BIOLOGY 12 **NAME: _____**

CELL BIOLOGY

CHARACTERISTICS OF LIFE

All living things share some common properties:

1. Living things are organized = their parts are specialized for specific functions.
2. Living things take material/energy from the environment = they need an outside source of nutrients
3. Living things are homeostatic = internally they stay just about the same despite changes to the external environment
4. Living things respond to stimuli = they react to internal and external events
5. Living things reproduce = they produce offspring that resemble themselves
6. Living things grow + develop = during their lives they change- most multicellular organisms undergo various stages from fertilization to death
7. Living things adapt = they have modifications that make them suited to a particular way of life

CELL STRUCTURE

The cell was first discovered by Robert Hooke in 1665 using a microscope. It is known now that the cell is the basic building block of all life or the smallest unit that can continue to function on its own.

=***a cell is the lowest level of biological organization to have the characteristics of life***

Cells make up all living things, from the smallest and simplest to the largest and most complex organisms. All of us, with more than 100 trillion cells in our bodies, started from the tiny cell, the fertilized egg.

THE CELL THEORY

The cell theory forms the basic framework in which biologists have tried to understand living things. The cell theory states:

1. All organisms are composed of 1 or more cells
2. cells are the basic unit of life (structure and function) in organisms
3. All cells come from other pre-existing cells

MICROSCOPY: The Cell Under the Microscope

With some exceptions, such as bird and frog eggs, cells are not readily visible to the human eye. Our eyes can only see objects that are ***larger*** than 0.1mm, therefore, a microscope is needed to view anything smaller than this.

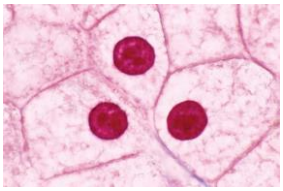
Two types of microscopes are commonly used in the study of cells:

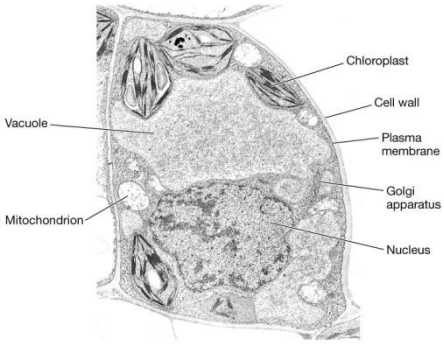
1. Light Microscope
2. Electron microscope

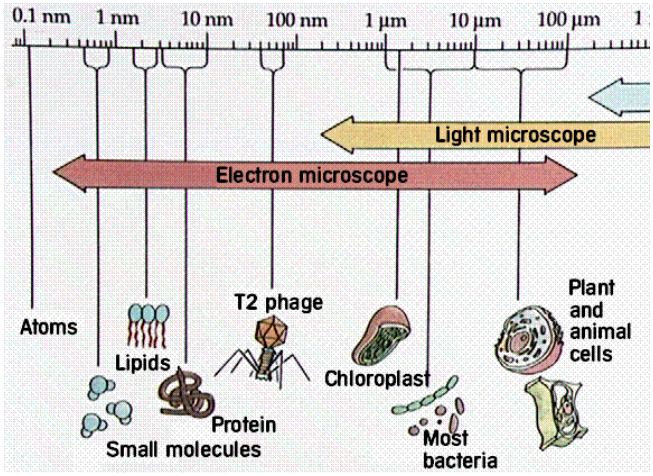
As suggested by their names, light microscopes use light to view an object, whereas the electron microscope utilizes electrons.

- Although the magnification (enlargement) produced by the electron microscope is much higher than that of the light microscope, a comparison of these two types of microscopes shows that the most important difference between them is not the degree to which they magnify but instead their **resolving power**
- **Resolving Power (Resolution)**
  = the ability to distinguish between two separate objects
  - Resolution is dependent on the wavelength of the illumination, and is improved as the wavelength of the illumination becomes shorter. An electron has a much shorter wavelength than visible light. Therefore, at very best, a light microscope can distinguish between points separated by 200 nm, but the electron microscope can distinguish two points separated by only 0.5 nm. Thus the electron microscope gives a much more detailed image.

Pictures obtained using the light microscope are called photomicrographs, and pictures resulting from the use of the electron microscope are called electron micrographs (EMs)







SIZE AND SHAPE OF CELLS

Cells exist in a great variety of sizes and shapes.

- The smallest cells are bacteria-like organisms called mycoplasmas. They are about 0.1-0.3 micrometer (µm) in diameter. They can only be seen with an electron microscope. The smallest cells that can be seen with a light microscope are larger bacteria, from 1 to 5 µm in diameter.
- At the opposite extreme, the largest cell is the ostrich egg cell, which measures about 100 mm in diameter.

DIFFERENCES IN CELLS:

Scientific study has determined that there are two different types of cells:

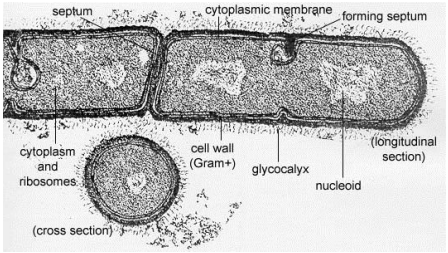
1. PROKARYOTIC
2. EUKARYOTIC

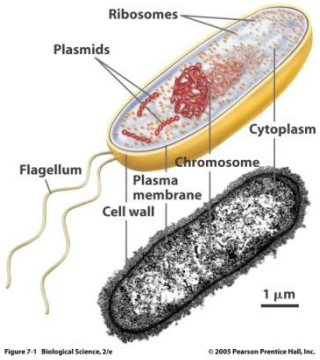
Prokaryote Cell Structure

- All living organisms are typically classified into one of the five Kingdoms of Life:
  Kingdom: *Monera, Protista, Fungi, Plantae, Animalia*
- Prokaryotic cells are considered to be the simplest forms of life and occur only in Kingdom Monera. Organisms found in the other four Kingdoms are Eukaryotes.
  - Monera are unicellular
  - They are smaller than plant/animal cells which are microscopic
    - Range in size from 1 µm to 10 µm
  - All monerans are **prokaryotic cells** (prokaryotes).
    = They lack a "true" nucleus, and except for thylakoids they do not have membrane-bound organelles.
  - They do have DNA, but it is not contained within a nuclear membrane (envelope)

= Consist of a single, continuous loop of DNA in direct contact with the cytoplasm.

- Like plant cells, moneran cells have cell walls.
  = However, almost all monerans' cell walls contain peptidoglycan instead of cellulose. (plants).



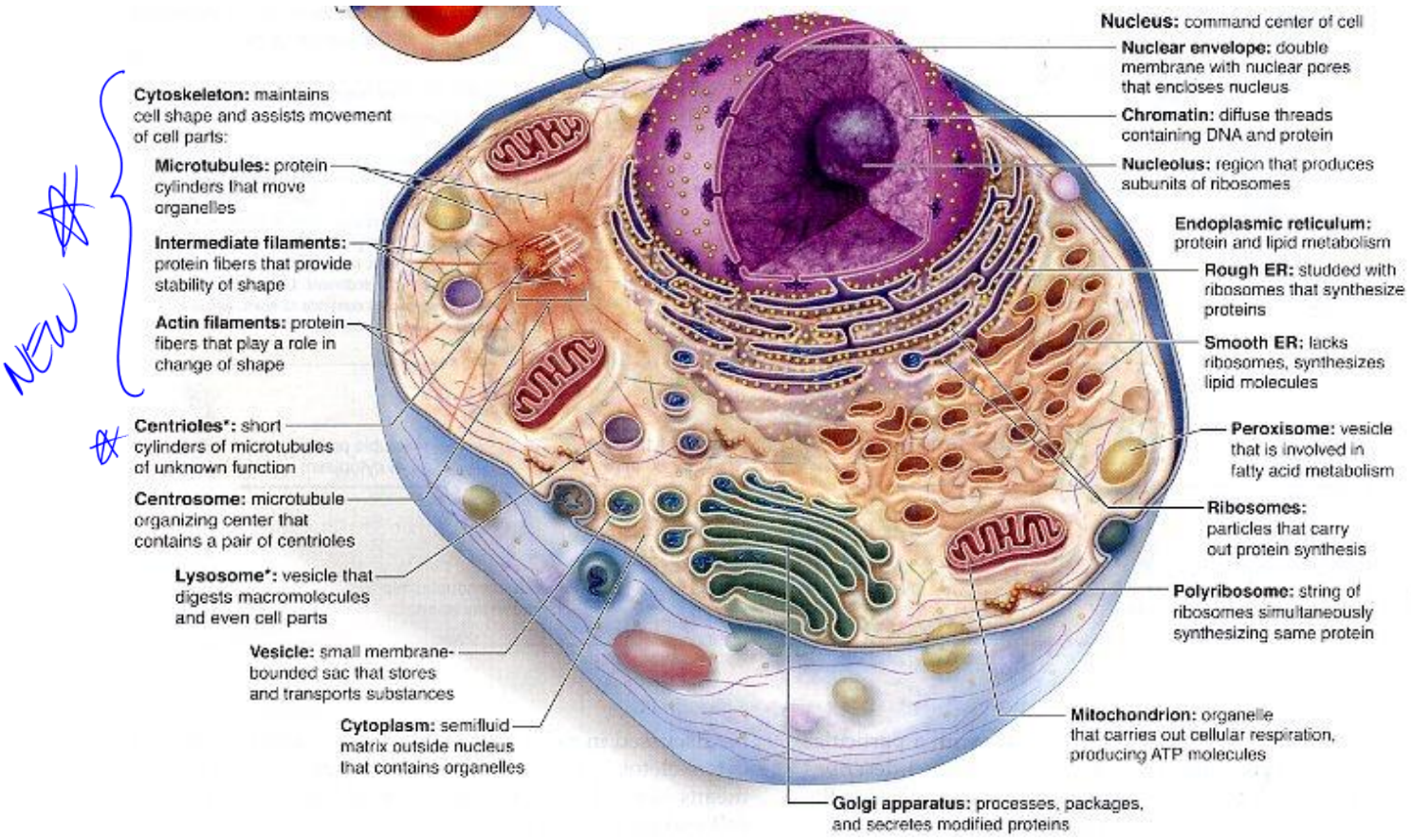


Eukaryote Cell Structure

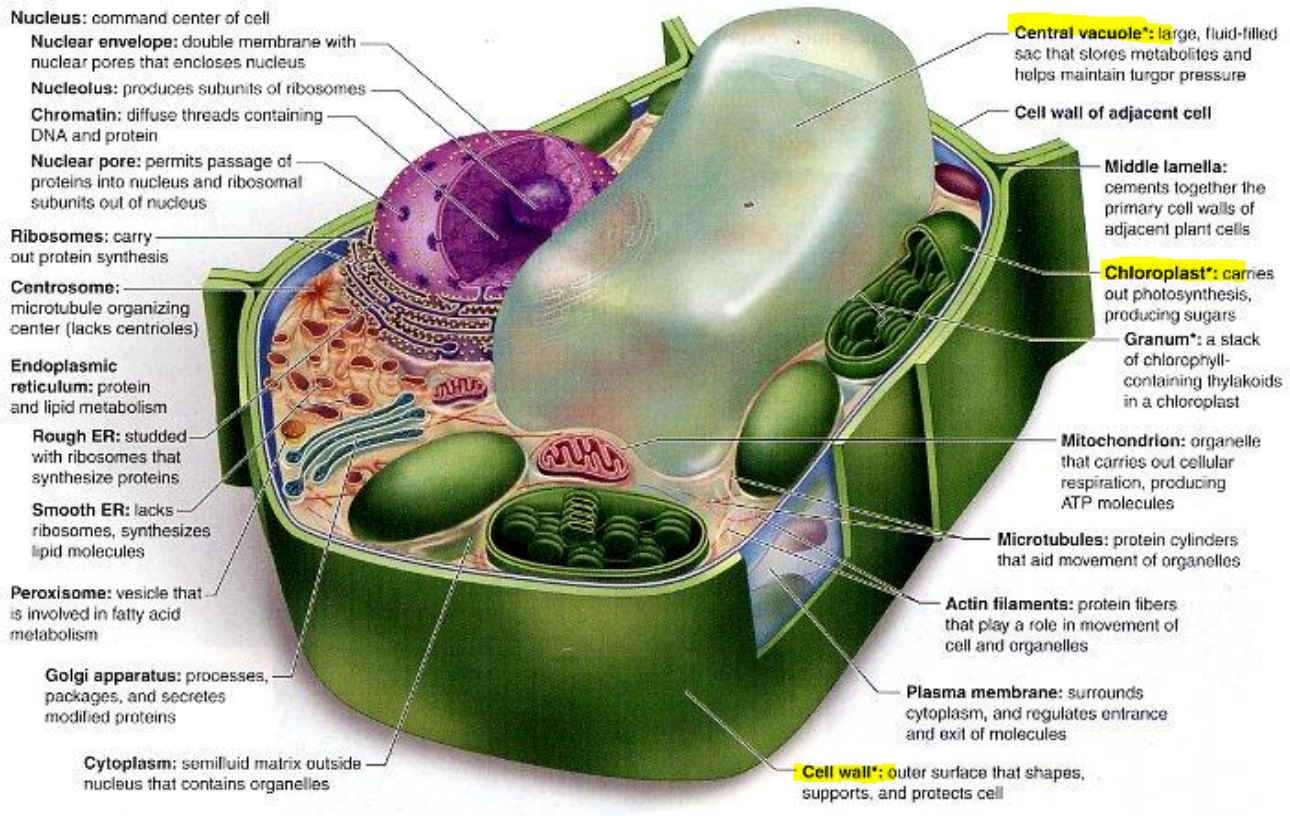
- All organisms except those in the Kingdom Monera are **Eukaryotes**, and are made up of **Eukaryotic cells**:
  - They have a well-defined ('true') nucleus surrounded by a nuclear envelope/membrane
  - They contain numerous organelles

Even though there are a great variety of Eukaryotic cells, differing in regard to specific structure and function, they all have the same basic organization. This course will only stress the generalized animal and plant cell as depicted below:

ANIMAL CELL:



PLANT CELL:



A typical cell cannot be described any more successfully than a typical animal. Nevertheless, most eukaryotic cells do have certain characteristics in common. The structure of most cells can be divided into three basic parts: the **nucleus,** or control center, the **cell membrane,** or outer boundary of the cell, and the **cytoplasm,** or everything between the nucleus and the membrane.

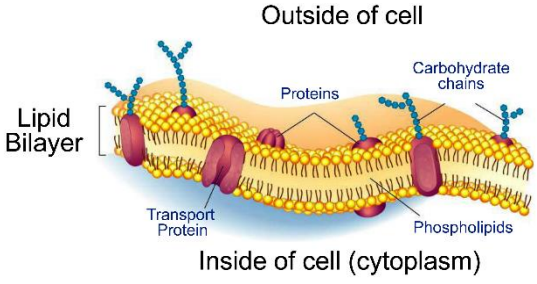
Within the cytoplasm are cell organelles: tiny specialized structures that preform specific functions

- Each organelle has a special task that helps maintain the life of the cell

EUKARYOTIC CELL STRUCTURES IN ANIMAL AND PLANT CELLS:

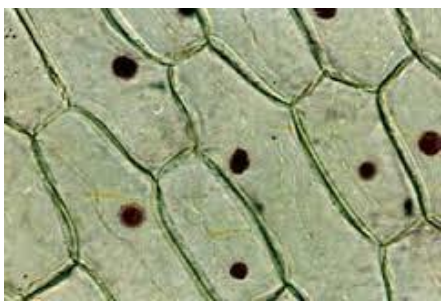
ORGANELLE	STRUCTURE	FUNCTION

1. **CELL MEMBRANE (Plasma Membrane)**
   =defines the cell boundary (separates the external environment With CYTOPLASM, a semifluid medium that contains organelles); controls what moves into and out of the cell



2. **CELL WALL**
   Plants possess a cell wall in addition to a cell membrane
   - Lies outside of the cell membrane
   - Contains many criss-crossing cellulose microfibrils
   - Is very porous and allows water and dissolved substances to pass through

   = Functions to provide strength, support (yet elastic), shape



and protection to plant cells

3. **NUCLEUS**
   = Storage of genetic information as DNA;
   Synthesis of DNA and mRNA

   NUCLEOLUS
   = produces rRNA
   (ribosomal RNA) makes ribosomes

   CHROMATIN
   = threadlike mix of DNA
   -condenses into distinct CHROMOSOMES
   During cell division (mitosis and meiosis)

   NUCLEAR ENVELOPE
   (Nuclear Membrane)
   =double membrane with NUCLEAR PORES
   Continuous with the endoplasmic reticulum

   NUCLEOPLASM
   = semifluid medium in nucleus that contains chromatin

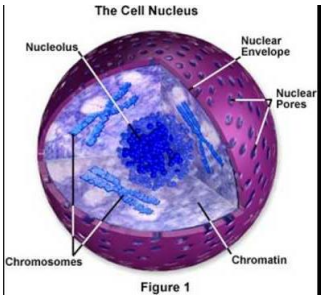
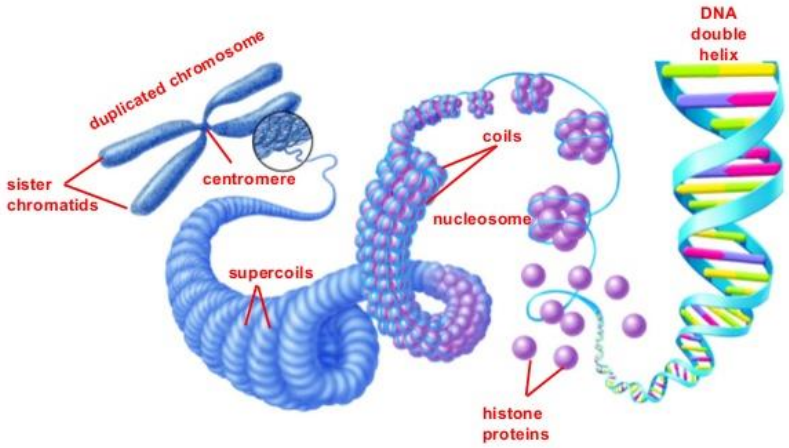


Figure 1

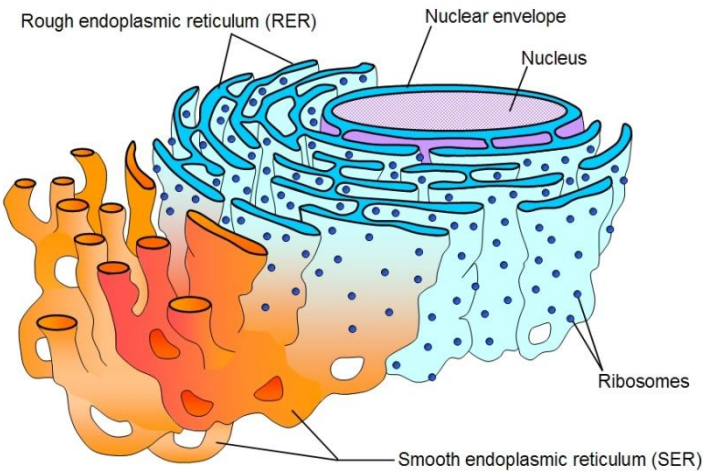
4. **CHROMOSOMES**
   = Rod-like structures in the nucleus, seen only during cell division
   - Contains the genetic material (DNA) and proteins (histones)



5. **RIBOSOMES**
   = Site of PROTEIN SYNTHESIS
   Made of ribosomal RNA (rRNA) and protein
   Can be found individually in the cytoplasm as well as in groups called polyribosomes.
   Either:
   i. Attached to the rough ER (make proteins for export from the cell)
   ii. Free-floating in cytoplasm (make proteins to be used in the cell)

6. **ENDOPLASMIC RETICULUM**
   = Tubular canals which are continuous with the nuclear envelope
   - Function to transport materials within the cell

   ROUGH ER (Ribosomes attached)
   = produces proteins (ie. Hormones & enzymes) for export from the cell
   - Ribosomes sitting on rough ER make protein which moves into the lumen of the system to the SMOOTH ER where it is eventually packaged into a TRANSPORT VESICLE for distribution inside the cell (usually to the GOLGI BODY or CELL MEMBRANE)



SMOOTH ER (No ribosomes attached)

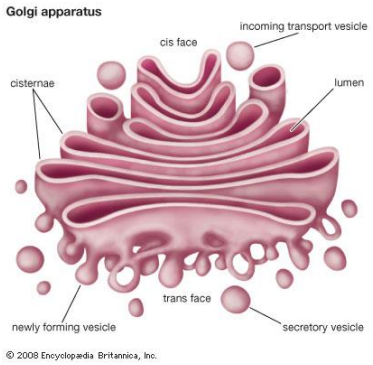
- Continuous with the rough ER

= synthesize phospholipids for the cell membrane; in testes, it produces testosterone; and in the liver it helps to detoxify drugs

- Packages materials into TRANSPORT VESICLES for distribution inside the cell (usually to the GOLGI BODY or CELL MEMBRANE)

7. **GOLGI BODY** (Golgi Apparatus)
   - Consist of a stack of 3-20 slightly curved, flattened saccules

   = processes, packages and secretes materials (proteins and lipids) from the ER into the SECRETORY VESICLES which move to the cell membrane, where they are discharged (SECRETED) from the cell
   - Also produces LYSOSOMES



8. **LYSOSOMES** (more common in animal cells)

   = membrane-bound vesicles produced by the GOLGI BODY
   - Involved in INTRACELLULAR DIGESTION
   - Contain hydrolytic digestive enzymes which digest large molecules (macromolecules) found in the cell, into simpler substances

9. **PEROXISOME**

   Similar to lysosomes, are membrane-bound vesicles which enclose enzymes. Produce and degrade hydrogen peroxide, toxic compound that can be produced during metabolism

10. **VESICLES**

    (more common in animal cells)

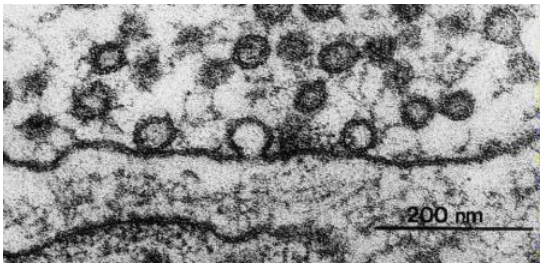
    = Small vacuoles (less than 100 nm)

    TRANSPORT VESICLE

    = between smooth ER and Golgi Body

    SECRETORY VESICLE

    = between Golgi Body and the cell membrane



11. **VACUOLES**

    (more common and larger in plant cells)

    = Large membrane-bound sacs that act as storage areas for water, sugars, salts, pigments and toxic molecules

    -Animal cells have vacuoles called vesicles, but they are much more prominent in plant cells. Typically plant cells have a large **CENTRAL VACUOLE,** or water vacuole, which is so filled with water that it gives added support to the plant cell.

12. **CYTOSKELETON**

    (Unique to eukaryotic cells)

    -Functions as both skeleton and muscle for the cell

    → provides stability and allows movement

    -Made up of 3 types of fibers:

    -Microfilaments, Microtubules, and Intermediate filaments

    -Difference = size and structure

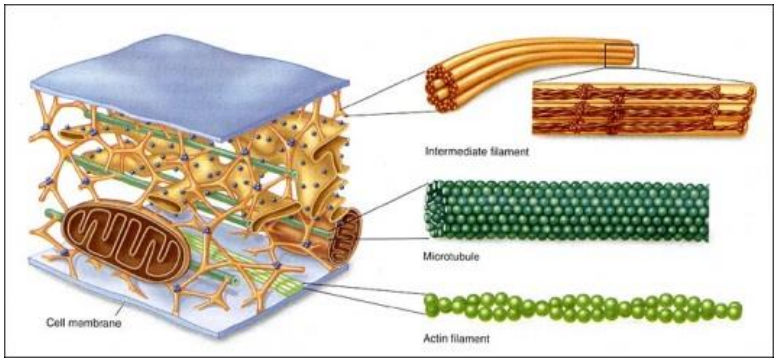
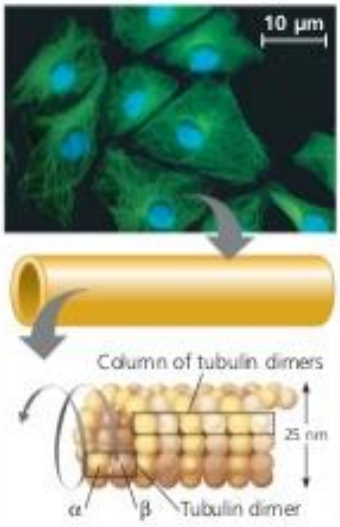
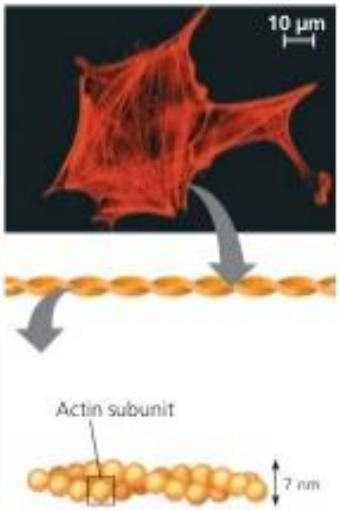
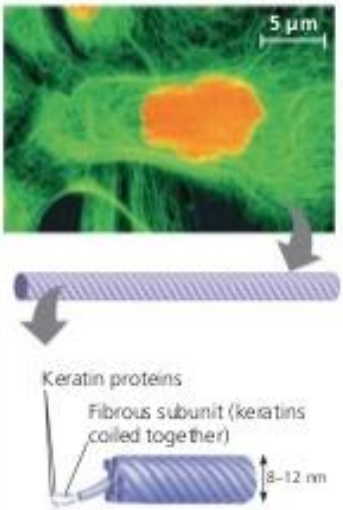


Table 6.1 The Structure and Function of the Cytoskeleton

Property	Microtubules (Tubulin Polymers)	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes	Two intertwined strands of actin	Fibrous proteins coiled into cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, a dimer consisting of α-tubulin and β-tubulin	Actin	One of several different proteins (such as keratins)
Main functions	Maintenance of cell shape (compression-resisting "girders"); cell motility (as in cilia or flagella); chromosome movements in cell division; organelle movements	Maintenance of cell shape (tension-bearing elements); changes in cell shape; muscle contraction; cytoplasmic streaming in plant cells; cell motility (as in amoeboid movement); division of animal cells	Maintenance of cell shape (tension-bearing elements); anchorage of nucleus and certain other organelles; formation of nuclear lamina
Fluorescence micrographs of fibroblasts. Fibroblasts are a favorite cell type for cell biology studies. In each, the structure of interest has been tagged with fluorescent molecules. The DNA in the nucleus has also been tagged in the first micrograph (blue) and third micrograph (orange).			

13. CENTRIOLES

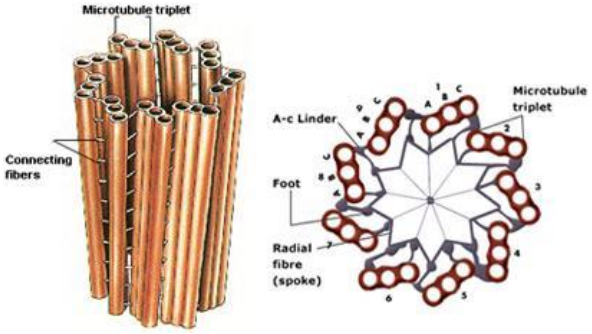
(found only in animal cells)

=a pair of short cylinders which lie at right angles to each other, made up of nine sets of MICROTUBULE triplets with none in the middle ("9 + 0")

-Replicate during cell division and help move the chromosomes (during mitosis and meiosis)

-may be called basal body

-forms part of structure called centrosome (not important but may be mentioned in text)

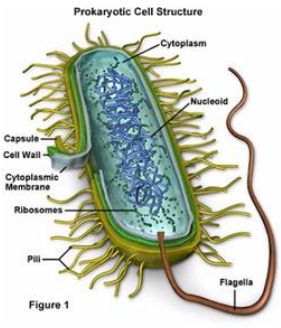


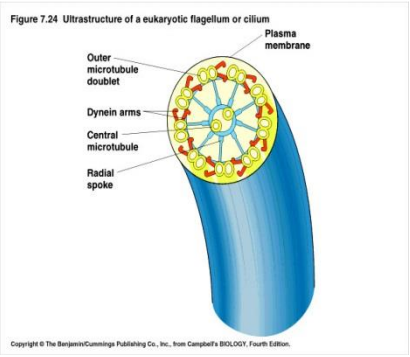
14. CILIA and FLAGELLA

(found in eukaryotic and prokaryotic cells)

-used for cell movement and moving liquid past the cell

-made up of centrioles hence microtubules

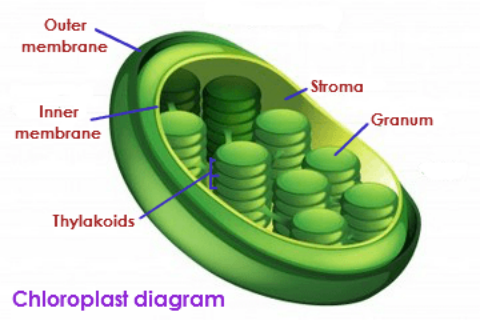




15. CHLOROPLAST
(found only in plant cells)
= Site of PHOTOSYNTHESIS
(production of glucose from light energy)

-OUTER MEMBRANE
-INNER MEMBRANE

-STROMA (fluid-filled)



GRANUM
= stack of Thylakoids

THYLAKOIDS (flattened sacs)

LAMELLA
=tubular connections between grana

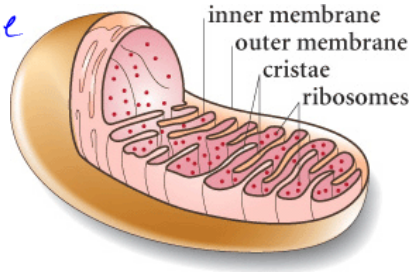
EQUATION FOR PHOTOSYNTHESIS:

$CO_2 + H_2O + \text{sunlight} \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + O_2$

16. MITOCHONDRIA (singular mitochondrion)
(found in both animal and plant cells)
= Site of CELLULAR RESPIRATION
(production of ATP from glucose)

-OUTER MEMBRANE
-INNER MEMBRANE

-MATRIX
-CRISTAE



EQUATION FOR CELLULAR RESPIRATION:

$\underset{\text{glucose}}{C_6H_{12}O_6} + O_2 \rightarrow \underset{\text{(energy)}}{ATP} + CO_2 + H_2O$