بسم الله الرحمن الرحيم

King Saud University

College of Science

Department of Biochemistry

Biochemical fundamentals of Life

(BCH 103)

Cellular Foundation of Biochemistry

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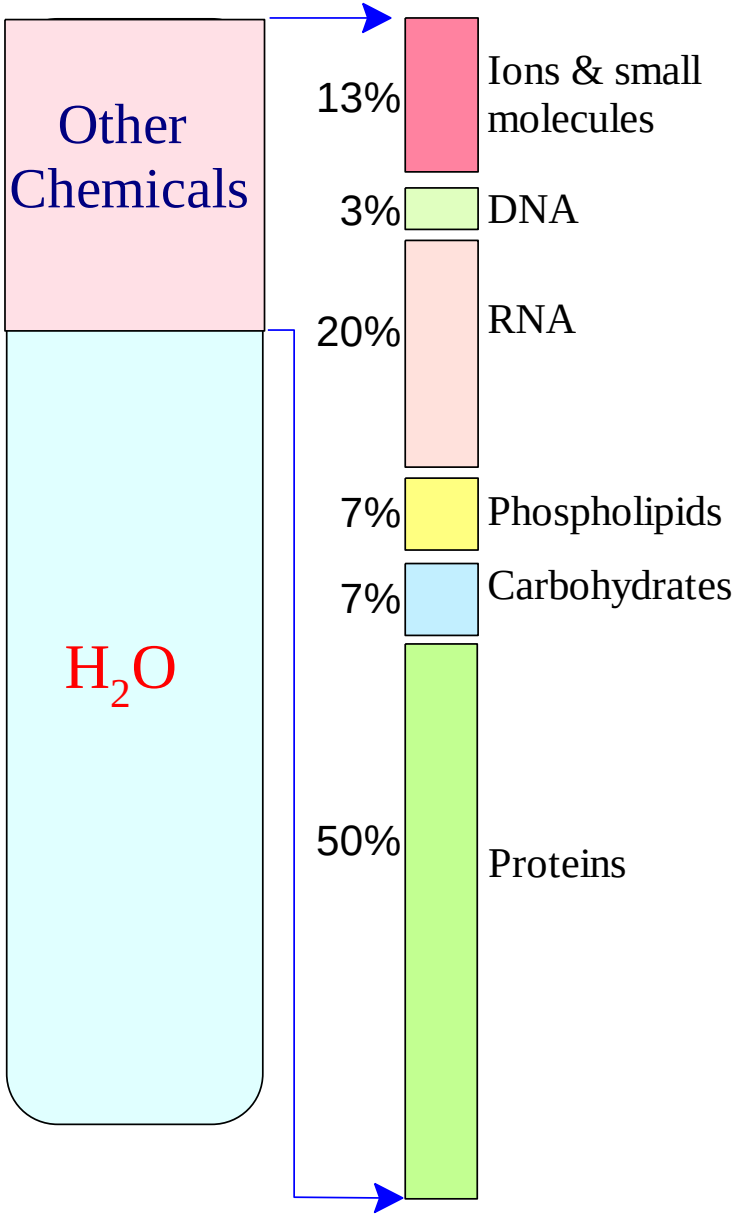
The cell

Basic Materials in Cell

All cells have these basic common materials:

- H_2O: The solvent of life. All cellular reactions are carried out in aqueous environment.
  - All chemical reactions in a cell make up its METABOLISM.
- And 4 Major macromolecules:
  1. Proteins (the cell work horses)
  2. Nucleic Acids (genetic materials)
  3. Carbohydrates (many functions)
  4. Lipids (membrane and energy source and depot)

  Notice that all macromolecules are organic compounds (i.e. contain carbon).
- Plus ions & metabolites (small amounts)



Cell Theory

The cell theory is proposed and developed in the 1600-1800s. The main parts of the cell theory today are:

- Cell is the smallest unit of living matter.
  - Don't confuse this with electrons, protons, atoms, proteins, DNA, etc. These are lifeless molecules
- Cell is the structural & functional unit of all organs and/or organisms.
- All organisms are composed of one or more types of cells.
- All cells come from pre-existing cells by division.
  - Spontaneous generation does not occur.
  - Cell is capable of reproduction.
- Cells contains hereditary information which is passed from cell to cell during cell division.
- All energy flow (metabolism & biochemistry) of life occurs within cells.
- **So, The Cell is The Universal Building Block for living organisms**

Three Distinct Domains of Life Defined by Cellular and Molecular Differences That Evolved over Time

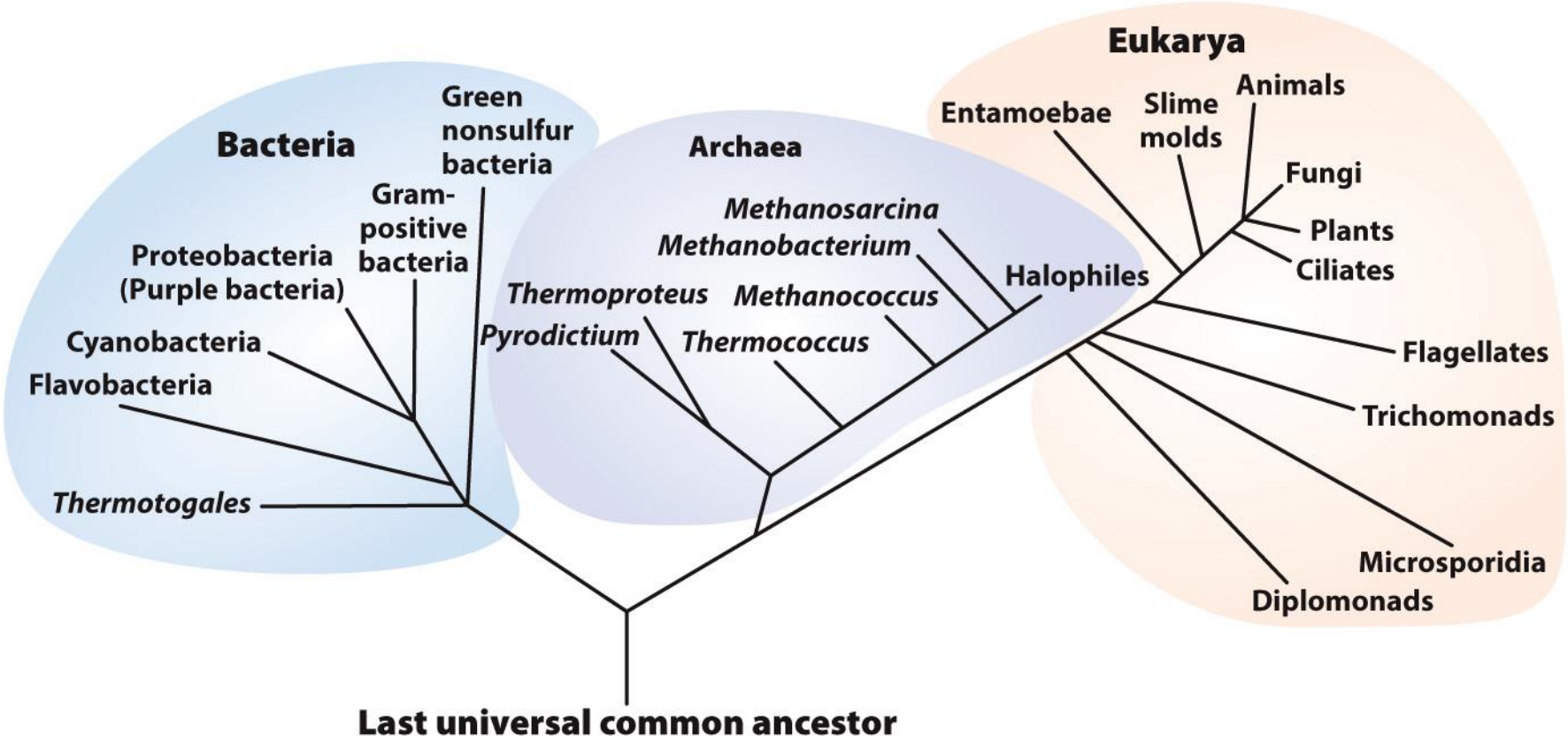


Figure 1-5
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Six Kingdoms of Life Defined by Organism, Cellular, and Molecular Differences

Six kingdoms	Cellular organization
• Archaea	Unicellular prokaryote
• Bacteria	Unicellular prokaryote
• Protista	Unicellular eukaryote
• Fungi	Uni- or Multicellular eukaryote
• Plantae	Multicellular eukaryote
• Animalia	Multicellular eukaryote

Typical Cells

- Cells from different organisms have different shapes, structures, and sizes but **all Cells Share Some Common Features**
- All cells have protoplasm.
- They are usually divided into two broad groups: Eukaryotes and Prokaryotes.
  - Eukaryotic cells (Eu = true; kary = nucleus): have a membrane-bound nucleus and a variety of organelles and internal membranes.
  - Prokaryotic cells (Pro = before) are smaller (a general rule) and lack much of the internal compartmentalization and complexity of eukaryotic cells; No membrane-bound nucleus or other organelles.
  - Viruses do not always conform to cell theory:
    - one or more of the basic cell components is missing.
    - Inside the host cell, viruses are living matters.

All Cells Share Some Common Features

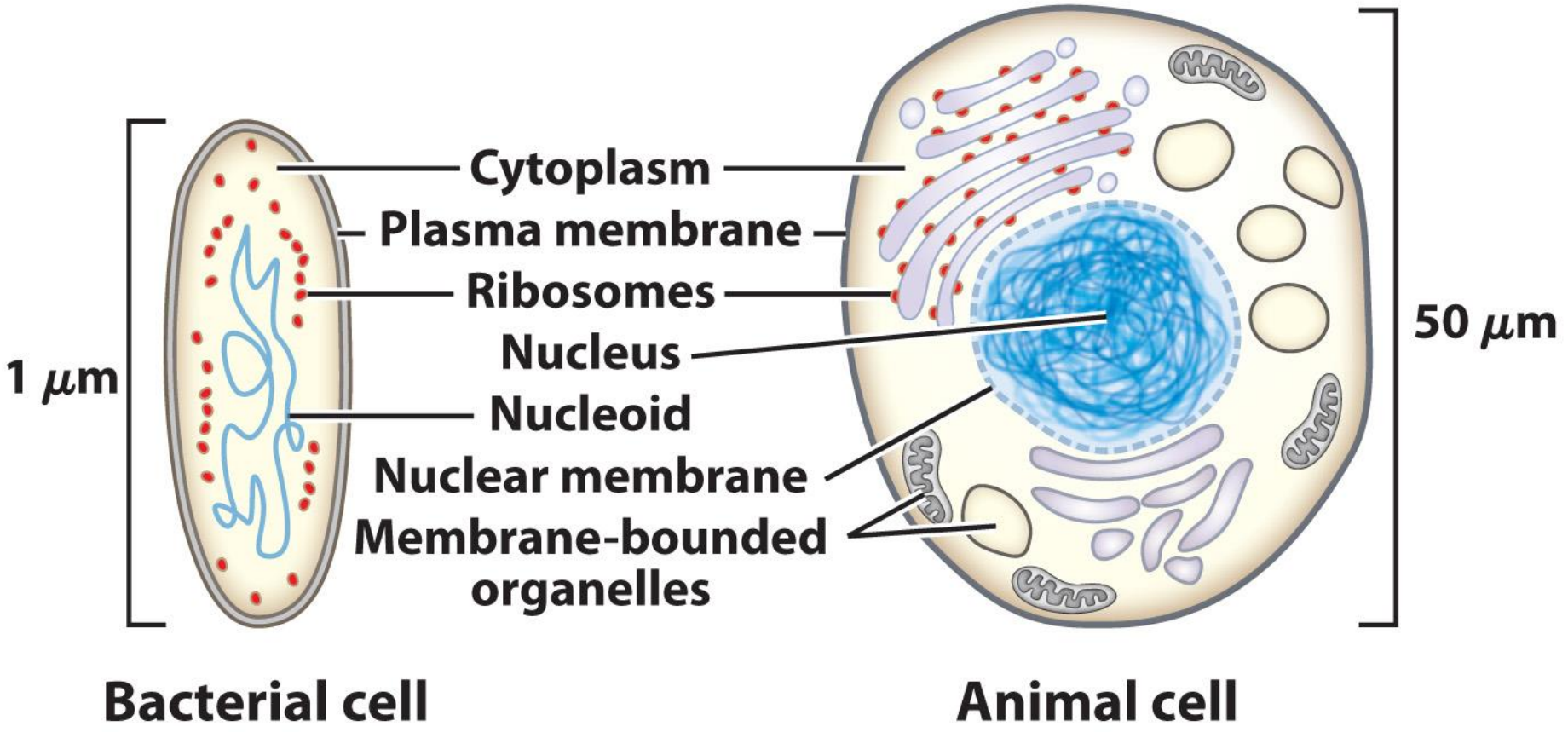

Figure 1-3
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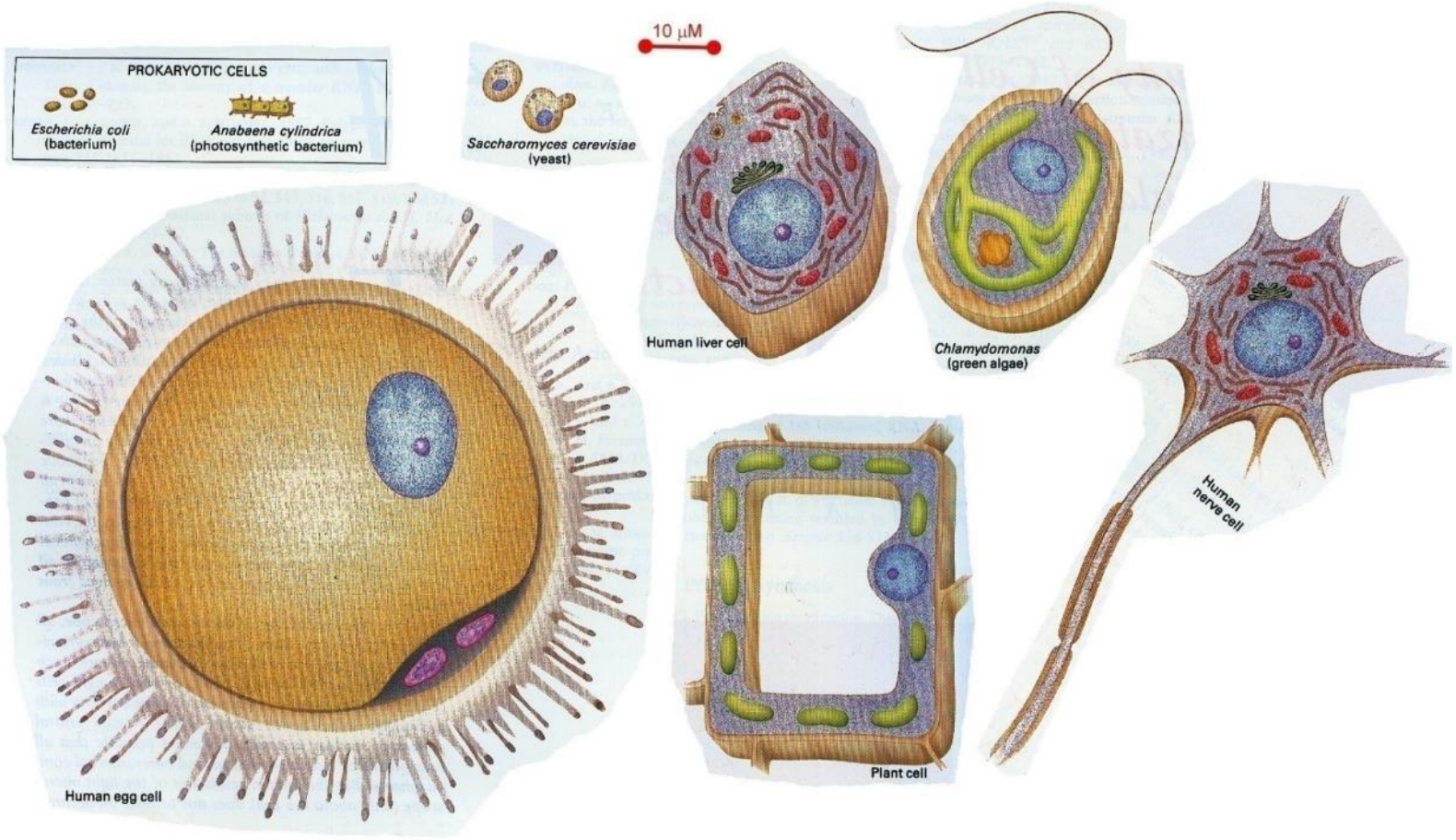
Sizes and Shapes of Cells

Notice: Cells in the figure is represented according to the proportion of its size using the suitable scale.



Prokaryotes

- Prokaryotes; all in one!!
  - It shows a limited range of morphologies but very diverse metabolic capabilities.
- Prokaryotes are single-celled organisms.
  - Do NOT have true nucleus or organelles.
  - Most have circular or "looped" DNA
  - lack much of the internal membranous compartmentalization
  - Mainly unicellular organisms
- Prokaryotes are divided into two major lineage:
  - Archeabacteria (Greek *arche-,* "origin"): most inhabit extreme environments—salt lakes, hot springs, highly acidic bogs, and the ocean depths. It includes:
    - Methanogens (oxygen-free milieus)
    - Halophiles (require high concentrations of salt)
    - Thermophiles (live in hot regions, 80^{o}C, in a pH< 2)
  - Eubacteria (true bacteria): inhabit soils, surface waters, and the tissues of other living or decaying organisms. Most of the well studied bacteria, including *Escherichia coli,* are eubacteria.

Components of Bacterial Cell

Structure	Composition	Function
Cell wall	Carbohydrate + protein	Mechanical support
Cell membrane	Lipid + protein	Permeability barrier
Nucleoid	DNA + protein	Genetic information
Ribosomes	RNA + protein	Protein synthesis
Pili	Protein	Adhesion, conjugation
Flagella	Protein	Motility
Cytoplasm	Aqueous solution	Site of metabolism

Prokaryotic Cells

Prokaryotes have different shapes:

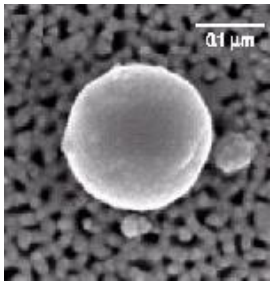
- Rode-like (Bacillus)
- Round (Coccus)
- Thread-like (Spirillum)

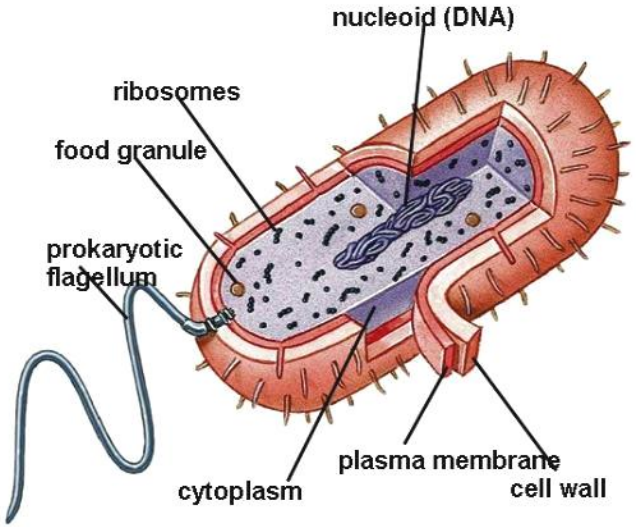
Bacillus-

The typical model of prokaryotes has:

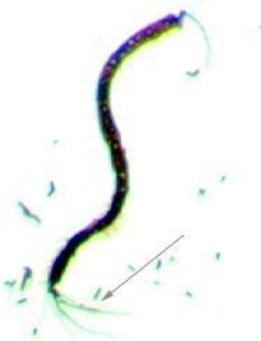
- cell wall (capsule or pili),
- cell membrane,
- nucleoid region, Contains a single, simple, long circular DNA.
- Ribosomes (site of protein synthesis)
- Flagella (for movement)

Coccus-





Spirillum-



The Cytosol Is Very Crowded

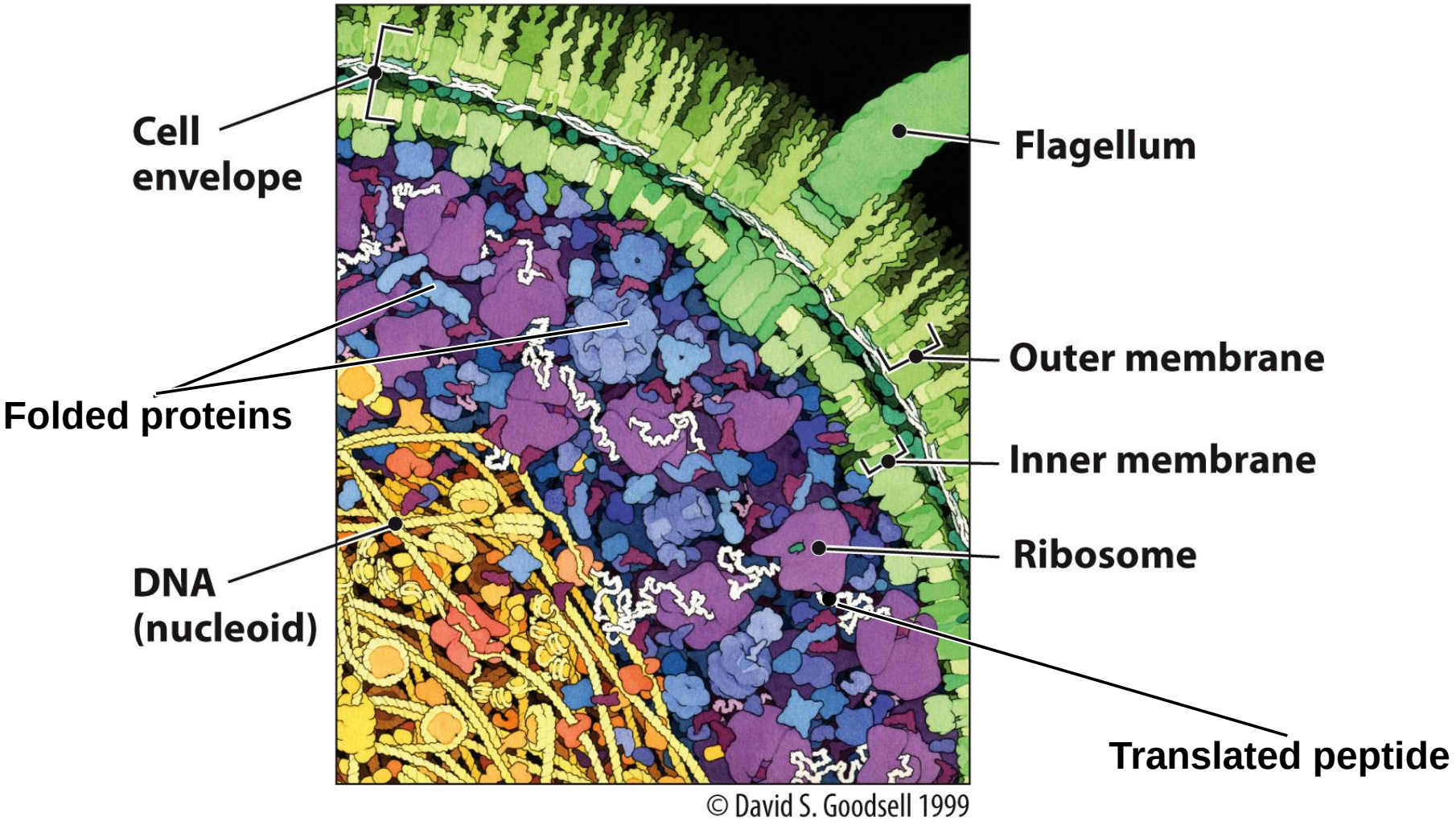


Figure 1-13
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Eukaryotic Cells

- Eukaryotes are found in Animal, Plant, Protists, and Fungi kingdoms
  - Few eukaryotes are single-cell but the majority are multicellular organisms
    - So, not all unicellular organisms are eukaryotes because bacteria are unicellular prokaryotic organisms
    - On contrary, all multicellular organisms are eukaryotes

- Eukaryotic cells are complex cells (different sizes, shapes, and structures) and specialized but they all have:
  - Membrane-bound nucleus which contains the cell's genetic material; DNA
  - Organelles, each is surrounded by a membrane or two like lysosome, mitochondria, chloroplast and other membranous structures like Golgi bodies, endoplasmic reticulum,, etc
  - Eukaryotic DNA is organized in linear structures (chromosomes), associated with proteins (histones)

Generic Animal Cell (cont.)

- Animals have a variety of cells that differ in shapes, structures, and sizes.

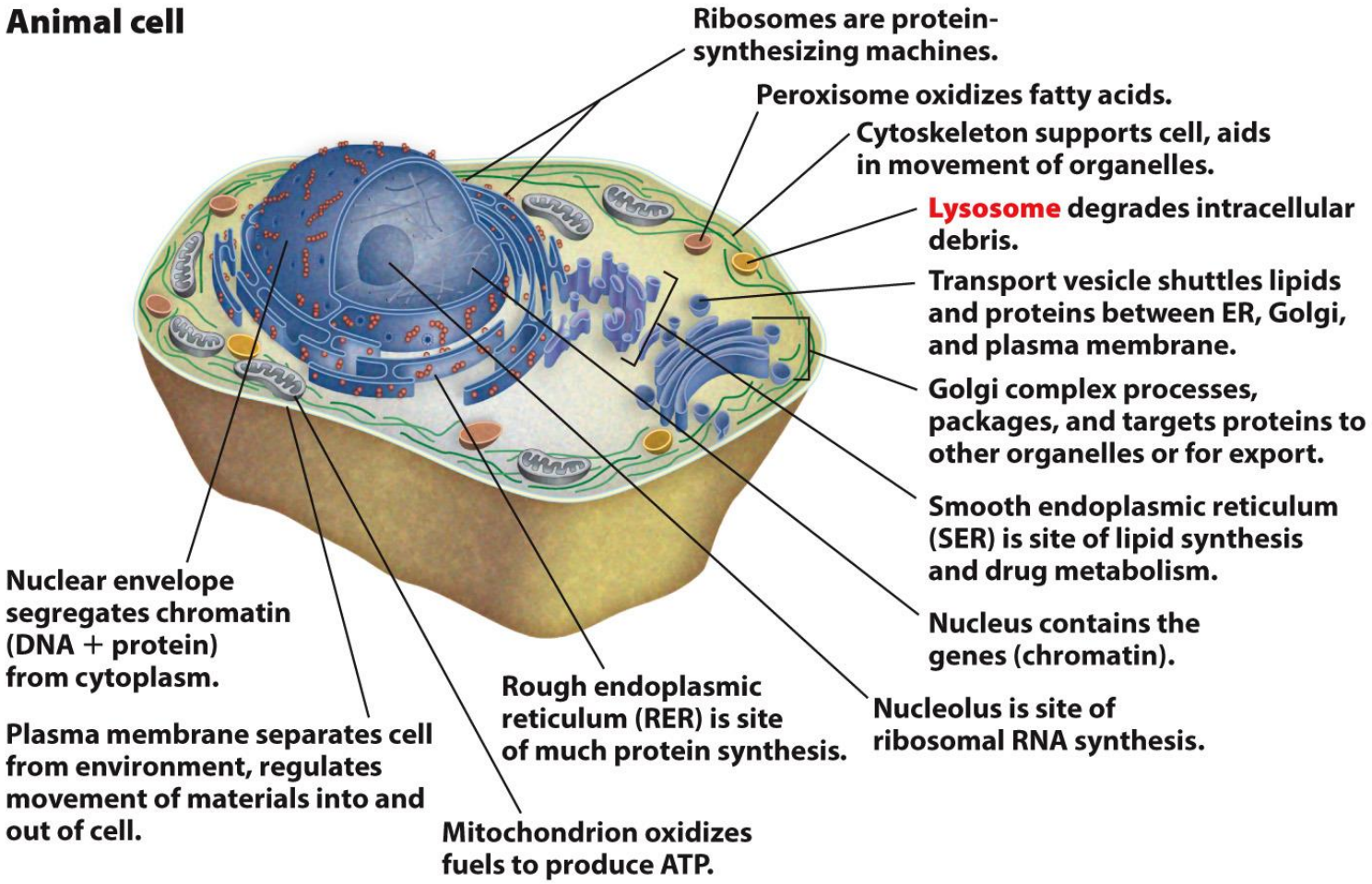

Figure 1-8a
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Generic Animal Cell (Cont.)

- The animal cell is surrounded by lipid bilayer plasma membrane.
- The content inside the plasma membrane is called protoplasm. It contains many organelles and subcellular structures as:
  - **Nucleus:** contain the genetic materials and surrounded by porous nuclear membrane. It contains liquid called neucleoplasm.
  - **Ribosome:** the site of protein synthesis. It is a group of protein subunits and ribosomal RNA.
  - **Mitochondria:** the site of energy production. It is a double –walled organelle having many enzymes for energy production (The Power House). The inner membrane is highly folded to increase the area of energy production. The number of mitochondria increases as the energy needs increases.
  - **Lysosome:** the site of removal of cell degraded waste substances. It contains many digestive enzymes and it is known as suicide bag as it burst and its contents release to lyse the cell when the cell die.
  - **Golgi Bodies,** a membranous structure. It packages proteins into membrane-bound vesicles inside the cell before the vesicles are sent to their destination.
  - **Endoplasmic reticulum (ER);** a network of membranes that may carry ribosomes or not. It share in the synthesis and export of proteins and membrane lipids.
  - **Centrosome; It presents only in animal cells** and serves as the main microtubule organizing center of the animal cell as well as a regulator of cell-cycle progression.

ORGANELLES

Eukaryotic cells have specialized membrane-bound structures called *organelles* that carry out particular functions for the cell.

Organelles include the nucleus, endoplasmic reticulum, Golgi apparatus, lysosomes, microbodies, vacuoles, mitochondria, and chloroplasts.

The lipid bilayer membranes that surround organelles also regulate and partition the flow of material into and out of these compartments, just as the plasma membrane does for the cell with its exterior environment.

Generic Plant Cell

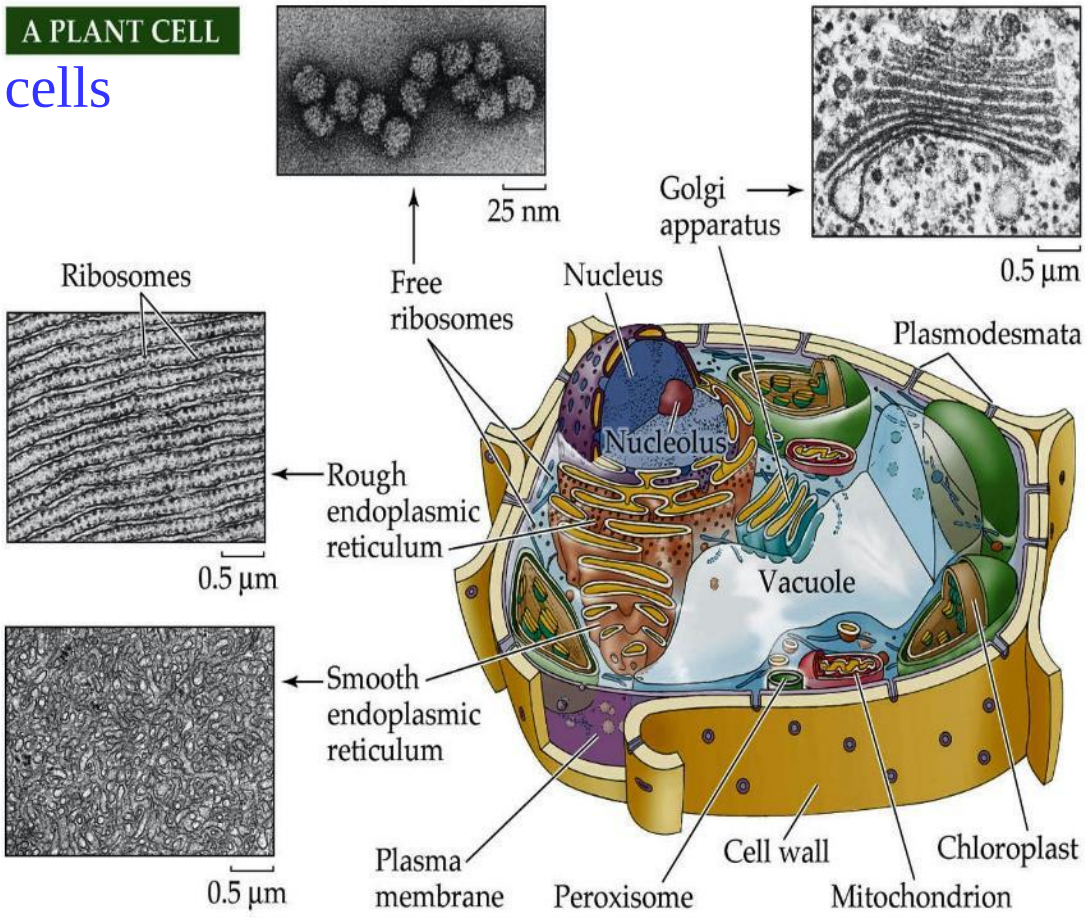
Plant cells is larger that animal cells and have some similarity with animal cells and differ in some specific plant structures like:

Organelles that present in plant cells but not in animal cells:

- External cell wall
- Chloroplast (for photosynthesis)
- Vacuoles (instead of lysosomes)
- Starch granules
- Thylakoids for ATP synthesis and
- Glyoxysome for glyoxylate cycle
- It DOESN'T have centrosome

Compare and contrast between animal and plant cells (Similarities and differences)

Compare and contrast between prokaryotes and eukaryotes (Similarities and differences)



Animal and Plant Cells Contain Unique Components

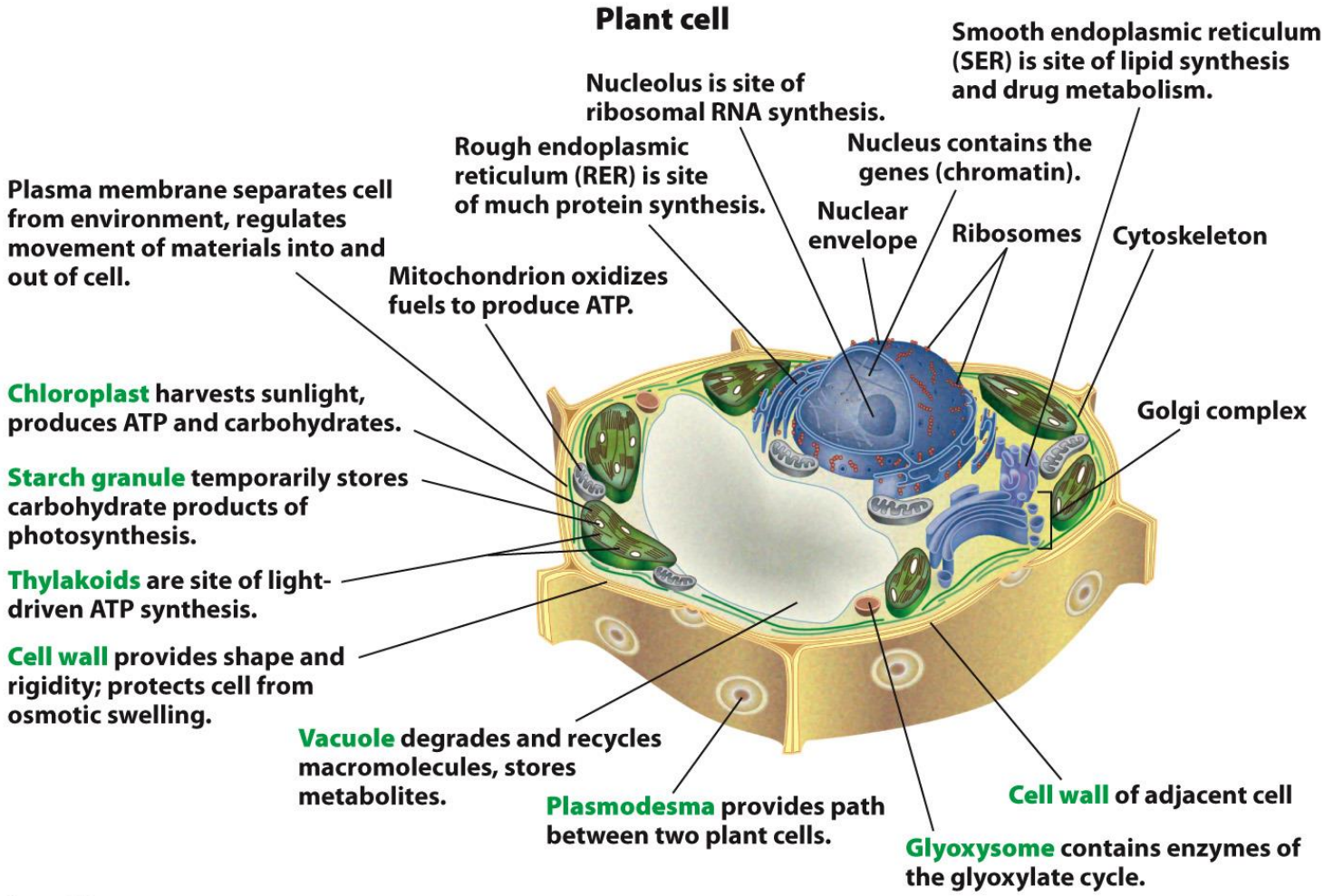


Figure 1-8b
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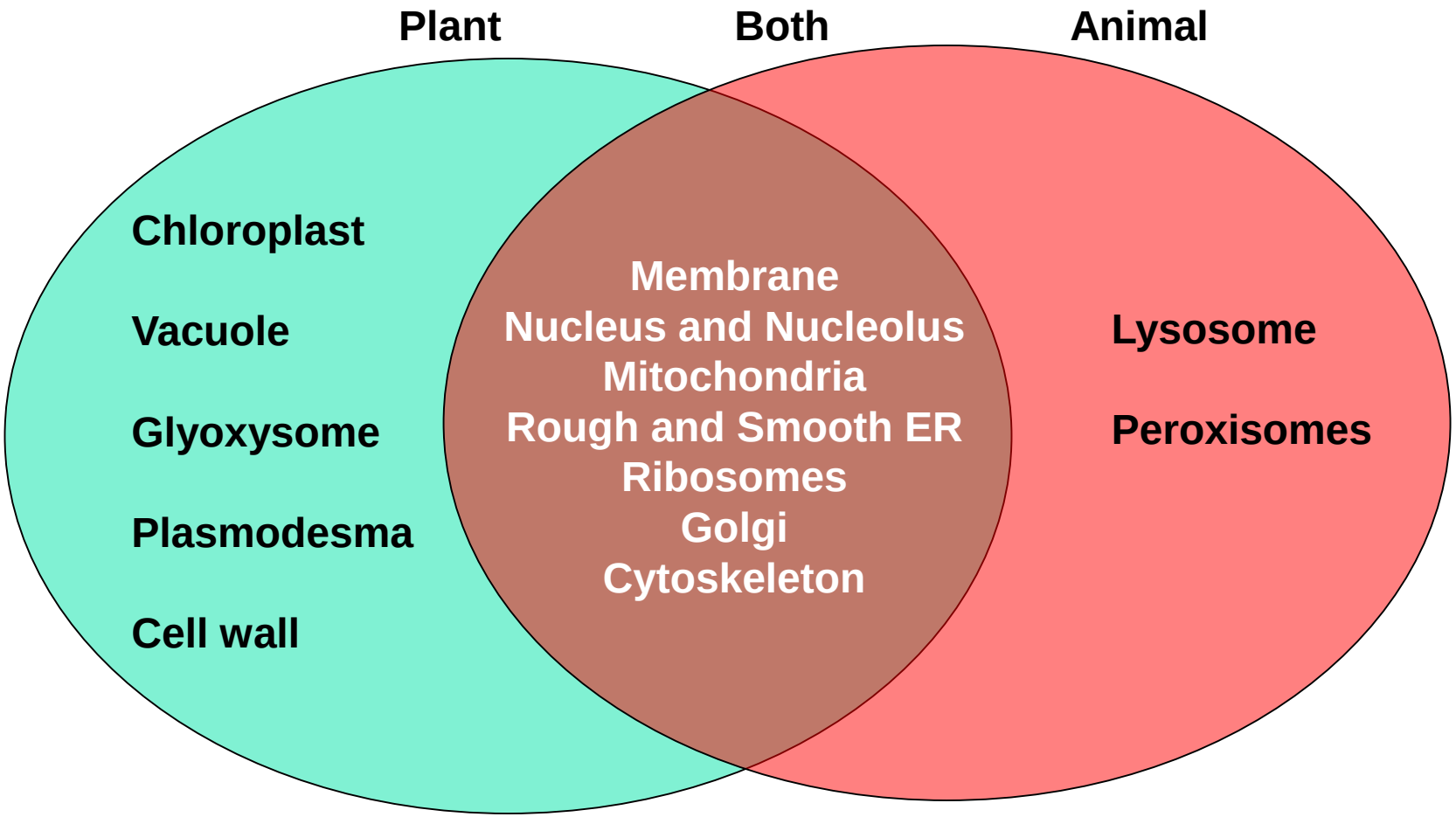
Animal and Plant Cells Contain Identical and Unique Components



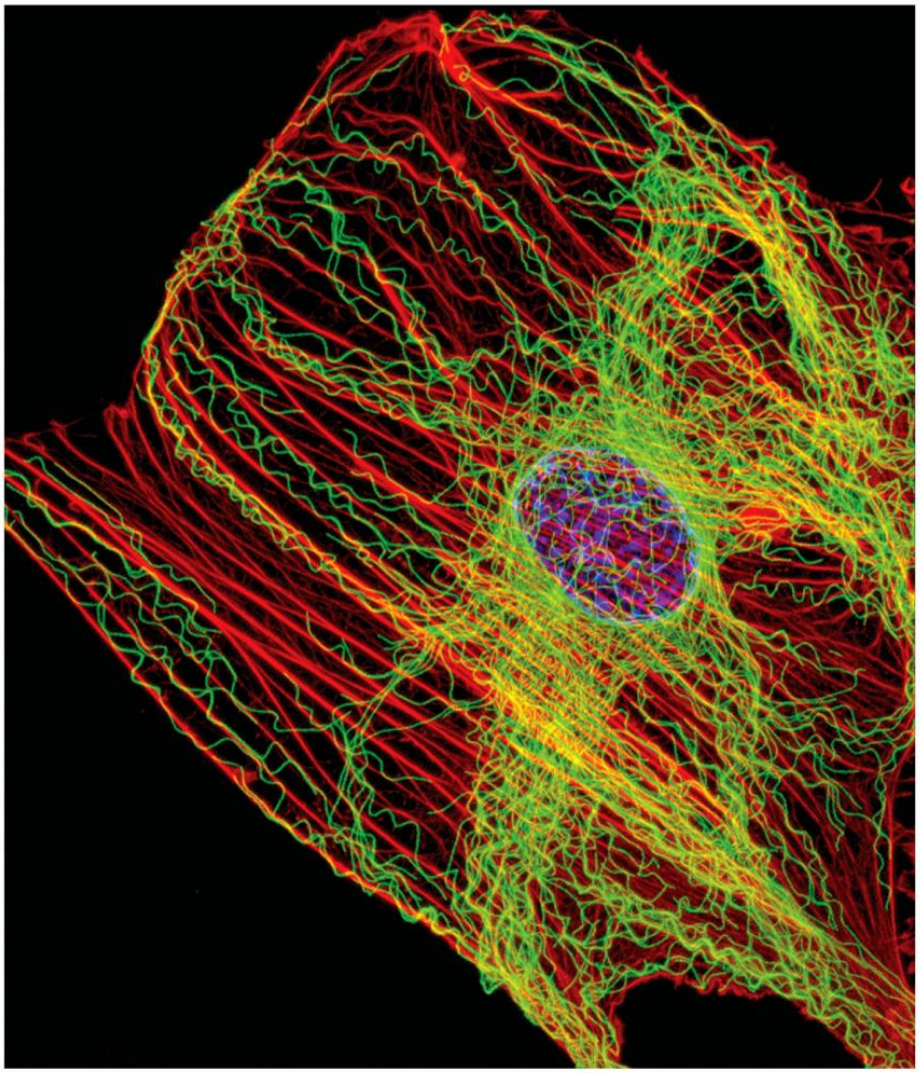
Lehninger 7th ed.

Cytoplasm and Cytoskeleton

- Cytoplasm is a highly viscous solution where many reactions take place.
- Cytoskeleton consists of microtubules, actin filaments, and intermediate filaments.
  - cellular shape and division
  - intracellular organization
  - intracellular transport paths
  - cellular mobility

Lehninger 7th ed.

Cytoskeleton Maintains Cellular Organization



James J. Faust and David G. Capco, Arizona State University/NIH National Institute of General Medical Sciences

Figure 1-10a
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Organisms Can Also Be Classified by Different Energy and Carbon Sources

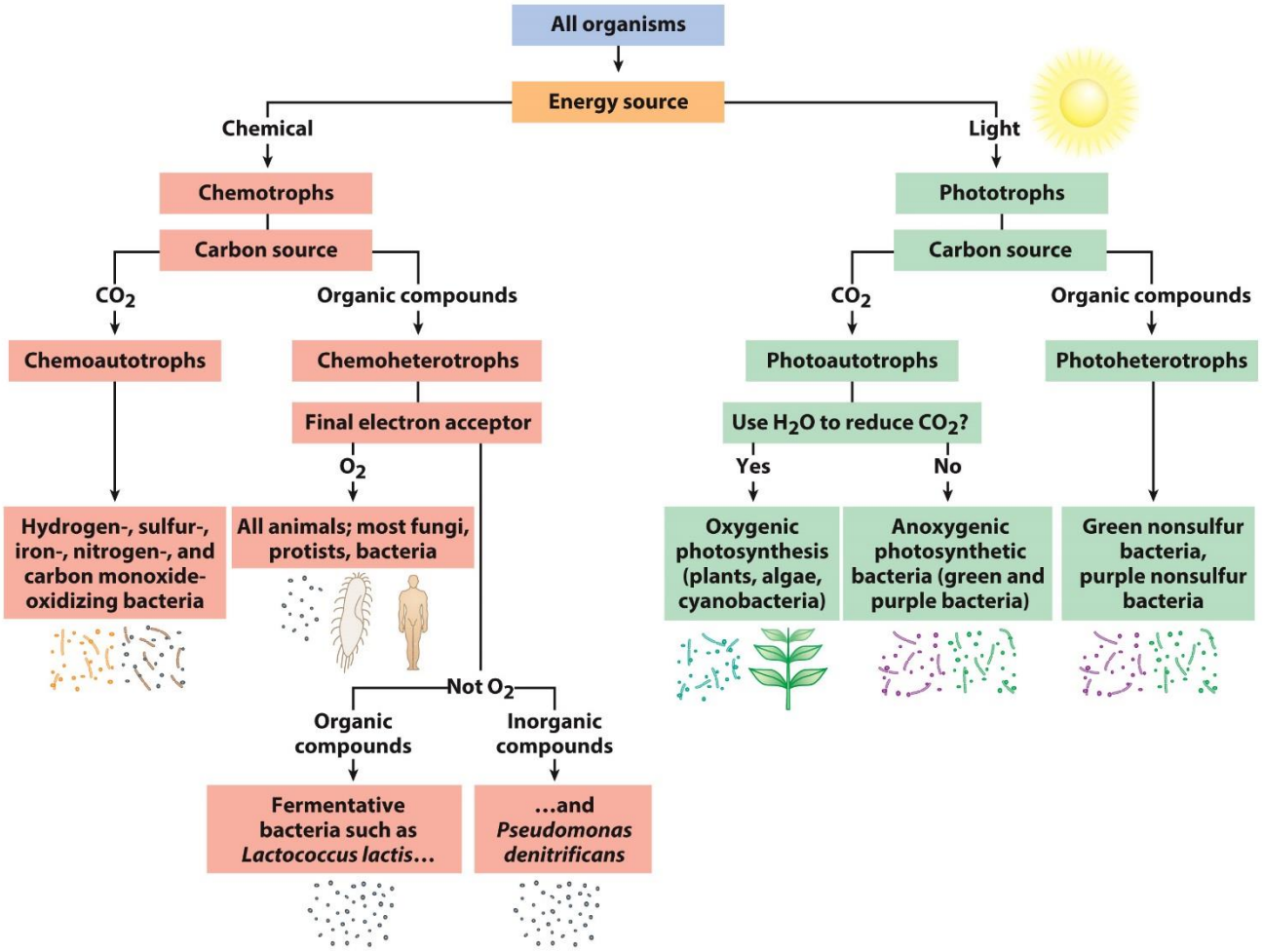


Figure 1-6
Lehninger Principles of Biochemistry, Seventh Edition

Living Systems Extract Energy

- From sunlight
  - plants
  - green bacteria
  - cyanobacteria
- From fuels
  - animals
  - most bacteria

• Energy input is needed in order to maintain life.

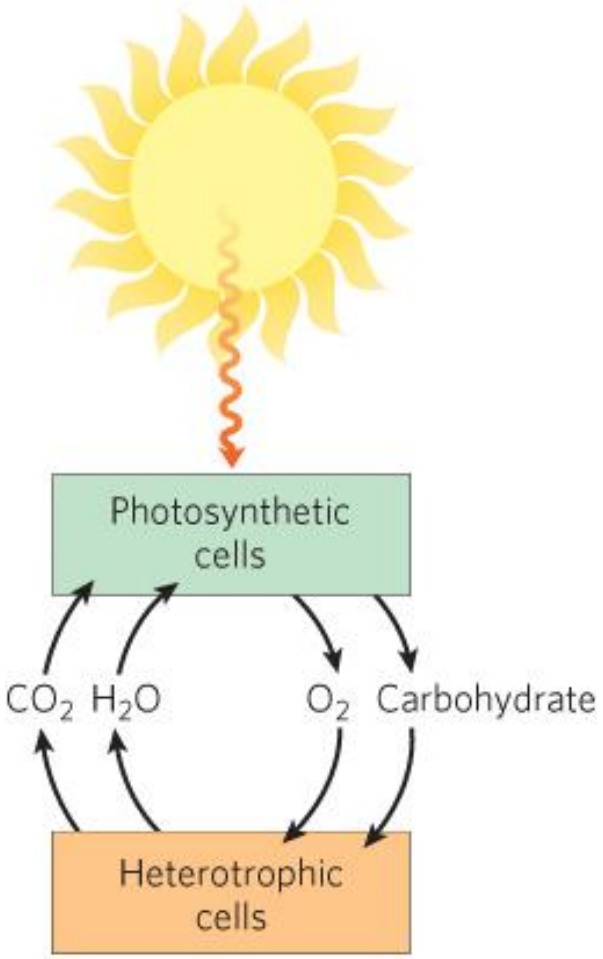
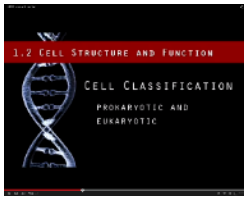


Figure 20.1
Nelson/Cox, *Lehninger Principles of Biochemistry*, 7e, © 2017 W.H. Freeman and Company

video

Cell, tissue, organ
https://www.youtube.com/watch?v=HBvfBB_oSTc



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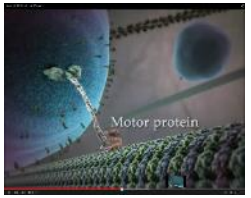


https://www.youtube.com/watch?v=g4L_QO4WKtM

Quiz

http://quizlet.com/10449142/study-guide-exam-2-cells-flash-cards/

Plant cells differ from animal cell in

a) contain plastids b) contain cell wall c) contain cellulose d) all of the above

Which organelle will use up oxygen and give off carbon dioxide AND water?

a) lysosome b) Golgi c) mitochondria d) chloroplasts

Which organelle will give off oxygen and use up carbon dioxide?

a) chloroplasts b) rough ER c) lysosomes d) mitochondria

Which organelle forms a membranous system of CHANNELS for intracellular transport?

a) ER b) mitochondria c) Golgi apparatus d) lysosome

The _____ will mostly produce vesicles:

a) rough ER b) lysosome c) mitochondria e) Golgi

Mitochondria are/synthezise:

A) structures involved in the breakdown of ATP
B) organelles involved in the synthesis of proteins
C) involved in producing ATP for cellular energy
D) synthesize proteins for use outside the cell

Lysosomes:

A) have a highly alkaline internal environment
B) are used mainly for the cell to "commit suicide"
C) contain digestive enzymes used to break down pathogens, damaged organelles, and whole cells

The major functions of the endoplasmic reticulum are _____.

A) hydrolysis, osmosis
B) detoxifying and packaging
C) synthesis, storage, transport
D) pinocytosis, phagocytosis

According to cell theory:

A) all organisms are composed of tissues.
B) the smallest unit of life is a nucleus.
C) animals, not plants, are composed of cells.
D) multicellular organisms have many cells.
E) new cells arise only from preexisting cells.

Compared with a eukaryotic cell, a prokaryotic cell:

A) lacks organelles
B) is larger.
C) does not require energy.
D) is not alive

Which of the following is a prokaryotic cell?

A) plant cell
B) liver cell
C) muscle cell
D) bacterium

Which structure regulates passage of molecules into and out of the cell?

A) plasma membrane
B) nucleus
C) mitochondria
D) chloroplast

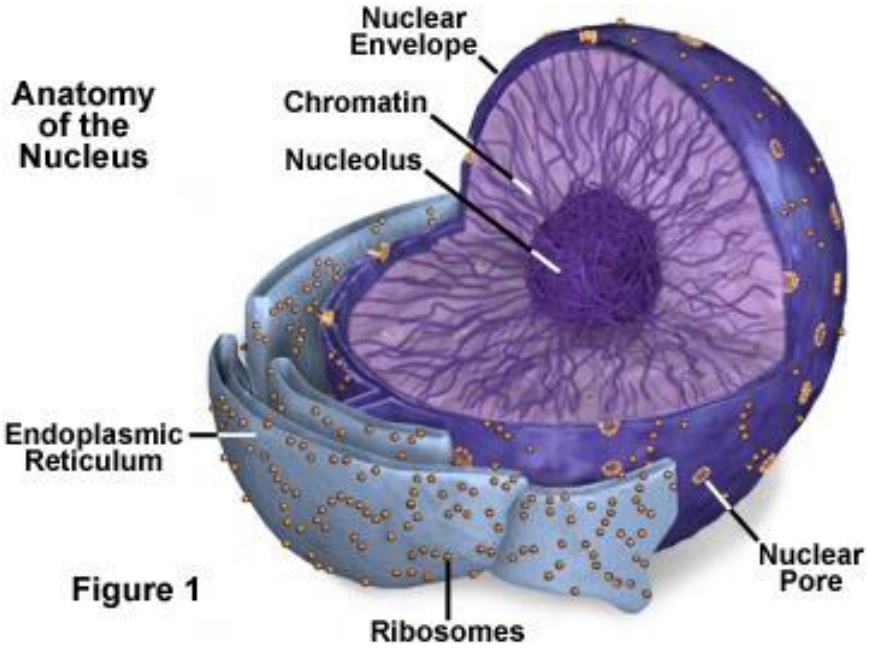
NUCLEUS

- It is found in eukaryotes
- Most functions of the cell are controlled by the nucleus.
- Functions: “Brain” of the cell.
- Large round structure located inside the cytoplasm.
- It contains genetic material (DNA).
- Controls the activity of the cell.
- It is composed of :
  - Nuclear membrane containing nuclear pores
  - Nucleoplasm
  - Nucleolus
  - Chromatin

- *Nucleus* is one of the largest organelles of the cell is the *nucleus* . The nucleus is the site in which genes in DNA are read to produce messenger RNA (transcription), mRNA is spliced, and the DNA genome is replicated when the cell divides. Other activities such as glycolysis and protein synthesis are excluded from the nucleus.
- The nucleus is surrounded by a two-layer *nuclear membrane* (or nuclear envelope) that maintains a nuclear environment distinct from that of the cytoplasm. Nuclear pores in this membrane allow selective two-way exchange of materials between the nucleus and cytoplasm, importing some proteins into the nucleus that are involved in transcription, mRNA splicing, and DNA replication, and keeping out other factors such as those involved in glycolysis and translation. The nucleus contains the DNA genome complexed with proteins called *histones* involved in packaging DNA and regulating access to genes. DNA packaged with histones is called *chromatin* and forms chromosomes, the highest level of structure in the genome, in which each chromosome contains a fully packaged and immensely long molecule of DNA containing many different genes.

Nucleolus

- It is a dense part of the nucleus.
- It is the largest structure in the nucleus of eukaryotic cells.
- It is best known as the site of ribosome biogenesis.
- Site where DNA is concentrated.



The Nucleus

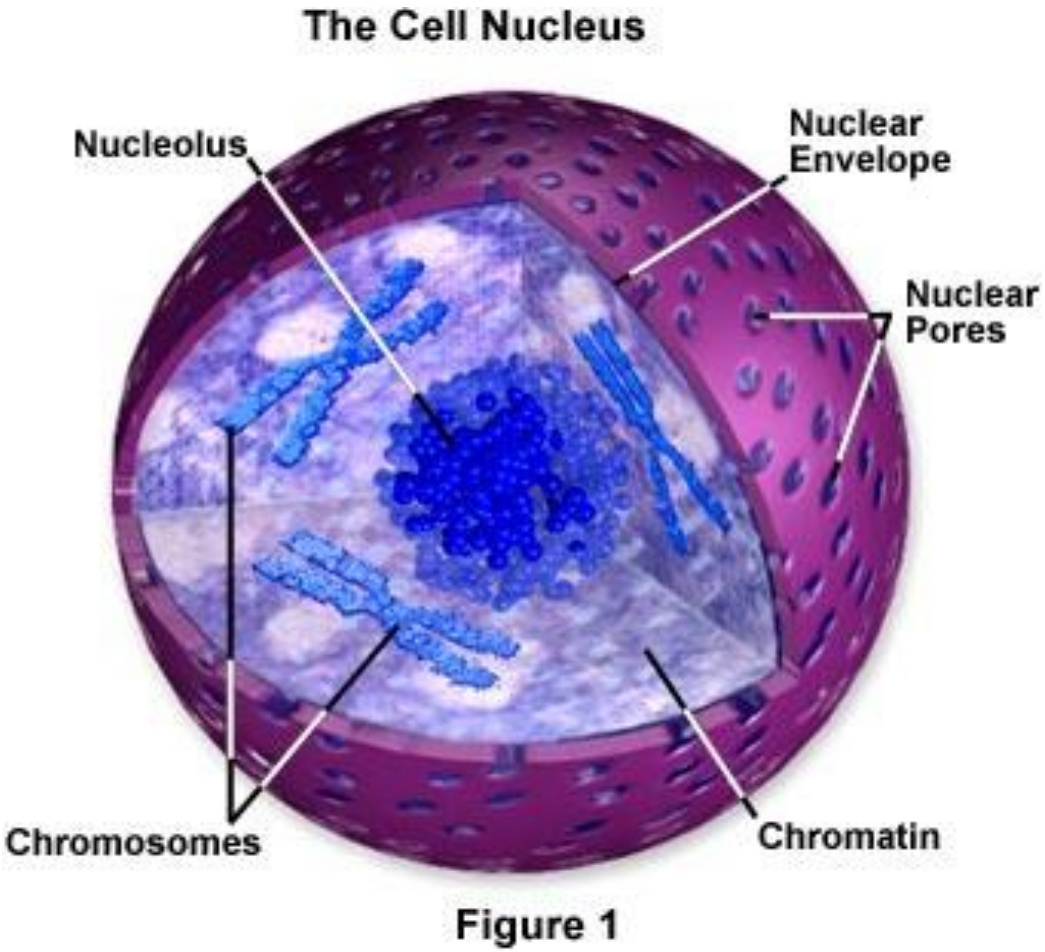


Figure 1

- Why have nuclear pores at all?
- What materials can pass through the nuclear envelope? What materials are retained?
- What is in the nucleolus?
- What molecules are in chromatin?

Nuclear membrane:

A double layer membrane that covers the nucleus. Each layer is made of phospholipid bilayers.

Nuclear pores:

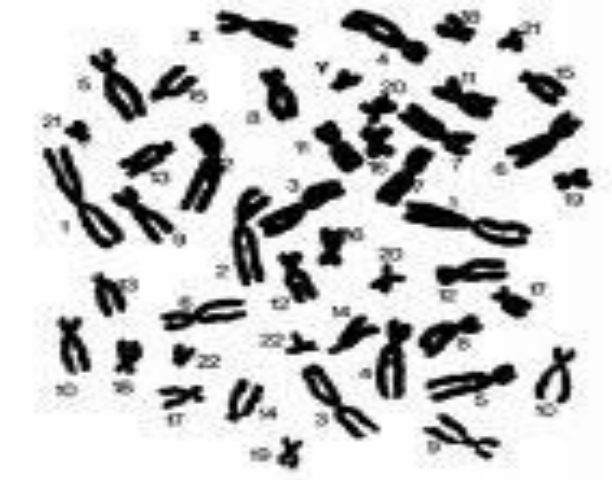
Holes in the nuclear membrane that allow passageways for RNA and other things entering and leaving the nucleus.

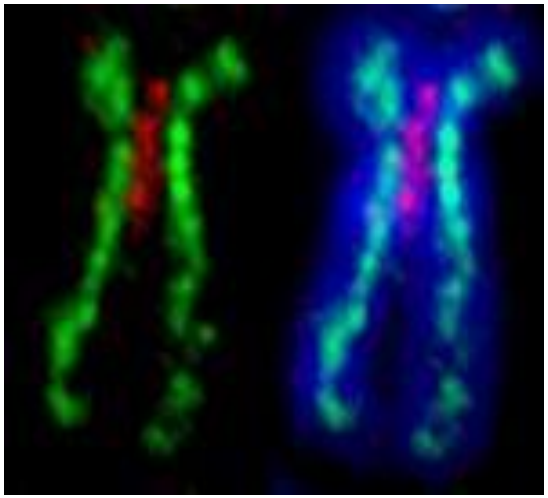
Nucleoplasm

- It is the liquid that exist inside the nucleus.
- It can be called nucleoplasm, karyoplasm, or nucleus sap.
- The nucleoplasm includes the chromosomes and nucleolus.
- Many substances such as nucleotides (necessary for purposes such as the replication of DNA) and enzymes (which direct activities that take place in the nucleus) are dissolved in the nucleoplasm.

Chromosomes

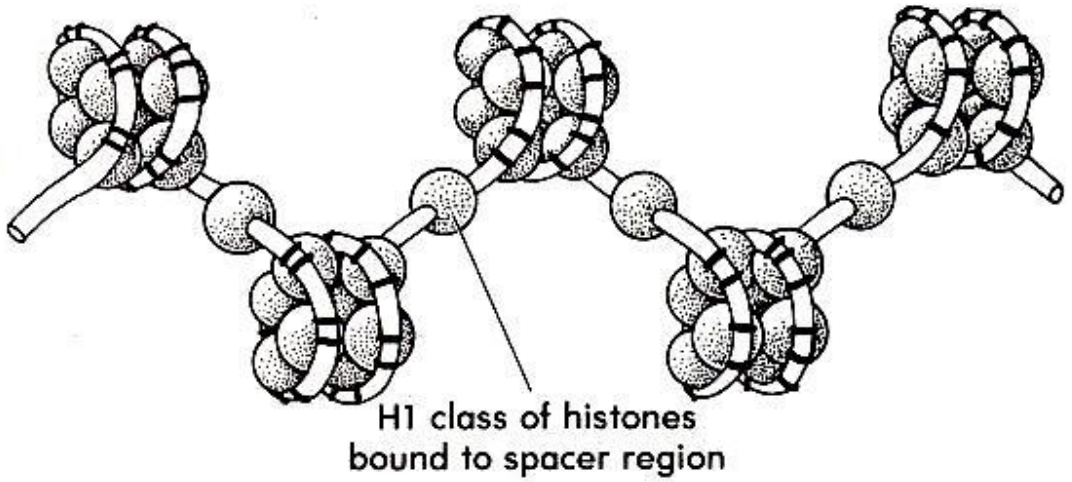
- Long thread-like structures found in the nucleus of the cell.
- Contain hereditary information.
- Genes are hereditary units made up of DNA.





Chromosome Packaging

A typical eukaryotic chromosome contains 1 to 20 cm of DNA. During metaphase of meiosis/mitosis, this DNA is package into a chromosome with a length of only 1 to 10 μm (a condensation of almost 10^4-fold in length from the naked DNA molecule).

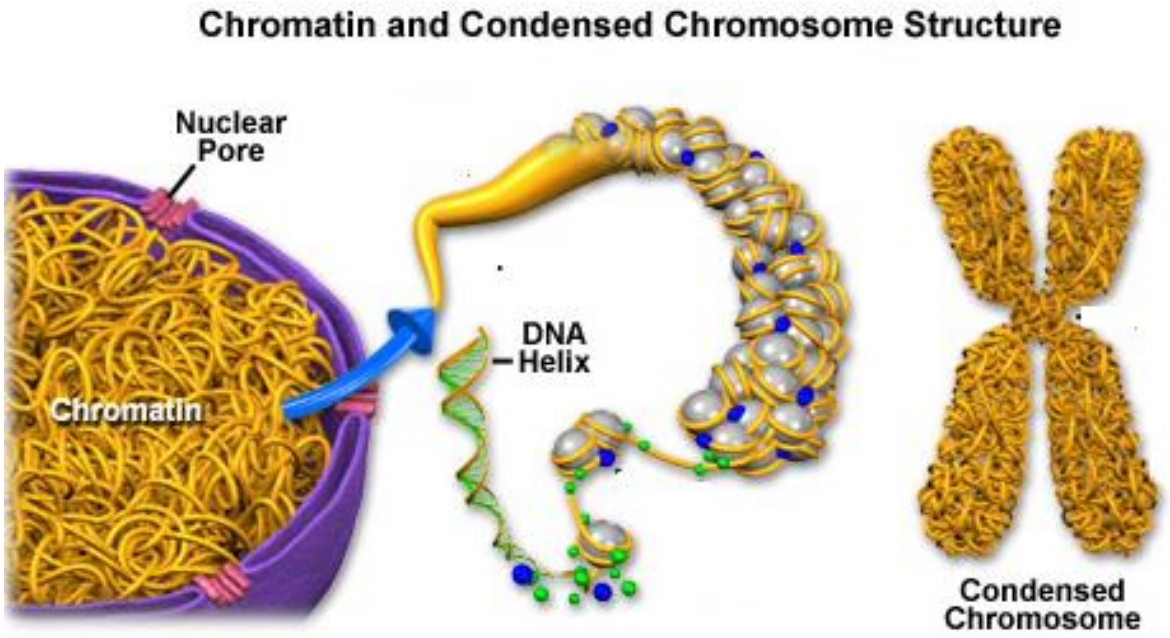


beaded string – nucleosome structure of chromatin

Chromatin

- Chromatin is a complex of macromolecules found in cells, consisting of DNA, protein, and RNA.
- The primary functions of chromatin are
  - 1) to package DNA into a more compact, denser shape,
  - 2) to reinforce the DNA macromolecule to allow mitosis,
  - 3) to prevent DNA damage, and
  - 4) to control gene expression and DNA replication.
- Chromatin is only found in eukaryotic cells .
- The primary protein components of animal chromatin are histones to which the DNA is wrap around..

- **There are three levels of chromatin organization:**
  - Nucleosomes, DNA wraps around histone proteins forming a bead-like structure (euchromatin).
  - Multiple histones wrap into a 30 nm fiber consisting of nucleosome arrays (heterochromatin).
  - Higher-level DNA packaging of the 30 nm fiber.

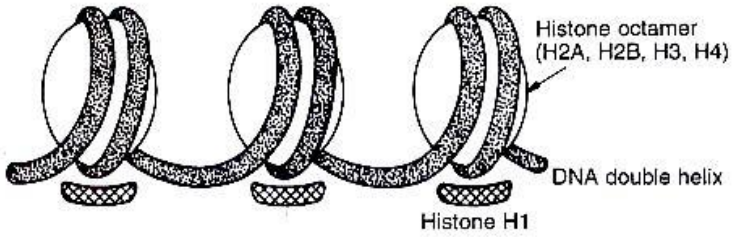


Chromosome Packaging

Nucleosome

- nucleosome contains histones (2 of each H2A, H2B, H3 and H4, and one H1)

- the diameter of nucleosome (bead) is 11nm.

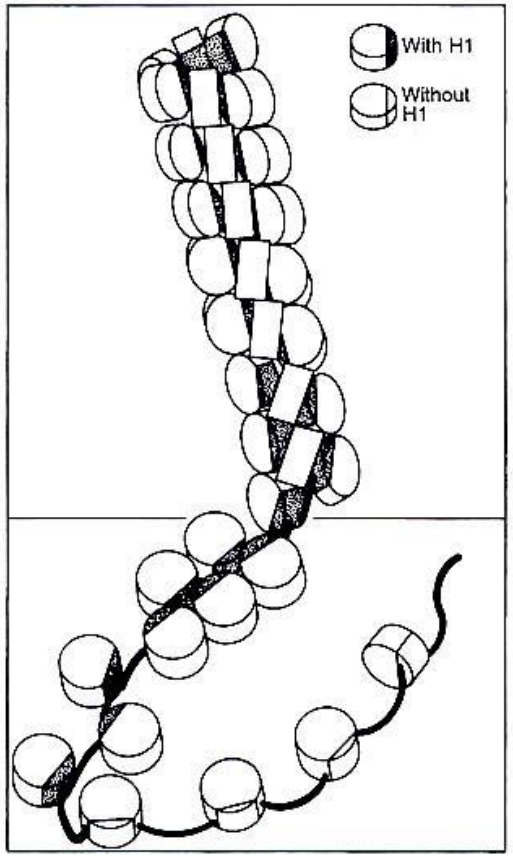


Solenoid

- the nucleosome is supercoiled and organised into a solenoid structure, with 6-7 nucleosomes per turn.

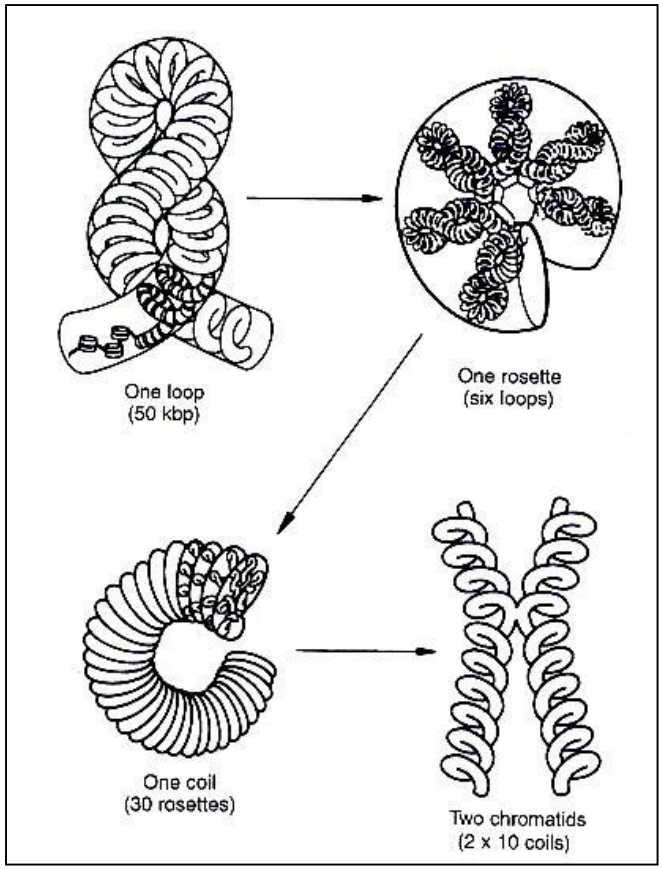
- H1 stabilize the structure of solenoid.

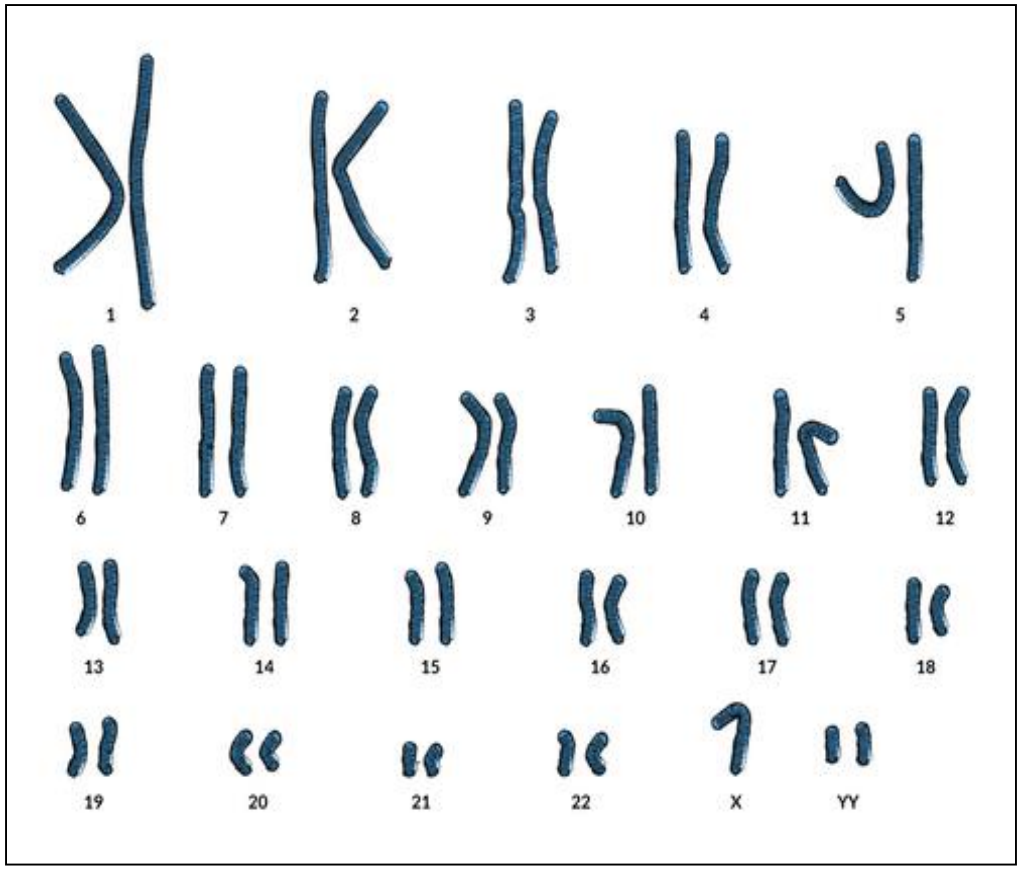
- the supercoiling produces a fibre of approximately 30nm in diameter.



Chromosome Packaging

Higher order folding of chromatin into chromosome





Questions

- Where is chromatin located?
- In the nucleus.
- Where is DNA located?
- In the chromatin.
- What does DNA do?
- In controls the activities in the cell.

- The shape of chromatin changes when a cell begins to divide.

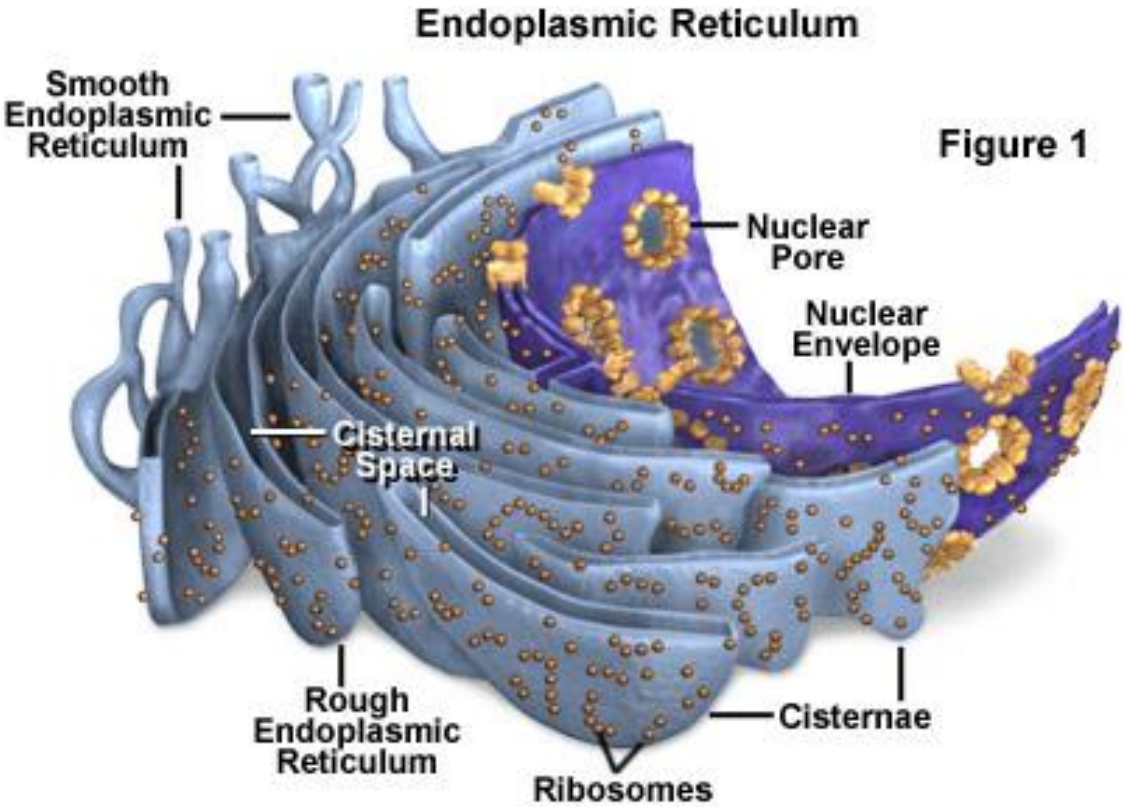
- When a cell begins to divide the chromatin coils and takes the form of chromosomes.

Endoplasmic Reticulum (ER)

- Network of fluid filled tubules (**cisternae)**
- cytoplasmic channels from the cell membrane to the nuclear membrane
- Roughly ½ of eukaryotic membrane tissue
- associated with the storage, synthesis, and transport of materials within the cell
- “HIGHWAY” for cell transport

- The *endoplasmic reticulum* (ER) is a network of membrane-enclosed spaces connected at points with the nuclear membrane. The network extends in sheets and tubes through the cytoplasm. If this network has ribosomes lining its outer surface, it is termed *rough endoplasmic reticulum* (RER); without ribosomes, it is known as *smooth endoplasmic reticulum* (SER). The ER is involved in the transport of proteins in cells, especially proteins destined to be secreted from the cell. SER is involved in lipid synthesis and the detoxification of drugs and poisons, while RER is involved in protein synthesis. Proteins that are found in the cytoplasm are made by free ribosomes. Proteins that are secreted, found in the cell membrane, the ER, or the Golgi, are made by ribosomes on the RER.
- Proteins synthesized by the bound ribosomes cross into the *cisternae* (the interior) of the RER. Small regions of ER membrane bud off to form small, round, membrane-bound vesicles that contain newly synthesized proteins. These cytoplasmic vesicles are transported next to the Golgi apparatus

There are two types of ER



- What are the two types of ER?
- How does the role of each type differ?
- What kind of cells would have a lot of rough ER? Smooth ER?

The endomembrane system regulates protein traffic and performs metabolic functions in the cell

Endoplasmic reticulum

A system of membranes forming channels within the cytoplasm

Function:

•Assists in the production, processing, and transport of material

Smooth ER

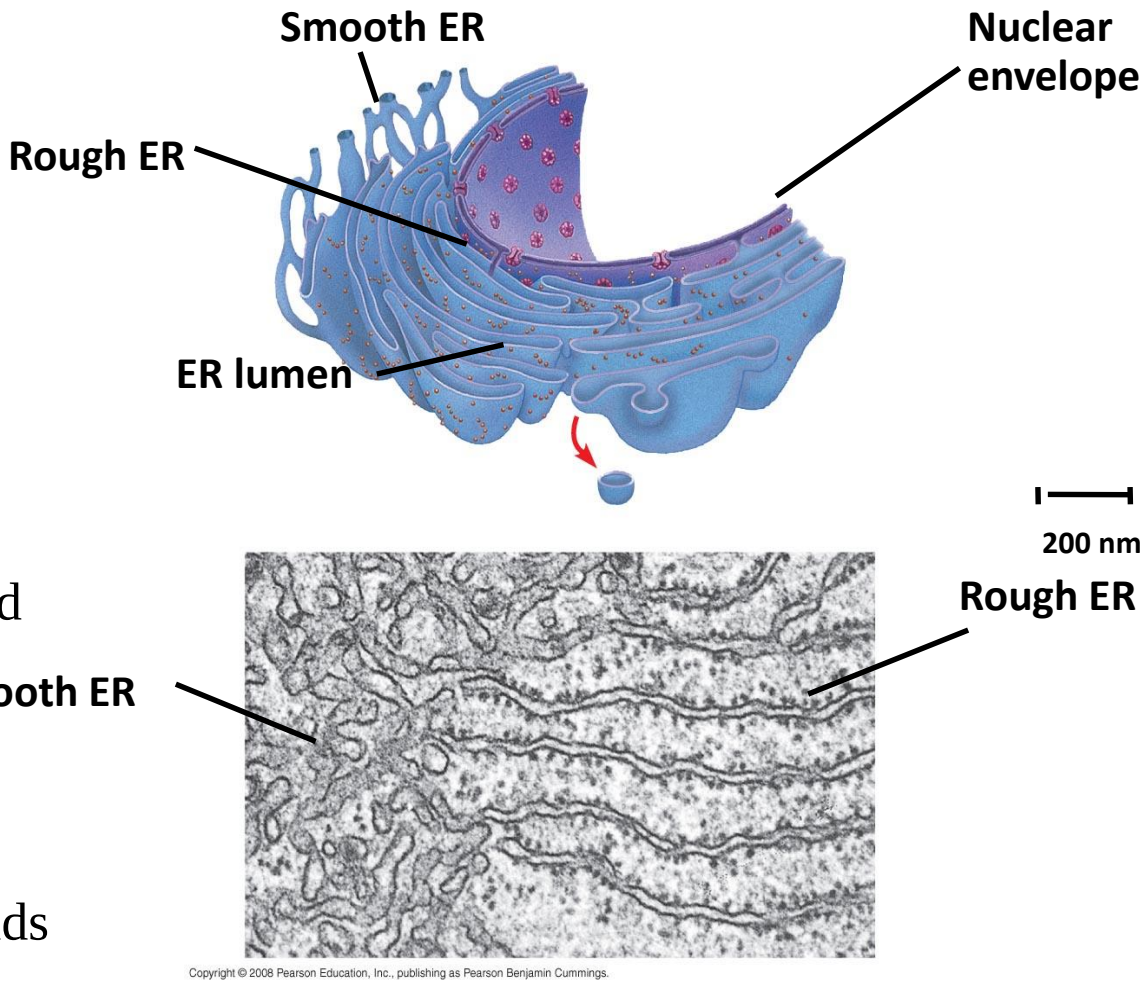
•lacks ribosomes

•Involved in synthesis of lipids, metabolism of carbohydrates, and detoxification of poisons

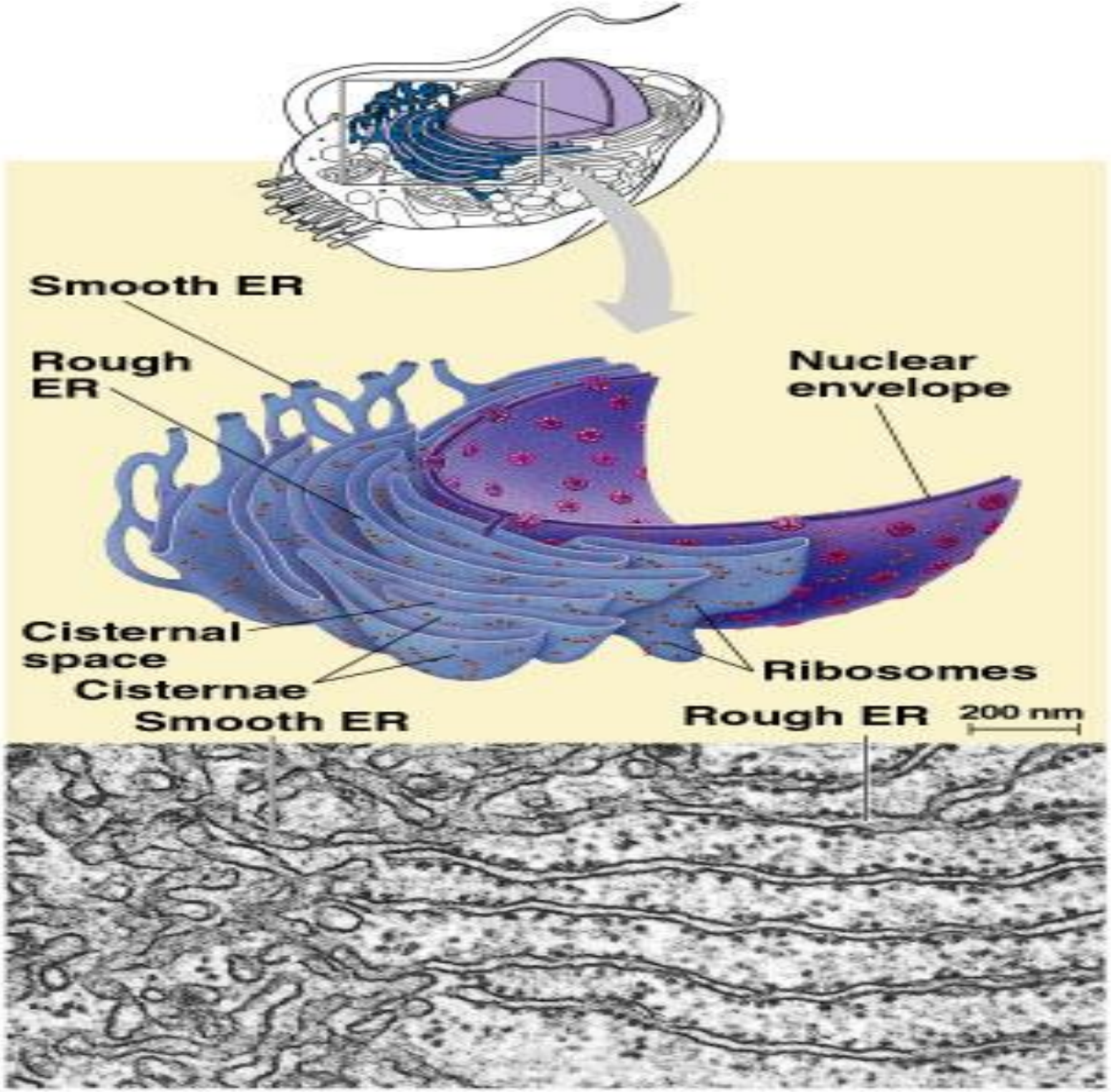
Rough ER

•Has attached ribosomes

•Makes proteins and phospholipids which are released by a vesicle



Structure of the ER



The Smooth ER

- Synthesis of lipids, steroids (ie: sex hormones)
- Carbohydrate metabolism (ie: liver cells hydrolysis glycogen into glucose utilizes enzymes in smooth ER)
- Detoxification of drugs/poisons (ie: smooth ER enzymes make drugs more soluble→ add –OH). Tolerance = more Smooth ER
- Involved in Ca^{2+} ion movement during muscle contraction.

Functions of Rough ER

- Attached ribosomes = protein synthesis. It is abundant in cells that make proteins. The manufactured proteins are “threaded” through pore into the cisternal space of ER.
- **Secretory proteins** are packaged into **transport vesicles** and sent to various locations in the cell.
- Also manufactures phospholipids from precursors in cytoplasm.
- Assembles phospholipids and proteins into new membrane sections.
- ER membrane can expand or transfer new membrane via vesicles to other parts of endomembrane system.

MITOCHONDRIA

Tiny, double-membrane organelles that transfer ENERGY from organic molecules to ATP.

- **Functions in Cellular Respiration.**

ATP powers most of the cell's chemical reactions.

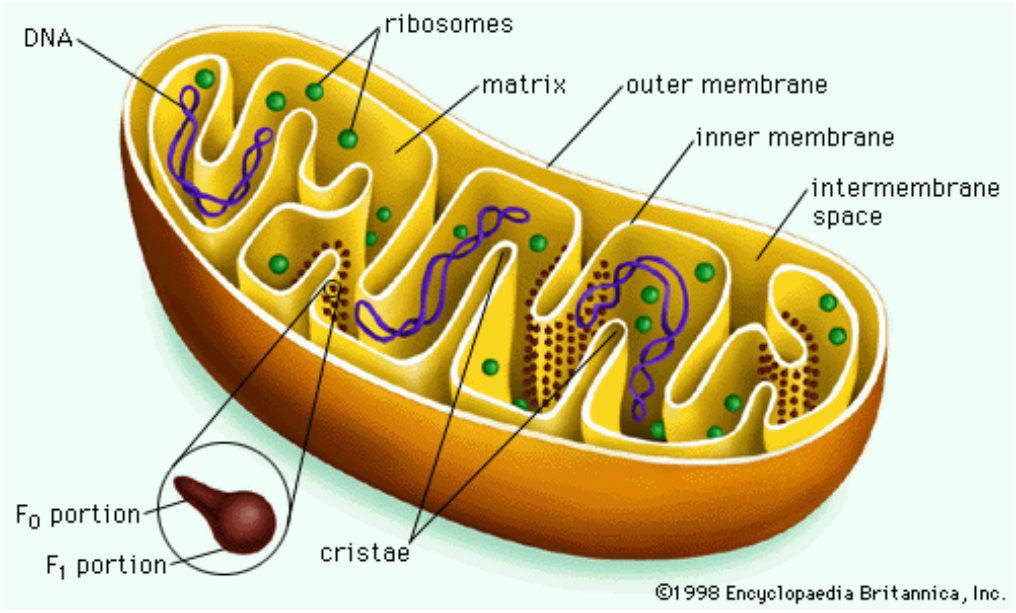
Found in large amounts in muscle cells and cells requiring ENERGY.

Function: ***Powerhouse of the cell.***

- What types of cells you expect to have more mitochondria? why
- More active cells like muscle cells because they need more energy.

What are mitochondria?

- An intracellular organelle.
- There are 100 to 1000s of mitochondria/cell.
- All mitochondria *come from the mother*.
- Mitochondria have their *own DNA*.
- Found in all cell types, *except the RBC*.
- Major functions of mitochondria:
  - Makes energy in the form of ATP.
  - Programmed cell death (apoptosis).



- How many membranes? Why?
- What cells would have high numbers of mitochondria?
- What do mito. have to do with cloning?
- What is the current theory on mito. origin?

- *Mitochondria* are sites of aerobic respiration within the cell and are important suppliers of energy.
- Each mitochondrion has an outer and inner phospholipid bilayer membrane.
- The outer membrane has many pores and acts as a sieve, allowing molecules through on the basis of their size.
- The area between the inner and outer membranes is known as the intermembrane space.
- The inner membrane has many convolutions called *cristae* , as well as a high protein content that includes the proteins of the electron transport chain.
- The area bounded by the inner membrane is known as the *mitochondrial matrix* and is the site of many of the reactions in cell respiration, including electron transport, the Krebs cycle, and ATP production

- Mitochondria are somewhat unusual in that they are semiautonomous; they contain their own circular DNA and ribosomes, which enable them to produce some of their own proteins, and they self-replicate through binary fission.
- They are believed to have developed from early prokaryotic cells that evolved a symbiotic relationship with the ancestors of eukaryotes and still retain vestiges of this earlier independent life.
- This hypothesis for the evolution of the eukaryotic cell is called the endosymbiotic theory.

Lysosomes

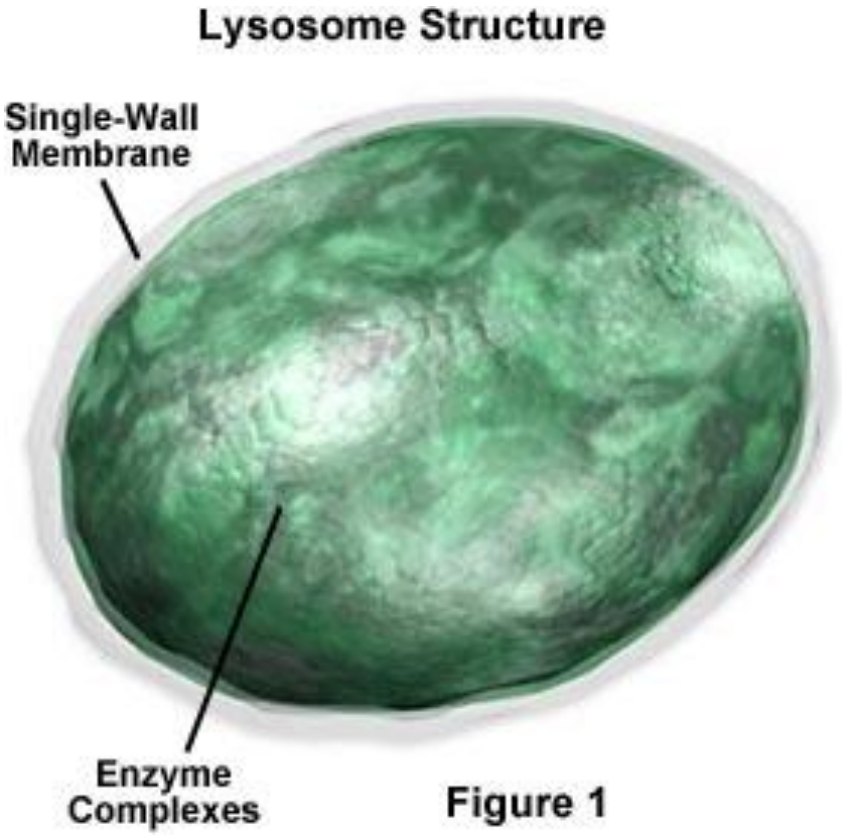
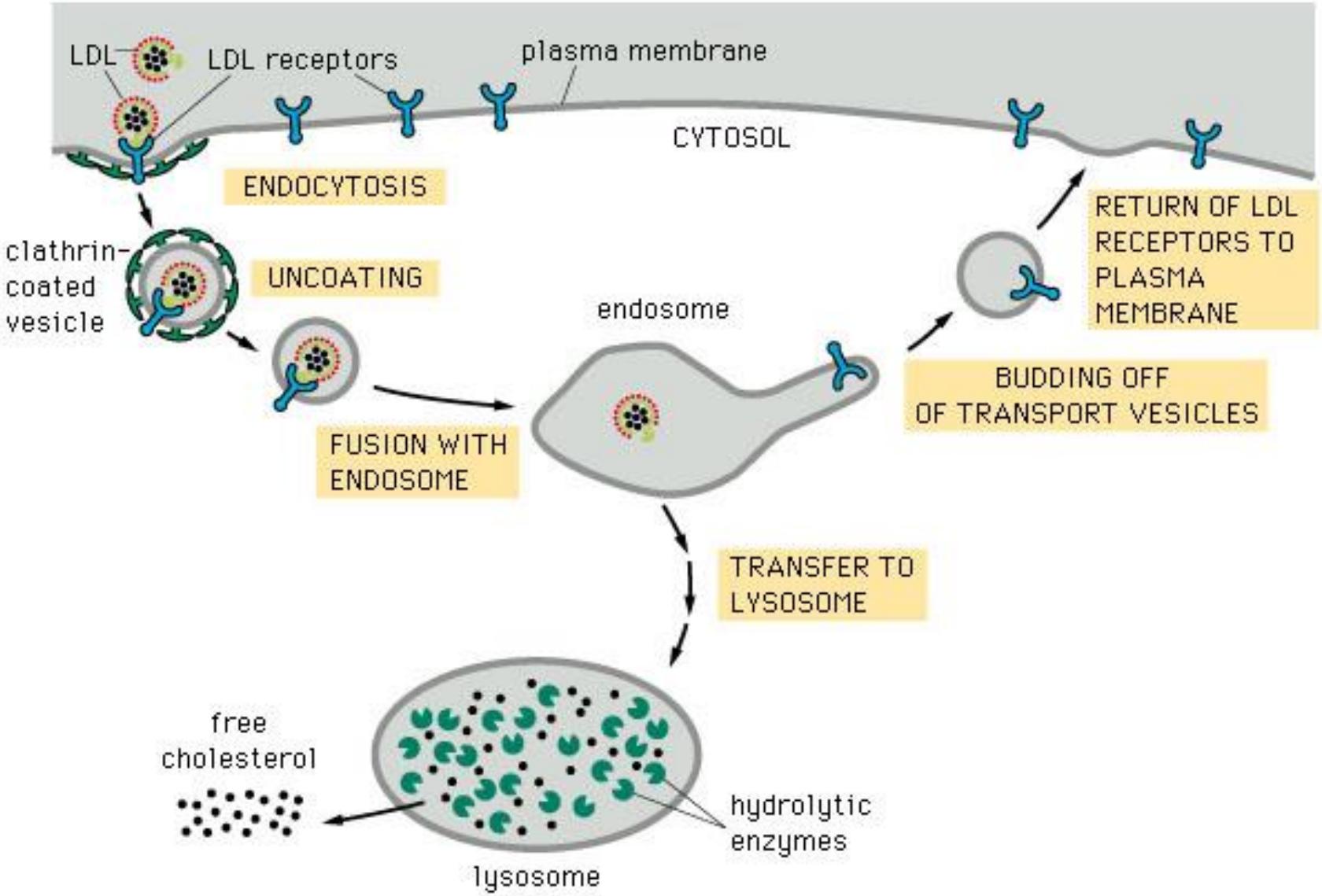


Figure 1

- How many membranes?
- Where are lysosomes formed?
- Contain what?
- Describe the internal environment of a lysosome.
- List three major functions.
- What is the relationship between Tay Sachs disease and lysosomes?

Lysosomes

- Internal sacs. It is a membranous sac bound by *single membrane and contain* hydrolytic enzymes that can hydrolyze macromolecules like proteins, fats, polysaccharides, and nucleic acids
- Internal pH about 5 (very acidic)
- Responsible for degrading cell components that have become obsolete for cell or organism—digestive system of cells.
- Originate by budding from Golgi based on sorting of mannose-6-phosphate “tags” on proteins
- Compartmentalization ESSENTIAL! Failure can lead to many known disease states that result from waste accumulation in the organelle



Lysosomes

Lysosomes contain hydrolytic enzymes involved in intracellular digestion, degrading proteins and structures that are worn out or not in use.

Maximally effective at a pH of 5, these enzymes are enclosed within the lysosome, which has an acidic environment distinct from the neutral pH of the cytosol (the fluid portion of the cytoplasm).

Lysosomes fuse with endocytic vacuoles, breaking down material ingested by the cells. They also aid in renewing a cell's own components by breaking them down and releasing their molecular building blocks into the cytosol for reuse.

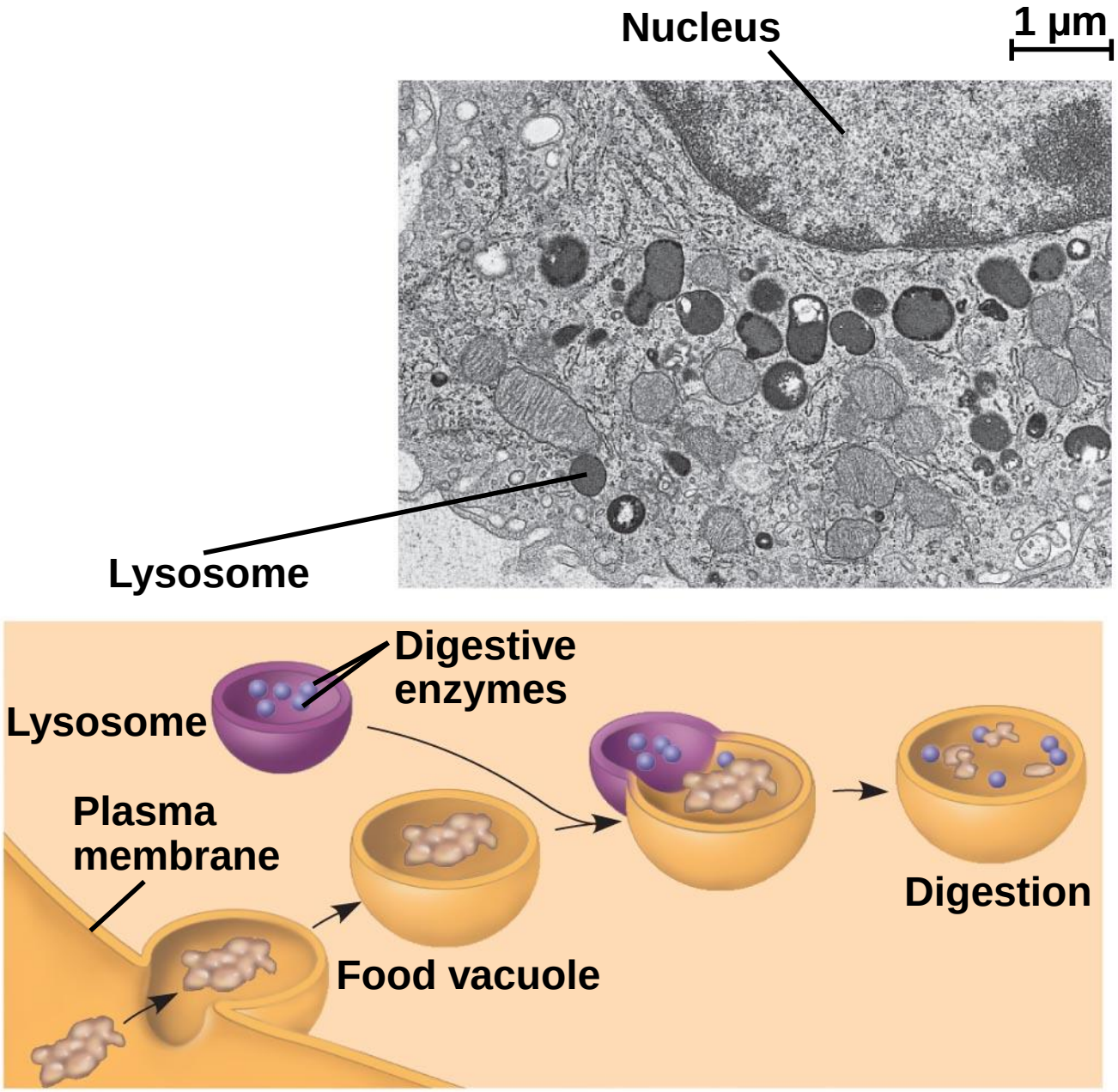
Lysosomes

- contain a mixture of some 40 types of digestive enzymes, all with optimum activity at about pH 5.
- this acid pH is maintained in lysosomes, as in endosomes, by proton pumps in the membrane.
- membrane of the lysosome is resistant to action of its own digestive enzymes *due to the extensive glycosylation of the proteins on the lumenal side of the membrane.*

Endocytosis/Exocytosis

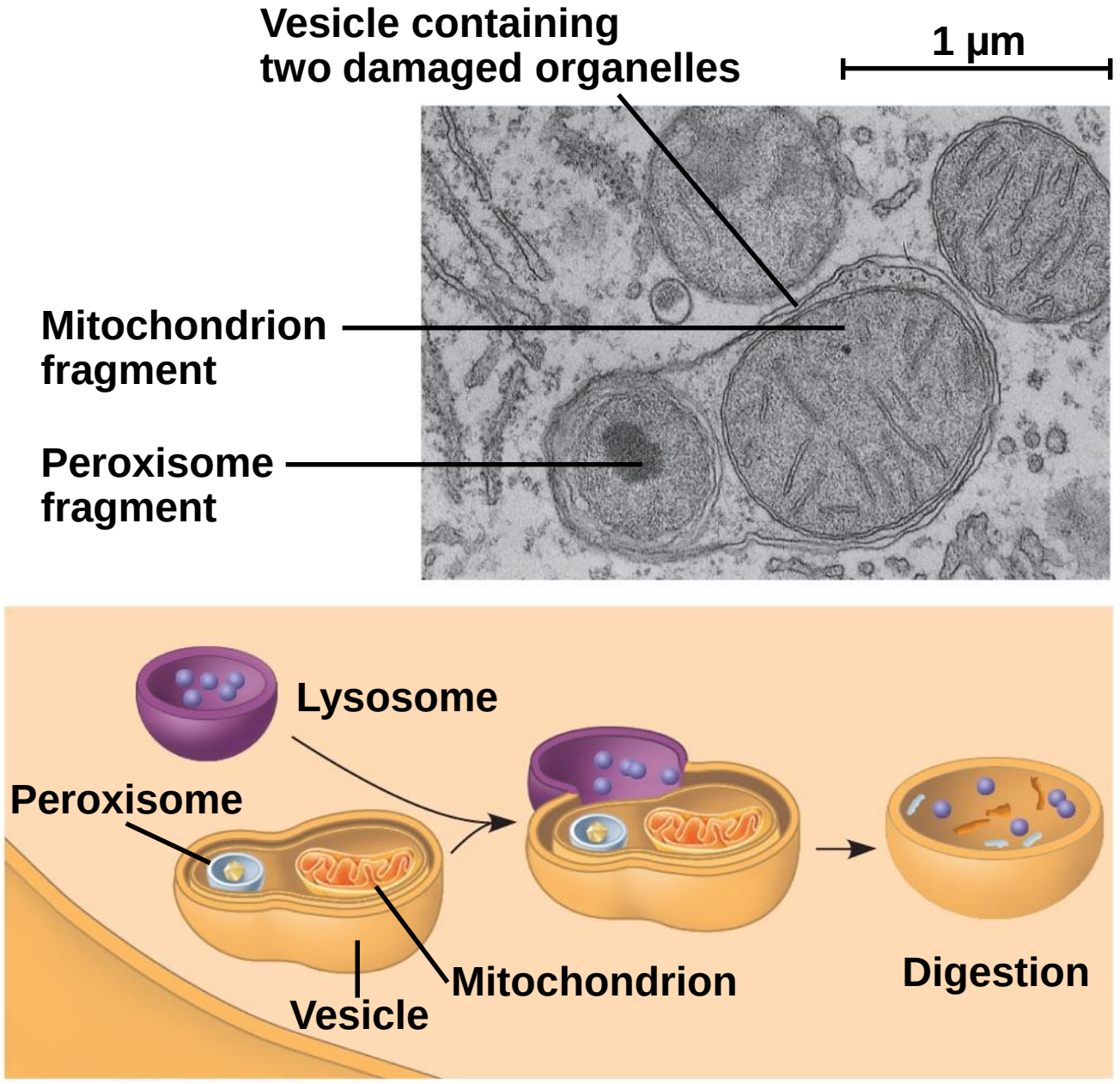
- Some types of cell can engulf another cell by **phagocytosis**; this forms a food vacuole
  - pinocytosis; exocytosis
- A lysosome fuses with the food vacuole and digests the molecules
- Lysosomes also use enzymes to recycle the cell's own organelles and macromolecules, a process called autophagy

Fig. 6-14a



(a) Phagocytosis

Fig. 6-14b



(b) Autophagy

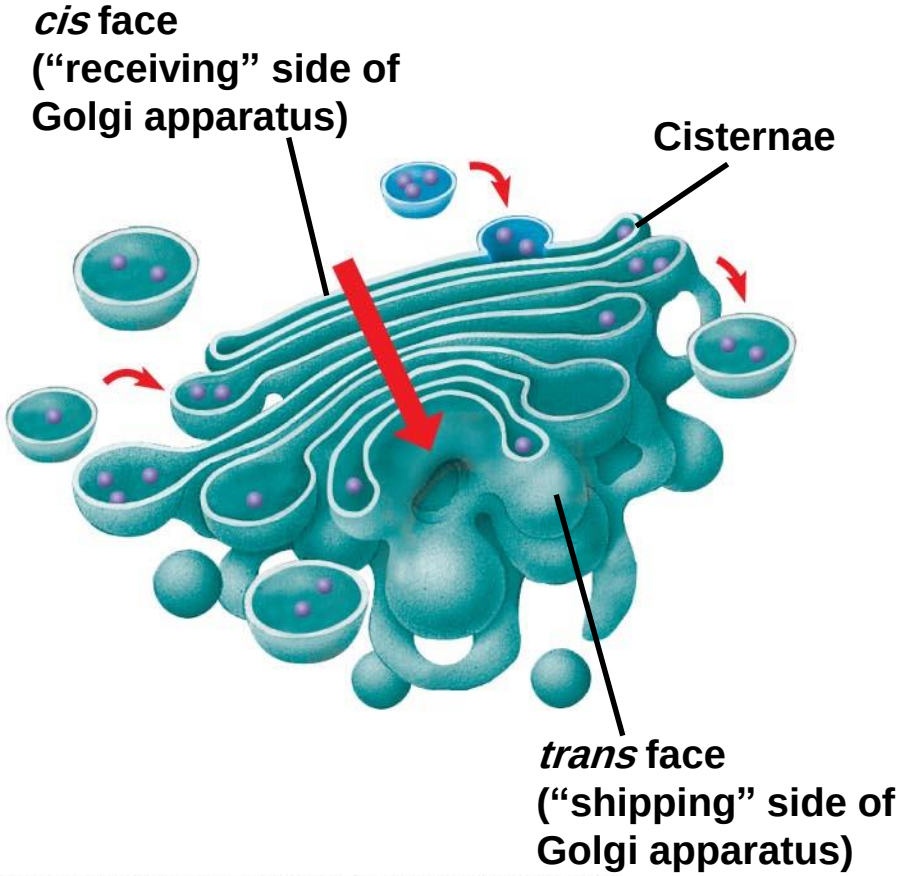
The Golgi Apparatus: Shipping and Receiving Center

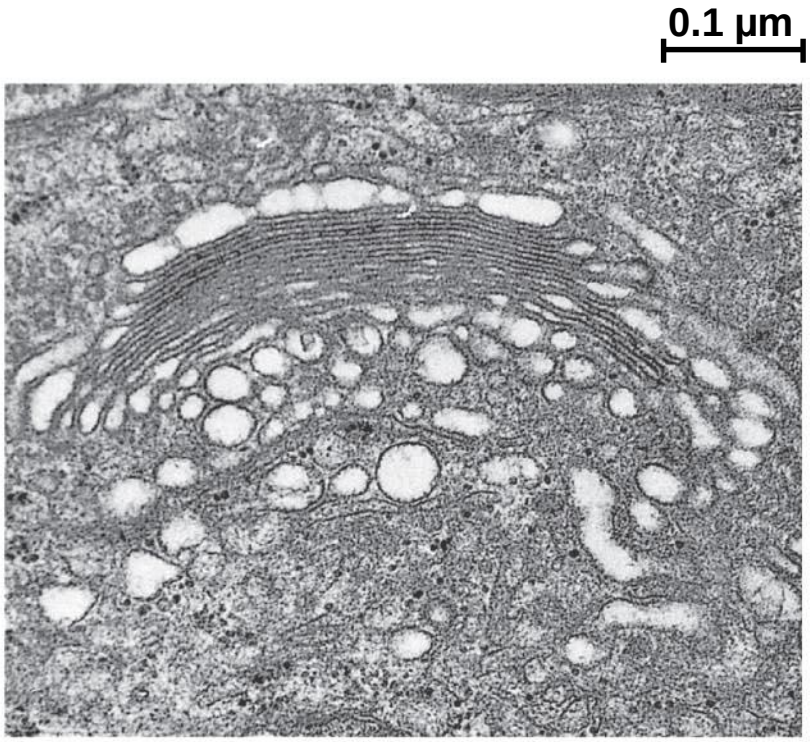
- The **Golgi apparatus** consists of flattened membranous sacs called cisternae
- Functions of the Golgi apparatus:
  - Modifies products of the ER
  - Manufactures certain macromolecules
  - Sorts and packages materials into transport vesicles

Golgi Apparatus

- **Structure:** Golgi bodies are formed when small sac like pieces of membrane are pinched away from the cell.
- **Function:** purpose in the cell are to prepare and store chemical products produced in the cell, and then to secrete these outside the cell.

Fig. 6-13

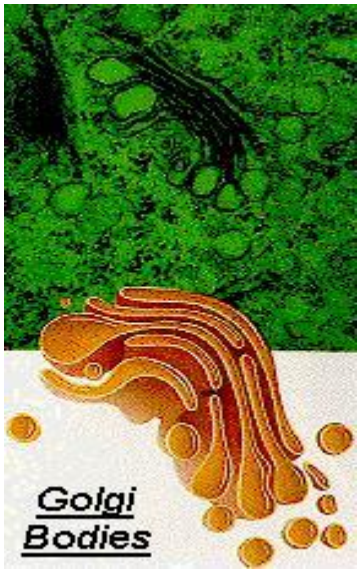




TEM of Golgi apparatus

- The *Golgi* is a stack of membrane-enclosed sacs. It receives vesicles and their contents from the ER and modifies proteins (through glycosylation, the process of modifying proteins with carbohydrate chains, for example).
- Next, it repackages them into vesicles and ships the vesicles to their next stop, such as lysosomes, or the plasma membrane.
- In cells that are very active in the secretion of proteins, the Golgi is particularly active in the distribution of newly synthesized material to the cell surface.
- Secretory vesicles, produced by the Golgi, release their contents to the cell's exterior by the process of exocytosis.

Golgi Apparatus



- In the endoplasmic reticulum, proteins synthesized by ribosomes are sent through the canals of the ER, where they meet up with the Golgi bodies.
- The proteins are then packaged in vesicles.
- The membranes of these vesicles are then able to bond with the cell membrane, where their contents are secreted outside the cell.
- Proteins are not the only material packaged in the Golgi bodies.
- A portion of materials in the wall of a plant cell are assembled in the Golgi bodies.

Golgi Apparatus

- It appears like sets of flattened discs, usually near nucleus and SER
- Involved in protein processing and trafficking to other organelles (e.g., lysosomes, Plasma Membrane)—addition/modification of carbohydrate moieties on proteins or lipids
- Also involved in formation (biogenesis) of lysosomes, secretory vesicles (hormones, blood plasma proteins, digestive enzymes)

Ribosomes

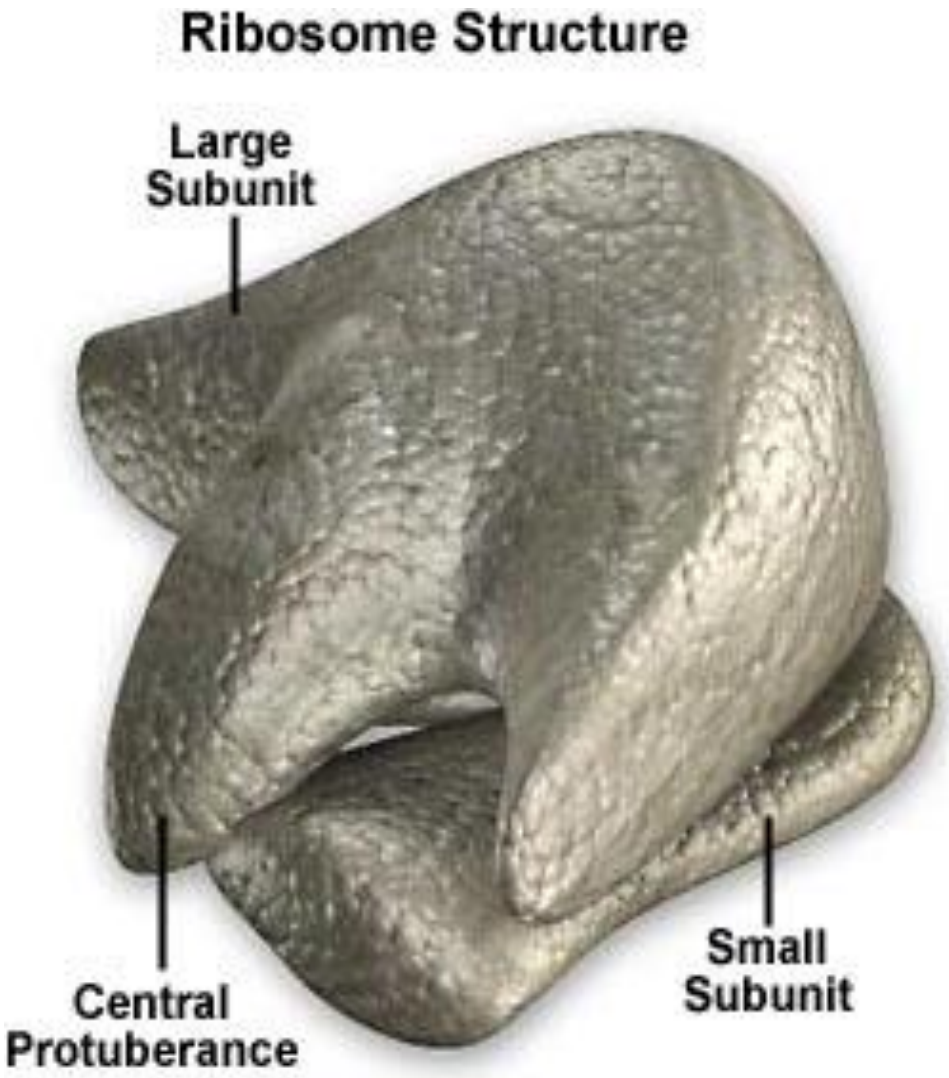


Figure 1

- Non-membrane bound!
- Composed of _____ and _____.
- Sites to synthesize _____.
- How are prokaryotic ribosomes different from eukaryotic ribosomes?
- Antibiotics, including tetracycline and streptomycin, paralyze prokaryotic ribosomes. Why don't these drugs harm eukaryotic ribosomes?

Ribosomes are NOT membrane-bound organelles but are relatively large complex structures that are the sites of protein production and are synthesized by the nucleolus.

They consist of two subunits, one large and one small; each subunit is composed of rRNA and many proteins. Free ribosomes are found in the cytoplasm, while bound ribosomes line the outer membrane of the endoplasmic reticulum.

Prokaryotes have ribosomes that are similar in function to eukaryotic ribosomes, although they are smaller.

Microbodies

Microbodies can be characterized as specialized containers for metabolic reactions.
The two most common types of microbodies are *peroxisomes* and *glyoxysomes* .
Peroxisomes contain oxidative enzymes that catalyze a class of reactions in which hydrogen peroxide is produced through the transfer of hydrogen from a substrate to oxygen.
These microbodies break fats down into small molecules that can be used for fuel; they are also used in the liver to detoxify compounds, such as alcohol, that may be harmful to the body.

Glyoxysomes, on the other hand, are usually found in the fat tissue of germinating seedlings.
They are used by the seedling to convert fats into sugars until the seedling is mature enough to produce its own supply of sugars through photosynthesis.

Peroxisome

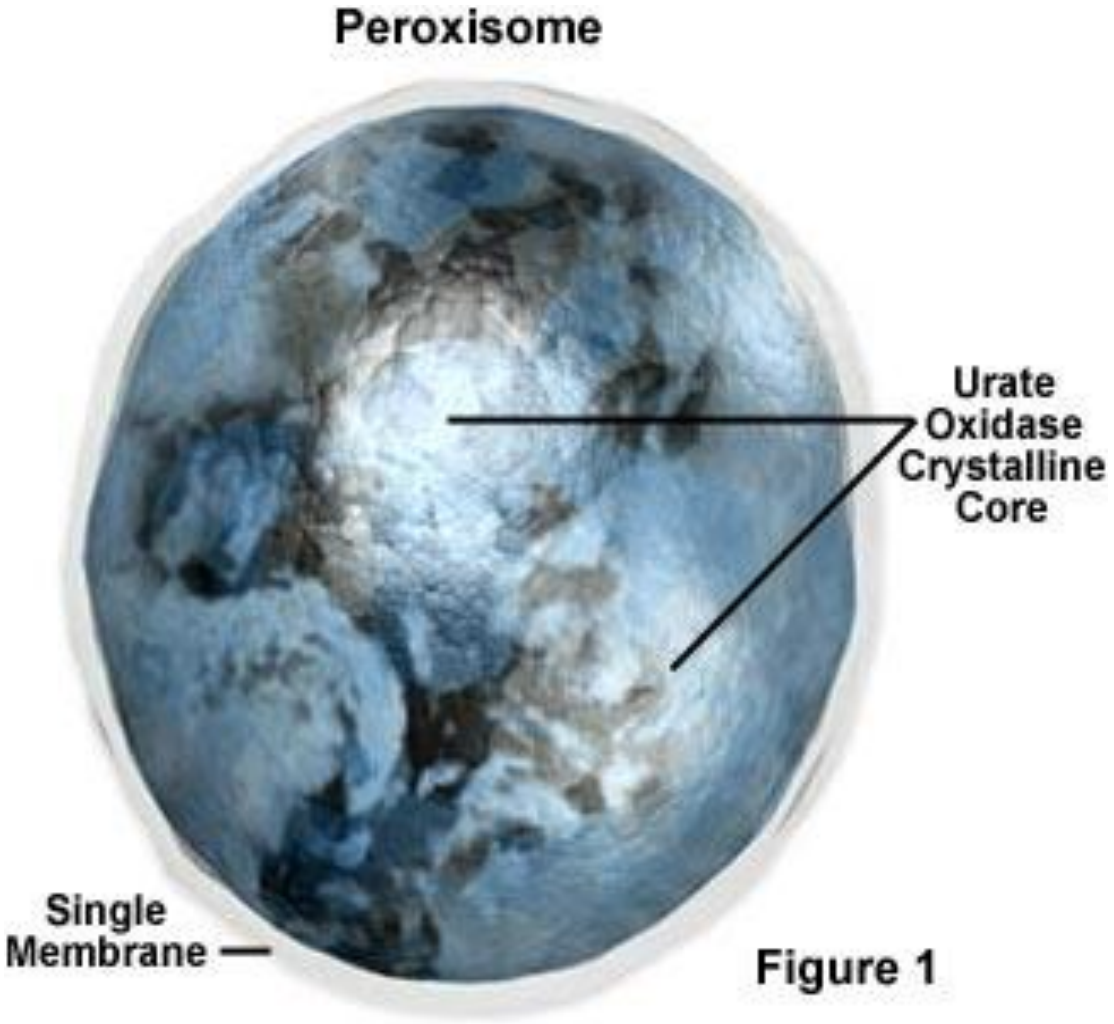


Figure 1

- How do the enzymes in peroxisomes differ from the enzymes in lysosomes?
- What cells have many peroxisomes? Why?
- Plants have special peroxisomes called glyoxysomes. What is their function?

Vacuoles

Vacuoles are membrane-enclosed sacs within the cell. They are formed after endocytosis and can fuse with a lysosome to digest their contents.

Contractile vacuoles in freshwater protists pump excess water out of the cell.

Plant cells have a large central vacuole called the tonoplast that is part of their endomembrane system.
In plants, the tonoplast functions as a place to store organic compounds, such as proteins, and inorganic ions, such as potassium and chloride. Wastes can be stored here as well.

Chloroplasts

Chloroplasts are found only in algal and plant cells.

With the help of one of their primary components, chlorophyll, they function as the site of photosynthesis.

They contain their own DNA and ribosomes, exhibit the same semiautonomy as mitochondria, and are also believed to have evolved via symbiosis.

Cytoskeleton

Cytoskeleton

The cell is not a blob of gelatin enclosed by a membrane bag. The cell has shape, and in some cases actively moves and changes its shape. The cell gains mechanical support, maintains its shape, and carries out cell motility functions with the help of the *cytoskeleton*, composed of *microtubules* , *microfilaments* , *intermediate fibers* , and chains and rods of proteins, each with distinct functions and activities.

Microtubules. *Microtubules* are hollow rods made of polymerized tubulin proteins. When polymerized, microtubules radiate throughout the cells and provide it with support and a framework for organelle movement within the cell.

Centrioles and the *mitotic spindle,* which direct the separation of chromosomes during cell division, are composed of microtubules.

Cilia and Flagella. *Cilia* and *flagella* are specialized arrangements of microtubules that extend from certain cells and are involved in cell motility. Prokaryotic flagella are entirely distinct in structure from eukaryotic flagella.

Microfilaments. Cell movement and support are maintained in part through the action of solid rods composed of actin subunits; these are termed *microfilaments* . Muscle contraction, for example, is based on the interaction of actin with myosin in muscle cells. Microfilaments are involved in cell movement and in changing cell shape; they are active, for instance, in the contraction phase of cell division and in amoeboid movement.

Intermediate Fibers. These structures are a collection of fibers involved in the maintenance of cytoskeletal integrity. Their diameters fall between those of microtubules and microfilaments.

Organisms, Organs, & Organelle

- Organism is a complete living entity
  - Unicellular organisms such as Bacteria, Protists, etc (mostly prokaryotic).
  - Multicellular organisms such as all animals and most plants. These organisms have different Levels of Cellular Organization, (mostly eukaryotic).

  - The Level of Cellular Organization is arranged from lower to higher level as follows:
    1. Cells
    2. Tissues (Epithelia, Connective, Muscle, Nerve Tissue)
    3. Organs (Heart, skin, kidney, etc.)
    4. Organ systems (circulatory, respiratory, digestive, etc)
    5. Organisms (Human, bovine, etc)

Characteristics of Living Organisms

There are 6 main Characteristics:

1- The highly organized Cells with a high degree of complexity and organization. The interactions of individual components being dynamic and coordinated

2- Relation with energy (the extraction, transformation, and systematic use of energy to create and maintain structures and to do work)

3- Grow and Reproduce with high fidelity. A capacity for fairly precise self-replication while allowing enough change for evolution

4- Interact with environment, the ability to sense and respond to changes in surroundings.

5- Movement

6- Homeostasis

Characteristics of Living Organisms

1-The highly organized Cells

- The cell is the building block of the living organisms.
- It is structurally complicated and highly organized.
- Cell group together to form tissue or organ to perform specific function.
  - **Cell intricate internal structures like:**
    - Biological structures that serve functional purposes, e.g.:
      - Nucleus:
      - Ribosome:
      - Mitochondria:
      - lysosome:

State the function of each organelle.

    - Many kinds of complicated chemical molecules like:
      - Proteins, DNA, RNA, carbohydrates, lipids, etc.

Properties of living Organisms

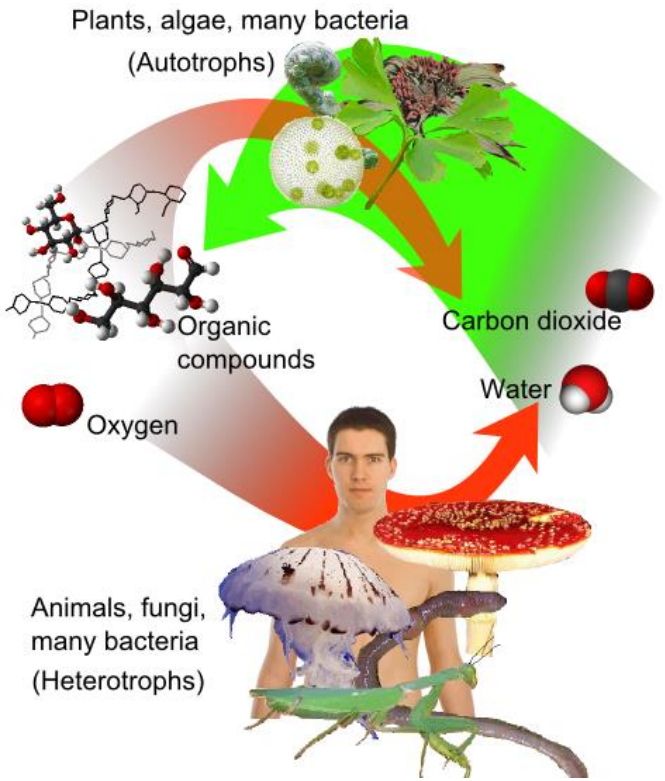
2- Relation with energy

Living organisms operate within the same laws of Thermodynamics that apply to physics and chemistry

All living organisms have the ability to:

Extract, Transform, Store, and Use ENERGY.

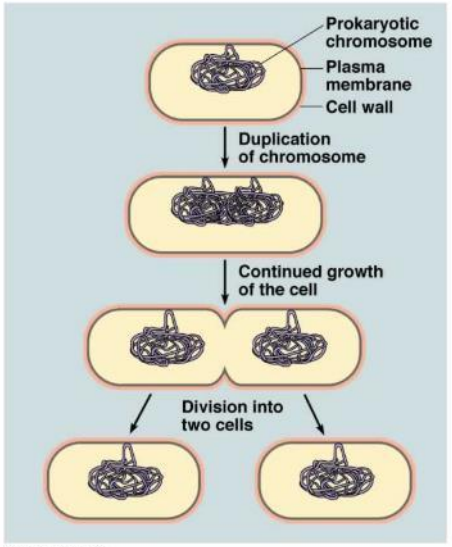
- First Law of Thermodynamics: "Energy can not be created or destroyed, but can be transformed".
  - Sun is the ultimate source of energy for all living things.
  - The energy in the sunlight is transformed into usable form by autotrophs (photosynthesis).
  - Other living things extract energy from autotrophs, directly or indirectly (herbivores, carnivores or omnivores).
  - Energy is stored in chemical bonds: e.g. ATP, GTP, NADH, etc. and releases when these bonds are broken,
- Second Law of Thermodynamics – Spontaneous processes are characterized by an increase in the **entropy** of the universe by the conversion of order and disorder.



Properties of living Organisms

3- Grow and Reproduce with high fidelity

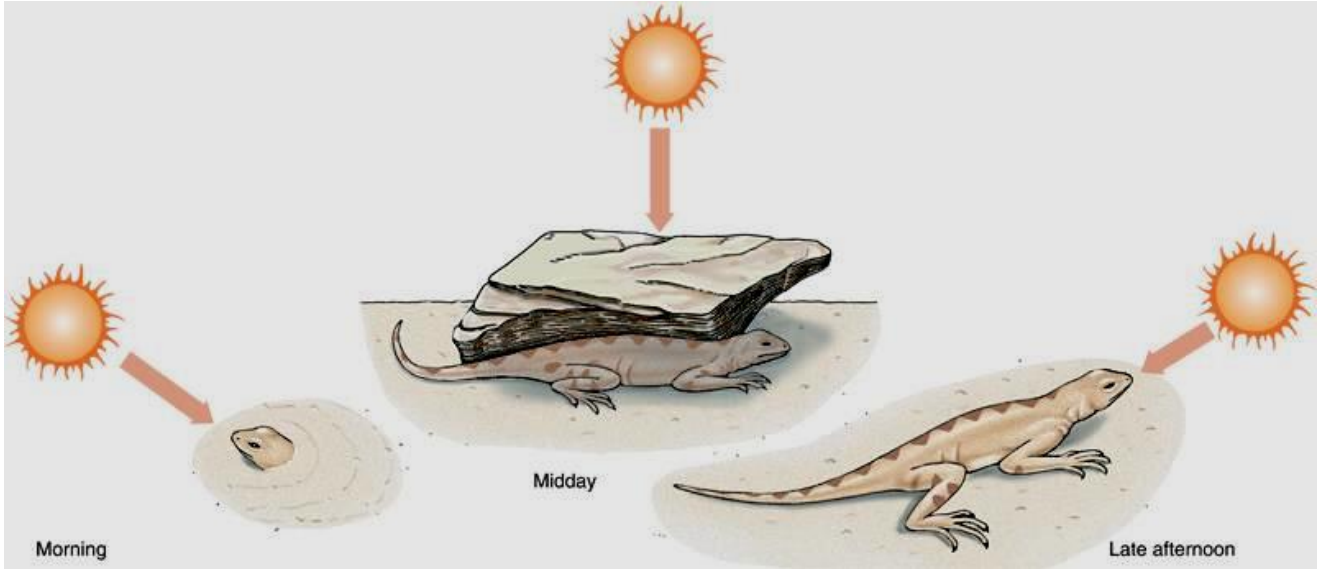
- All living organisms grow and undergo development
- The most characteristic attribute is the near- perfect fidelity of self- replication and self assembly
  - Cells divide to produce new cells.
  - Organisms reproduce to produce new generations.



Properties of living Organisms

4- Interact with environment

- Living organisms interact with their environments.
- It undergoes accommodation, hibernation and/or adaptation.
- **Ecology** is the study of
  - interaction between organisms
  - Interaction between organisms and their environment



Properties of living Organisms

5- Movement

- **Movement** – Living systems and their parts can have precise and controlled movements.
- Movements are required for:
  - Extraction of energy from their environments.
  - Responses to stimuli
  - Reproduction
  - Growth
  - Development in multicellular organisms

- On contrary, the nonliving matter often needs external forces to be moved and is Not precisely controlled by the moving objects.

Properties of living Organisms

6- Homeostasis

- Homeostasis is a characteristic of living organisms in which the internal conditions remain stable and relatively constant and regulated regardless the different biological and environmental factors affecting the organism.
- Examples of homeostasis include the regulation of temperature and the balance between acidity and alkalinity (pH).

Quiz

1. All organisms are composed of one or more types of cells ..... ( )
2. Living cells can be generated spontaneously ..... ( )
3. Ribosomes contains hereditary information which is passed from cell to cell ..... ( )
4. Prokaryotes are single-celled organisms ..... ( )
5. Mitochondria is responsible for cytoplasmic protein synthesis ..... ( )
6. Living organisms operate within the same laws that apply to physics and chemistry ( )
7. Angestrom is larger than micrometer ..... ( )
8. Lysosome is a cellular organelle responsible for digestion of cell component and is called Suicide Bag ..... ( )

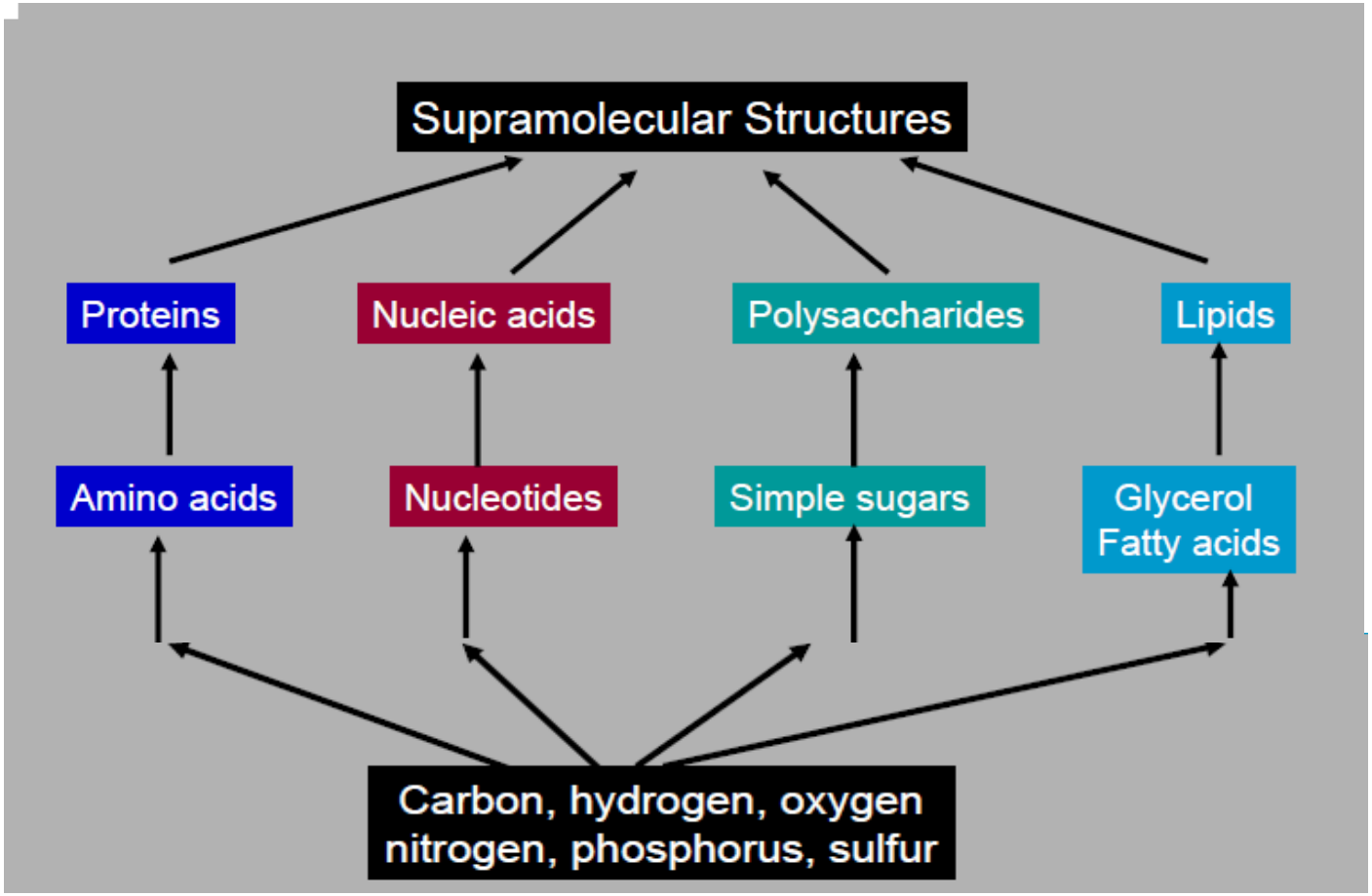
For more training visit http://quizlet.com/10449142/test

The 4 Major macromolecules

There are 4 major macromolecules (polymers) in the cell formed by condensation of smaller building blocks (monomers) by the removal of H_2O (dehydration):

Macromolecule (polymers)	Building blocks (monomers)	Name of bond
Carbohydrate	Monosaccharides	Glycosidic bond
Proteins	Amino acids	Peptide bond
Nucleic acids	Nucleotides	Phospho diester bond
Lipids	Fatty acids + alcohol	Ester bond

CHNOPS vs monomer vs macromolecules

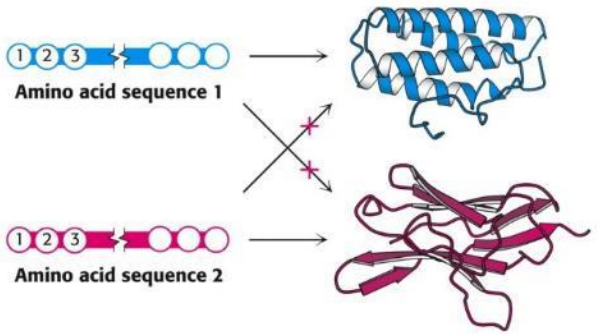


Characteristics of biological molecules

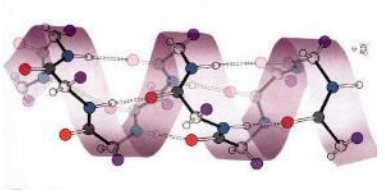
- All macromolecules have a “Sense” or Directionality
  - DNA : -ATC- ≠ -CTA-
  - Protein: -Gly-Ser- ≠ -Ser-Gly-
  - Carbohydrate: -Glu-Gal ≠ -Gal-Glu-

- Macromolecules are Informational:
  - Examples: AUC=Ile; ACU=Thr; UAC=Tyr

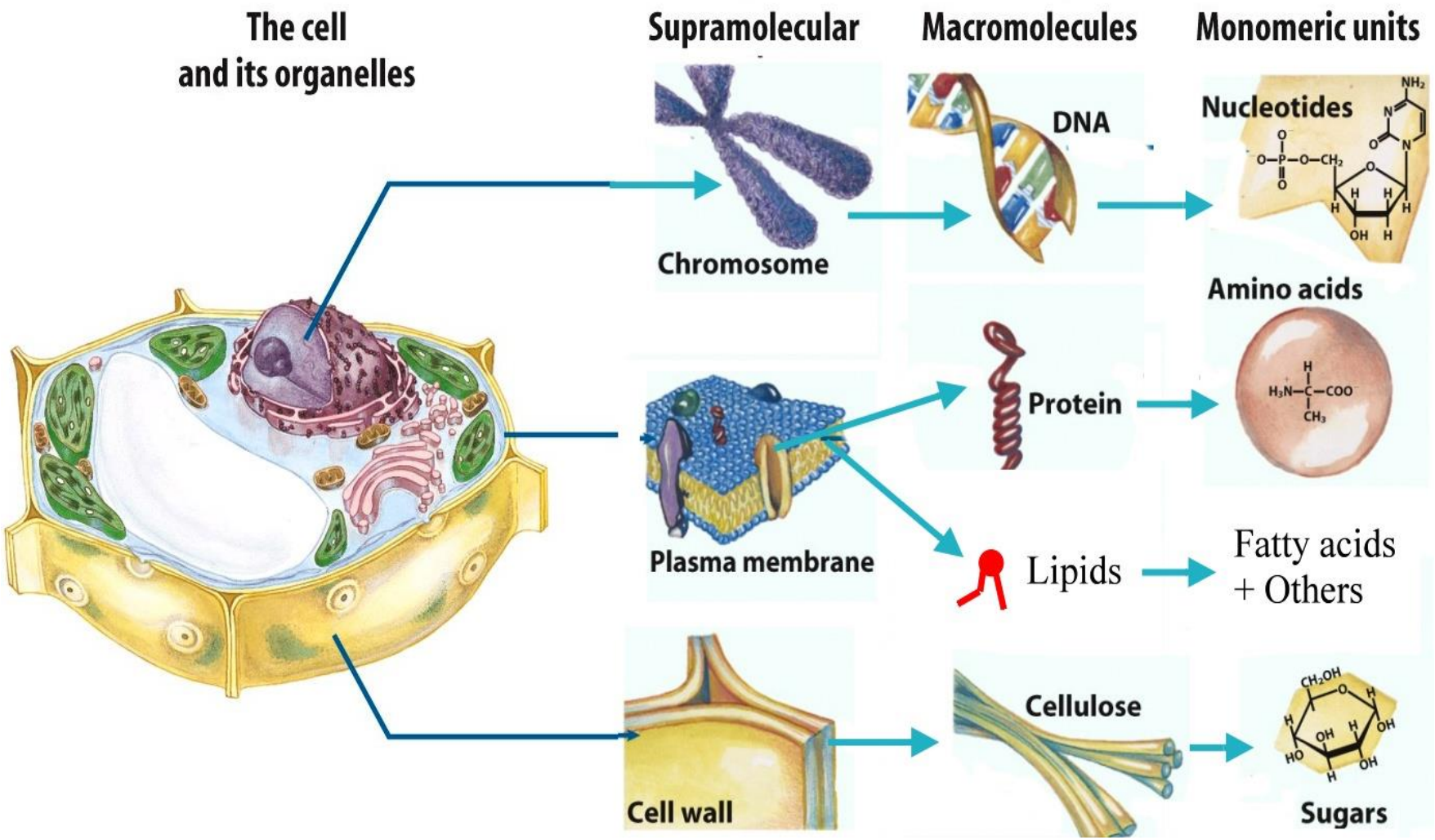
- Macromolecules Have Characteristic Three-Dimensional Architecture



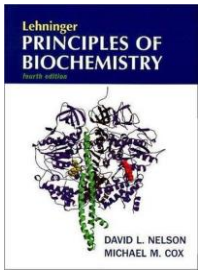
- Weak forces maintain biological structure and determine biomolecular interactions



Structural Levels of Cell Molecules



Summary of the Cellular Foundation of Biochemistry



- All cells are bounded by a plasma membrane; have a cytosol containing metabolites, coenzymes, inorganic ions, and enzymes; and have a set of genes contained within a nucleoid (prokaryotes) or nucleus (eukaryotes).
- Phototrophs use sunlight to do work; chemotrophs oxidize fuels, passing electrons to good electron acceptors: inorganic compounds, organic compounds, or molecular oxygen.
- Bacterial cells contain cytosol, a nucleoid, and plasmids. Eukaryotic cells have a nucleus and are multicompartmented, segregating certain processes in specific organelles, which can be separated and studied in isolation.
- Cytoskeletal proteins assemble into long filaments that give cells shape and rigidity and serve as rails along which cellular organelles move throughout the cell.
- Supramolecular complexes are held together by noncovalent interactions and form a hierarchy of structures, some visible with the light microscope. When individual molecules are removed from these complexes to be studied in vitro, interactions important in the living cell may be lost.