BTC01 – LIFE SCIENCE

1. Cell Biology

a) Introduction to life science: prokaryotes & eukaryotes
Definition; Difference

a) Introduction to cells - Define cell, different types of cell

b) Cellular organelles - All organelles and functions in brief

c) Cellular communications
Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation

2. Biochemistry

a) Biological function of carbohydrate and lipid - Introduction, structure and function

b) Biological function of nucleic acids and protein - structure and function

c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose-Glycolysis, TCA; overall degradation of proteins and lipids

d) Biosynthesis of Macromolecules
Generation of ATP (ETS), Generation of Glucose (Photosynthesis)

3. Microbiology

a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases

b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc,

c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve

d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle

4. Immunology

a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system

b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody

c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination

d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell

5. Molecular Biology

a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear

b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon, packaging, chromatin

c) Central Dogma (Replication, Transcription and Translation)

d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning

6. Bioprocess Development

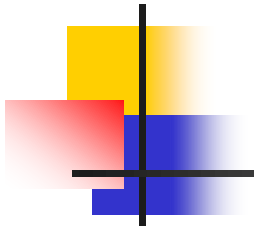
a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation

b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation
Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki

a) Microbial sterilization techniques and kinetics
Introduction to sterilization, dry and moist sterilization

a) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions

b) Material and energy balance for biological reactions - Stoichiometry



CELL BIOLOGY - 1

All present-day cells have apparently evolved from the same ancestral cell

Figure 1–3 All living organisms are constructed from cells. A colony of bacteria, a butterfly, a rose, and a dolphin are all made of cells that have a fundamentally similar chemistry and operate according to the same basic principles.

A cell reproduces by replicating its DNA and then dividing in two, passing a copy of the genetic instructions encoded in its DNA to each of its daughter cells. That is why daughter cells resemble the parent cell. However, the copying is not always perfect, and the instructions are occasionally corrupted by mutations that change the DNA.

The Cell Theory

The cell theory was proposed independently in 1838 and 1839 -

All organisms are composed of one or more cells

Cells are the smallest living things.

Cells arise only by division of previously existing cells.

All organisms living today are descendants of an ancestral cell.

Matthias Schleiden

Theodor Schwann

Cells vary enormously in appearance and in function

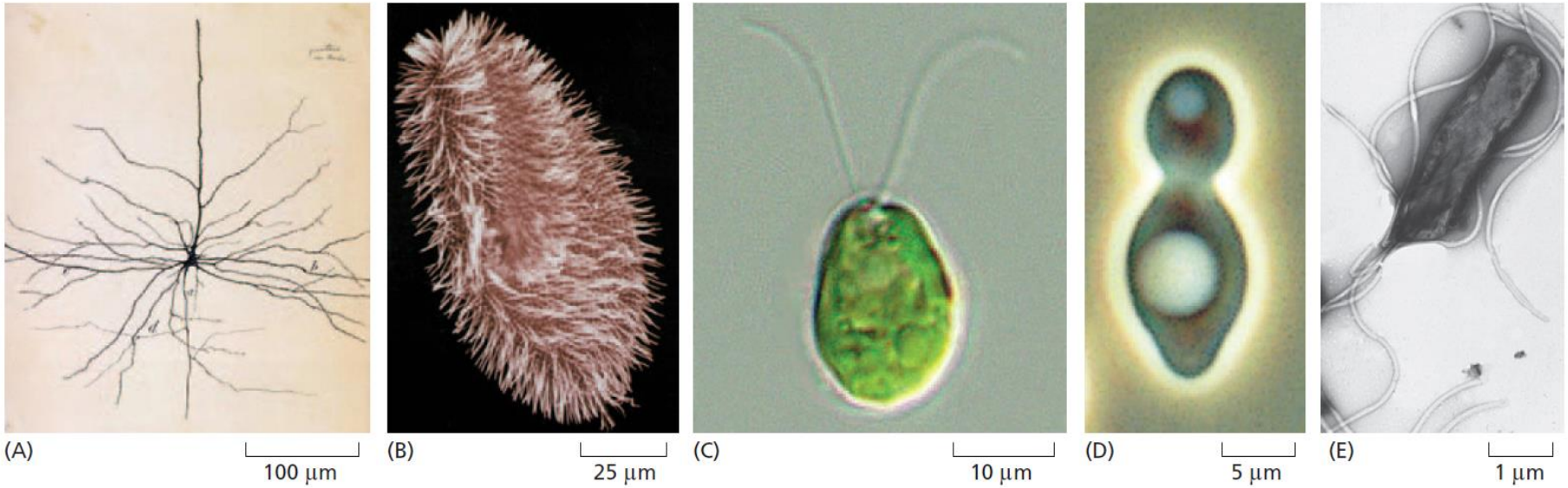


Figure 1–1 Cells come in a variety of shapes and sizes. Note the very different scales of these micrographs. (A) Drawing of a single nerve cell from a mammalian brain. This cell has a huge branching tree of processes, through which it receives signals from as many as 100,000 other nerve cells. (B) *Paramecium*. This protozoan—a single giant cell—swims by means of the beating cilia that cover its surface. (C) *Chlamydomonas*. This type of single-celled green algae is found all over the world—in soil, fresh water, oceans, and even in the snow at the top of mountains. The cell makes its food like plants do—via photosynthesis—and it pulls itself through the water using its paired flagella to do the breaststroke. (D) *Saccharomyces cerevisiae*. This yeast cell, used in baking bread, reproduces itself by a process called budding. (E) *Helicobacter pylori*. This bacterium—a causative agent of stomach ulcers—uses a handful of whiplike flagella to propel itself through the stomach lining. (A, copyright Herederos de Santiago Ramón y Cajal, 1899; B, courtesy of Anne Fleury, Michel Laurent, and André Adoutte; C, courtesy of Brian Piasecki; E, courtesy of Yutaka Tsutsumi.)

The Cell

Cell is the fundamental structural and functional unit of living organisms. It is the vehicle for the hereditary information, which defines a particular species.

Cell includes the machinery to gather raw materials from the environment to construct out of them a new cell of its own image - complete with a new copy of the hereditary information.

Nothing less than a cell has this capability.

Universal features of Cells

1. **All cells store their hereditary information in the same linear chemical code – the DNA molecule.**

2. **All cells replicate their hereditary information by DNA polymerization process – DNA replication**

3. **All cells transcribe their hereditary information into the same intermediary form (product) – the RNA molecules – the process is Transcription**

4. **All cells translate RNA into protein in the same way - Translation**

5. **All cells use proteins as catalysts – the enzymes.**

Universal features

6. All cells function as biochemical factories to produce various metabolites/products using the same chemical building blocks.

7. All living cells require free energy – to replicate genetic information faithfully – to make all its chemical complex molecules according to correct specifications.

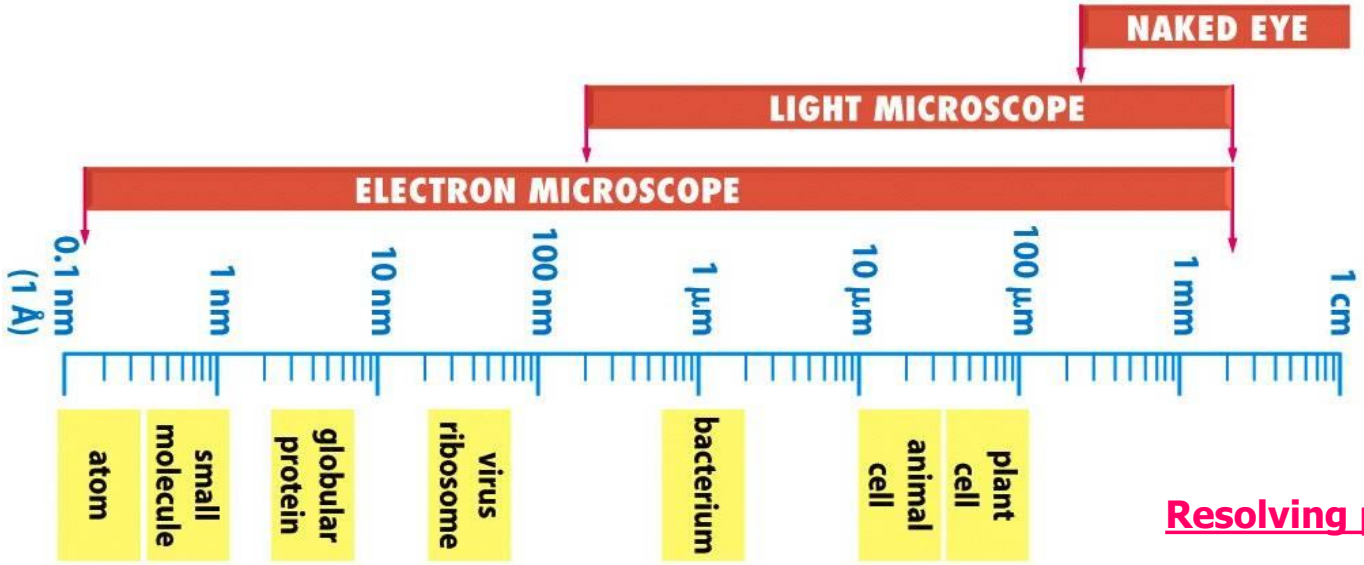
8. A living cell can even exist with fewer than 500 genes – one gene is a segment of DNA molecule coding for one protein.

9. All cells are enclosed in a plasma membrane across which nutrients and waste materials must pass.

Visualizing Cells

Cells are small and complex. Understanding cellular structural organization is an essential prerequisite to learn about their structures and functions

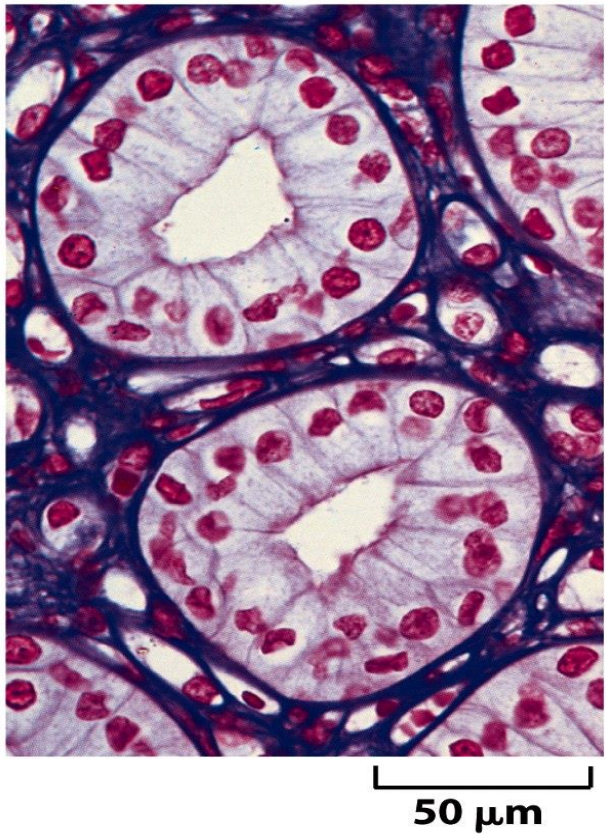
Microscopy: Optical (light) microscopes, Electron microscopes

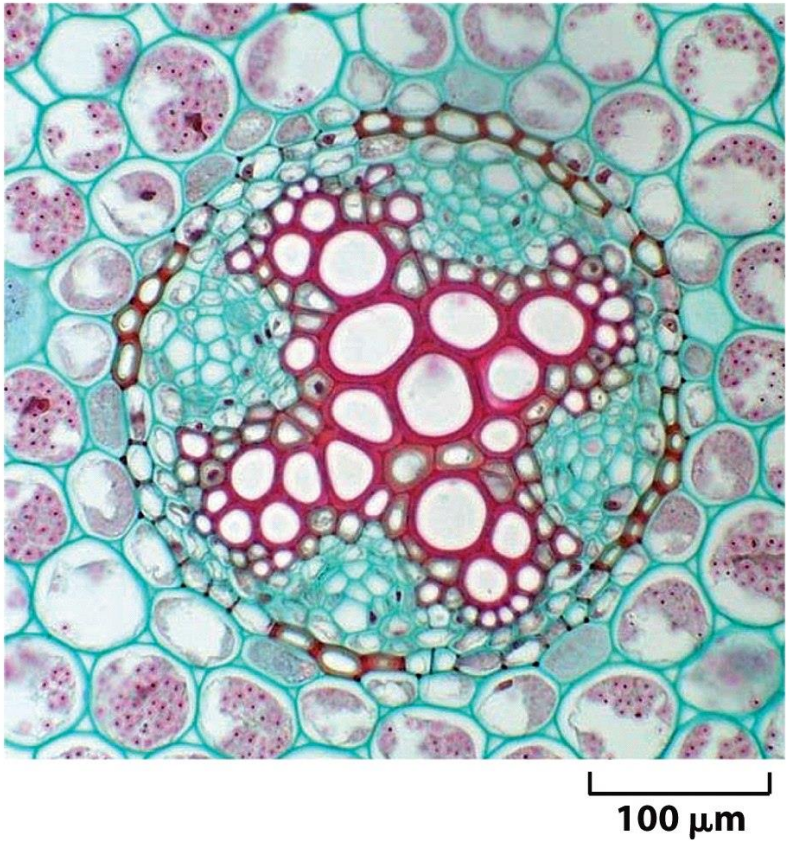


Resolving power

Visualizing Cells through Light microscopy

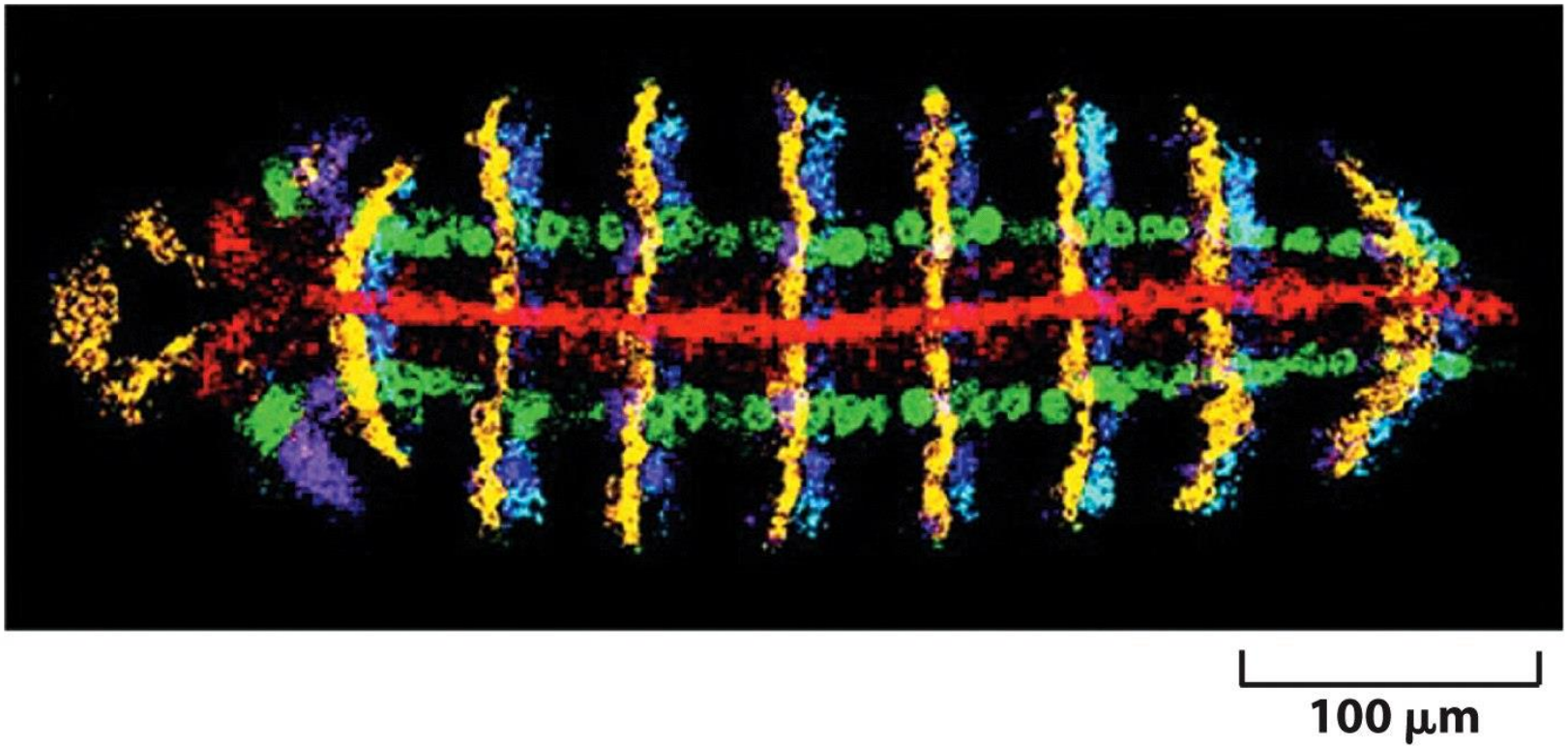
Staining of cellular components





Left – cells in urine collecting duct of kidney stained with hematoxylin and eosin; **Right** – cells in plant root stained with safranin and fast green

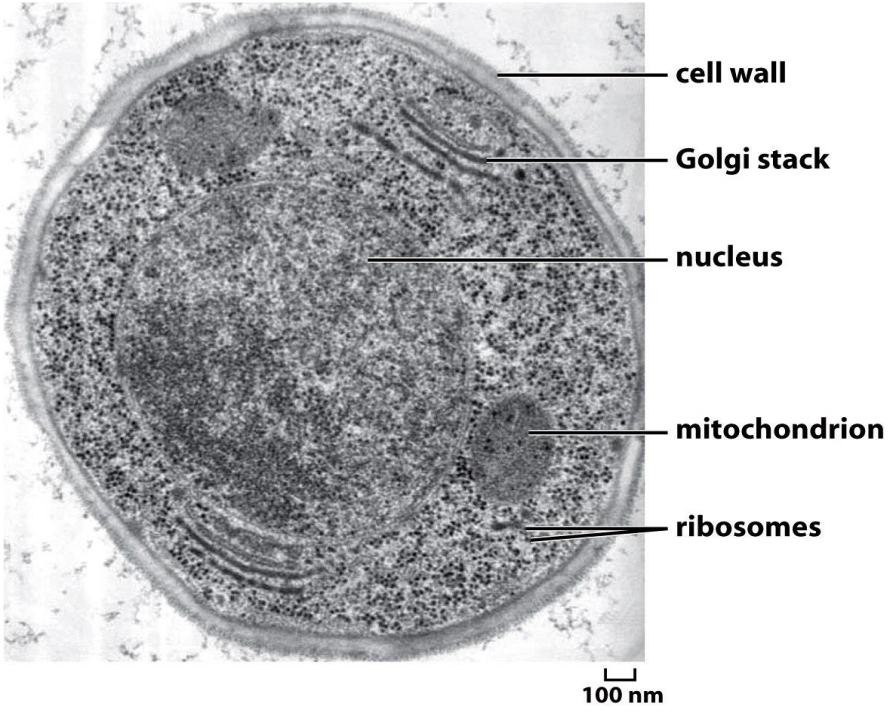
Visualizing Cells: Fluorescence Microscopy



Different RNAs in tissues

Visualizing Cells Using Electron Microscopes

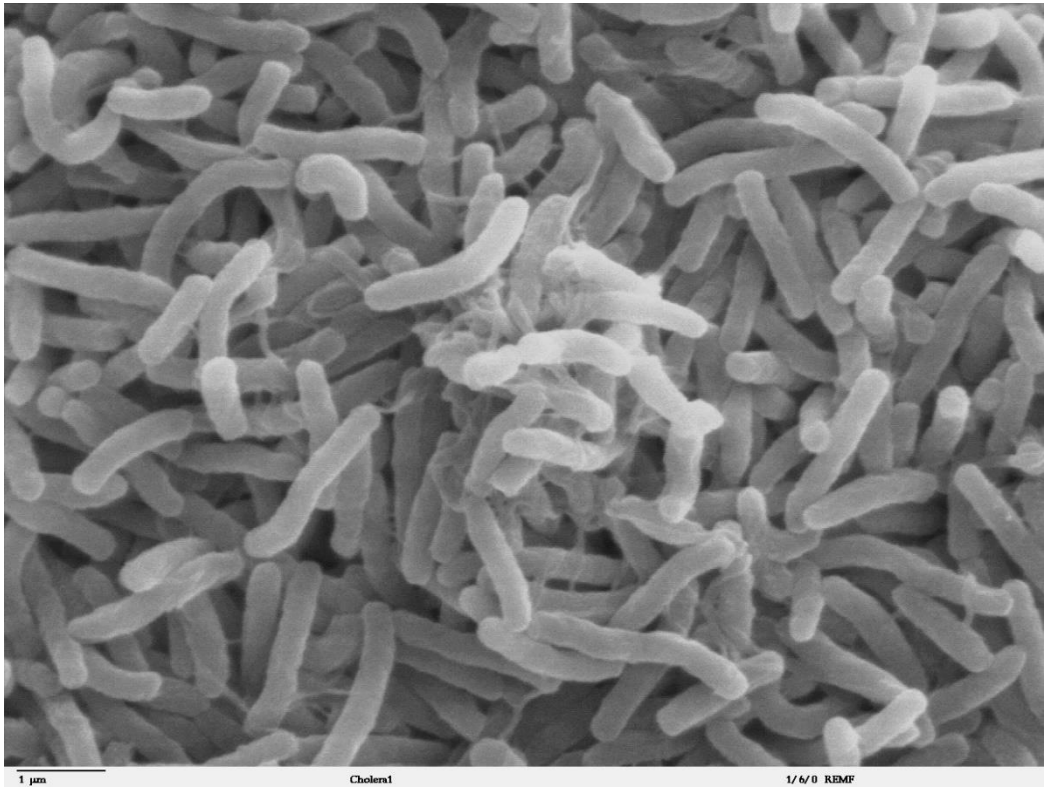
Transmission Electron Microscope



Thin section of a yeast cell seen under TEM

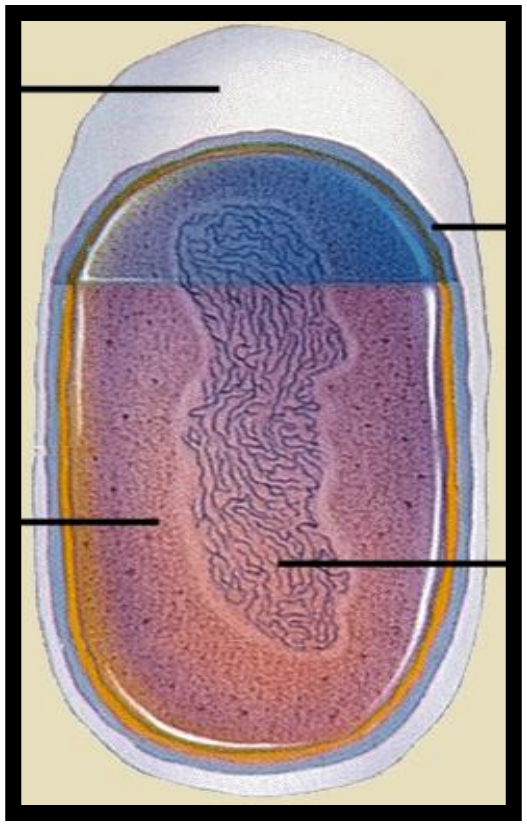
Visualizing Cells

Scanning Electron Microscopy



SEM image of bacteria – *Vibrio cholerae*

Fundamentally two different types of cells: the prokaryotic cell and the eukaryotic cell

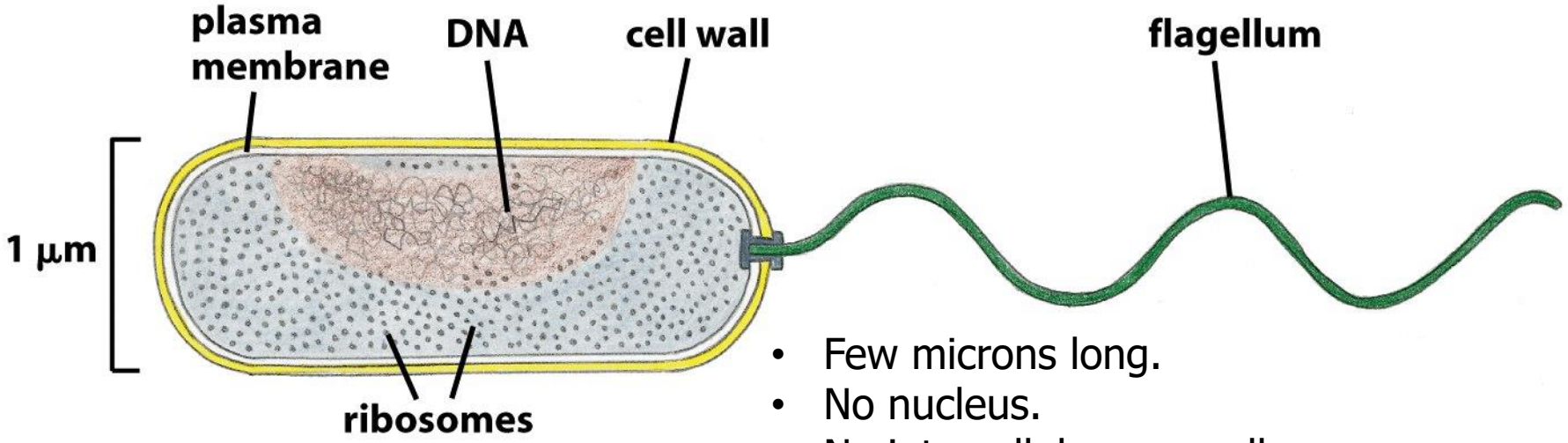


Prokaryotic cell

Eukaryotic cell

The prokaryotic cells

*Bacteria have the simplest structure and come closest to showing us life stripped down to its essentials. Indeed, a bacterium contains essentially no organelles—not even a nucleus to hold its DNA. This property—**the presence or absence of a nucleus—is used as the basis for a simple but fundamental classification of all living things**. Organisms whose cells do not have a nucleus are called prokaryotes (pro, meaning "before") karyon - a "kernel" or "nucleus").*

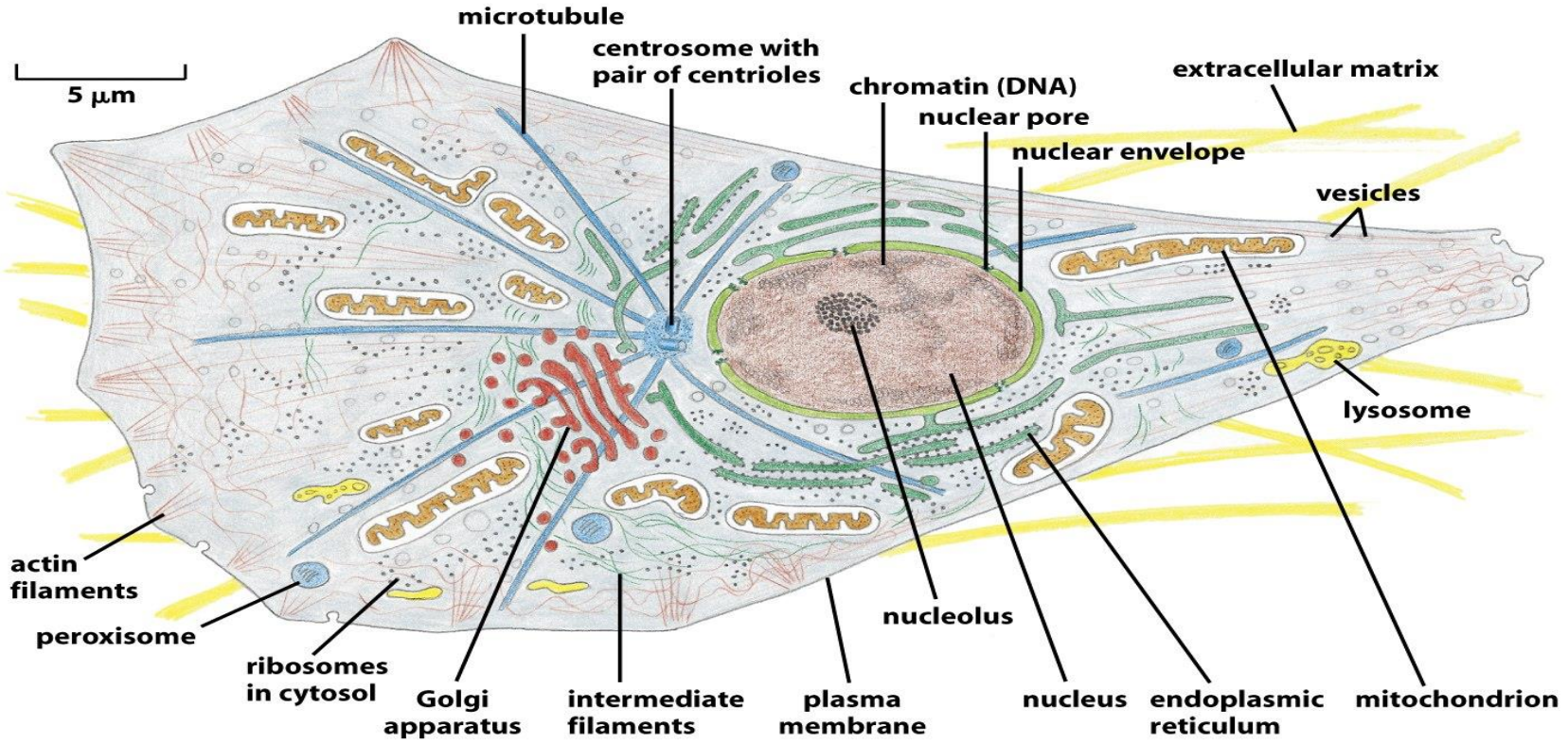


- Few microns long.
- No nucleus.
- No intracellular organelles.
- Quick cell duplication.
- Single cell organism. Can make colonies.

The eukaryotic cells

Eukaryotes (from the Greek words eu, meaning "well" or "truly," and karyon, a "kernel" or "nucleus").

- **Tens of microns long.**
- **Have nucleus.**
- **Diverse types of intracellular organelles (Compartmentalization).**
- **Single celled (amoeba, yeast), or multi cell organisms like plant, animal, human.**



DIFFERENCES

PROKARYOTIC CELL	EUKARYOTIC CELL
Generally smaller in size than the eukaryotic cell (1-10μm)	Larger in size than the prokaryotic cell (5-100μm)
Membrane bound organelles are absent.	Membrane bound organelles are present.
The chromosome is singular.	More than one chromosomes are present.
The nuclear region is not very well defined and is called as the nucleoid.	The nuclear region is very well defined in form of separate membrane bound organelle called as the nucleus.

Eukaryotic Cellular Organization

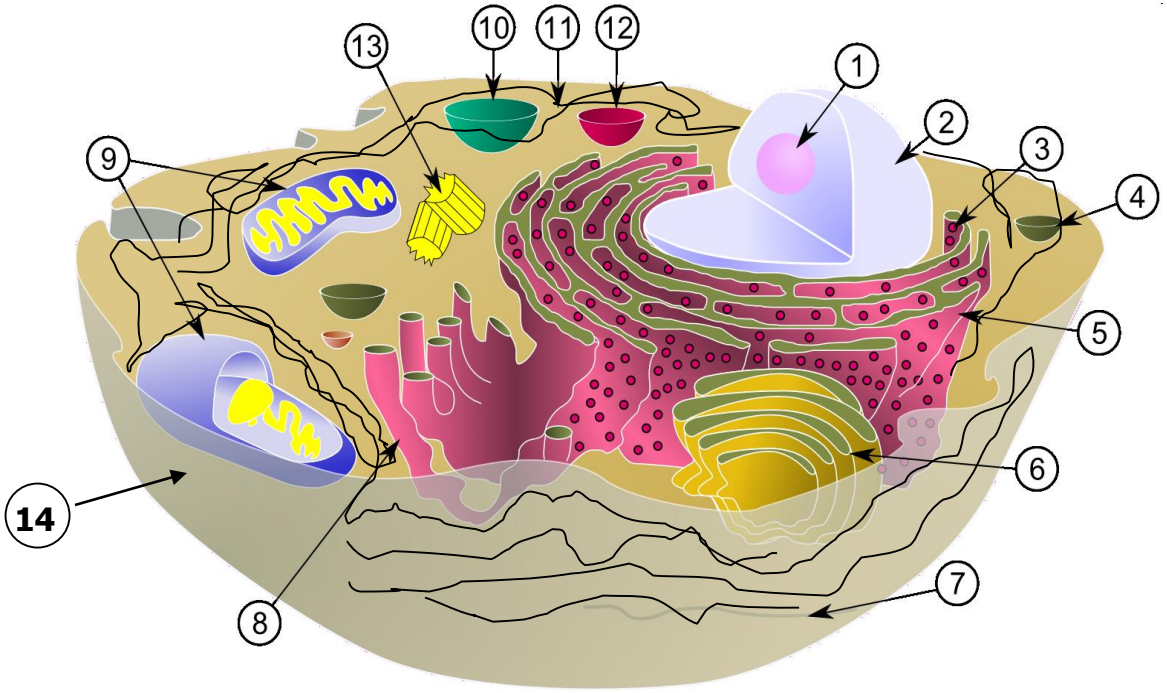
Nucleus and Cytoplasm – surrounded by Plasma (cell) membrane

1. Nucleolus
2. Nucleus

Cytoplasm

3. Ribosome
4. Vesicle
5. Rough endoplasmic reticulum
6. Golgi apparatus
7. Cytoskeleton
8. Smooth endoplasmic reticulum
9. Mitochondrion
10. Vacuole
11. Cytosol
12. Lysosome
13. Centriole

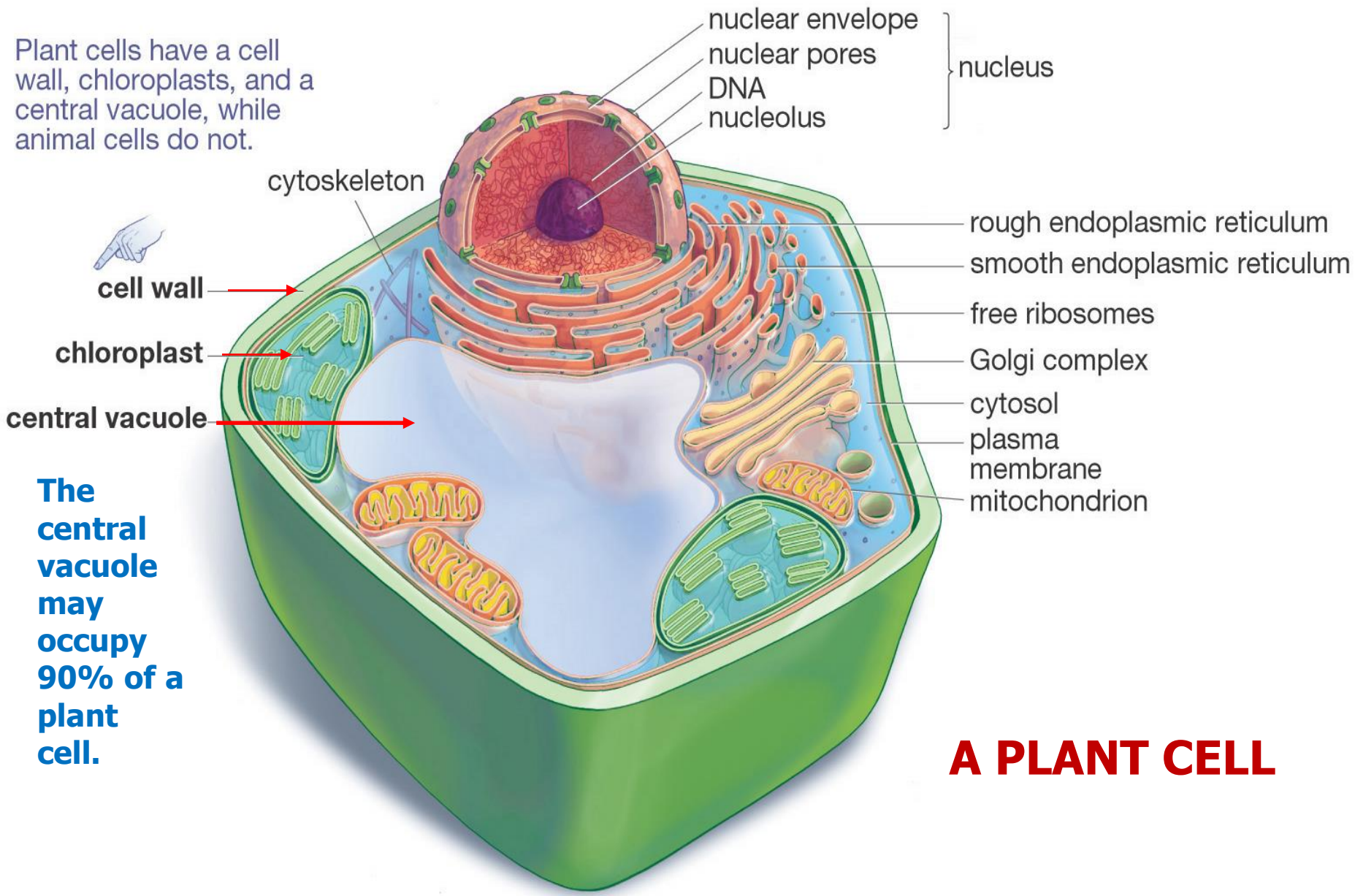
14. Cell membrane



A typical animal cell showing the major organelles and cellular structures

Animal and Plant Cells Have More Similarities Than Differences

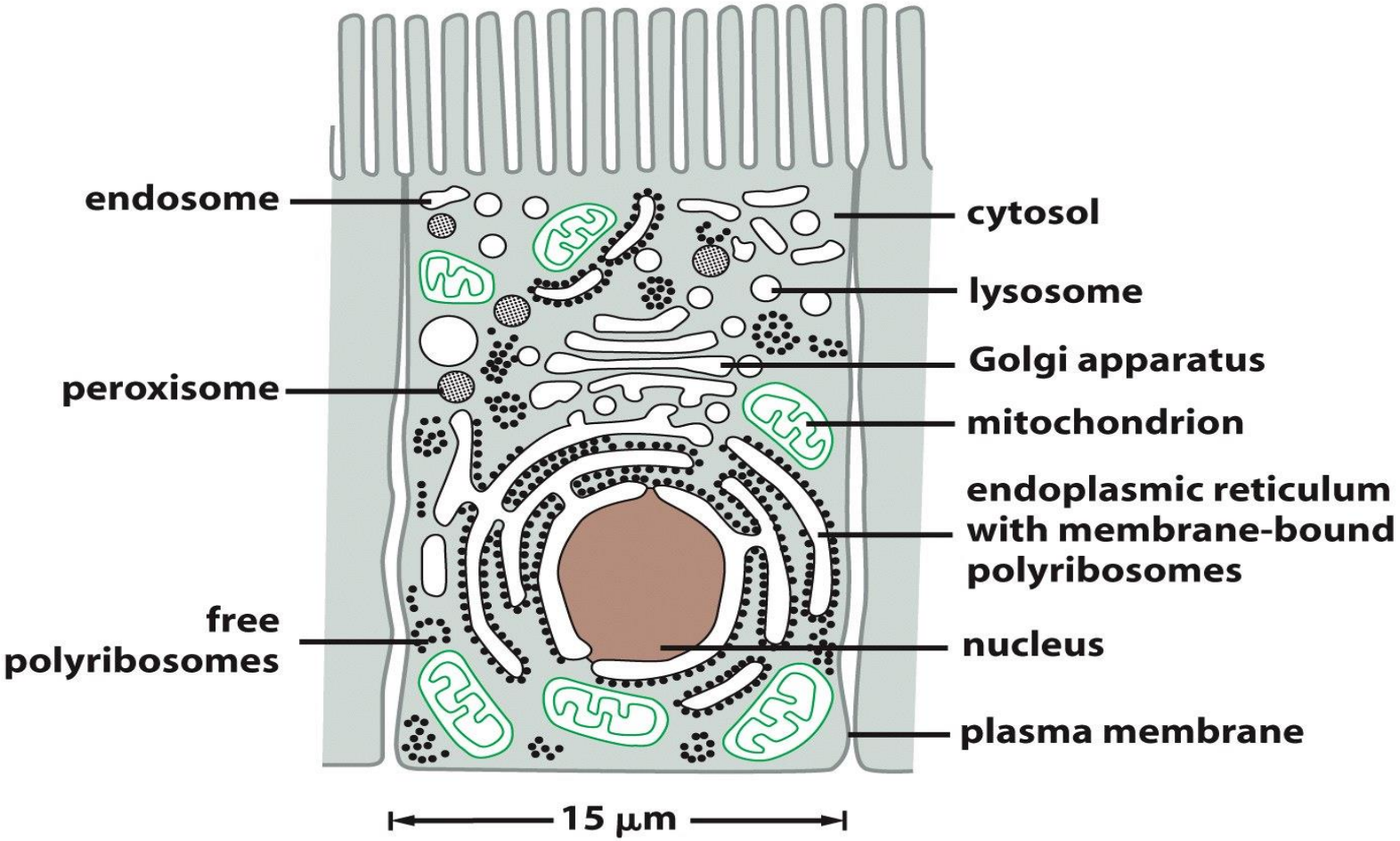
Plant cells have a cell wall, chloroplasts, and a central vacuole, while animal cells do not.



The central vacuole may occupy 90% of a plant cell.

A PLANT CELL

Cellular Organization



Cell Membrane
-Functions-

- Cell membranes are crucial to the life of the cell.

- The plasma membrane encloses the cell, defines its boundaries and maintains the essential differences between the cytosol and the extracellular environment.

- The membranes of the Endoplasmic reticulum, Golgi apparatus, Mitochondria and other membrane-enclosed organelles maintain the characteristics differences between the contents of each organelle and the cytosol.

Cell Membrane
-Functions-

- Membranes act in transmembrane movement of selected molecules – membrane transport. Membrane serves as a selectively permeable barrier, which allows the passage of some molecules, but restricts the entry of other molecules.

- Membrane takes part in ATP synthesis and in production and transmission of electrical signals in nerve/muscle cells.

- The plasma membrane also contains proteins that act as sensors/receptors of external signals, allowing the cell to change its behavior in response to environmental factors, including signals from other cells. These protein sensors/receptors transfer information across the membrane.