


Chapter 6.

The Cell: Basic Unit of Life



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Based on work by K. Foglia
www.kimunity.com

Why do we study cells?



PLANTAE (Multicellular, eukaryotic)

ANIMALIA (Multicellular, eukaryotic)

FUNGI (Multicellular, eukaryotic)

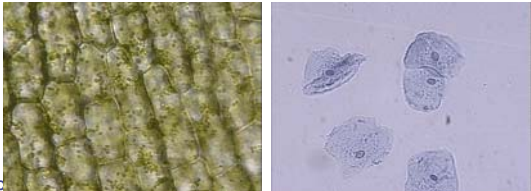
PROTISTA (Eukaryotic, unicellular and multicellular)

EUBACTERIA (Unicellular, prokaryotic)

ARCHAEBACTERIA (Unicellular, prokaryotic)

Cell Theory

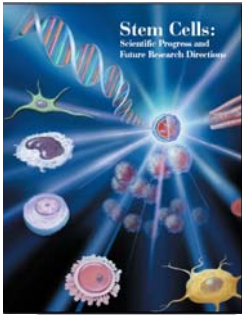
- All organisms are made up of cells
- The cell is the basic *living* unit of organization for all organisms
- All cells come from pre-existing cells



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Biological diversity & unity

- Underlying the diversity of life is a striking unity
 - DNA is universal genetic language
 - Cells are the basic units of structure & function
 - lowest level of structure capable of performing all activities of life



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Activities of life

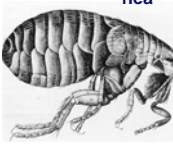
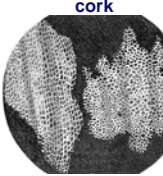
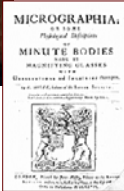


- Most everything you think of a whole organism needing to do, must be done at the cellular level...
 - reproduction
 - growth & development
 - energy utilization
 - response to the environment
 - homeostasis



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How do we study cells?

- Microscopes opened up the world of cells
 - Robert Hooke (1665)
 - the 1st cytologist



Drawings by Hooke

cork

flea

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How do we study cells?

- Microscopes
 - light microscopes
 - electron microscope
 - transmission electron microscopes (TEM)
 - scanning electron microscopes (SEM)

Technology advancing science

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Light microscopes

- 0.2 μ m resolution
- ~size of a bacterium
- visible light passes through specimen
- can be used to study live cells

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Electron microscope

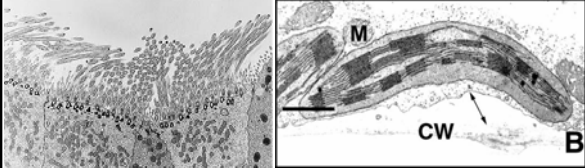
- 1950s
- 2.0nm resolution
- 100 times > light microscope
- reveals organelles
- but can only be used on dead cells

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Transmission electron microscopes

- **TEM**
 - ◆ used mainly to study internal structure of cells
 - aims an electron beam through thin section of specimen

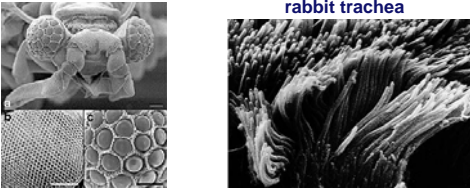
rabbit trachea cucumber seed leaf



Scanning electron microscopes

- **SEM**
 - ◆ studying surface structures
 - sample surface covered with thin film of gold
 - beam excites electrons on surface
 - great depth of field = an image that seems 3-D

rabbit trachea



SEM images grasshopper





Isolating organelles

- Cell fractionation
 - separate organelles from cell
 - variable density of organelles
 - ultracentrifuge

What organelle would be **heaviest**?
What organelle would be **lightest**?

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Ultracentrifuge

- spins up to 130,000 rpm
 - forces > 1 million X gravity (1,000,000g)

Why is it in a **BIG** thick lead-lined housing?

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Microcentrifuge

- Biotechnology research
 - study cells at protein & genetic level



Tour of the Cell



Cell characteristics

- All cells:
 - surrounded by a plasma membrane
 - have cytosol
 - semi-fluid substance within the membrane
 - cytoplasm = cytosol + organelles
 - contain chromosomes which have genes in the form of DNA
 - have ribosomes
 - tiny "organelles" that make proteins using instructions contained in genes

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Types of cells

- Prokaryotic vs. eukaryotic cells
 - Location of chromosomes

Prokaryotic cell <ul style="list-style-type: none">DNA in nucleoid region, without a membrane separating it from rest of cell	Eukaryotic cell <ul style="list-style-type: none">chromosomes in nucleus, membrane-enclosed organelle
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Cell types

- Prokaryote
- Eukaryote

internal membranes

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"Let's go to the video tape!"
[\(play movie here\)](#)


(a) A typical rod-shaped bacterium

(b) A thin section through the bacterium *Bacillus coagulans* (TEM)

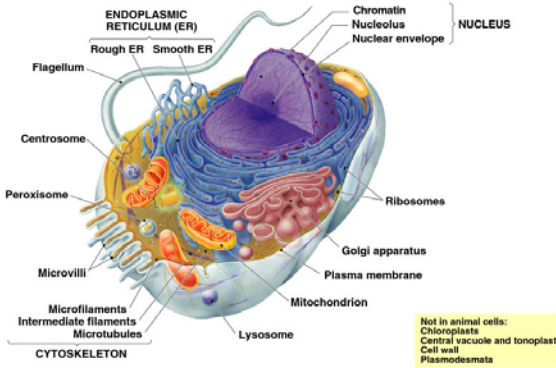
The prokaryotic cell is much simpler in structure, lacking a nucleus and the other membrane-enclosed organelles of the eukaryotic cell.

Eukaryotic cells

- Eukaryotic cells are more complex than prokaryotic cells
 - ◆ within cytoplasm is a variety of membrane-bounded organelles
 - ◆ specialized structures in form & function
- Eukaryotic cells are generally bigger than prokaryotic cells



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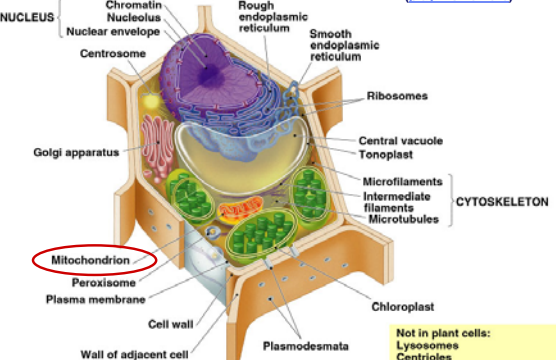


Labels: ENDOPLASMIC RETICULUM (ER) (Rough ER, Smooth ER), Chromatin, Nucleolus, Nuclear envelope, NUCLEUS, Flagellum, Centrosome, Peroxisome, Microvilli, Microfilaments, Intermediate filaments, Microtubules, CYTOSKELETON, Lysosome, Mitochondrion, Golgi apparatus, Plasma membrane, Ribosomes.

Not in animal cells:
Chloroplasts
Central vacuole and tonoplast
Cell wall
Plasmodesmata

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“Let’s go to the video tape!”
[\(clav movie here\)](#)



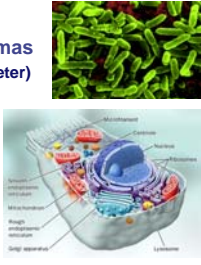
Labels: NUCLEUS (Chromatin, Nucleolus, Nuclear envelope), Centrosome, Rough endoplasmic reticulum, Smooth endoplasmic reticulum, Ribosomes, Golgi apparatus, Central vacuole, Tonoplast, Microfilaments, Intermediate filaments, Microtubules, CYTOSKELETON, Mitochondrion, Peroxisome, Plasma membrane, Cell wall, Wall of adjacent cell, Plasmodesmata, Chloroplast.

Not in plant cells:
Lysosomes
Centrioles
Flagella (in some plant sperm)

Limits to cell size

- Lower limit
 - smallest bacteria, mycoplasmas
 - 0.1 to 1.0 micron (μm = micrometer)
 - most bacteria
 - 1-10 microns
- Upper limit
 - eukaryotic cells
 - 10-100 microns

micron = micrometer = 1/1,000,000 meter
 diameter of human hair = ~20 microns



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What limits cell size?

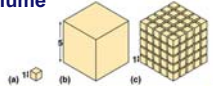
- Surface to volume ratio
 - as cell gets bigger its volume increases faster than its surface area
 - smaller objects have greater ratio of surface area to volume

Surface area increases while total volume remains constant

What cell organelle governs this?

Why is a huge single-cell creature not possible?

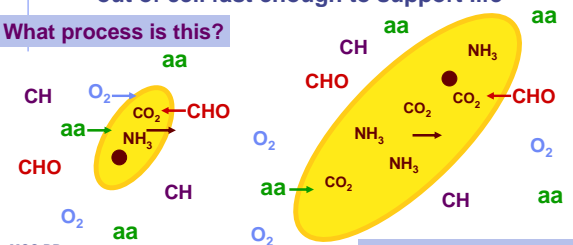
	(a)	(b)	(c)
Total surface area (height x width x number of sides x number of boxes)	6	150	750
Total volume (height x width x length x number of boxes)	1	125	125
Surface-to-volume ratio (area ÷ volume) s:v	6:1	~1:1	6:1



Limits to cell size

- Metabolic requirements set upper limit
 - in large cell, cannot move material in & out of cell fast enough to support life

What process is this?



What's the solution?

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How to get bigger?

- Become multi-cellular (cell divides)

But what challenges do you have to solve now?

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Cell membrane

- Exchange organelle
 - ♦ plasma membrane functions as selective barrier
 - allows passage of O₂, nutrients & wastes

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Organelles & Internal membranes

- Eukaryotic cell
 - ♦ internal membranes
 - partition cell into compartments
 - create different local environments
 - compartmentalize functions
 - membranes for different compartments are specialized for their function
 - ♦ different structures for specific functions
 - ♦ unique combination of lipids & proteins

