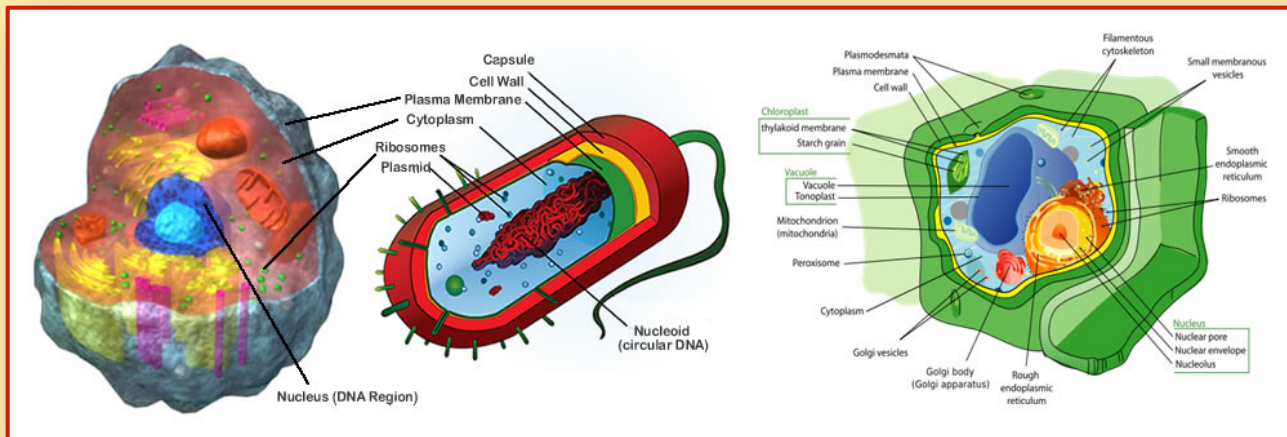


CELLS: THE BUILDING BLOCKS OF LIFE



Unit Overview

This unit provides information on cells, the building blocks of life –

- the different types of cells,
- aspects of their growth, and
- the types of organelles found within cells.

This information is necessary to better understand how bioMEMS use cells to create new diagnostic and therapeutic devices.

Objectives

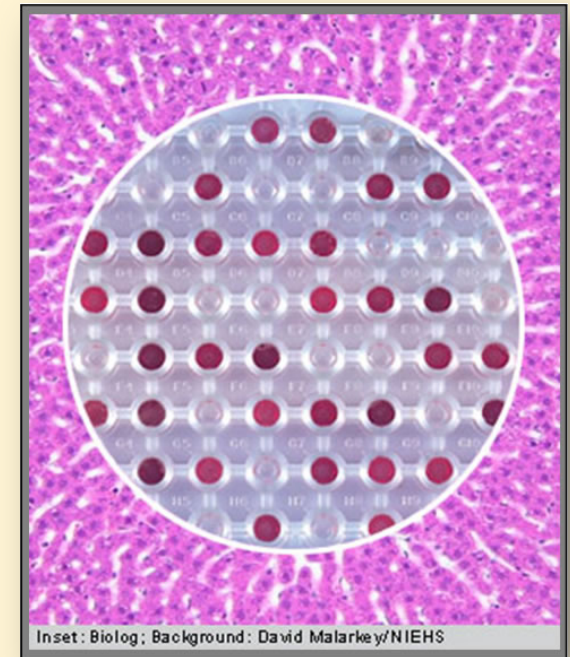
- ❖ Define and interpret The Cell Theory.
- ❖ Describe similarities and differences of prokaryotic and eukaryotic cells.
- ❖ Identify and describe the functions of cellular structures (cell membrane, cell wall, nucleus, cytoplasm, chloroplast, mitochondria) within a cell.

Introduction

The field of bioMEMS is rapidly growing. One area of major interest is in the development of miniature and portable instrumentation for cell-based [microassays](#) and sensor applications in areas such as

- ❖ health diagnostics,
- ❖ environmental risk management, and
- ❖ food safety.

All areas rely on a basic knowledge of a cell.



The Phenotype MicroArray™ (PM)

This image is from the Phenotype MicroArray™ (PM), a new tool which offers a panoramic view of cellular events. Just like a battery of tests on a person's blood can scan the health of vital organs, the PM can scan the physiology of cells, yielding data on hundreds of traits at once. Typical cell-based assays measure only one trait at a time (for example, cell death or DNA synthesis), but the PM can measure up to 2,000 traits--or phenotypes--under hundreds of growth conditions.

[Environmental Health Perspectives Volume 114, Number 3, March 2006](#)

Challenges

Challenges in using cells in bioMEMS:

- ❖ Incorporating living cells into sensors and diagnostic devices
- ❖ Creating environmental conditions conducive to cell organization into tissue-like structures
- ❖ Sorting and concentrating bacterial cells on a micro-fluidic biochip

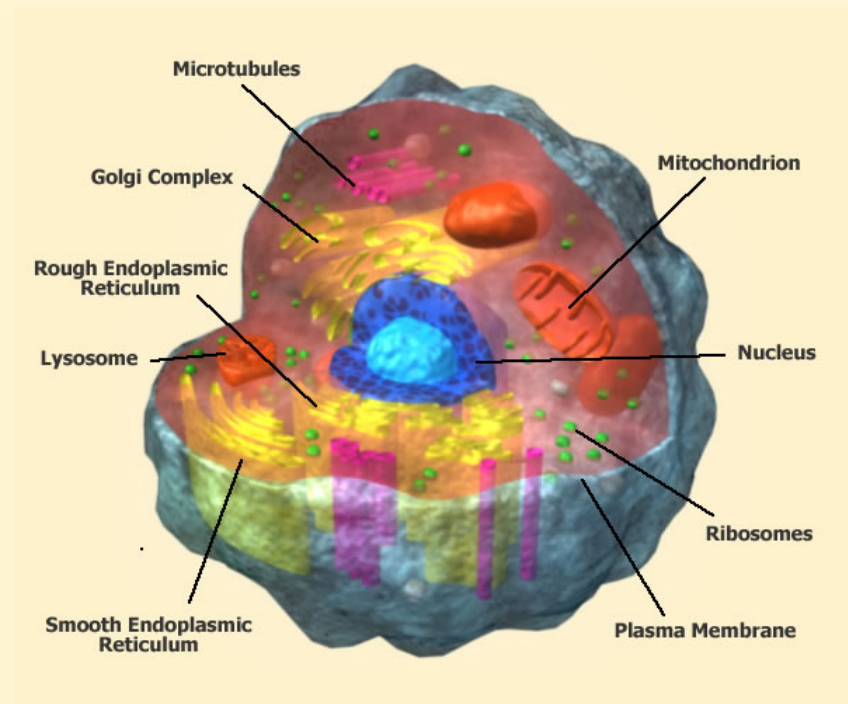
What is a cell?

A cell is the smallest unit exhibiting the property of life.

- ❖ Cells acquire and use energy.
- ❖ They acquire and organize materials.
- ❖ They grow and reproduce.

The graphic shows an animal cell, its organelles, nucleus and plasma membrane.

Note: Organelles are to a cell, like organs are to a human.

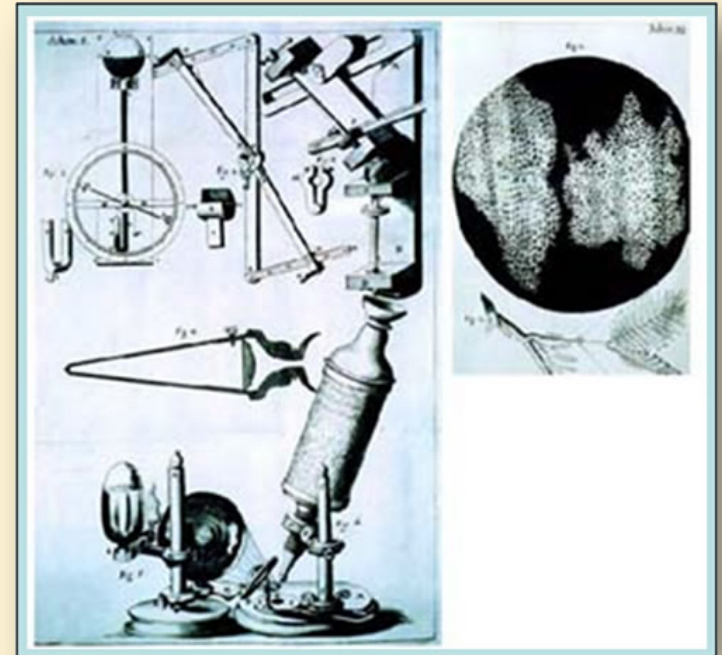


Animal Cell

Hooke's Microscope

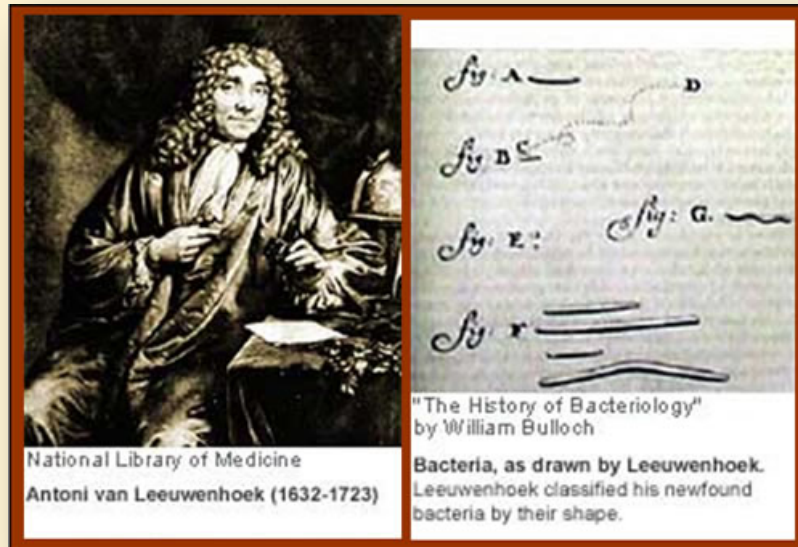
Cells are approximately 10X smaller than the visual limits of the human eye. Thus, the discovery of cells was dependent on the development of the microscope.

In 1662, Robert Hooke built a primitive microscope and used it to observe and describe individual cells of cork.



Robert Hooke's microscope and drawing of a thin layer of cork

Leeuwenhoek's Observations



Anton van Leeuwenhoek and his drawings of microorganisms

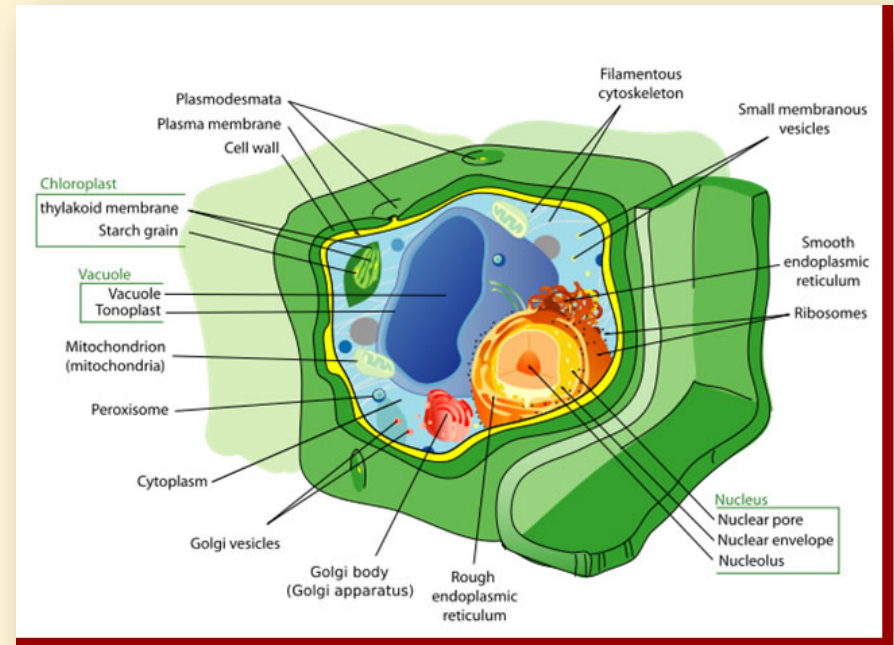
In 1675, Anton van Leeuwenhoek used a microscope to examine droplets of water. He described a multitude of "animalcules", thus becoming the first person to observe living, single-celled microorganisms.

It was another 100 years before scientists would describe cells in greater detail.

The Cell Theory

In the 1830's, Matthias Schleiden and Theodor Schwann proposed a set of hypotheses that came to be called the cell theory. The cell theory states

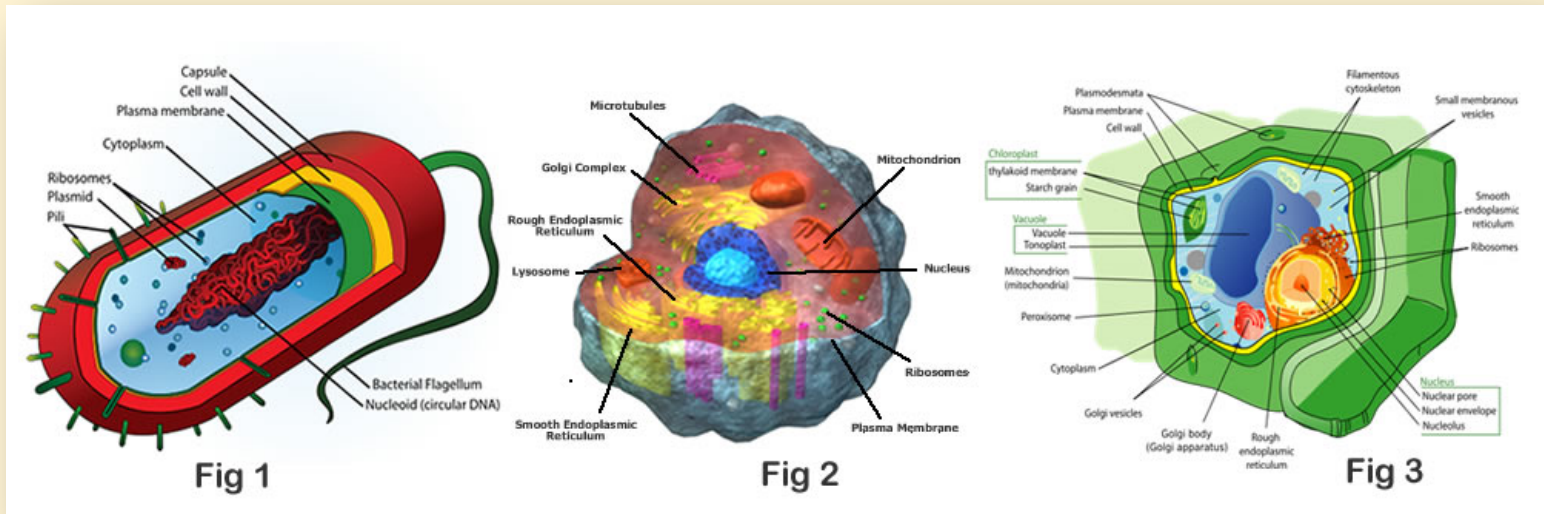
- (1) all organisms are composed of one or more cells
- (2) the cell is the structural unit of life
- (3) cells can arise only by division from a preexisting cell



Plant Cell

[Image courtesy of Mariana Ruiz Villarreal]

Prokaryotic and Eukaryotic Cells



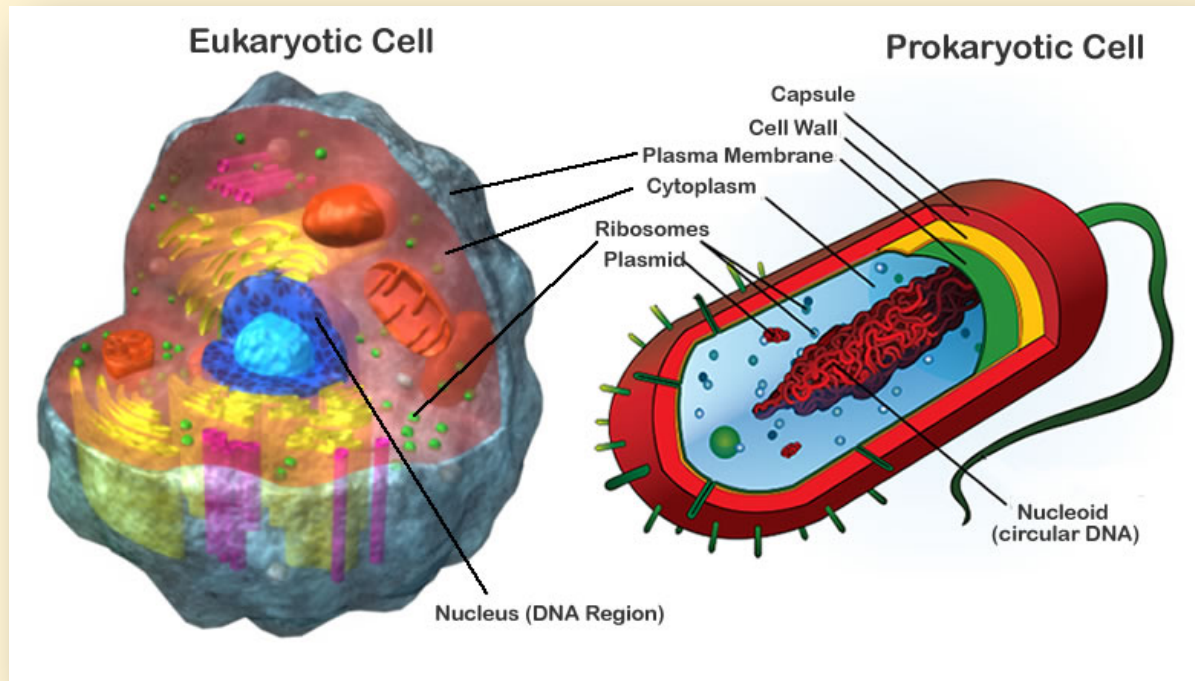
Bacteria

Animal Cell

Plant Cell

Cells vary in the types and complexity of structures found both internally and externally. However, they can be categorized into two broad types: prokaryotic and eukaryotic. The structurally simpler prokaryotic cells include bacteria (Fig 1). The more complex eukaryotic cells include protists, fungi, animals (Fig 2) and plants (Fig 3). *[Bacteria and plant cell graphics courtesy of Mariana Ruiz Villarreal]*

Eukaryotic and Prokaryotic Cell



Common features of Eukaryotic and Prokaryotic cells

The figure compares eukaryotic and prokaryotic cells. It points out common features found in both cell types.

Eukaryotic and Prokaryotic Comparison

Despite the common features, many characteristics distinguish these two types of cells. The table lists some of the differentiating features between prokaryotic and eukaryotic cells.

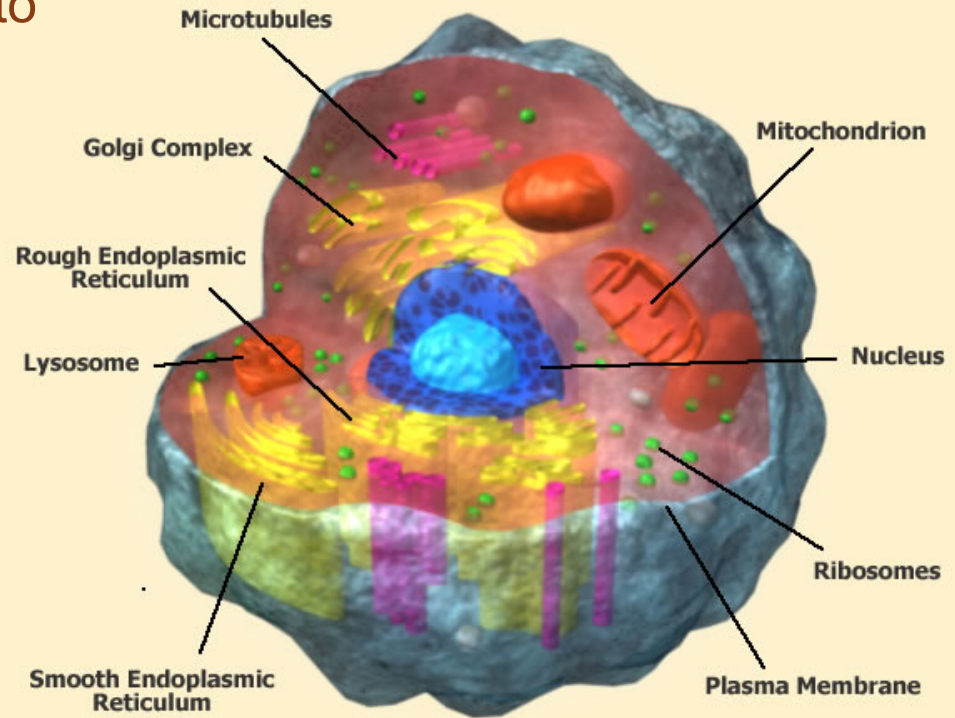
	Prokaryotic Cell	Eukaryotic Cell
Presence of a nucleus	Absent	Present
Complex membrane-bound cytoplasmic organelles	Absent	Present
Complex cytoskeletal system	Absent	Present
Cellulose-containing cell walls (plants)	Absent, contain cell walls made of different materials	Present in plants
Complex chromosomes composed of DNA and associated proteins	Absent, usually a single circular DNA molecule	Present
Size	Very small (0.1-10 mm)	Small (10-100 mm)

The Eukaryotic Cell

Compartmentalization is the key to eukaryotic cell function.

Eukaryotic cells are larger and more structurally complex than prokaryotic cells.

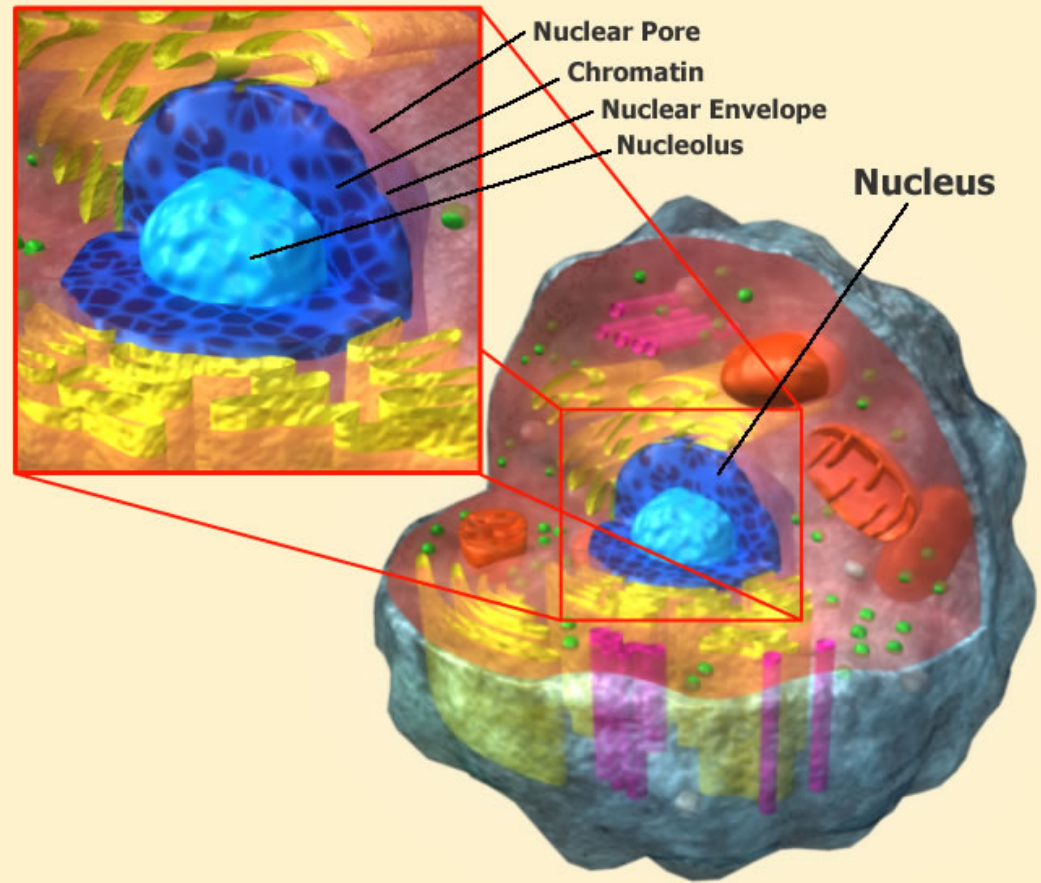
This complexity is largely due to the membrane-bound organelles that compartmentalize cellular functions.



The Eukaryotic Cell

The nucleus is the command center of the cell.

Surrounded by a porous, double membrane called the nuclear envelope, the nucleus contains the cell's hereditary material (DNA and associated proteins) organized into chromosomes.



The Eukaryotic Cell

Eukaryotic cells contain an extensive endomembrane system consisting of

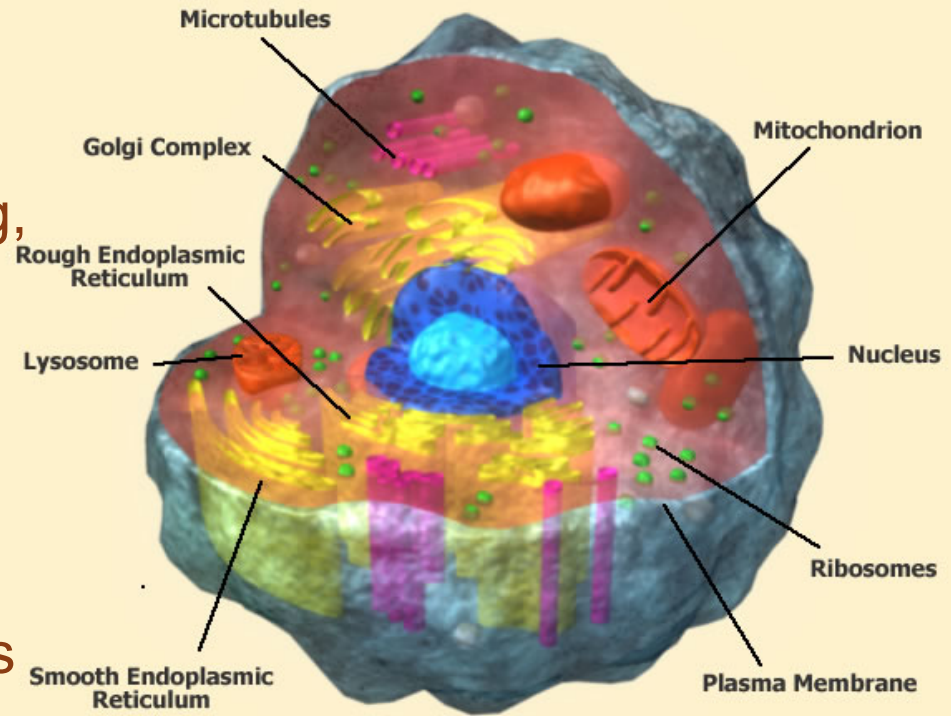
- ❖ the endoplasmic reticulum (both smooth and rough forms),
- ❖ the Golgi apparatus, and
- ❖ lysosomes.

These are the organelles of the cell.

Eukaryotic Organelles

These organelles form an interconnected set of membrane systems that function in compartmentalizing, transporting, and modifying proteins.

The lysosomes contain digestive enzymes that break down proteins, carbohydrates, and lipids. Lysosomes process cellular debris as well as food particles.

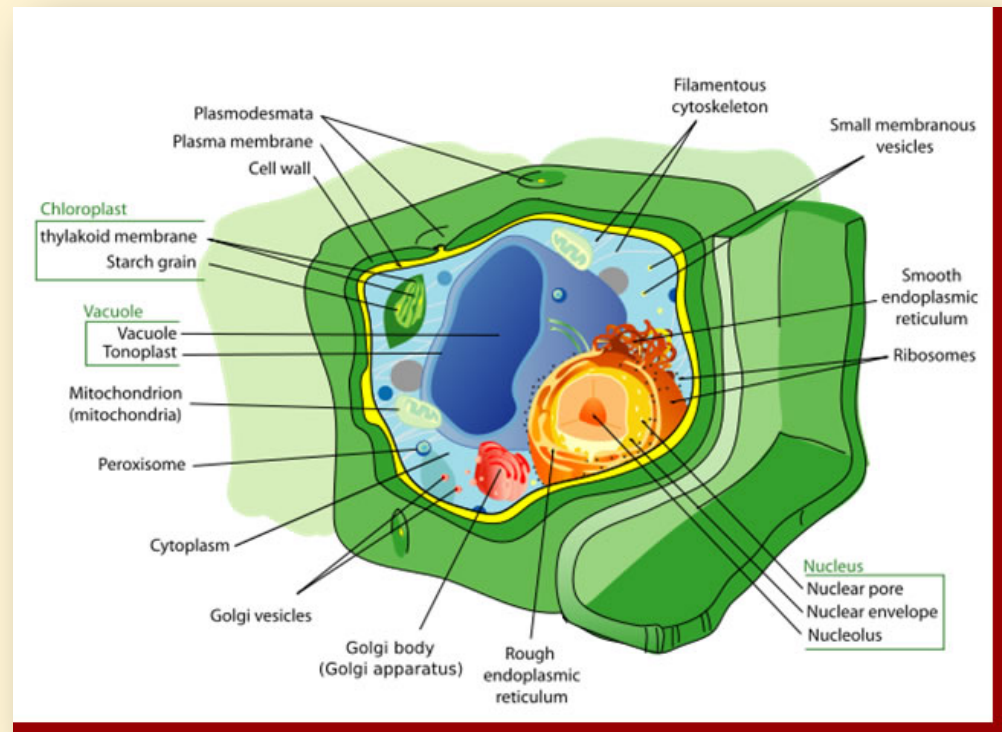


Organelles

Two organelles, mitochondria and chloroplasts, function specifically to supply energy to cells.

Nearly all eukaryotic cells contain mitochondria.

Chloroplasts are found only in photosynthetic cells such as plants and algae.



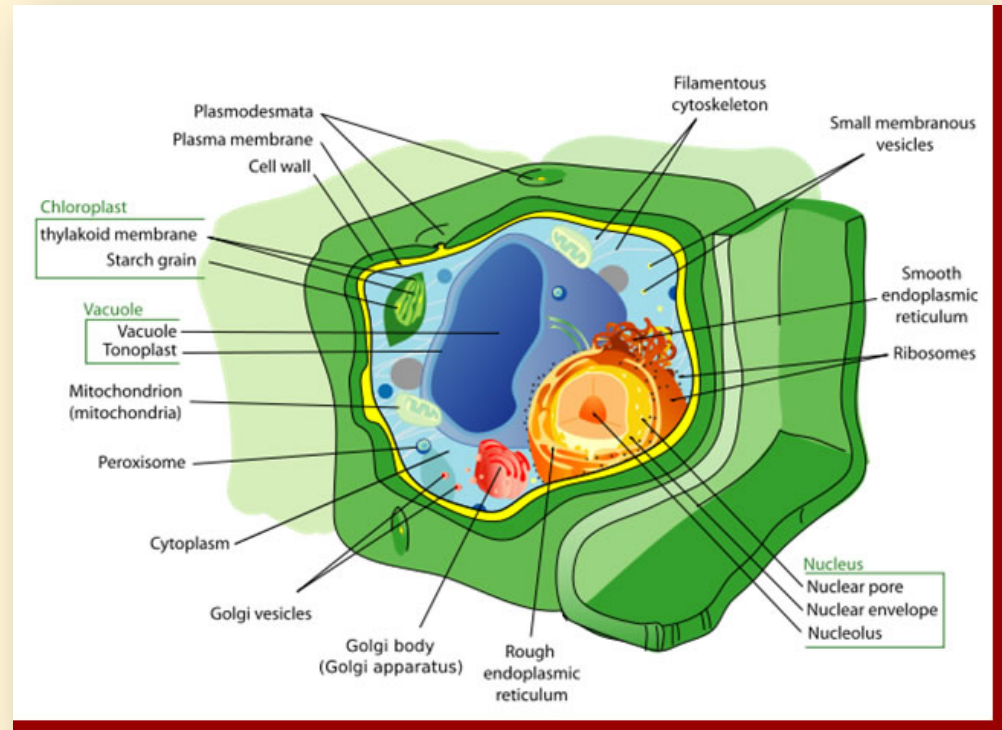
*Plant Cell showing organelles, Cytoplasm, Plasma Membrane and Cell Wall
[Image courtesy of Mariana Ruiz Villarreal]*

Organelles

Organelles are found within the cytoplasm of the cell.

For animal cells, the boundary of the cell is defined by the plasma membrane.

For plant cells, the boundary is defined by the plasma membrane plus a cell wall composed of cellulose (see graphic).



Plant Cell showing organelles, Cytoplasm, Plasma Membrane and Cell Wall
[Image courtesy of Mariana Ruiz Villarreal]

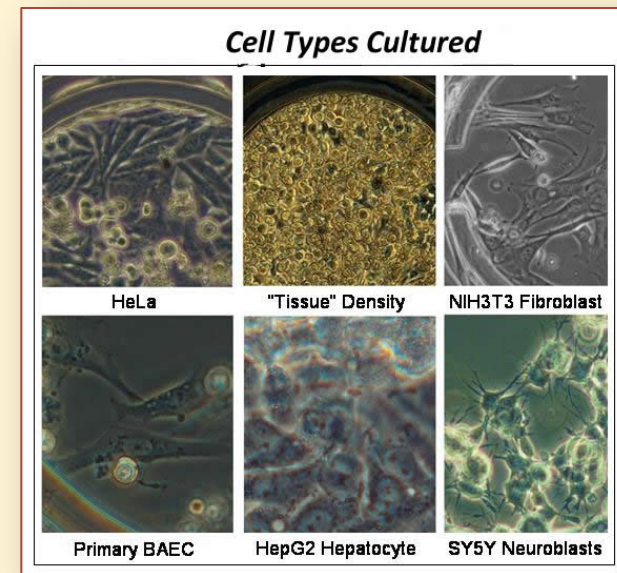
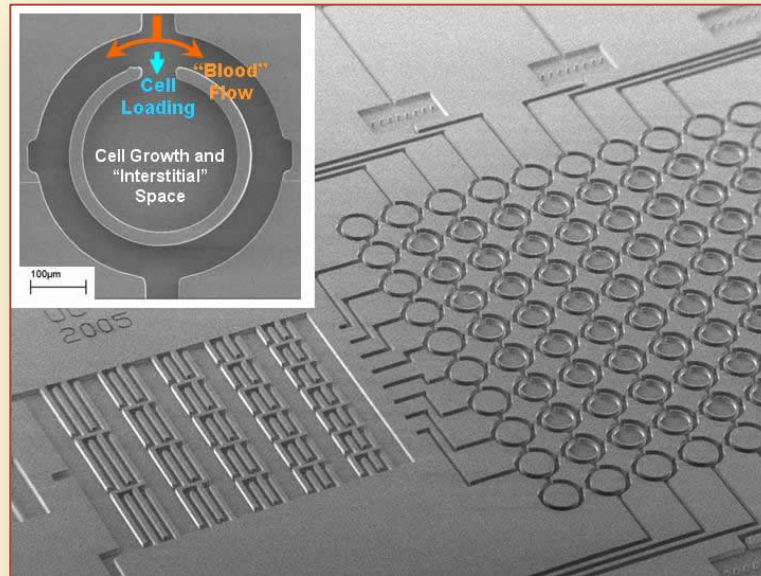
Growing Cells

Whole cells can be removed from a plant or animal and cultured in a laboratory (*in vitro*).

Applications for animal cell cultures include the following:

- ❖ Investigate the physiology or biochemistry of cells (e.g. cell metabolism).
- ❖ Test the effect of various chemical compounds or drugs on specific cell types (normal or cancerous cells, for example).
- ❖ Assist in the generation of artificial tissues (e.g. artificial skin or organ tissue). Generating artificial tissues is an emerging area of biotechnology known as “tissue engineering”.
- ❖ Synthesize valuable biologicals from large scale cell cultures. Biologicals encompass a broad range of cell products (e.g. specific proteins or viruses, therapeutic proteins)

Using MEMS for Cell Cultivation



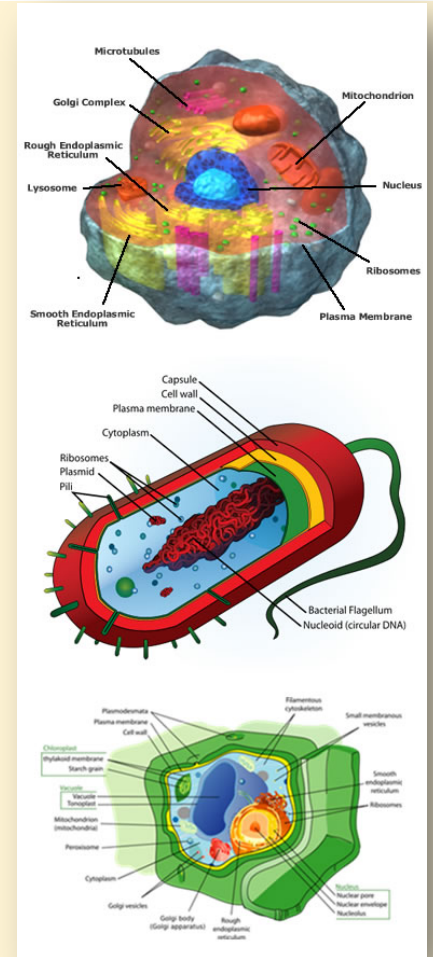
MEMS are being developed and tested for use in cell cultivation. BioPOETS at the University of California, Berkeley has developed a MEMS cell culture array (*left image*). The array uses microfluidics to create an optimal micro-environment for cell cultivation (*inset*). The right images are cells that have been cultivated in this array. [Images courtesy of BioPOETS Lab, UC-Berkeley]

Review of The Cell

A cell is the basic unit of life. Cells are highly complex and organized. They possess hereditary information and the means to use it.

Cells

- ❖ reproduce
- ❖ acquire and utilize energy
- ❖ carry out a variety of chemical reactions
- ❖ engage in mechanical activities
- ❖ respond to stimuli
- ❖ self-regulate



Let's see what you remember

- ❖ *What are the major tenets of the cell theory?*
- ❖ *How are prokaryotic and eukaryotic cells similar?*
- ❖ *How are prokaryotic and eukaryotic cells different?*
- ❖ *What is the primary tool of the cell biologist studying cells in the laboratory?*
- ❖ *How are MEMS being used in cell cultivation?*

Summary

Cells are divided into two main categories: prokaryotic and eukaryotic. Prokaryotic cells and eukaryotic cells share similarities, but eukaryotic cells are more complex structurally. The organelles found in the larger eukaryotic cell compartmentalize cellular functions.

MEMS applications will aid in the cultivation of cells for the purpose of creating new diagnostic and therapeutic bioMEMS.

Disclaimer

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