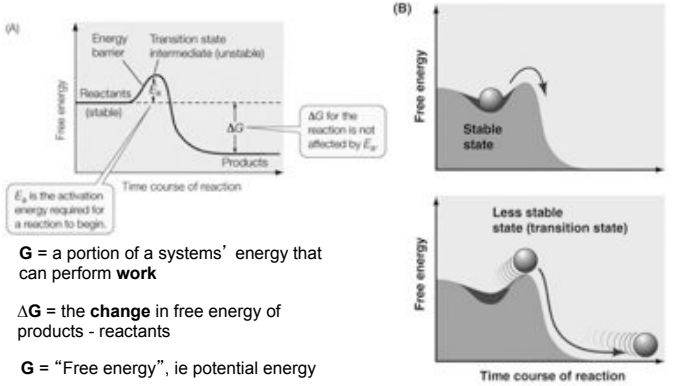
Topics

- Enzymes, continued
- The Cell
  - Prokaryotes vs. Eukaryotes
  - Organelles, introduction

Free Energy
Activation energy starts the reaction

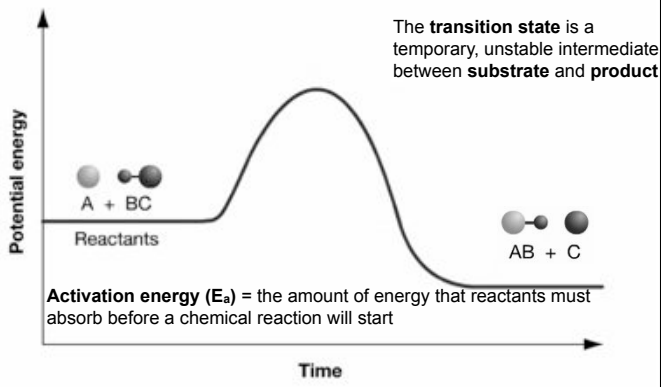


G = a portion of a systems' energy that can perform **work**

ΔG = the **change** in free energy of products - reactants

G = "Free energy", ie potential energy

Transition State

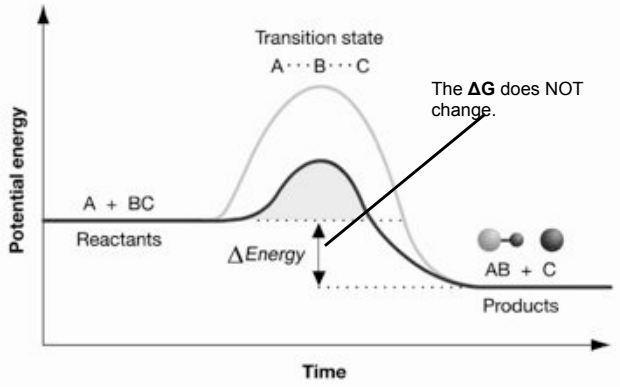


The **transition state** is a temporary, unstable intermediate between **substrate** and **product**

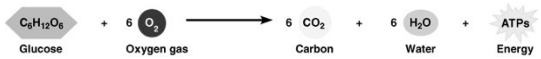
Activation energy (E_a) = the amount of energy that reactants must absorb before a chemical reaction will start

Every system seeks to achieve a minimum of free energy.

Enzymes Lower E_a



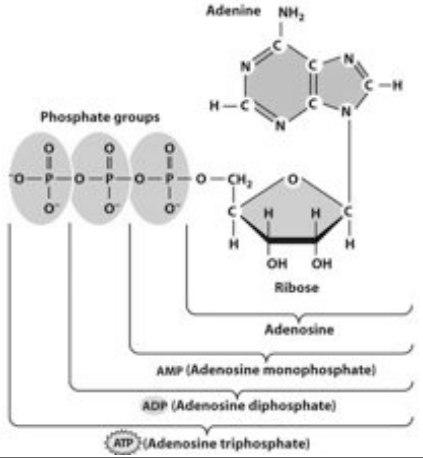
Why do we eat?



Reactants **Products**

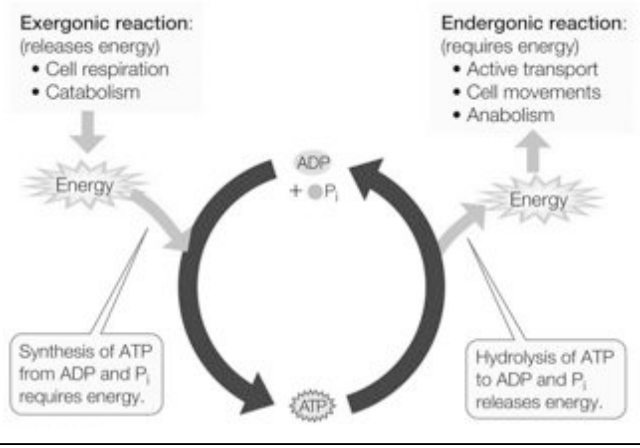
A large part of the study of metabolism is how do we go from food (i.e. glucose) to ATP?

What do cells use for energy?

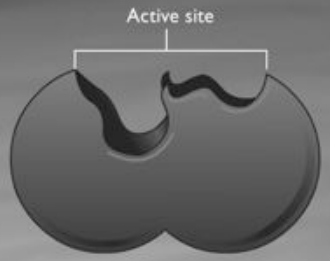


ATP hydrolysis
ATP + H2O ➔
ADP + Pi + free energy

Review- Exergonic vs Endergonic



Enzymes are Proteins



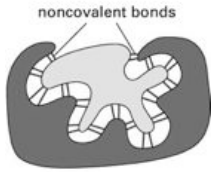
Enzymes are proteins that catalyze reactions

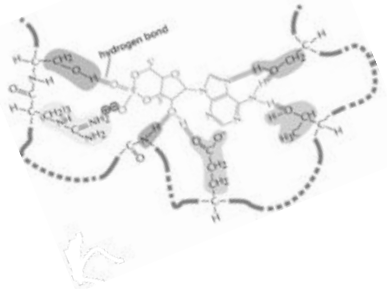
Substrates (reactants) bind the **active site**

The interaction with the enzyme promotes a chemical reaction (e.g. joining two molecules)

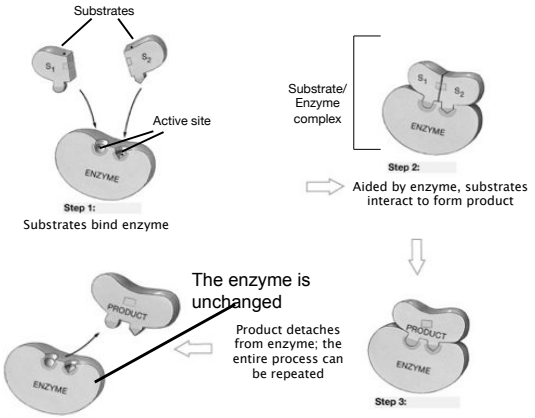
Enzymes

- The substrate/enzyme binding site is a perfect match
- Reversible, noncovalent bonds create the substrate/enzyme interaction

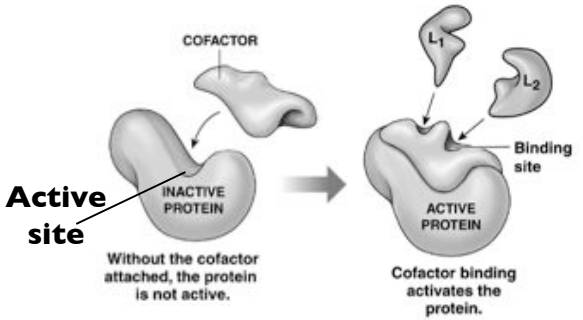




Enzymes



Enzyme "partners"

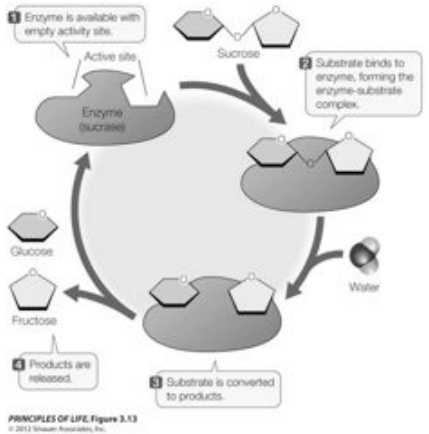


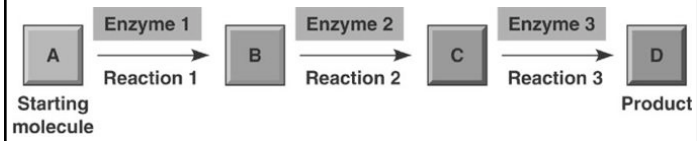
Enzyme action

TABLE 3.3 Some Examples of Nonprotein "Partners" of Enzymes

TYPE OF MOLECULE	ROLE IN CATALYZED REACTIONS
Cofactors	
Iron (Fe^{2+} or Fe^{3+})	Oxidation/reduction
Copper (Cu^{+} or Cu^{2+})	Oxidation/reduction
Zinc (Zn^{2+})	Helps bind NAD
Coenzymes	
Biotin	Carries $—COO^{-}$
Coenzyme A	Carries $—CO—CH_3$
NAD	Carries electrons
FAD	Carries electrons
ATP	Provides/extracts energy
Prosthetic groups	
Heme	Binds ions, O_2, and electrons; contains iron cofactor
Flavin	Binds electrons
Retinal	Converts light energy

Enzyme action





Enzymes are Sensitive

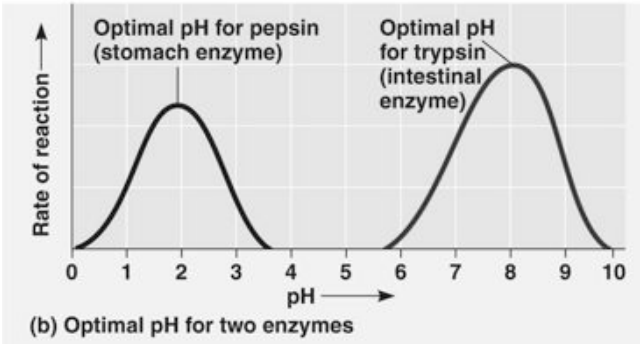
- Every enzyme is different, has its own set of optimal conditions
- Many factors affect enzyme activity...
  temperature, pH, ionic strength, time, etc.

pH

These are environmental, nonspecific factors that affect enzymes

Temperature

All Enzymes are Affected by Environment

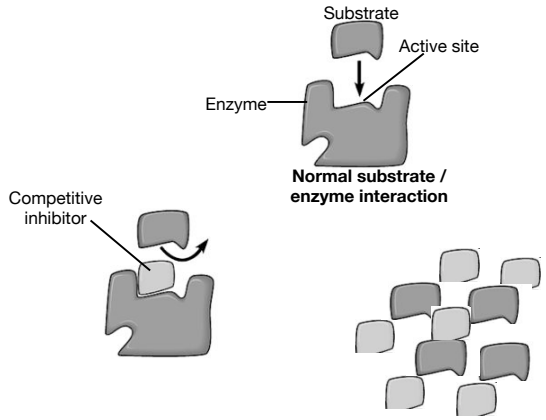


Specific Enzyme Inhibitors

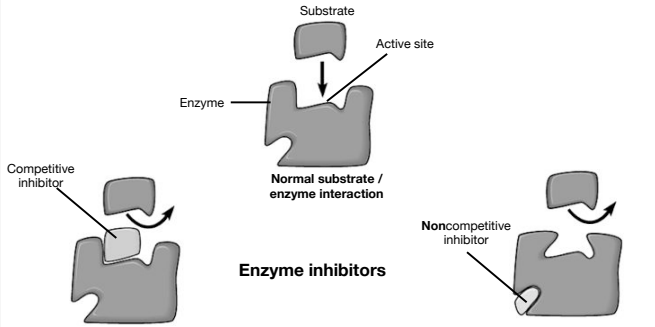
- Different than environmental inhibition, enzymes can be inhibited by other, *specific*, factors...

1. Irreversible- covalent inhibitors bind enzyme
2. Reversible
   a. Competitive Inhibition
      - "Something" directly prevents binding to the active site of the enzyme.
   b. Noncompetitive Inhibition

Specific Enzyme Inhibitors



Specific Enzyme Inhibitors

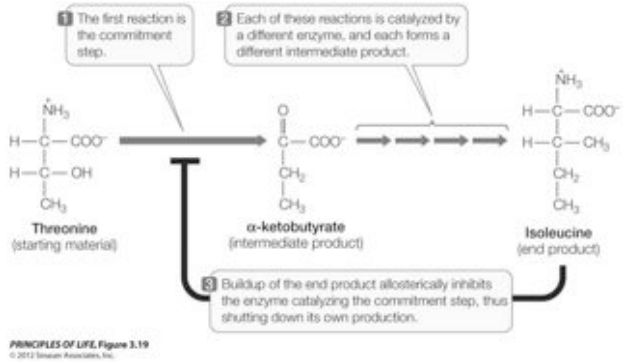


"Allosteric" inhibition

Noncompetitive inhibitor changes shape of enzyme so substrate cannot bind

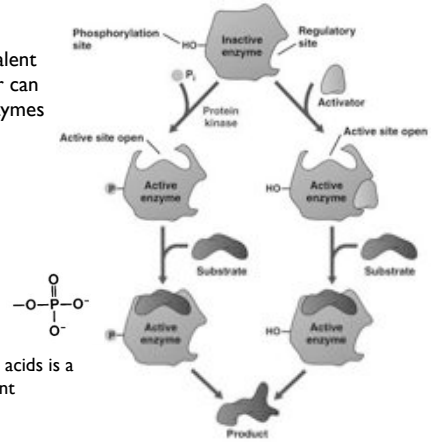
Other regulators of enzyme activity

Feedback inhibition- common in metabolism



Allosteric regulation of enzyme activity

Covalent or noncovalent binding of a regulator can activate or inhibit enzymes

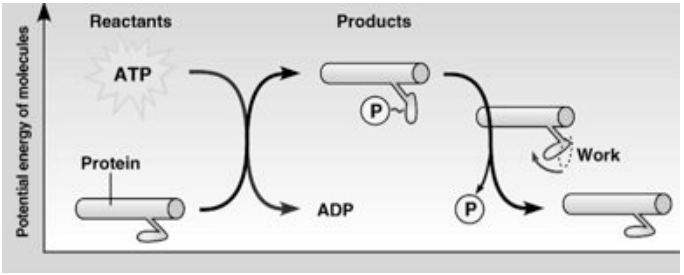


Phosphorylation of amino acids is a powerful, common covalent modification

How ATP works

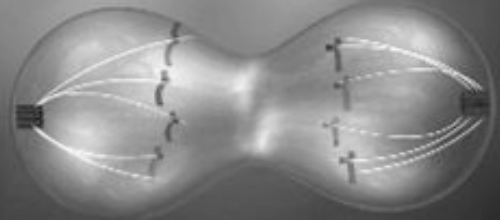
The transfer of a PO4 group to a protein is **phosphorylation**

Proteins can undergo **conformational** changes



Cell Theory

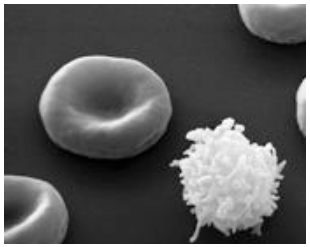
In essence, the study of cells = the study of life
....Life is continuous



Cells are the fundamental units of life
All living organisms are composed of cells
All cells arise from preexisting cells

Cells are Small

~1x



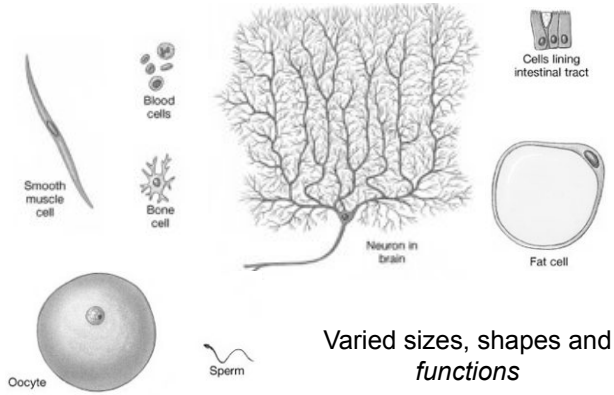
~9800x

•Larger organisms have ***more*** cells, not larger cells.

Why are cells so small?
Surface Area : Volume Ratio

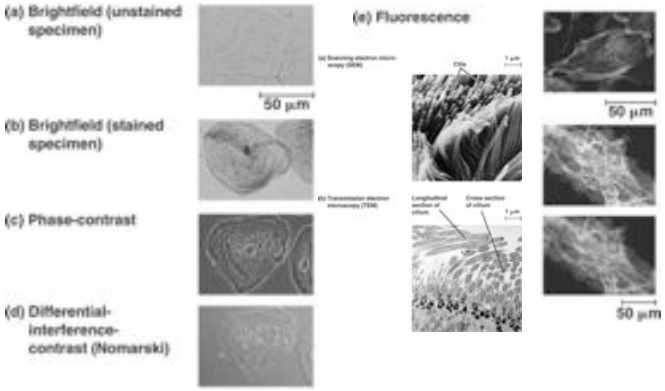
Total surface area (height × width × number of sides × number of cubes)		
96 cm^2	192 cm^2	384 cm^2
Total volume (height × width × length × number of cubes)		
64 cm^3	64 cm^3	64 cm^3
Surface area: Volume per cube (surface area ÷ volume)		
1.5:1	3:1	6:1

The Human Body is Composed of Cells



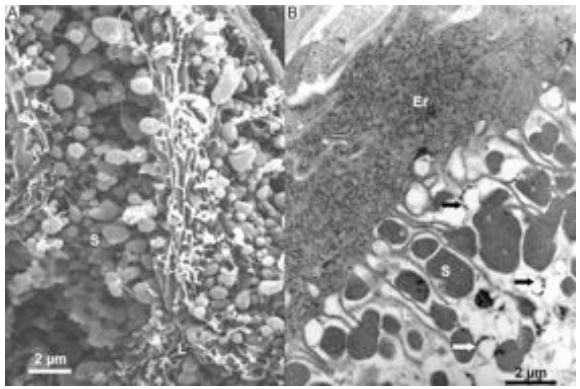
Varied sizes, shapes and *functions*

Exploring Microscopy



Exploring Microscopy

Scanning Electron (SEM) Transmission Electron (TEM)



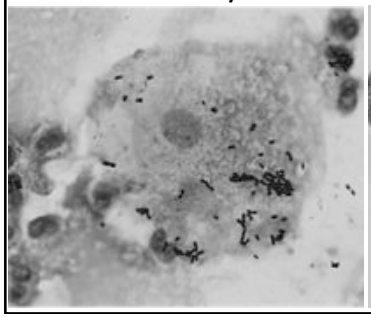
Eukaryotic Cells

Protists, Plants, Fungi, and Animal cells

- *Paramecium*, an animal cell

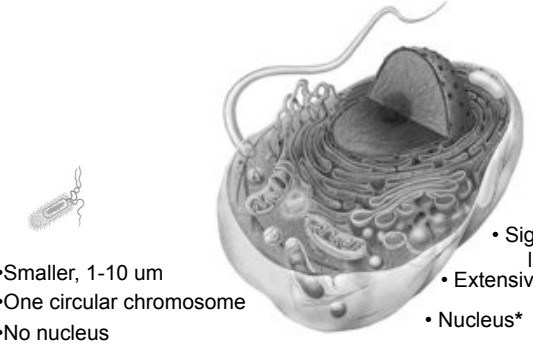
Prokaryotes

Prokaryotic compared to Eukaryotic



Magnified Prokaryotic

Prokaryotic vs. Eukaryotic Cells

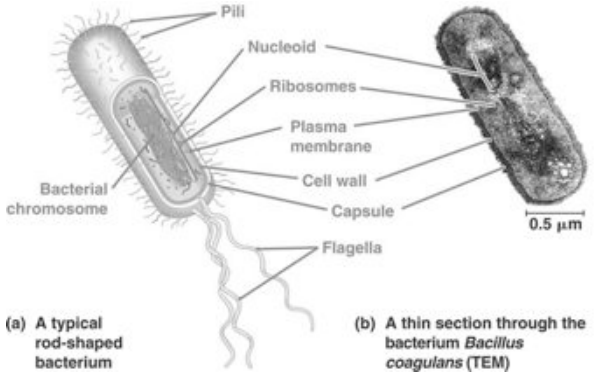


•Smaller, 1-10 um
•One circular chromosome
•No nucleus

• Significantly larger
• Extensive cytoskeleton
• Nucleus*
• Membrane-bound "organelles"

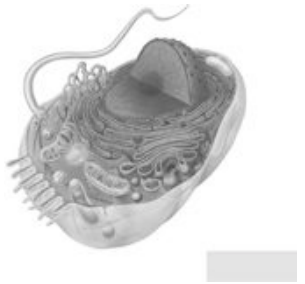
Similarities: plasma membrane, ribosomes, cytoplasm

Prokaryotic Cells

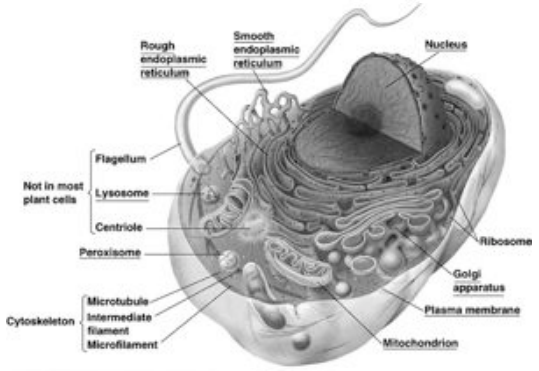


Organelles

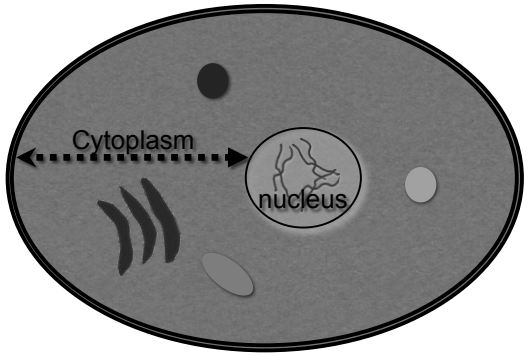
- specialized unit in a cell that has its own specific function
- usually enclosed within its own lipid bilayer

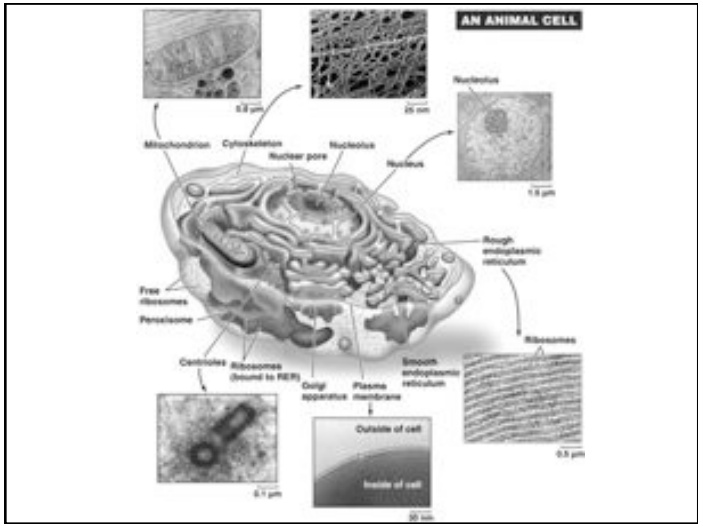


A Prototypical Eukaryotic Cell with **Organelles**



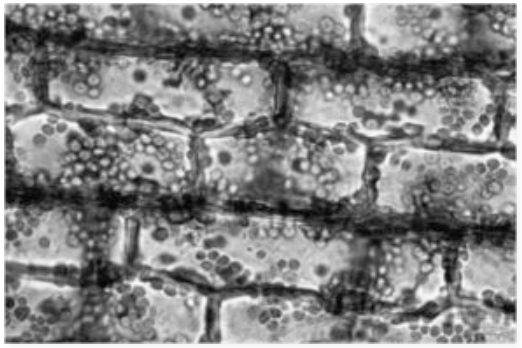
Cytoplasm vs. Cytosol

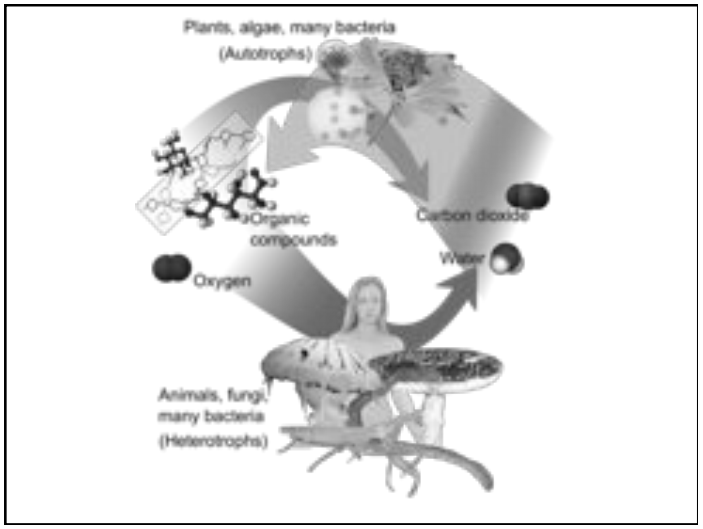


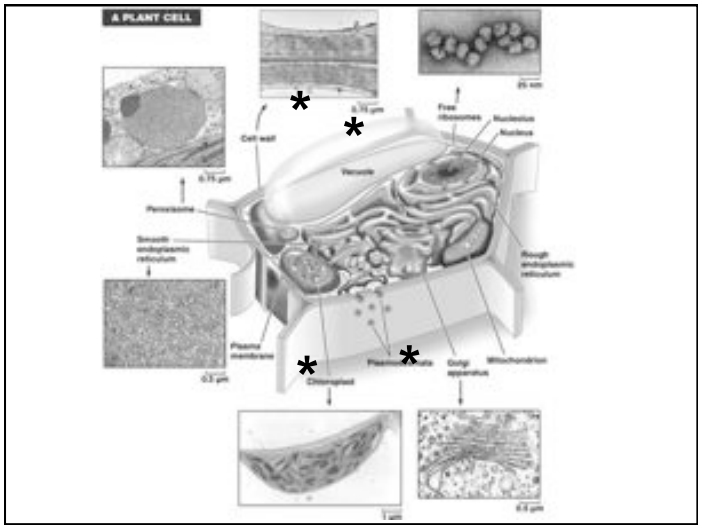


Plant cells are also Eukaryotic

- Plant cells have chloroplasts
- Plant cells have cell walls, animal cells do not







The Nucleus

• Contains the genetic material (DNA)
DNA is complexed with proteins,
ie **chromatin or chromosomes**

• Site of DNA replication and transcription

• Houses the **nucleolus** (for assembly of ribosomes)