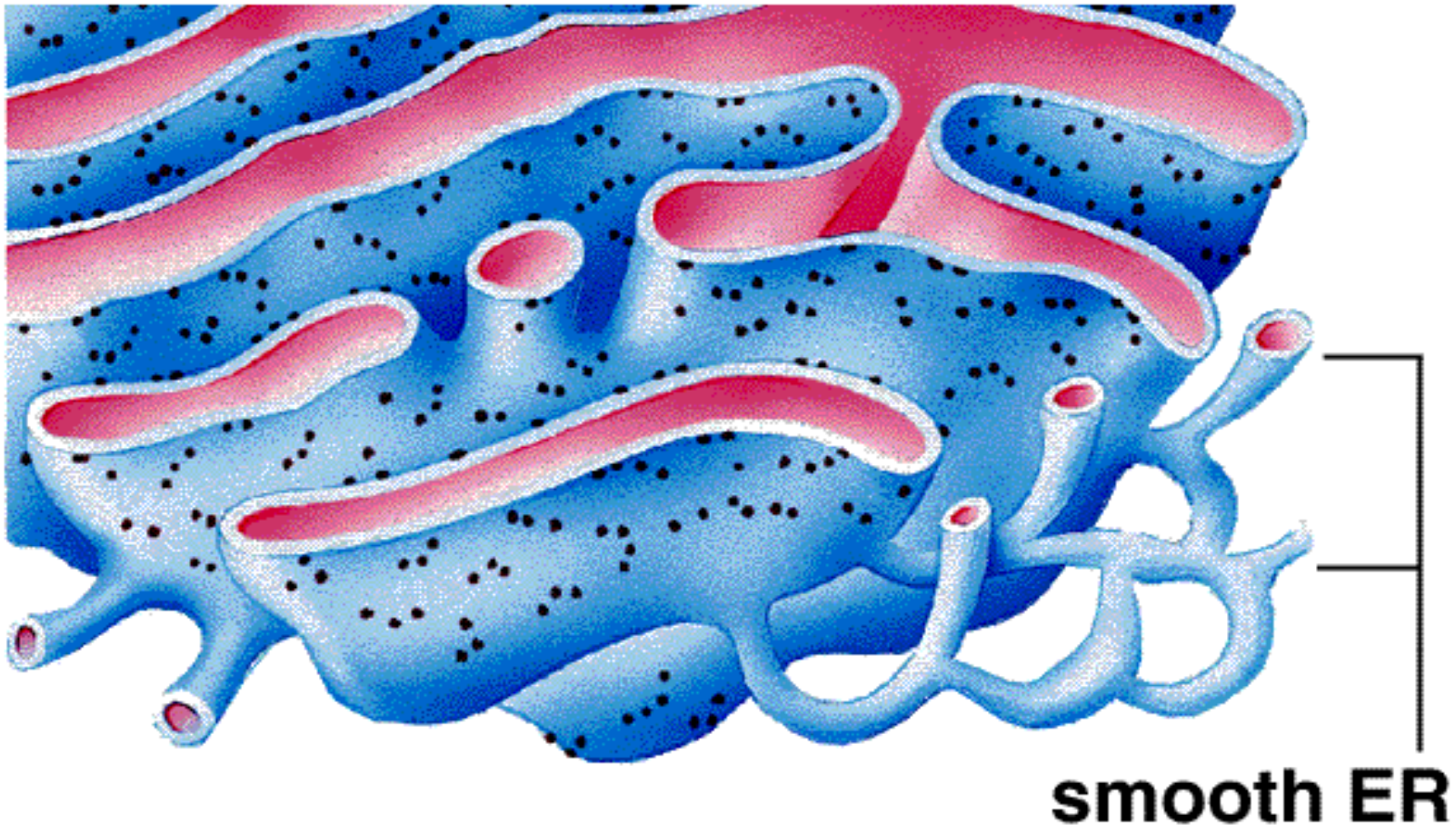
Animal Cell Organelles (2)



Endoplasmic Reticulum

- Within cell network
- Two kinds
  - Rough ER
    - interconnected flattened sacs
    - ribosomes attached
    - protein manufacture
  - Smooth ER
    - interconnected tubules
    - no ribosomes
    - lipid manufacture

Endoplasmic Reticulum

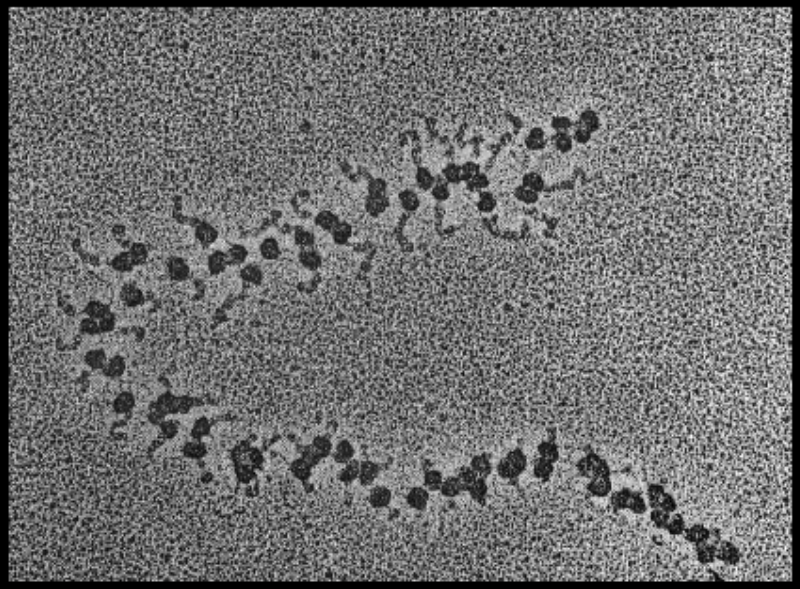


Ribosomes

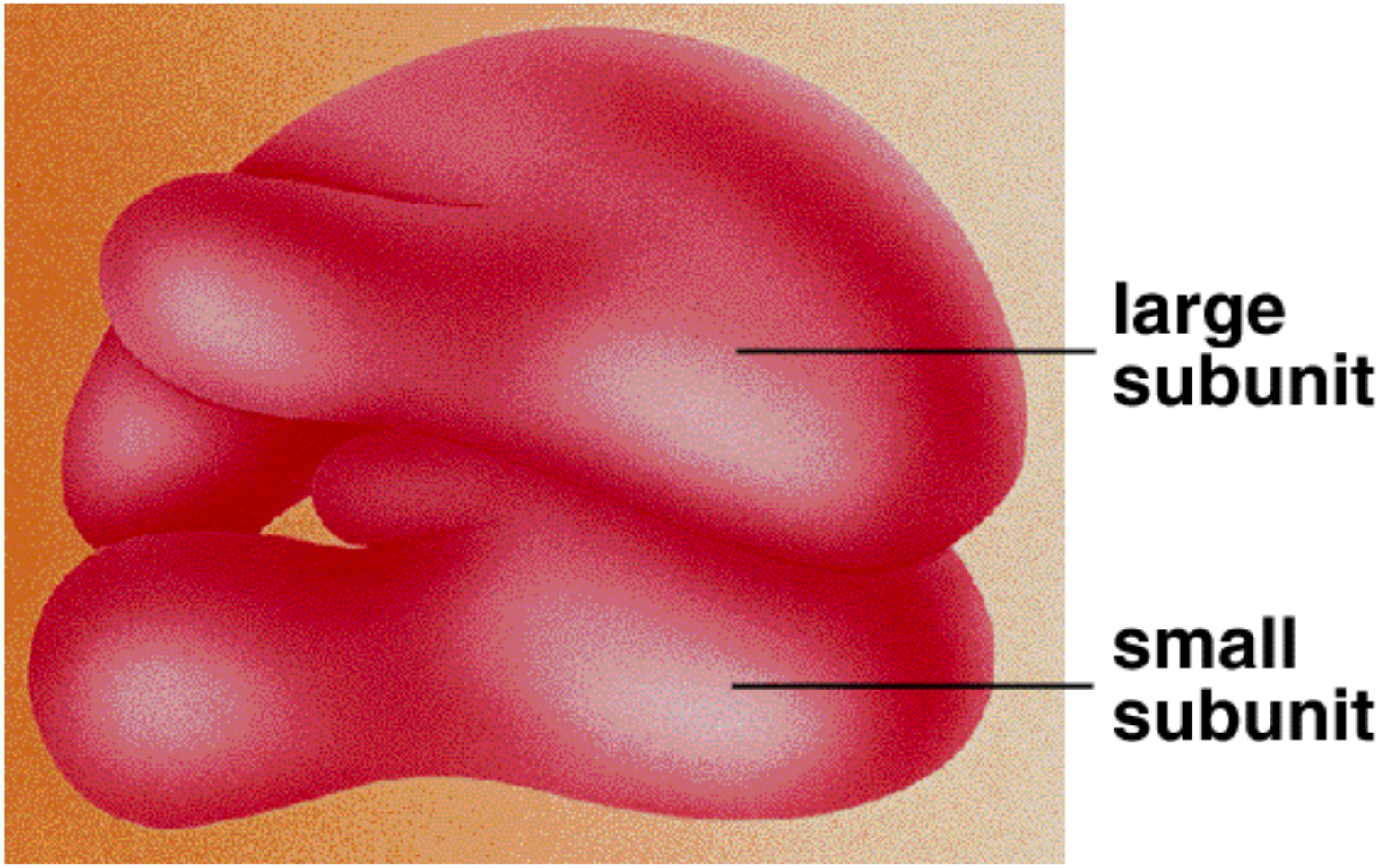
- protein assembly
- manufactured in nucleolus
  - protein and ribosomal RNA (rRNA)
- polyribosomes
  - large number of ribosomes producing identical proteins

Polyribosomes

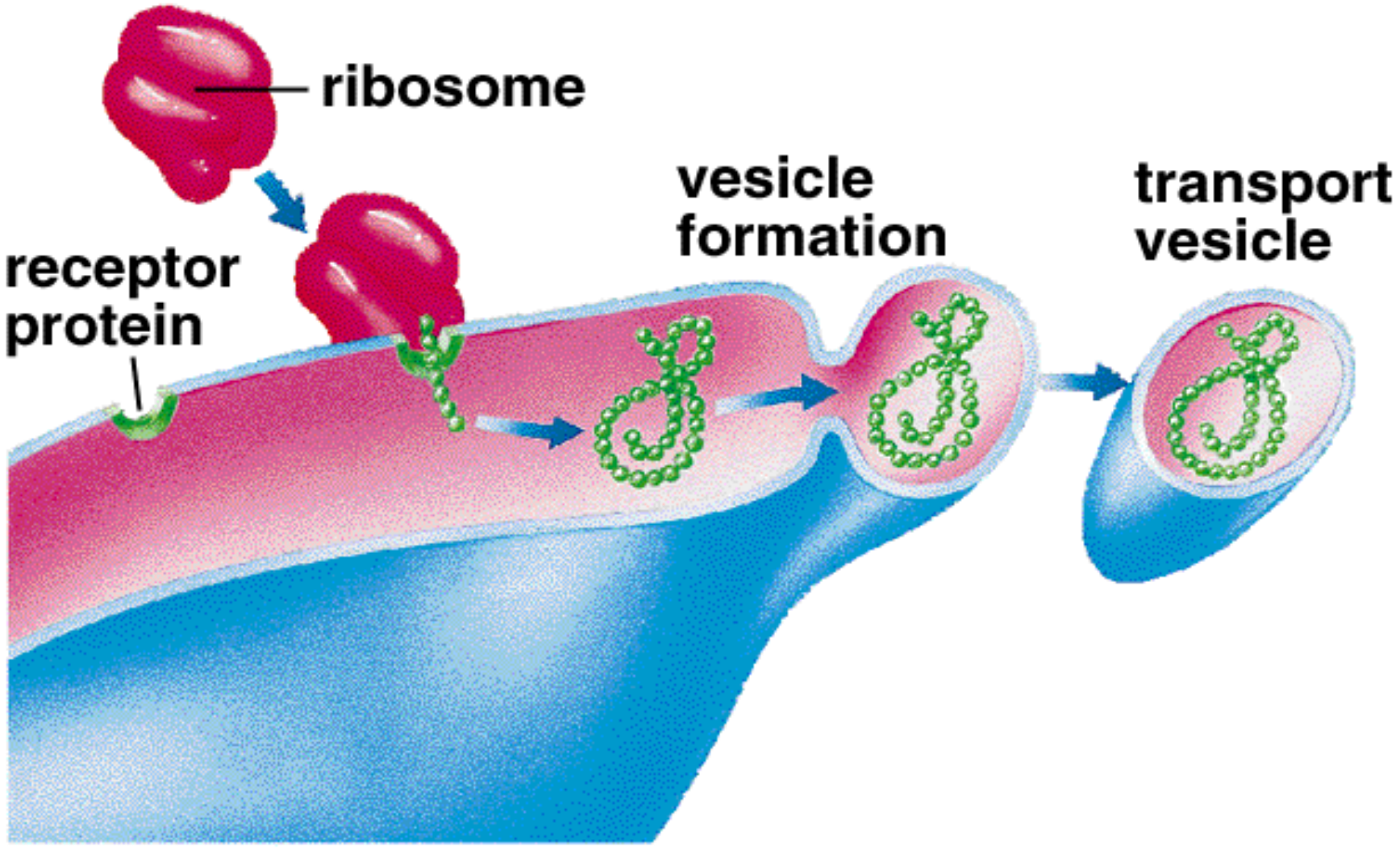
polyribosomes or polysomes are the EM visible granules. they are the many ribosomes bound to a single mRNA.



Endoplasmic Reticulum — Ribosome Structure



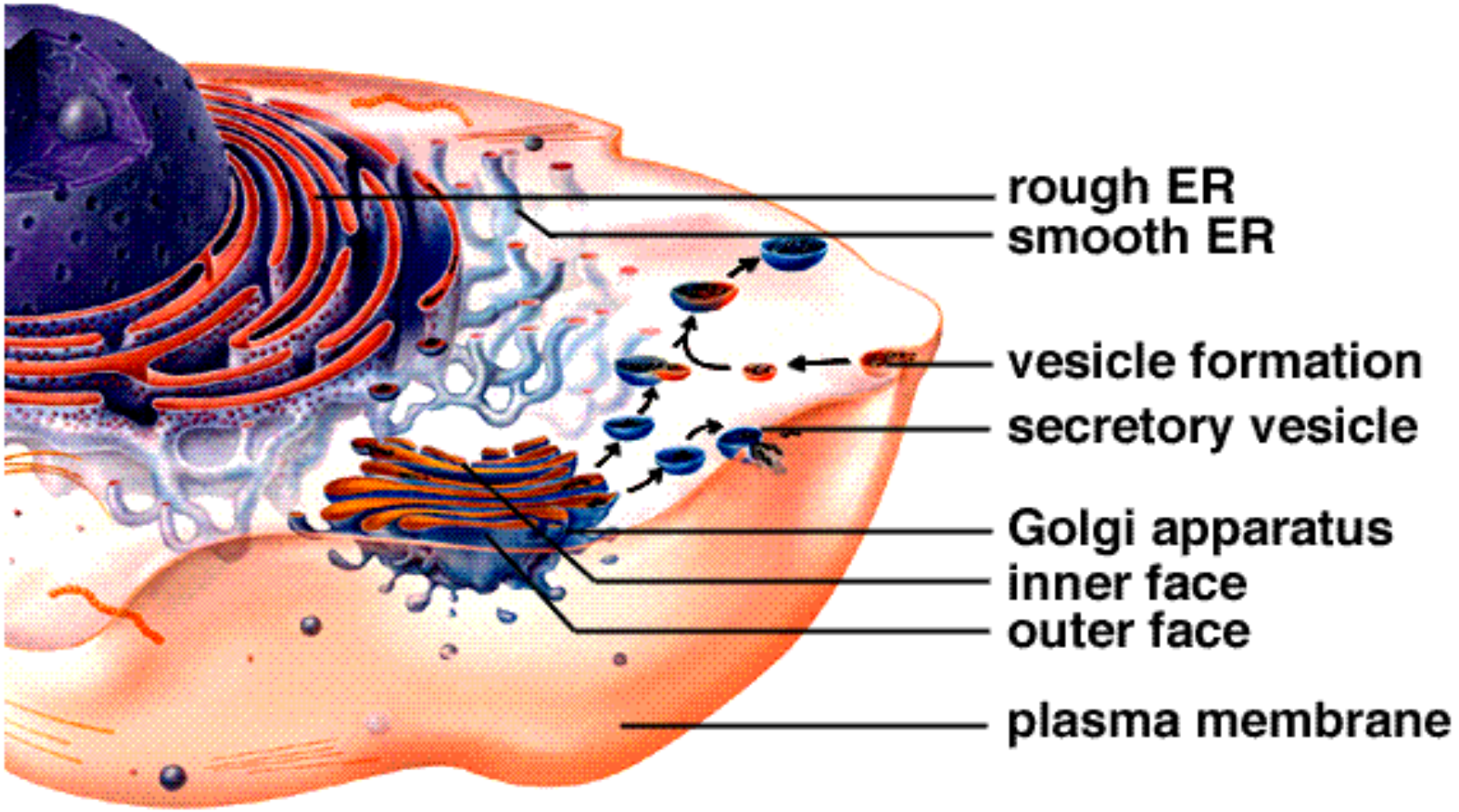
Endoplasmic Reticulum — Transport



Golgi Apparatus

- stack of saccules (3-20)
  - pancakes
- receiving side
  - faces ER
  - protein or lipid filled sacs
- sending side
  - faces plasma membrane
  - vesicles of modified proteins or lipids
  - lysosomes produced here
- packages, modifies and distributes molecules

Golgi Apparatus Function



Lysosomes

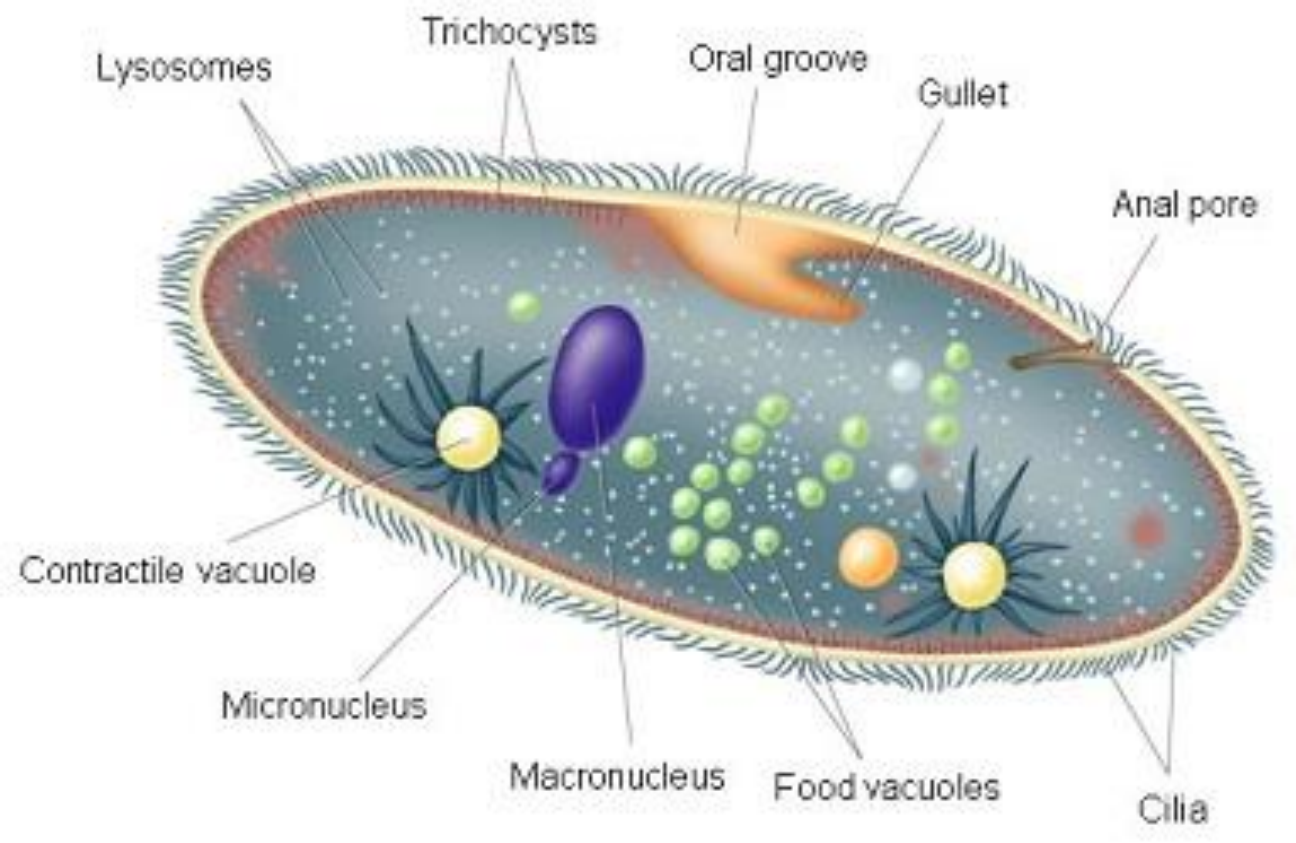
- produced in Golgi
- contain hydrolytic enzymes
  - used to digest particles
- used to destroy cells
  - finger webbing
  - tadpole tail
- Tay Sachs disease
  - unable to digest lipids

Cytoskeleton

- maintains cell shape
- produces cell movement
  - amoeboid motion
  - cilia and flagella
- guides movement of
  - lysosomes
  - chromosomes

Cilia

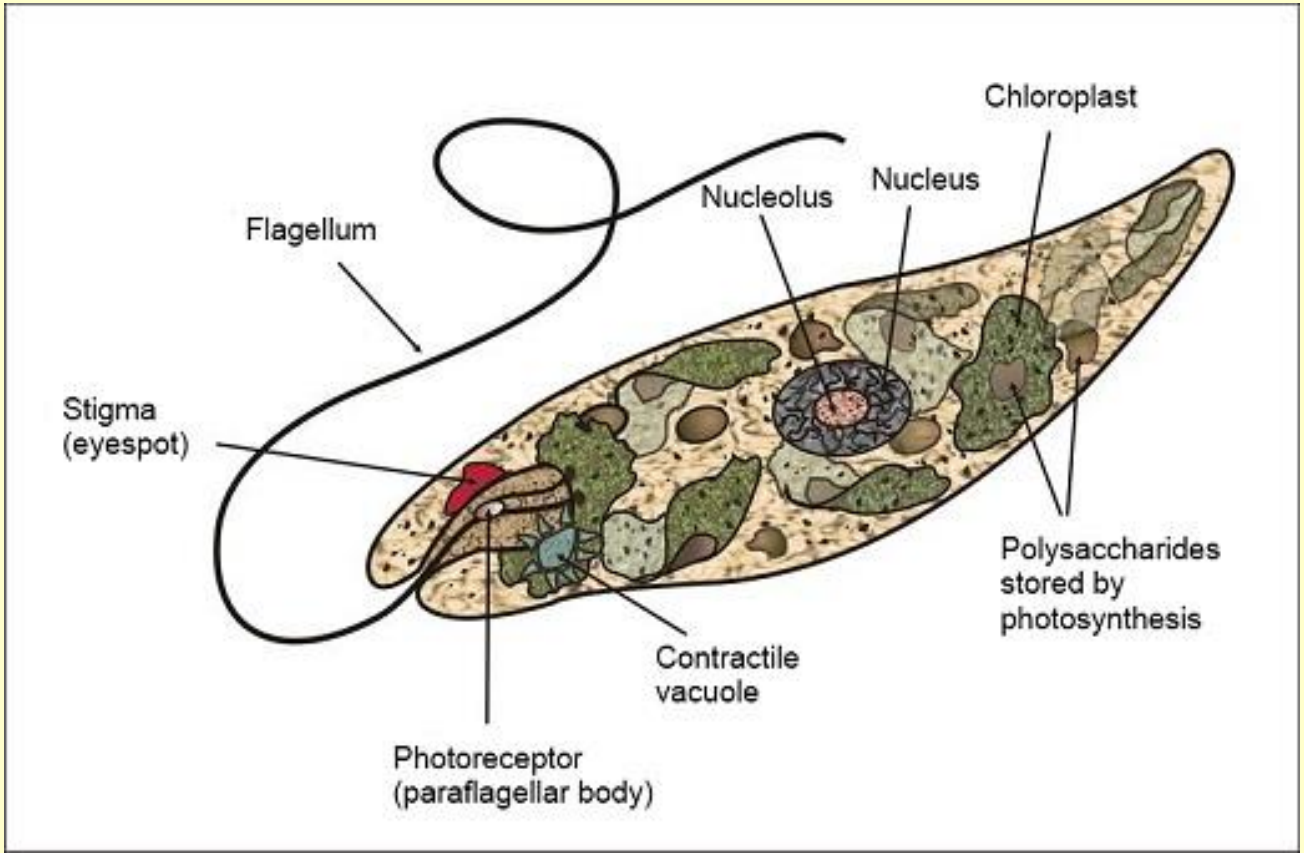
- A Paramecium is covered in hair-like cilia that beat in unison like oars to move the cell through water.



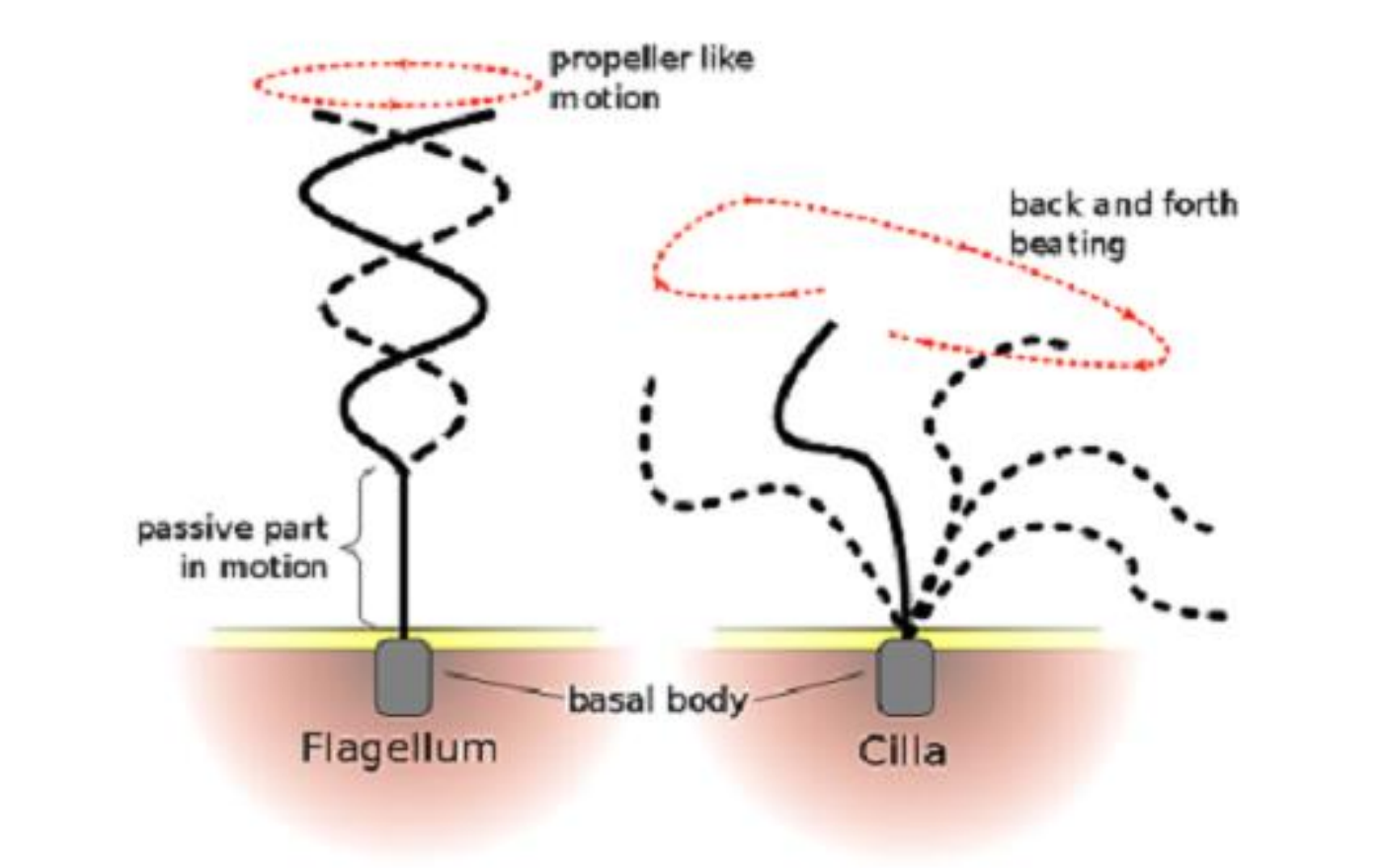
From goldiesroom.org.

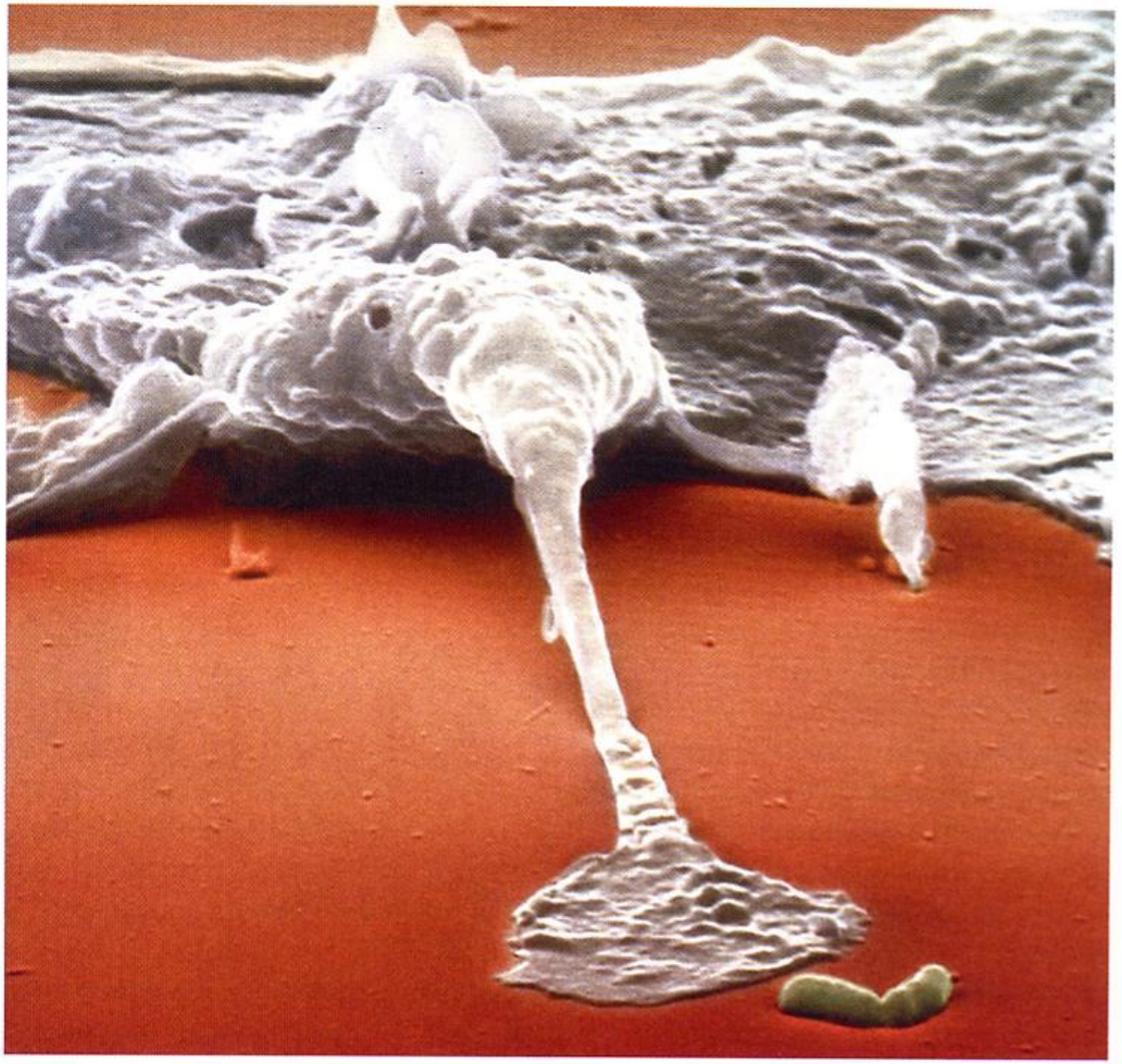
Flagellum

- Euglena is a Eukaryote that possesses a flagellum that allows it to move. Near the flagellum is an eyespot that lets it sense light.



Movement comparison

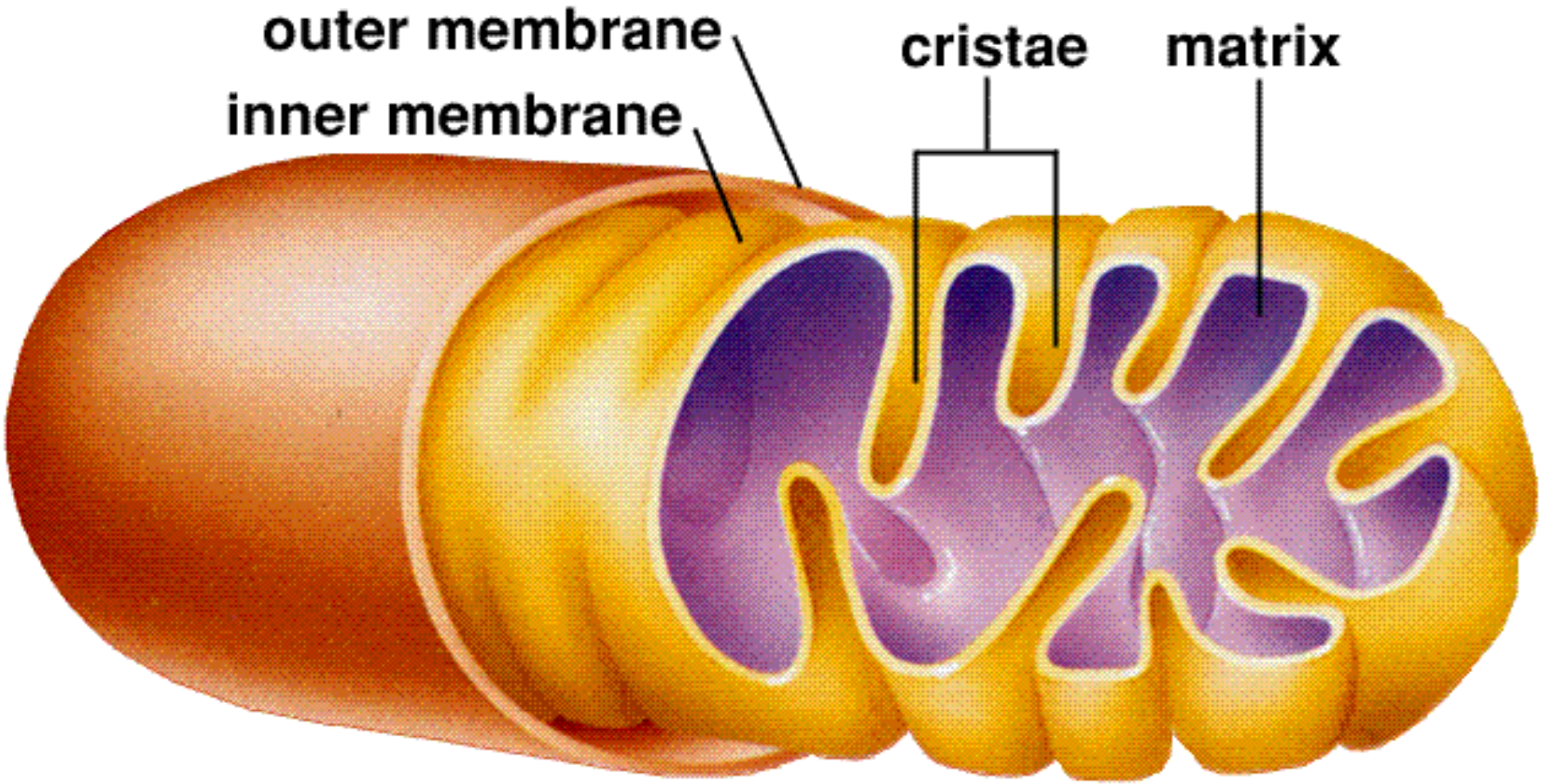


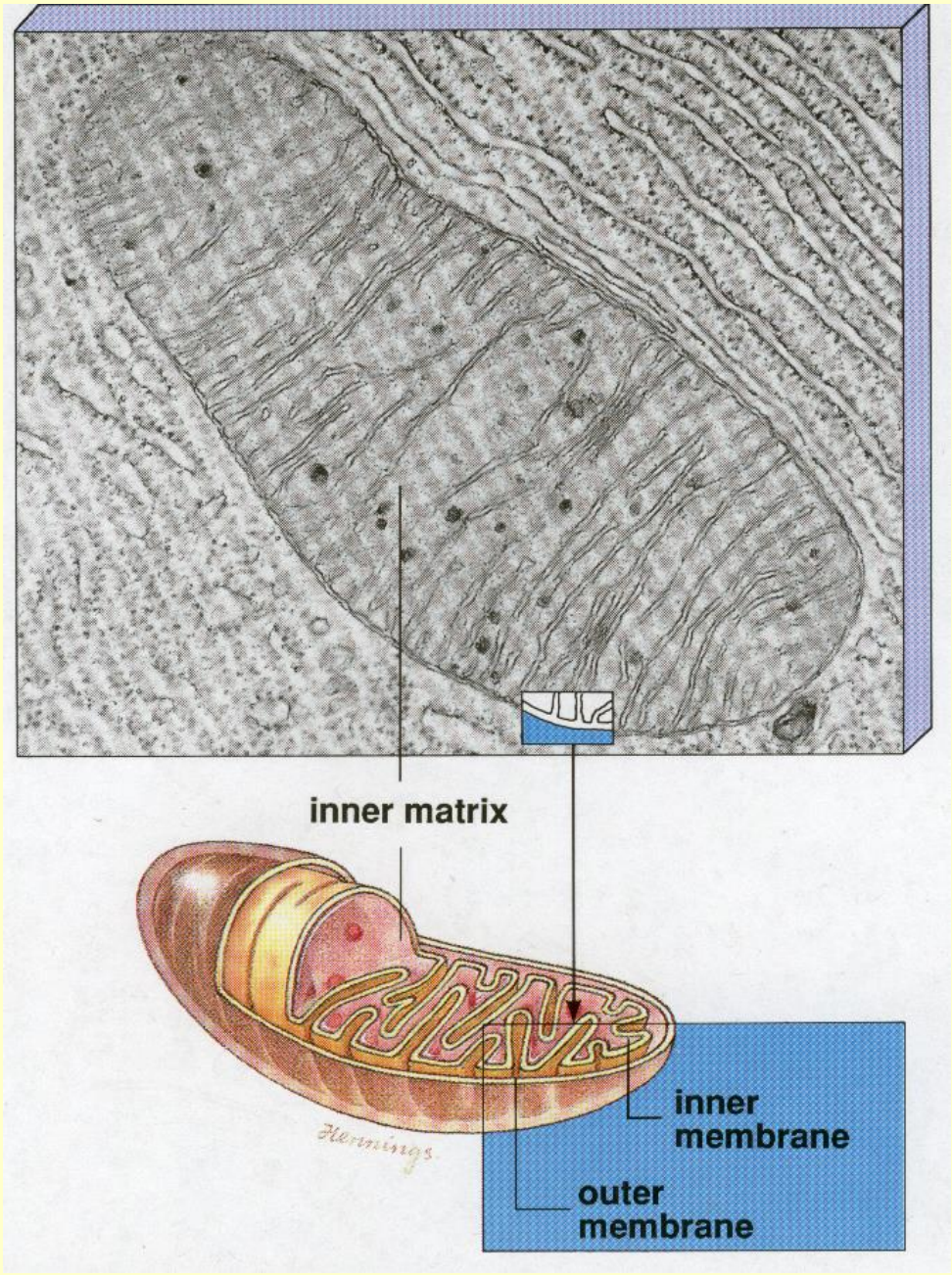


Mitochondria

- powerhouse of the cell
  - converts food energy into ATP energy (Cellular Respiration: glucose + oxygen
- double membrane
  - intermembrane space
  - matrix
- folds called cristae
  - increase surface area available for energy production

Mitochondrion Structure

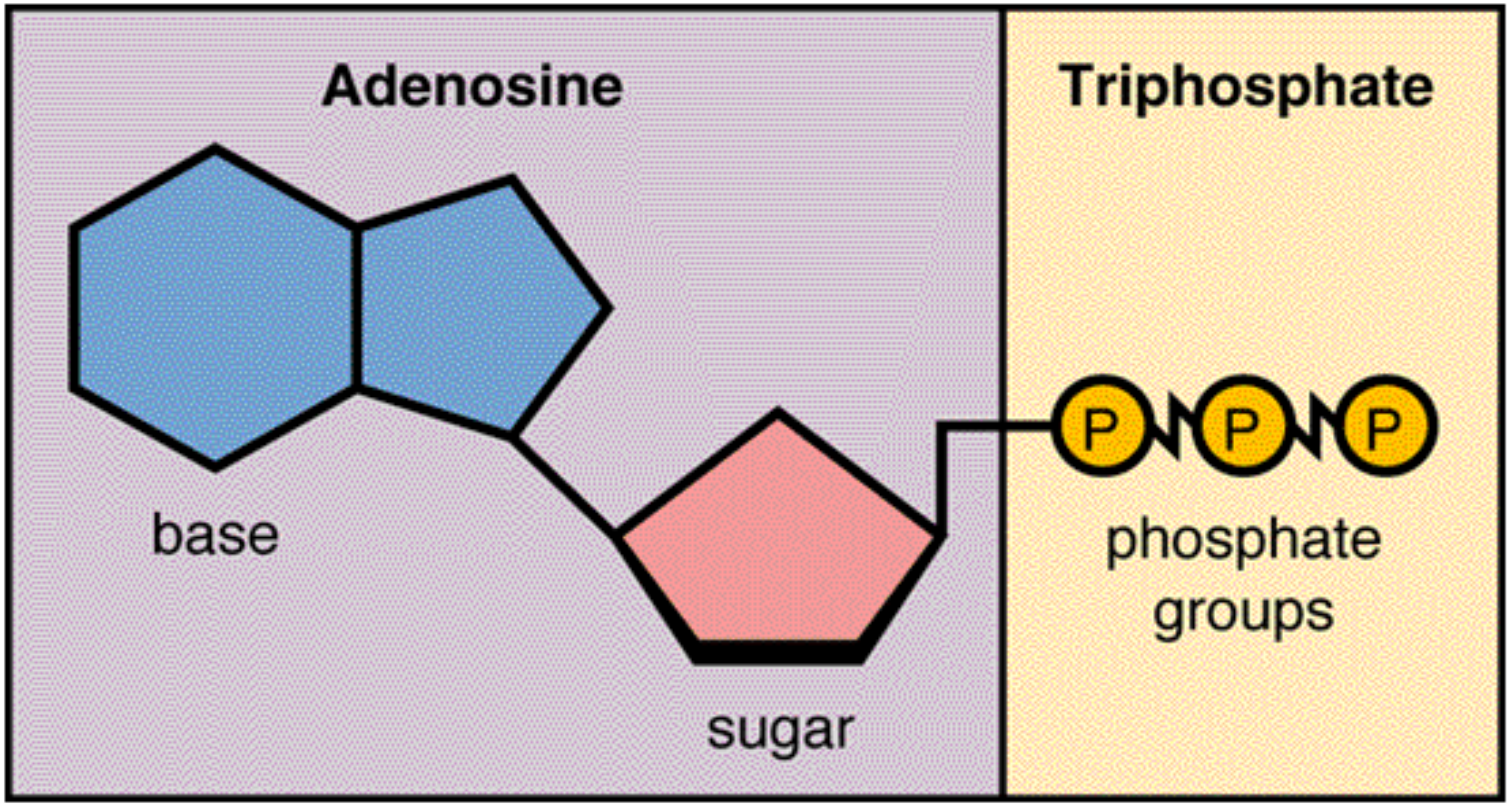



inner matrix
inner membrane
outer membrane

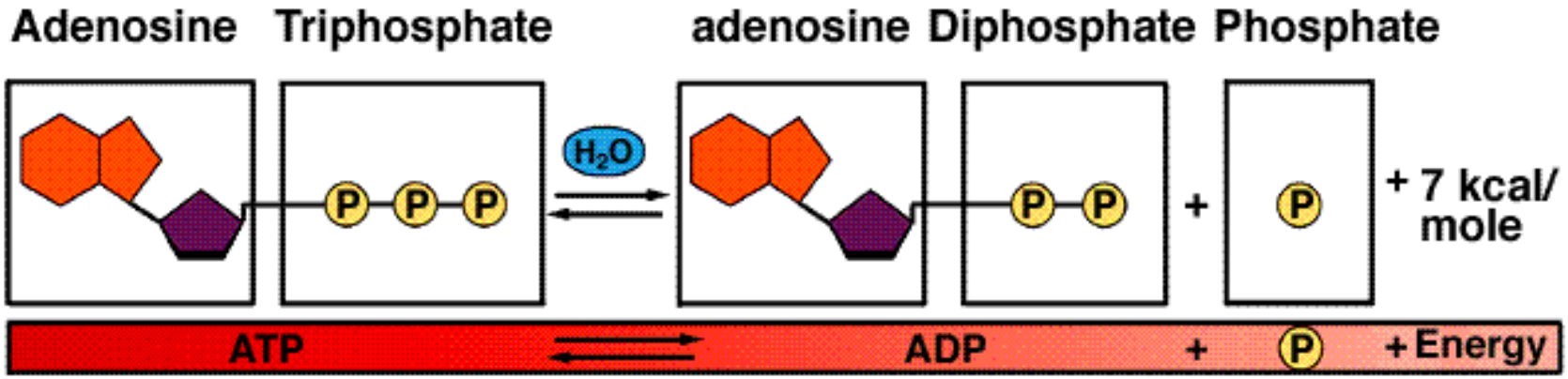
Cellular Respiration

- glucose + O_2 ---> H_2O + CO_2
- ATP = energy currency of cell
- A ---> B ---> C ---> D
  - raw material (A)
  - intermediates (B, C)
  - product (D)
- enzymes speed reactions
  - proteins

ATP Structure



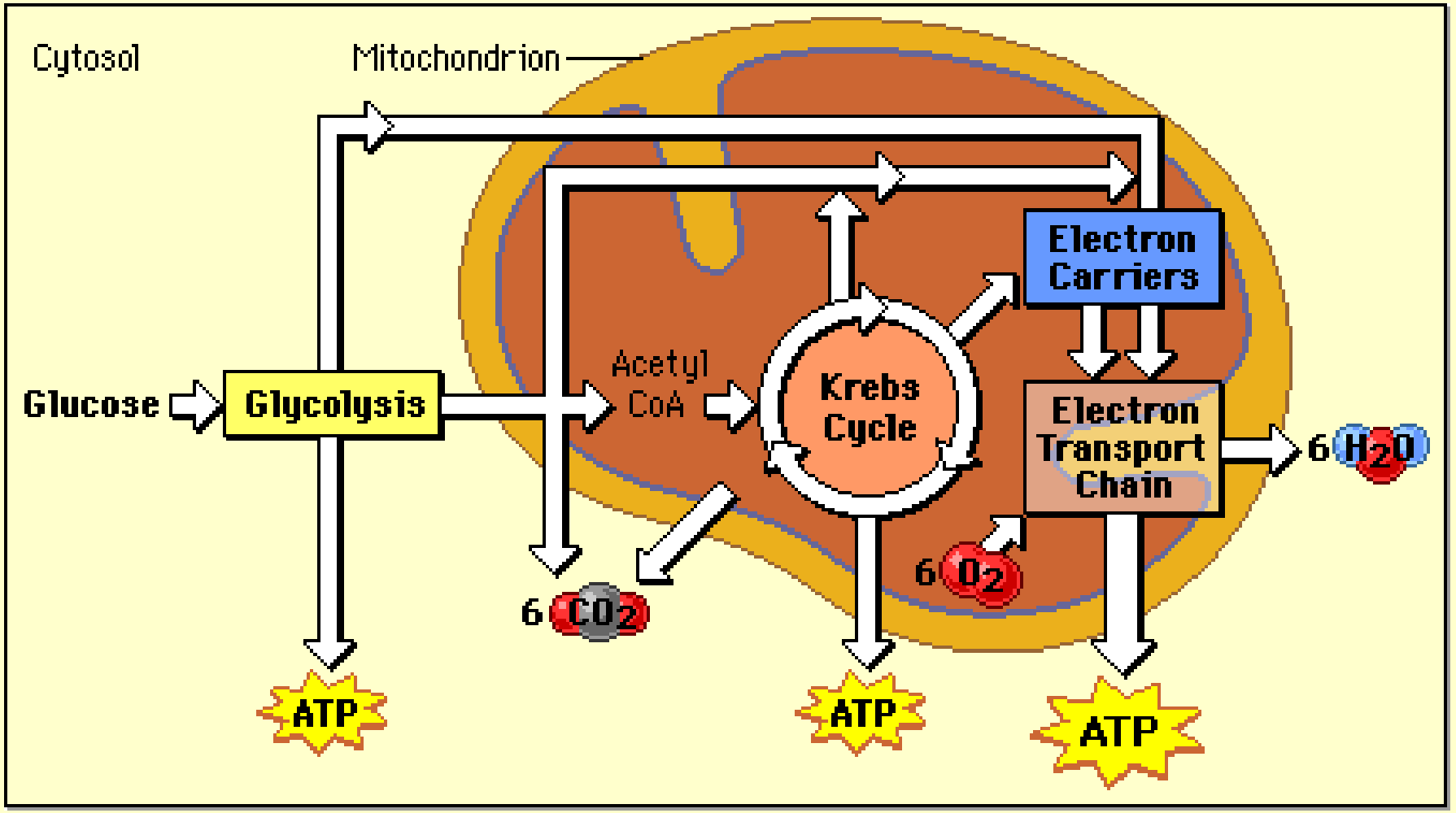
ATP Reaction



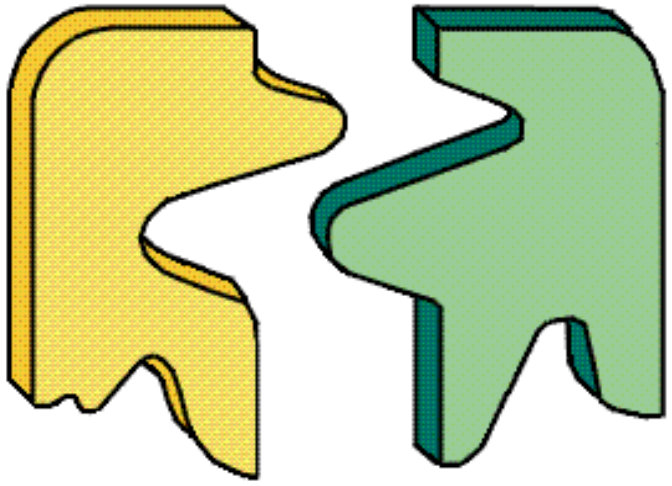
Cellular Respiration

- glucose + O_2 ---> H_2O + CO_2
- produces ATP
  - energy currency of cell

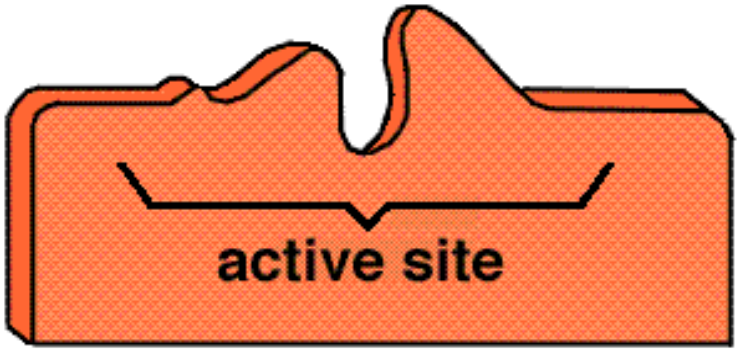
Cellular Respiration Overview



Enzyme Action (Stage 1)

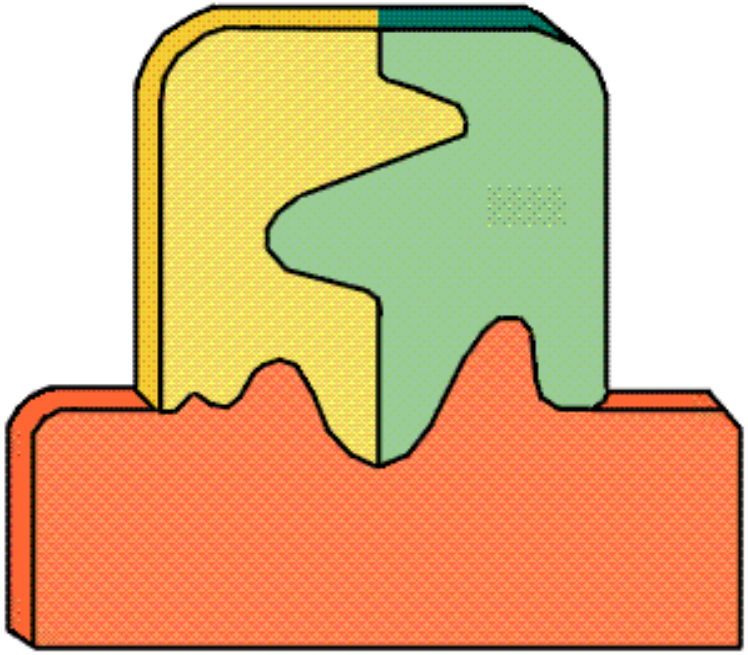


substrates (S)



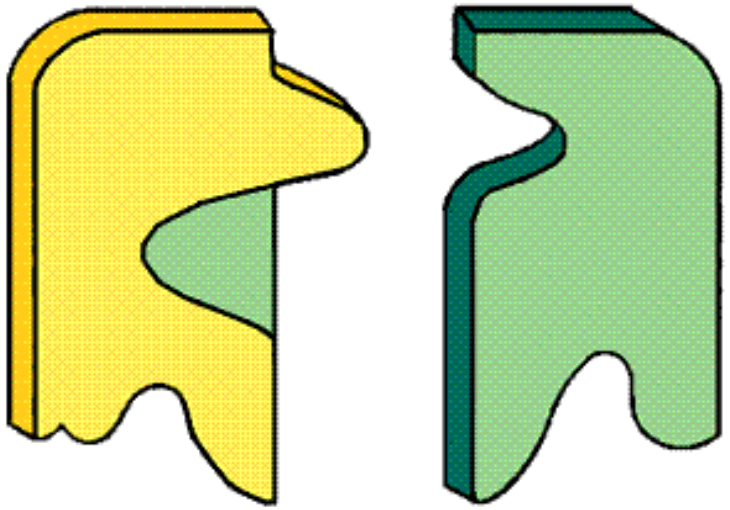
enzyme (E)

Enzyme Action (Stage 2)

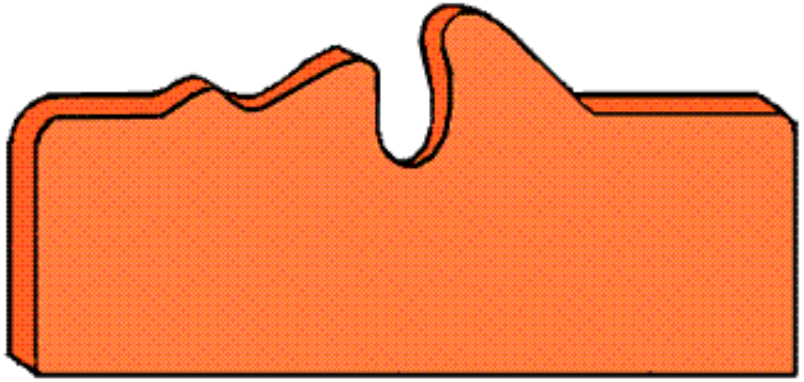


enzyme-substrate complex (ES)

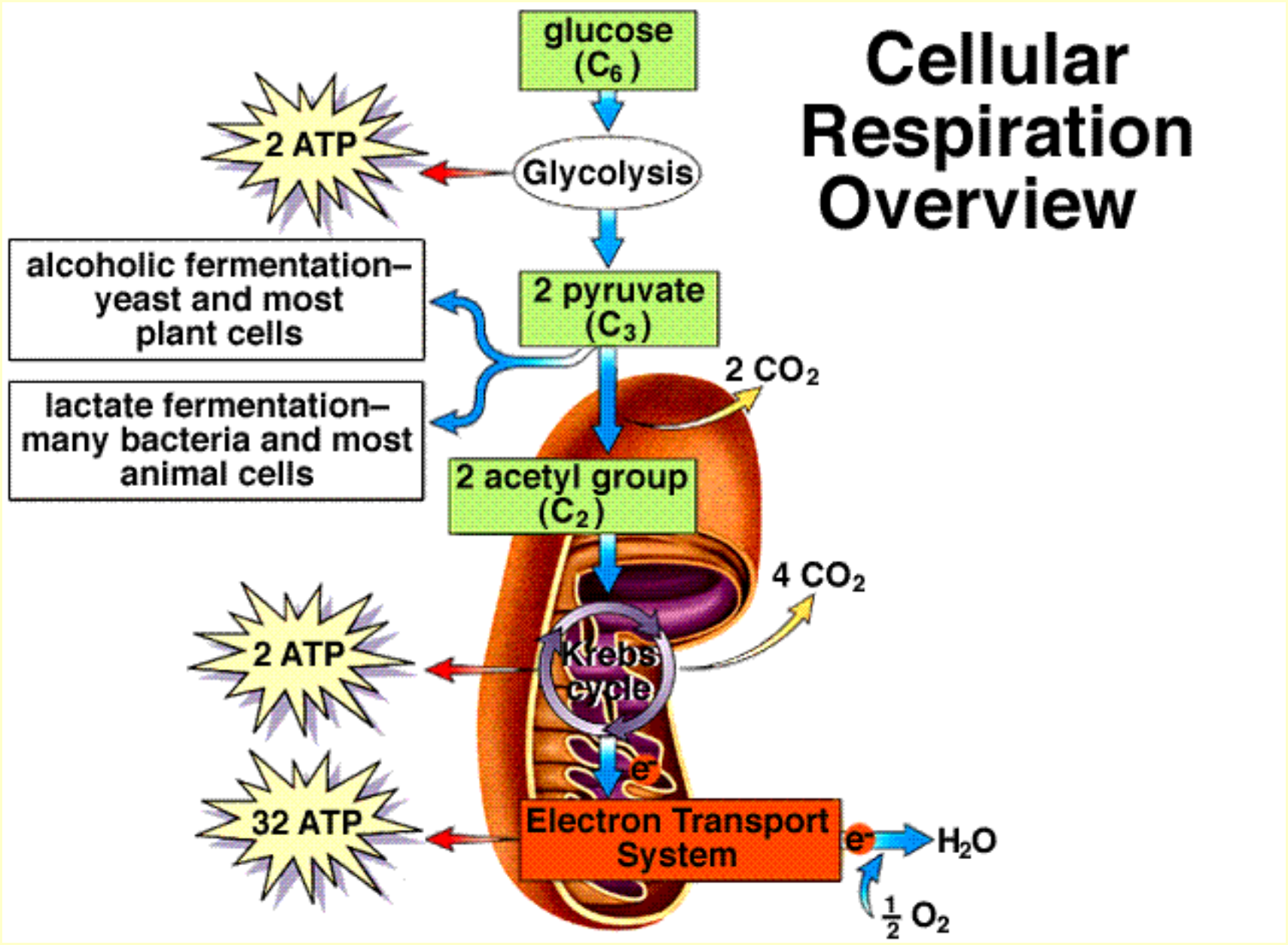
Enzyme Action (Stage 3)



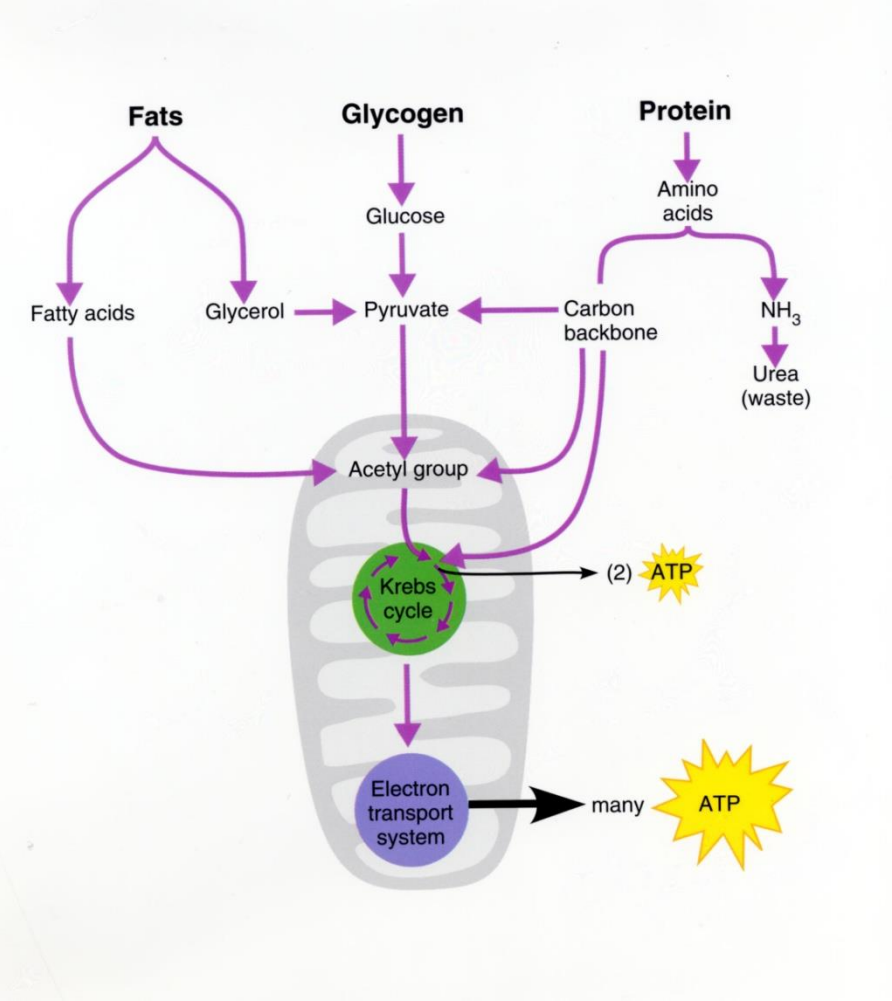
products (P)



enzyme (E)


Cellular Respiration Overview
glucose (C_6)
2 ATP
Glycolysis
alcoholic fermentation– yeast and most plant cells
lactate fermentation– many bacteria and most animal cells
2 pyruvate (C_3)
2 CO_2
2 acetyl group (C_2)
4 CO_2
2 ATP
Krebs cycle
e^-
32 ATP
Electron Transport System
e^-
H_2O
$\frac{1}{2}$ O_2

metabolic pathways



The End