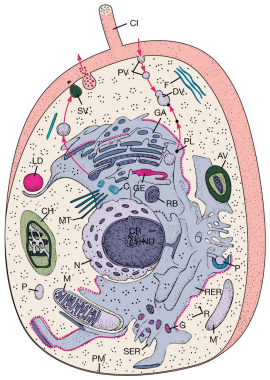
Chapter 4

Eucaryotic Cell Structure and Function

An Overview of Eucaryotic Cell Structure

- ✓ membrane-delimited nuclei
- ✓ membrane-bound organelles that perform specific functions
- ✓ more structurally complex than procaryotic cell
- ✓ generally larger than procaryotic cell

Eukaryotic cell



Plasma membrane

- ✓ Regulation of movement of materials in and out of the cell
- ✓ Receives and translates chemical and environmental signals from outside of the cell

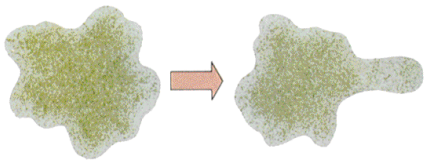
The Cytoplasmic Matrix, Microfilaments, Intermediate Filaments, and Microtubules

- ✓ cytoplasmic matrix
  - ✒ provides complex environment required for cellular activities
- ✓ cytoskeleton
  - ✒ network of microfilaments (4-7 nm), microtubules (25 nm), and intermediate filaments (8-10 nm)
  - ✒ plays role in both cell shape and cell movement

Cytoskeleton

- ✓ Comprised of 3 types of protein filaments.
  - ✒ Microtubules
  - ✒ Actin filaments (microfilaments)
  - ✒ Intermediate filaments

Amoeboid movement

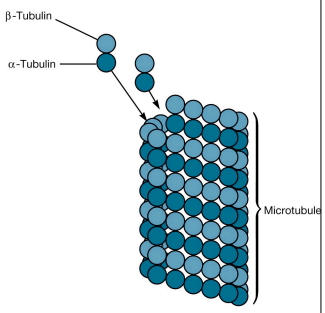


Resting amoeba with cytoplasm distributed evenly

Newly formed pseudopodium with less dense cytoplasm

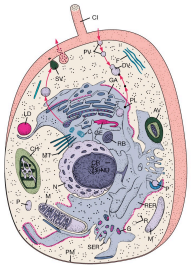
Microtubules

- ✓ hollow cylinders
- ✓ composed of tubulins
- ✓ participate in intracellular transport of substances
- ✓ involved in organelle movement



The Endoplasmic Reticulum

- ✓ irregular network of branching and fusing membranous tubules and flattened sacs (cisternae – s., cisterna)



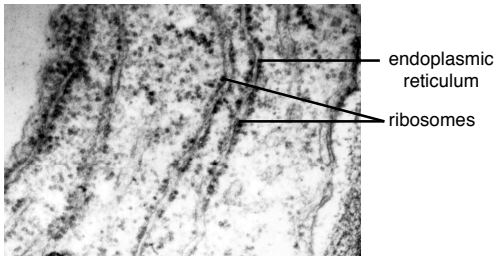
Two types of endoplasmic reticulum (ER)

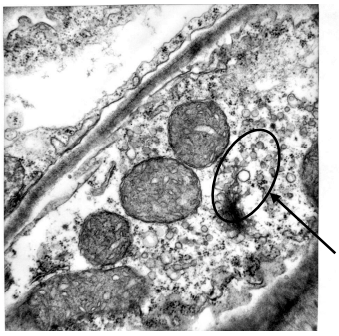
- ✓ rough (granular) ER
  - ✒ ribosomes attached
  - ✒ synthesis of secreted proteins by ER-associated ribosomes
- ✓ smooth (agranular) ER
  - ✒ devoid of ribosomes
  - ✒ synthesis of lipids by ER-associated enzymes

Functions of ER

- ✓ transports proteins, lipids, and other materials within cell
- ✓ major site of cell membrane synthesis
- ✓ synthesis of lysosomes

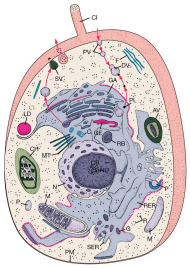
Rough ER



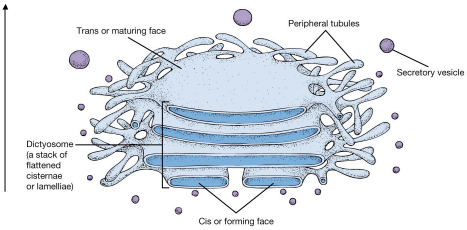


The Golgi Apparatus

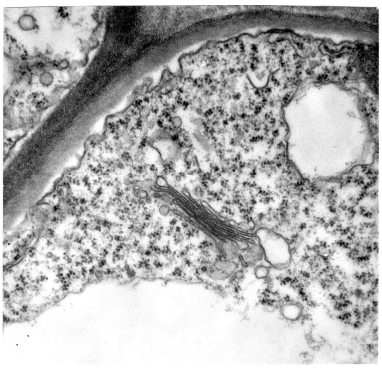
- ✓ membranous organelle made of cisternae stacked on each other
- ✓ dictyosomes
  - ✒ stacks of cisternae
- ✓ involved in modification, packaging, and secretion of materials



movement of materials



cis face associated with ER



Golgi complex

19,000×
enlarged 2×

Lysosomes and Endocytosis

- ✓ lysosomes
  - ✒ membrane-bound vesicles
  - ✒ contain hydrolytic enzymes needed for digestion of macromolecules
- ✓ endocytosis
  - ✒ uptake of solutes or particles by enclosing them in vesicles or vacuoles pinched off from the plasma membrane

Two types of endocytosis

- ✓ phagocytosis
  - ✒ uptake of large particles
  - ✒ phagosome (phagocytic vacuole)– vacuole containing engulfed particles
- ✓ pinocytosis
  - ✒ uptake of small amounts of liquid with its solute molecules
  - ✒ pinosome (pinocytotic vesicle) – vesicle containing engulfed liquid with its solutes
- ✓ endosomes
  - ✒ collective term for phagosomes and pinosomes

Lysosome function

- ✓ acquisition of nutrients
- ✓ host defenses
  - ✒ e.g., destruction of bacteria by white blood cells

The process

- ✓ primary lysosomes
  - ✒ newly formed lysosomes
  - ✒ fuse with phagosomes, pinosomes, and other vesicles

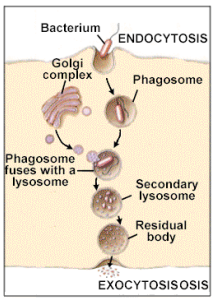
The process…

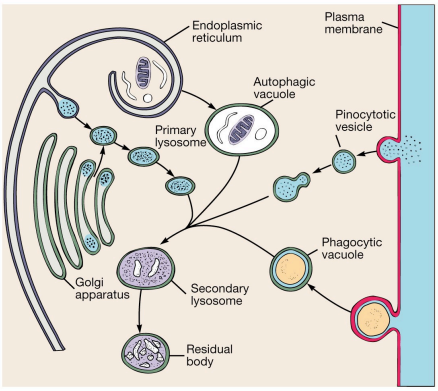
- ✓ secondary lysosomes
  - ✒ formed by fusion of primary lysosomes with endosomes
  - ✒ autophagic vacuoles
    - ☞ secondary lysosomes that selectively digest portions of cell's own cytoplasm

The process…

- ✓ residual bodies
  - ✒ lysosomes that have accumulated large quantities of indigestible material

Endocytosis and exocytosis

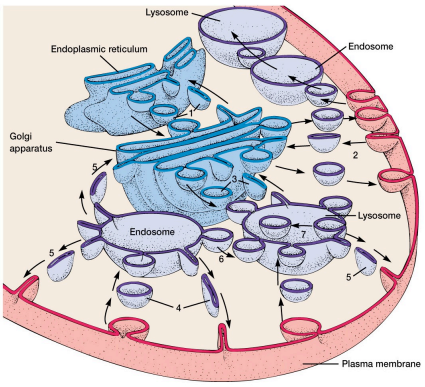




The vacuome

✓a functional unit composed of the Golgi, lysosomes, endosomes, and associated structures

- ✒materials outside cell flow in via endosomes and then flow from one component of vacuome to another
- ✒materials inside cell flow from one component to another and can flow out via secretory vesicles

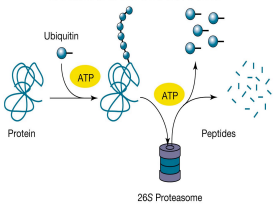


Proteasomes

✓nonlysosomal protein degradation system

✓observed in eucaryotes, some bacteria, and many archaea

✓involved in antigen presentation

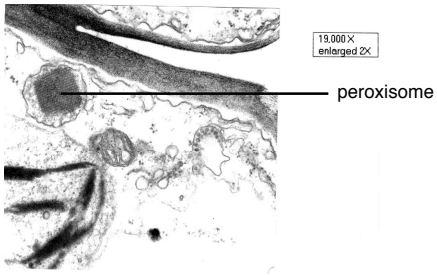


Function of peroxisomes

✓Contain degradative enzymes that use oxygen.

✓Contain the protective enzyme, catalase.

Peroxisomes

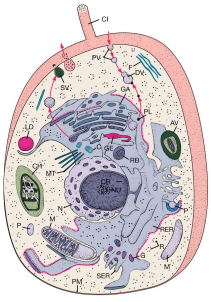


Eucaryotic Ribosomes

✓80S in size

- ✒60S + 40S subunits

✓may be attached to ER or free in cytoplasm

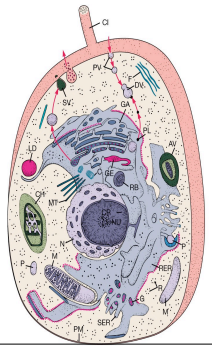


Eucaryotic ribosomes…

- ✓ ER-associated ribosomes
  - ✒ synthesize integral membrane proteins
  - ✒ synthesize proteins that are secreted
- ✓ free ribosomes
  - ✒ synthesize nonsecretory proteins and nonmembrane proteins
- ✓ polyribosomes (polysomes)
  - ✒ complexes of mRNA with numerous ribosomes

Function of the mitochondria

- ✓ site of tricarboxylic acid cycle activity or Kreb's cycle
- ✓ site where ATP is generated by electron transport and oxidative phosphorylation

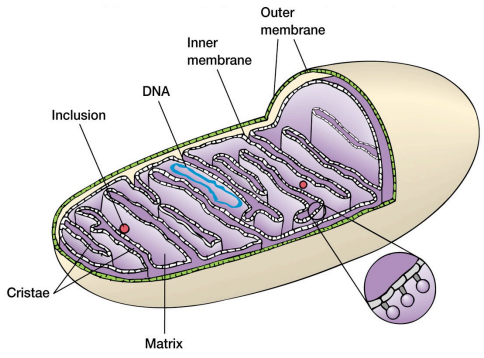


Mitochondrial structure

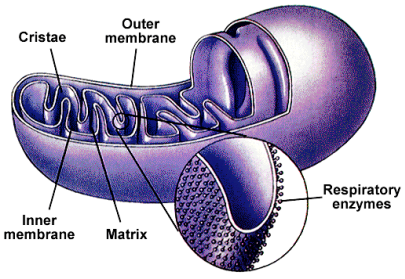
- ✓ outer membrane
- ✓ inner membrane
  - ✒ highly folded to form cristae (s., crista)
  - ✒ location of enzymes and electron carriers for electron transport and oxidative phosphorylation
    - ☞ F_1 particles = ATP synthase

Mitochondrial structure…

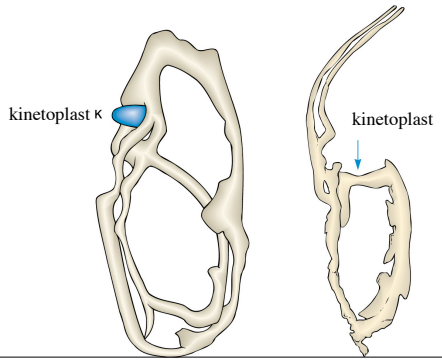
- ✓ matrix
  - ✒ contains ribosomes, mitochondrial DNA, and large calcium phosphate granules
  - ✒ contains enzymes of the tricarboxylic acid cycle and the ß-oxidation pathway for fatty acids



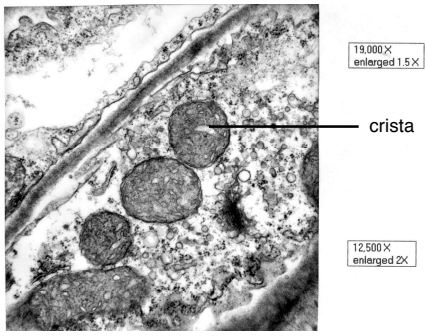
Mitochondria



Trypanosome Mitochondria

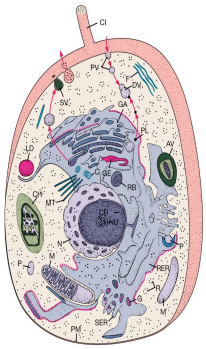


Mitochondria



Function of the chloroplast

- ✓ type of plastid
  - ✒ pigment-containing organelles observed in plants and algae
- ✓ site of photosynthetic reactions
  - ✒ Light capture in the thylakoid membranes of the grana.
  - ✒ Carbon fixation (forming carbohydrates) occurs in the stroma.

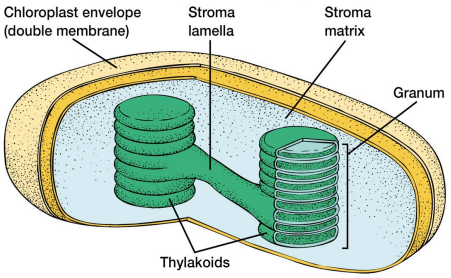


Chloroplast structure

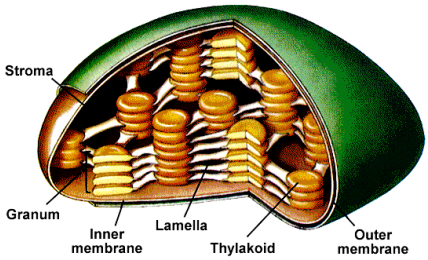
- ✓ double membrane system encompasses chloroplast
- ✓ stroma
  - ✒ contains DNA, ribosomes, lipid droplets, starch granules, and thylakoids
  - ✒ site of dark reactions of photosynthesis (formation of carbohydrates from water and carbon dioxide)

Chloroplast structure…

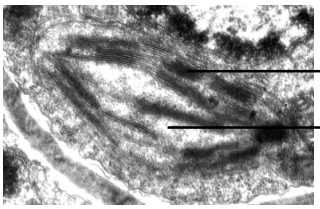
- ✓ thylakoids
  - ✒ flattened, membrane-delimited sacs
    - ☞ grana (s., granum) – stacks of thylakoids
  - ✒ site of light reactions (trapping of light energy to generate ATP, NADPH, and oxygen)
- ✓ pyrenoid
  - ✒ participates in polysaccharide synthesis



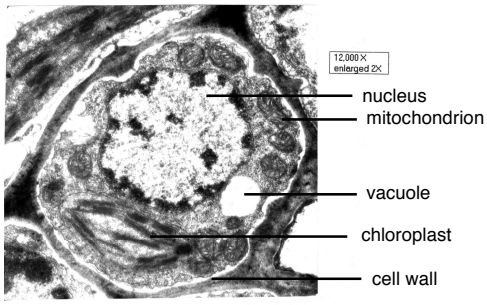
Chloroplast



Chloroplast

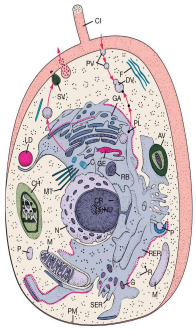


Plant Cell



The Nucleus and Cell Division

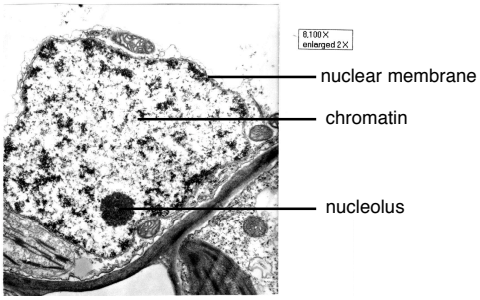
✓ nucleus
- membrane-bound structure that houses genetic material of cell



Nuclear structure

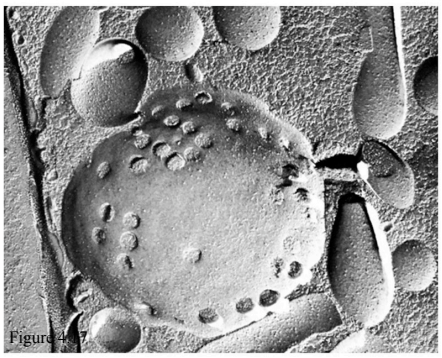
✓ chromatin
- dense fibrous material within nucleus
- contains DNA
- condenses to form chromosomes during cell division

Nucleus

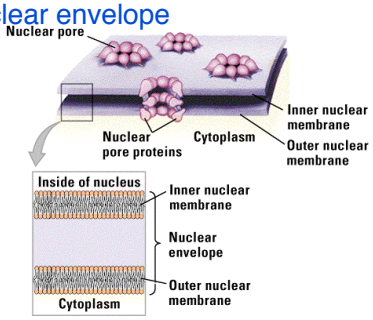


Nuclear structure…

- ✓nuclear envelope
  - ✒double membrane structure that delimits nucleus
  - ✒penetrated by nuclear pores
    - ☞pores allow materials to be transported into or out of nucleus



Nuclear envelope

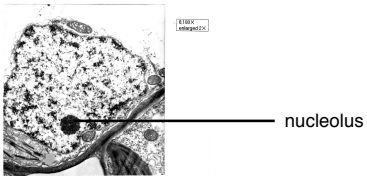


The Nucleolus

- ✓≥ 1 nucleolus/nucleus
- ✓Not membrane enclosed
- ✓Important in ribosome synthesis
  - ✒directs synthesis and processing of rRNA
  - ✒directs assembly of rRNA and ribosomal proteins to form ribosomes

Nucleolus

- ✓Structure found within nucleus.
- ✓Involved in the synthesis of ribosomes.



Mitosis and Meiosis

- ✓mitosis
  - ✒one component of cell cycle
  - ✒distributes DNA to 2 new nuclei
  - ✒ploidy (number of sets of chromosomes) of daughter cells is the same as the mother cell

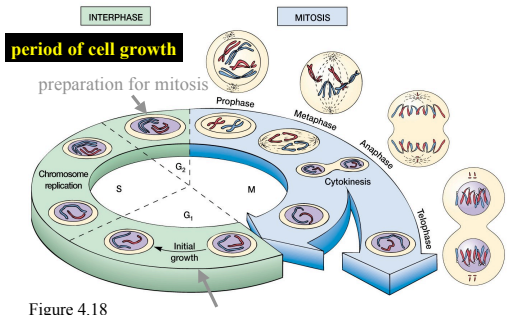
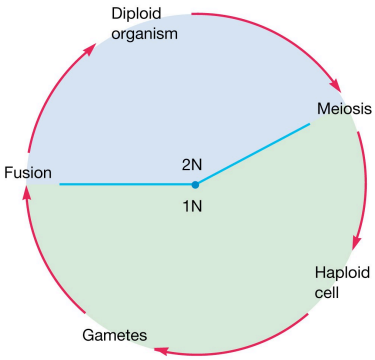


Figure 4.18

Mitosis and Meiosis…

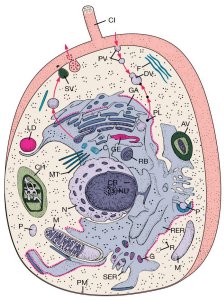
- ✓ meiosis
  - ✒ complex, two-stage process of nuclear division
  - ✒ number of chromosomes in the resulting daughter cells is reduced by 1/2

diploid haploid



External Cell Coverings

- ✓ cell wall
- ✓ pellicle

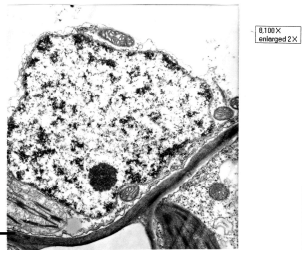


Cell wall

- ✓ rigid covering
- ✓ variable make-up
  - ✒ algae- cellulose and pectin
  - ✒ diatoms – silica
  - ✒ fungi – chitin and glucan
    - ☞ cellulose

Cell Wall

- ✓ Containment
- ✓ Protection
- ✓ Support



Pellicle

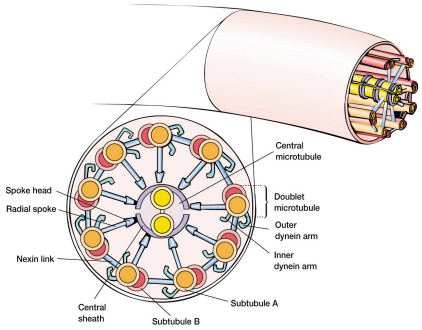
- ✓ relatively rigid layer of components just beneath plasma membrane
- ✓ common in protozoa
- ✓ not as strong or rigid as cell wall
- ✓ provides characteristic shape to cell

Cilia and Flagella

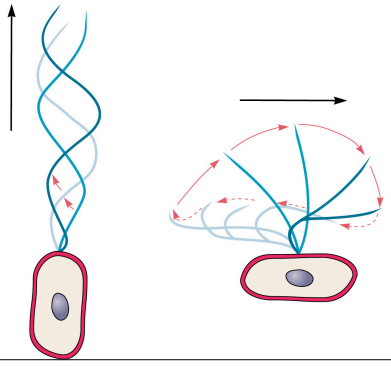
- ✓ cilia (s., cilium)
  - ✒ 5-20 μm long
  - ✒ beat with two phases, working like oars
- ✓ flagella (s., flagellum)
  - ✒ 100-200 μm long
  - ✒ move in undulating fashion

Structure of flagella and cilia

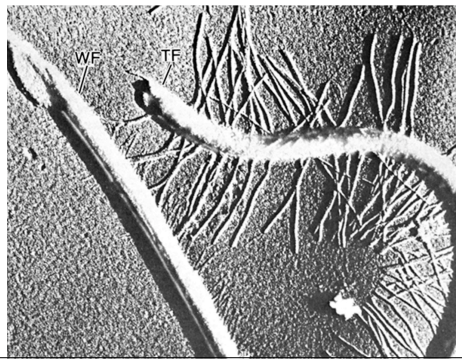
- ✓ membrane-bound cylinders ~ 0.2 μm in diameter
- ✓ axoneme
  - ✒ set of microtubules in a 9 + 2 arrangement
- ✓ basal body
  - ✒ at base of flagellum or cilium
  - ✒ directs synthesis of flagella and cilia



Flagellar Movement



Whiplash and tinsel flagella



Comparison of Procaryotic and Eucaryotic Cells

Table 4.2 Comparison of Procaryotic and Eucaryotic Cells

Property	Procaryotes	Eucaryotes
Organization of Genetic Material		
True membrane-bound nucleus	Absent	Present
DNA complexed with histones	No	Yes
Number of chromosomes	One[a]	More than one
Introns in genes	Rare	Common
Nucleolus	Absent	Present
Mitosis occurs	No	Yes
Genetic Recombination	Partial, unidirectional transfer of DNA	Meiosis and fusion of gametes
Mitochondria	Absent	Present
Chloroplasts	Absent	Present
Plasma Membrane with Sterols	Usually no[b]	Yes
Flagella	Submicrosopic in size; composed of one fiber	Microscopic in size; membrane bound; usually 20 microtubules in 9 + 2 pattern
Endoplasmic Reticulum	Absent	Present
Golgi Apparatus	Absent	Present
Cell Walls	Usually chemically complex with peptidoglycan[c]	Chemically simpler and lacking peptidoglycan
Differences in Simpler Organelles		
Ribosomes	70S	80S (except in mitochondria and chloroplasts)
Lysosomes and peroxisomes	Absent	Present
Microtubules	Absent or rare	Present
Cytoskeleton	May be absent	Present
Differentiation	Rudimentary	Tissues and organs

[a]Plasmids may provide additional genetic information.
[b]Only the mycoplasmas and methanotrophs (methane utilizers) contain sterols. The mycoplasmas cannot synthesize sterols and require them preformed. Many procaryotes contain hopanoids.
[c]The mycoplasmas and Archaea do not have peptidoglycan cell walls.

The molecular unity of procaryotes and eucaryotes

- ✓same basic chemical composition
- ✓same genetic code
- ✓same basic metabolic processes

The End.