The Nature of Life

Chapter 1: The Science of Biology

What do we know about science and the nature of life?

- All life is based on a universal genetic code written in DNA
- Scientific tools provide more information about the living world than we ever thought possible
- Science enables us to understand the natural world and allows us to predict and influence natural events

What discoveries lie in the future?

- Can new tools and techniques for studying DNA allow us to cure or prevent diseases?
- How will we respond to new information about humanity's complicated effects on the natural world?
- How will studying the smallest systems (molecules) affect our understanding of the largest biological systems (ecosystems)?

1-1 What is Science?

- Goals:
- To investigate and understand nature
- To explain events in nature
- Use explanations to make predictions

1-1 What is Science?

- Deals only with the natural world
- Scientists collect and organize information in a careful, organized way, looking for patterns and connections
- Scientists make predictions that can be tested by examining evidence
- Refers to a body of knowledge that scientists have built up after years of using this process

1-1 What is Science?

- Evidence is based on observation and is called data
- Evidence can be qualitative or quantitative
- Observations are followed by inferences, a logical interpretation of evidence based on prior knowledge

1-1 What is Science?

- A hypothesis is a possible explanation for an observation or an answer to a scientific question. It must be testable!
- They may come from prior knowledge, logical inferences or imaginative guesses
- Even incorrect hypotheses advance scientific knowledge

1-1 What is Science?

- All scientists have a problem solving attitude at work
- Scientists consider the universe as a system in which basic rules apply and assume those rules can be discovered through scientific inquiry
- Scientists must be open minded, curious , honest and skeptical

1-1 What is Science?

- Science involves human values (ethics)
- Make a list of all the things you need to understand in order to protect your life and the lives of those close to you
- Understanding all these things involve scientific information, but also involve moral principles, laws, and the economy
- Science makes recommendations, but people decide what to do with that information so it is important that everyone understand what science is, what it can do and what it cannot do

1.2 How Science Works

- Designing an experiment
- 6 steps
- Stating a problem
- Forming the hypothesis
- Designing controlled experiments
- Recording and analyzing results
- Drawing a conclusion
- Publishing and repeating investigations

1.2 How Science Works

- Read and quick write in pairs
- Discuss the work of Francesco Redi, Lazzaro Spallazani and Louis Pasteur
- What were the problems each experiment was designed to solve, their experimental steps and the conclusions of each experiment
- How did Pasteur improve upon Redi's experiments?
- What is the impact of their work on society?

1.2 How Science Works

- Sometimes model systems or alternative experiments are used when experiments on humans or animals have ethical implications

1.2 How Science Works

- A theory is developed after evidence from numerous investigations build up
- A theory is a well supported and tested hypothesis or explanation that unifies many observations

1.3 Studying Life

- Characteristics of living things
- Made up of cells
- Reproduce
- Based on a universal genetic code
- Grow and develop
- Obtain materials and energy
- Respond to their environment
- Maintain a stable internal environment
- As a group change over time

1.3 Studying Life

- Branches of Biology
- Zoology-animals
- Botany-plants
- Microbiology-microorganisms
- Neurobiology-neurons
- Biotechnology-recombinant DNA
- Ecology-ecosystems
- Ethologists-behaviors
- Paleontology-life as it was in the past
- And more!

1.3 Studying Life

- Levels of organization in life
- Molecules
- Cells
- Tissues
- Organs
- Organisms
- Populations
- Communities
- Ecosystems
- Biosphere

1.4 Tools and Procedures

- Common measuring system-metric

Metric Prefixes			
Prefix	Symbol	Meaning	
kilo-	k	1000	thousand
hecto-	h	200	hundred
deka-	da	10	ten
deci-	d	0.1	tenth
centi-	c	0.01	hundredth
milli-	m	0.001	thousandth

Figure 22

1.4 Tools and Procedures

- Common measuring system-metric

Common SI units (Base Units for Measurement)		
QUANTITY	**SI UNIT**	**SYMBOL**
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of substance	Mole	mol
Intensity of light	Candela	cd
and frequently used:		
Volume	Liter	L

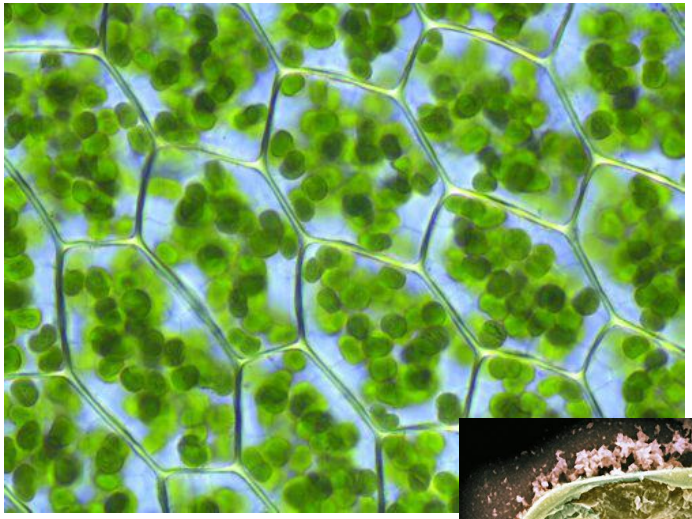
1.4 Tools and Procedures

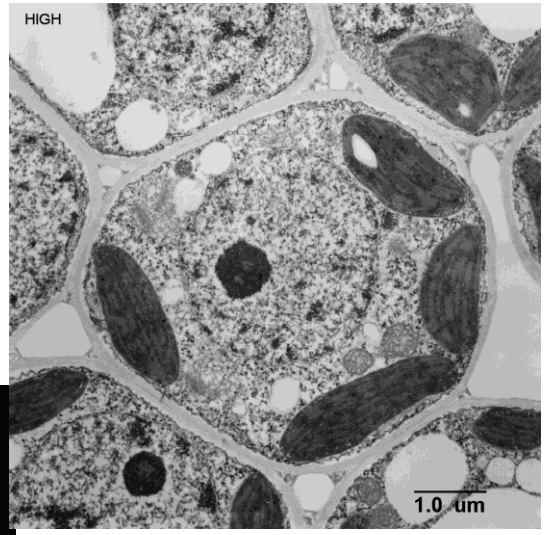
- Scientists used data tables and graphs to organize data and looks for patterns to help in understanding
- Technology helps with this

1.4 Tools and Procedures

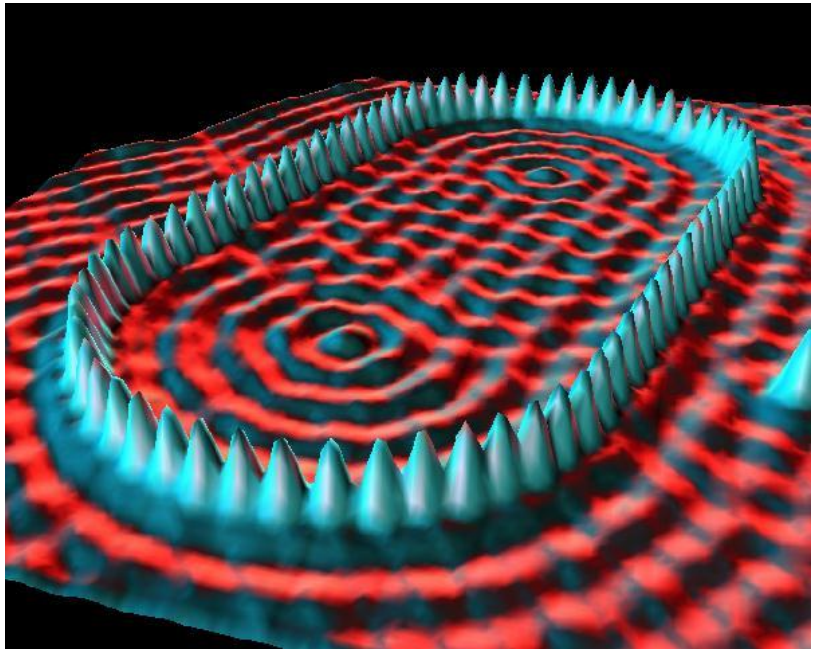
- Microscopes
- Produce magnified images of things too small to see
- Light microscopes focus visible light to produce images. Compound microscopes allow light to pass through a sample and use two lenses to form an image
- Electron microscopes focus beams of electrons. Includes transmission electron microscopes (TEM), scanning, scanning tunneling
- Atomic force used a movable tip that is dragged over the surface of the sample and maps the topography

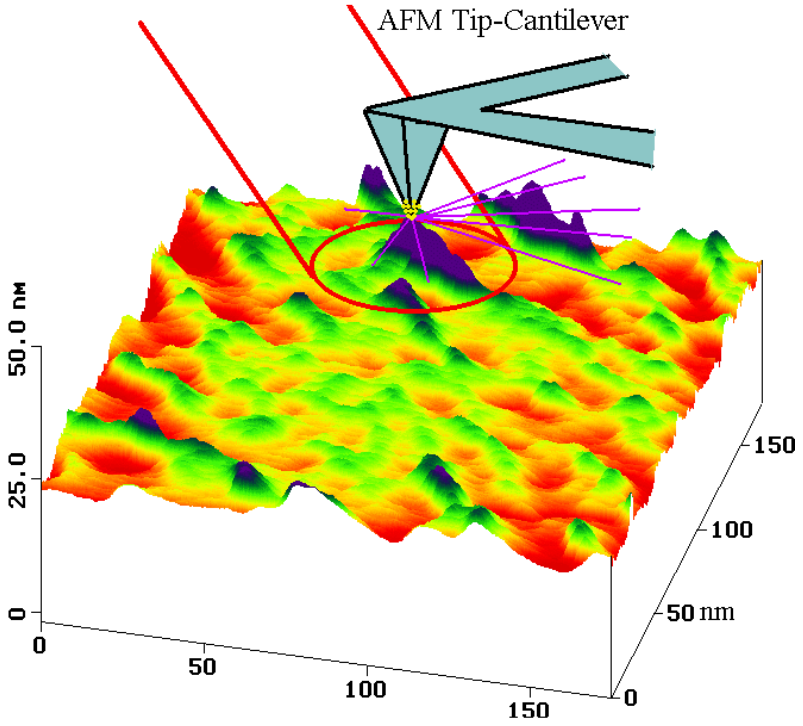
1.4 Tools and Procedures





1.4 Tools and Procedures





1.4 Tools and Procedures

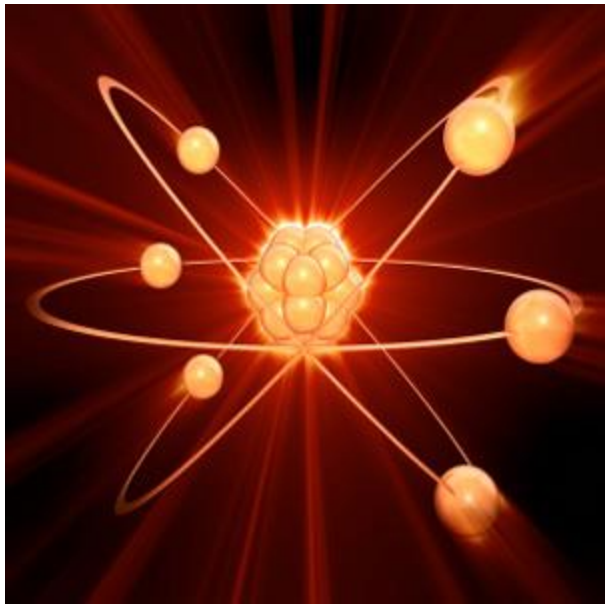
- Lab techniques for studying cells
- Cell culture
- Cell fractionation
- Lab techniques for studying organisms
- Animal experiments
- Lab safety and disposal of hazardous materials

The Nature of Life

Chapter 2: The Chemistry of Life

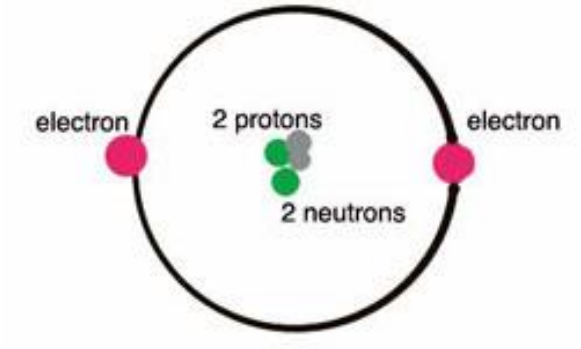
2.1 The Nature of Matter

- Atoms and subatomic particles
  - Protons and neutrons in the nucleus
  - Electrons outside the nucleus

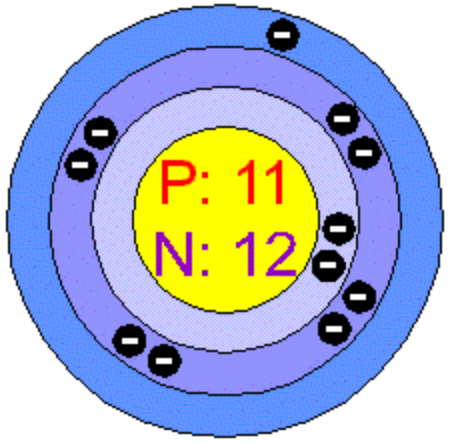


2.1 The Nature of Matter

- Atoms



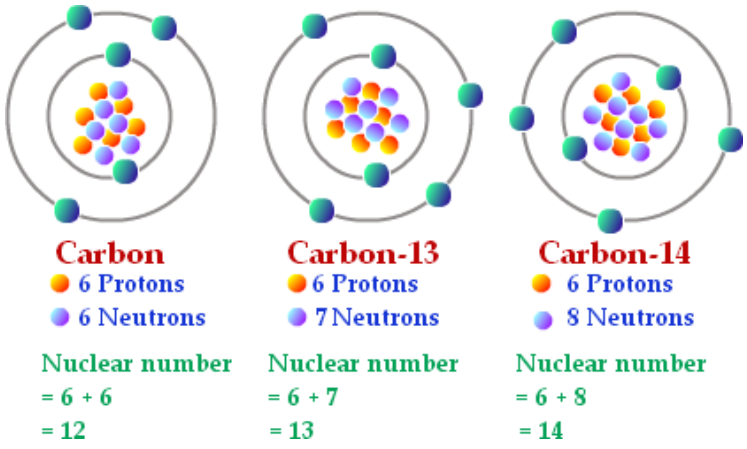
Helium atom
Element #2 in periodic table



Sodium atom
Element #11 in periodic table

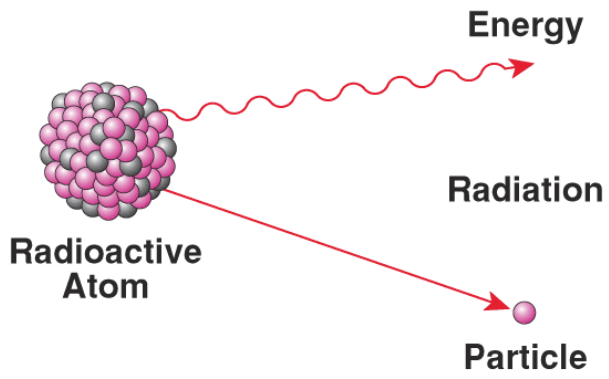
2.1 The Nature of Matter

- Isotopes
- Atoms of an element that have a different number of neutrons
- Same chemical properties, same number of protons and electrons



2.1 The Nature of Matter

- Radioactive isotopes
- Some isotopes have unstable nuclei; the nucleus breaks down and subatomic particles and/or electromagnetic radiation
- Used as tracers in the body or in an ecosystem, radiation therapy, radiocarbon dating



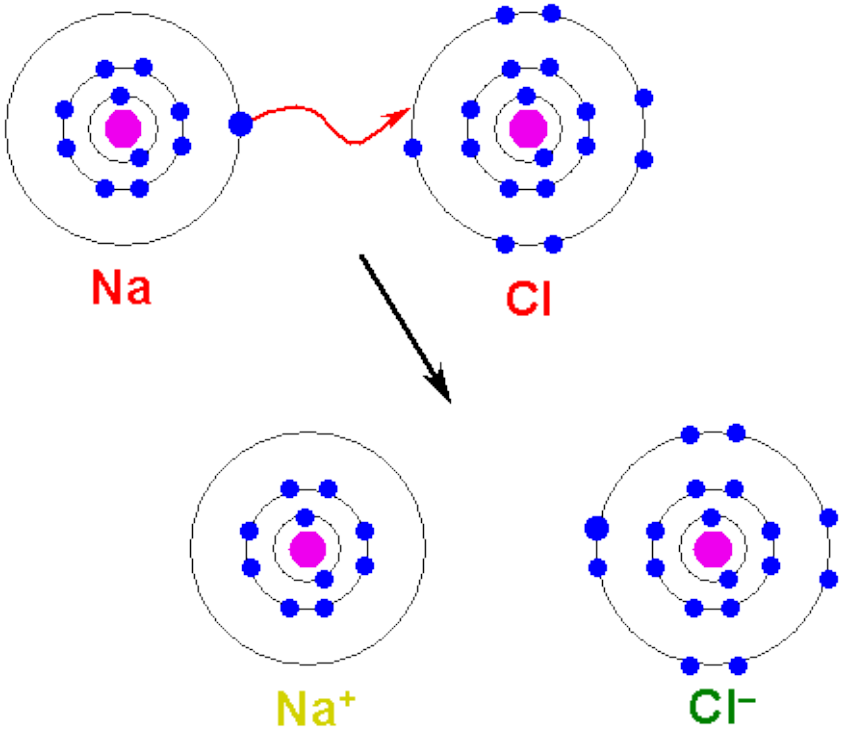
2.1 The Nature of Matter

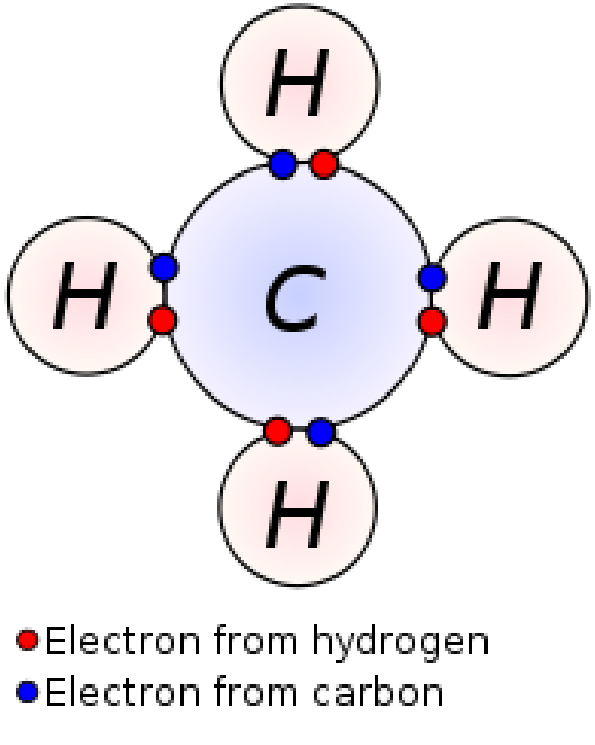
- Chemical Compound
- Elements combine with other elements to form compounds
- Named by chemical formulas
- Ex H_2O, CO_2, NaCl
- Atoms in a compound are held together by chemical bonds (ionic or covalent)- Intramolecular

2.1 The Nature of Matter

- Chemical Bonds
- Ionic-bond forms when one of more electrons are transferred from one atom to another, resulting in 2 charged atoms called ions. Opposite charges attract each other. Occurs between a metal and a nonmetal Ex NaCl
- Covalent-bond formed when electrons are shared between 2 atoms. Occurs between 2 non-metals Ex CH_4

2.1 The Nature of Matter



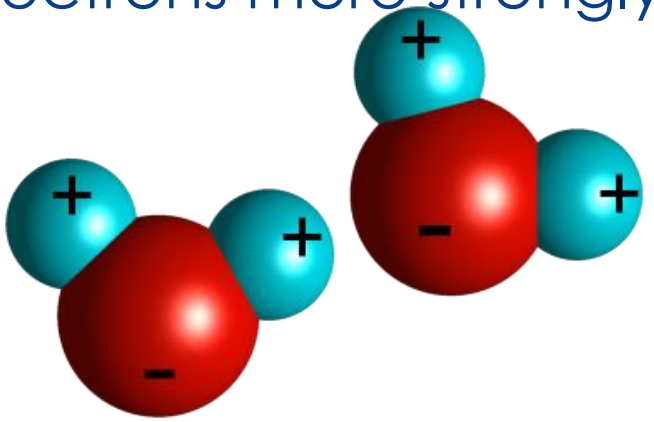


2.1 The Nature of Matter

- Van der Waals Forces
- An attraction between oppositely charged regions of nearby molecules
- Weak
- Hold molecules together-Intermolecular
- Gecko feet

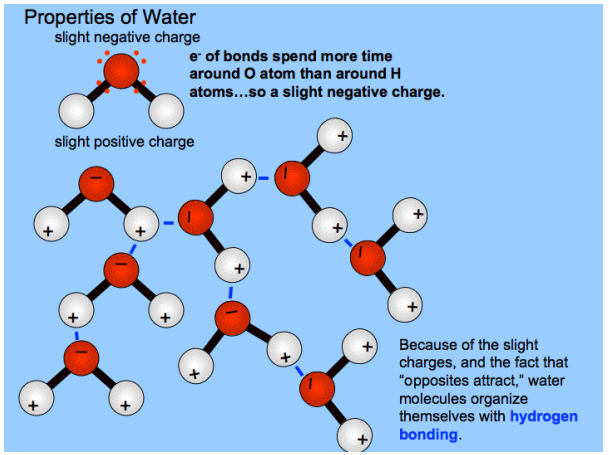
2-2 Properties of Water

- Polarity
- Water is polar; the electrons that are shared are not equally distributed between the hydrogens and the oxygen
- Oxygen is more electronegative and attracts electrons more strongly



2-2 Properties of Water

- Hydrogen bonds-polar molecules attract each other and form bonds between hydrogen and any small electronegative atom, like oxygen
- Results in cohesion (between molecules of the same substance) and adhesion (between molecules of different substances)



2-2 Properties of Water

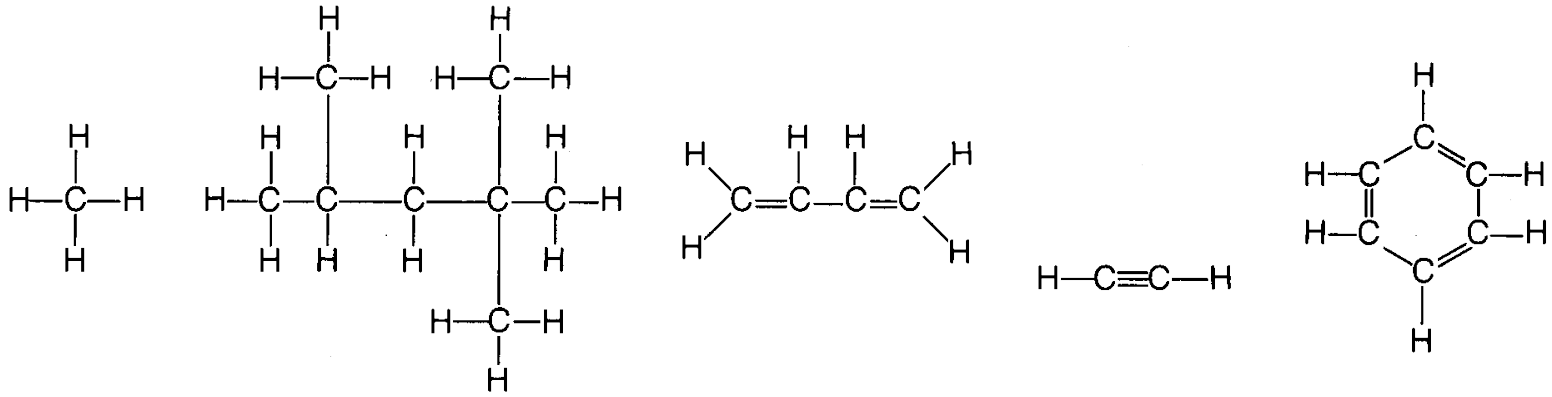
- Solutions and Suspensions
- Mixtures made with water
- Solution-a substance is dissolved in water
  - Solute-substance dissolved
  - Solvent-the substance the solute is dissolved in to
- Suspension-substance is not dissolved in water

2-2 Properties of Water

- Acids, bases and pH
- Ionization of water
- $2H_2O \leftrightarrow H_3O^+ + OH^-$
- H_3O^+ makes solutions acidic, OH^- makes solutions basic. When $H_3O^+ = OH^-$ the solution is neutral
- pH scale 0-14; lower number is more acidic
- Buffers are substances that help solutions resist pH change

2-3 Carbon Compounds

- Organic chemistry deals with carbon containing compounds
- Carbon forms 4 bonds; can form single, double or triple covalent bonds



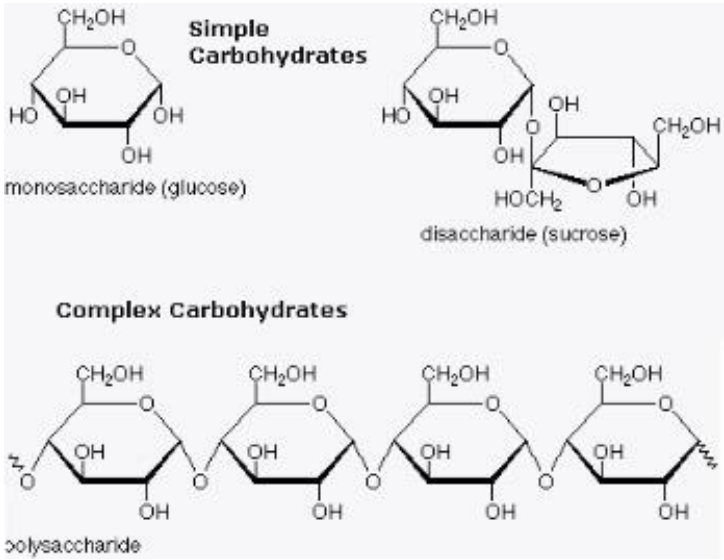
Methane **Iso-Octane** **Butadiene** **Acetylene** **Benzene**

2-3 Carbon Compounds

- Macromolecules
- Giant molecules
- Formed by polymerization-form polymers
- Four categories
  - Carbohydrates
  - Lipids
  - Nucleic acids
  - proteins

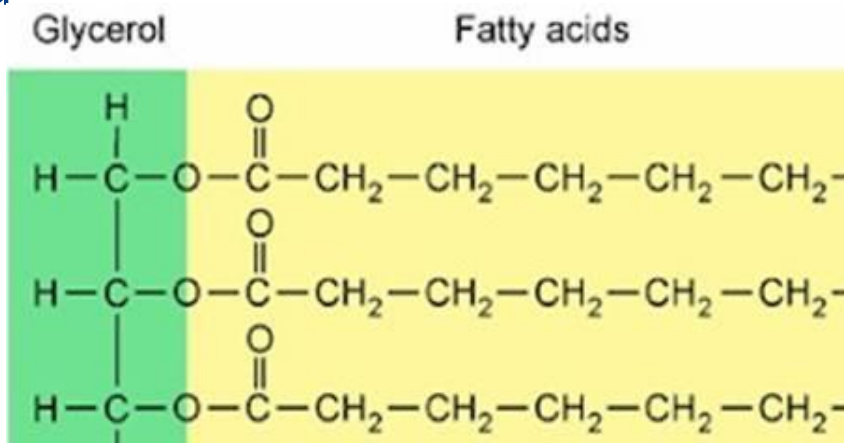
2-3 Carbon Compounds

- Carbohydrates
- C:H:O 1:2:1
- Energy and structural purposes
- Glucose is basic unit
- Starch and cellulose are polymers



2-3 Carbon Compounds

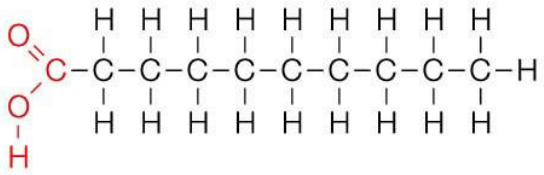
- Lipids
- Carbon and Hydrogen
- Stores energy and makes up cell and organelle membranes, messengers
- Glycerol + fatty acid



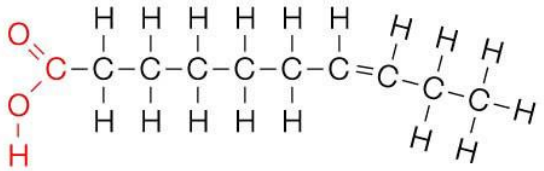
2-3 Carbon Compounds

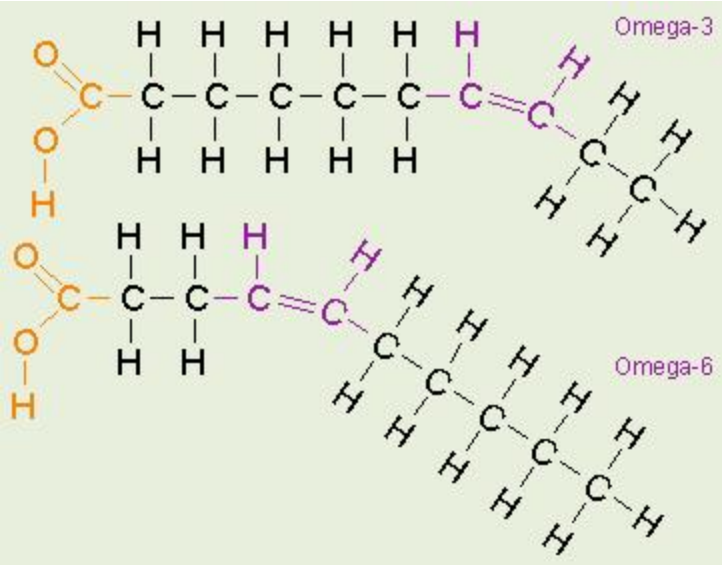
- Lipids
- Saturated (all single bonds between C's) and unsaturated (some double bonds)

Saturated



Unsaturated



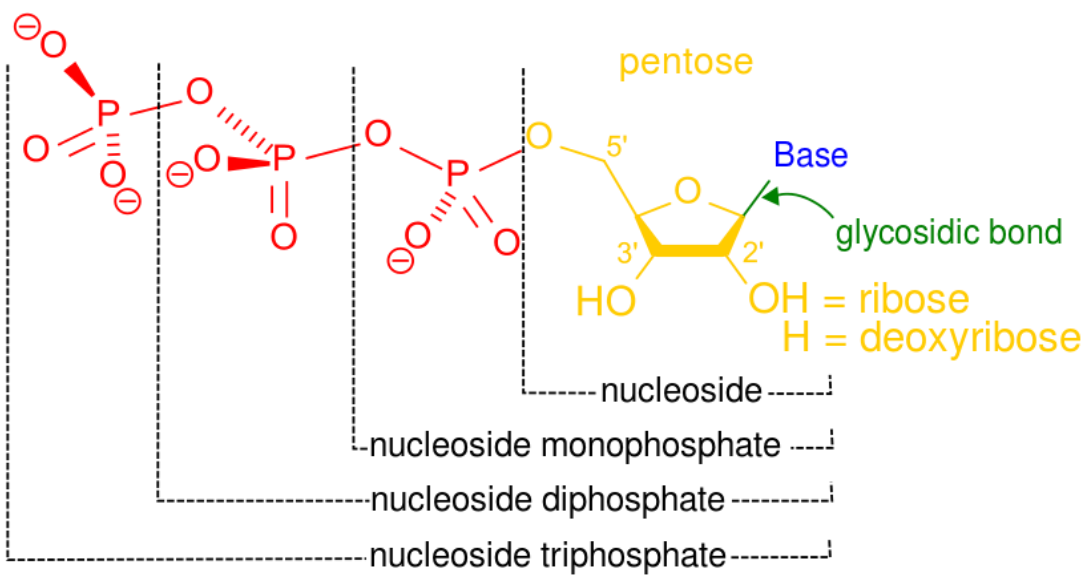


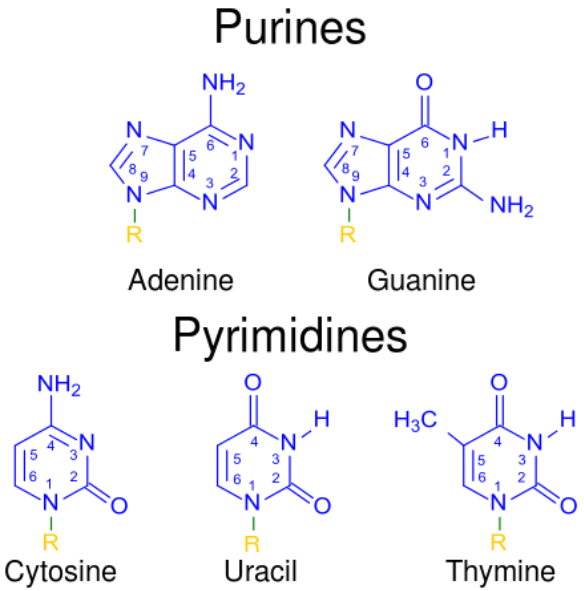
2-3 Carbon Compounds

- Nucleic Acids
- C, H, O,N,P
- Nucleotides-monomer
- Nucleic acid-polymer
- Stores and transmits information
- DNA (deoxy-)and RNA(ribonucleic acid)

2-3 Carbon Compounds

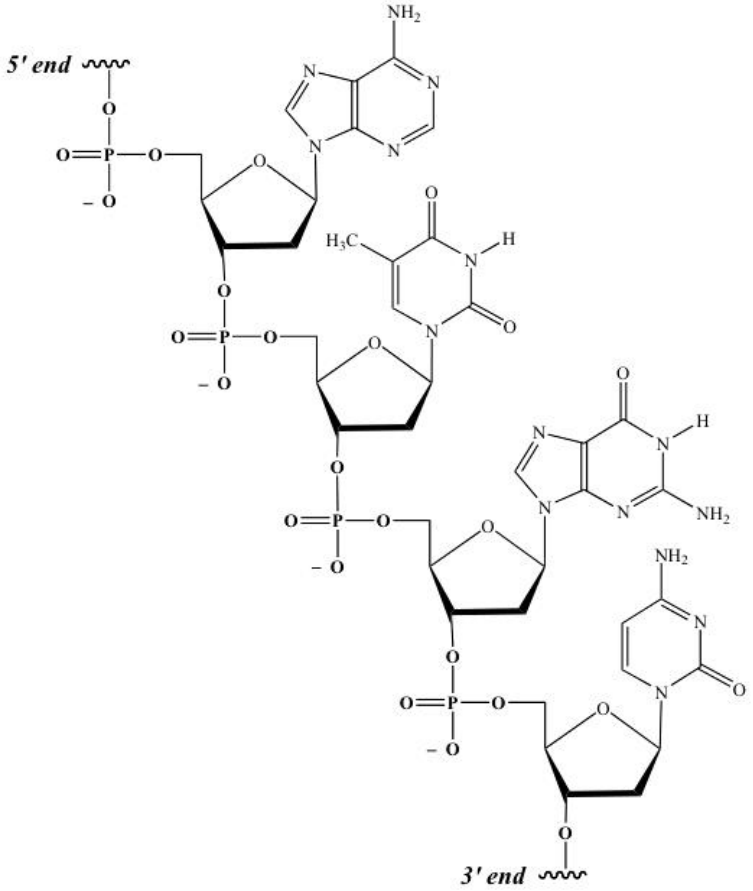
- Nucleotide





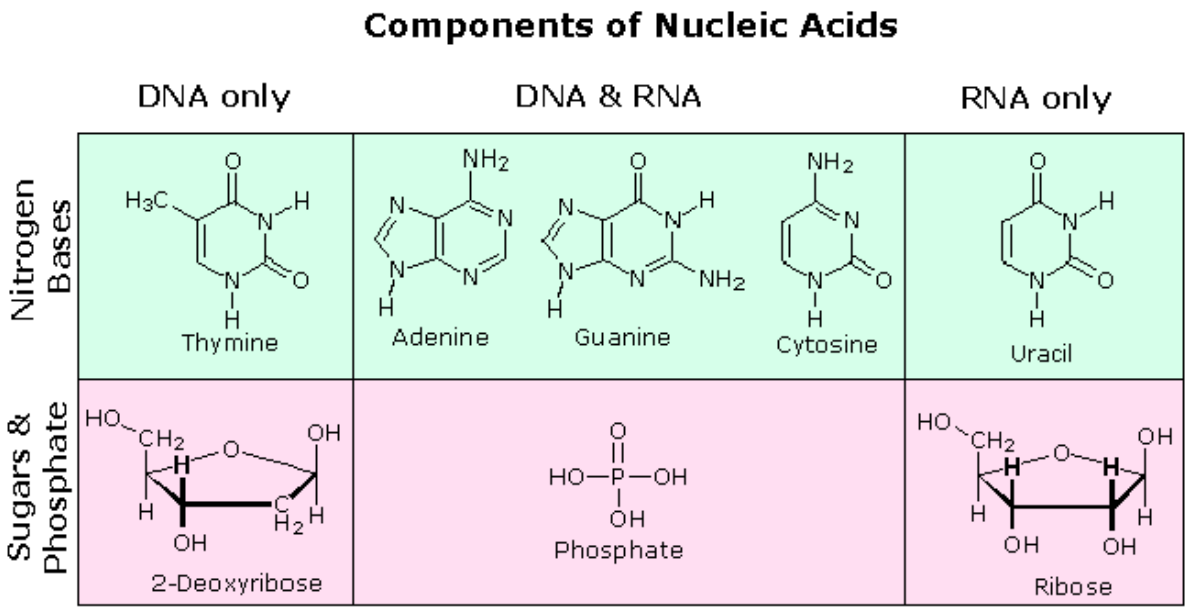
2-3 Carbon Compounds

- Nucleic acid



2-3 Carbon Compounds

- DNA vs RNA

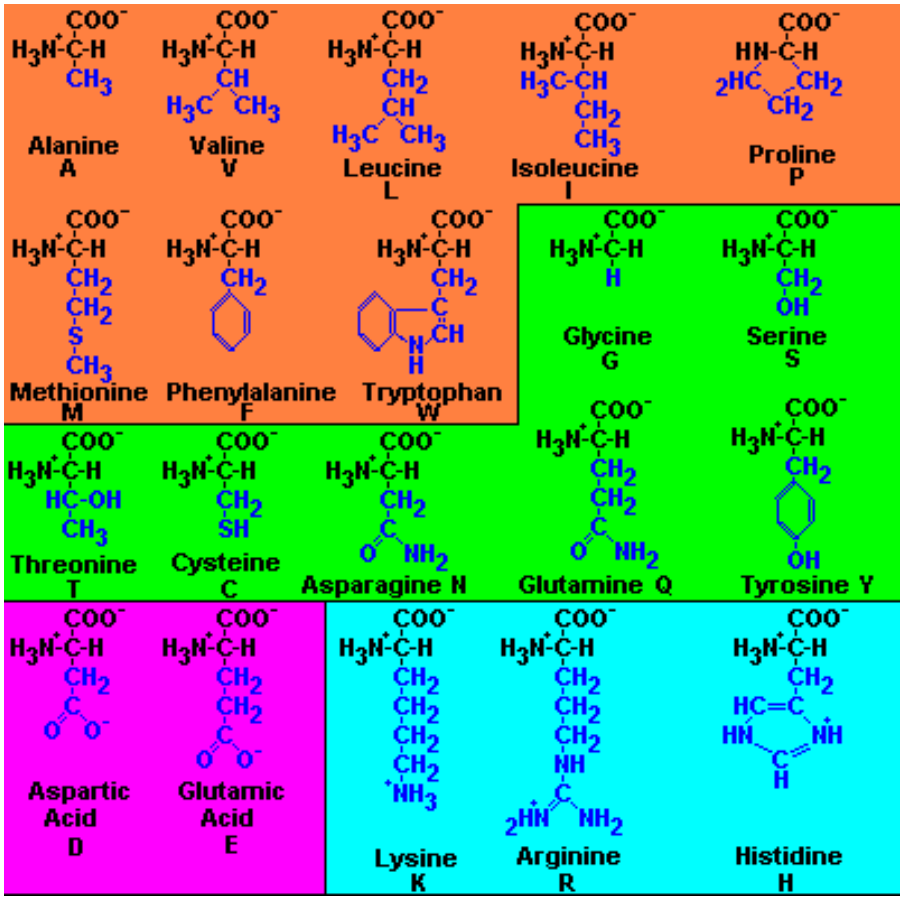


2-3 Carbon Compounds

- Proteins
- Polymers of amino acids
- Control the rate of reactions and regulate cell processes, form bones and muscle (structural), transport substances and fight disease
- Amino acids have an amino group end (-NH_2) and carboxylic acids end (-COOH)
- Amino acids joined by peptide bond

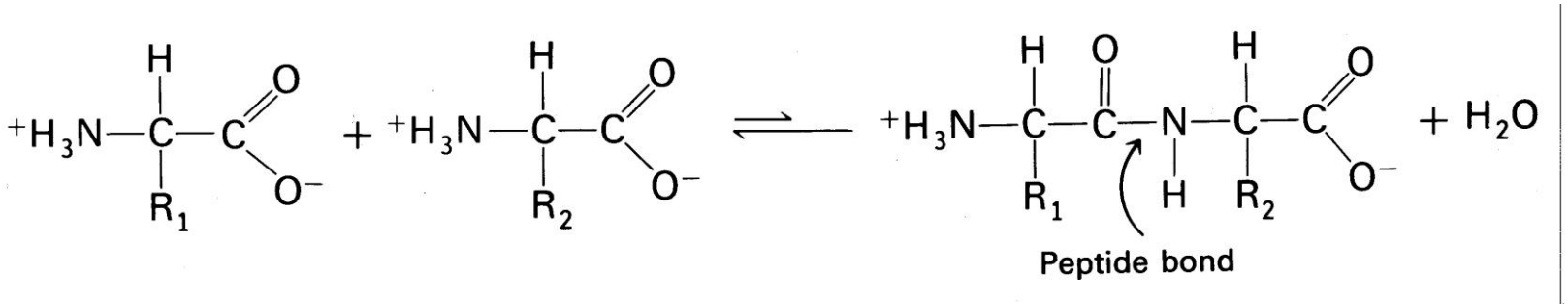
2-3 Carbon Compounds

- Amino acids



2-3 Carbon Compounds

- Peptide bond

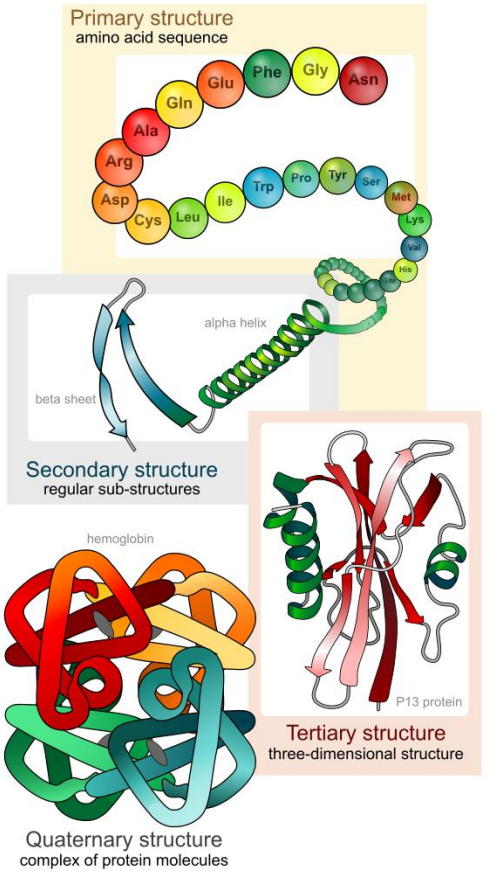


2-3 Carbon Compounds

- Protein Structure
- 4 levels
- Primary-sequence of amino acids
- Secondary-chains of AA's can be twisted or folded into alpha helices or beta sheets
- Tertiary-The twisted and folded chain can be twisted and folded again; 3-D structure of the protein
- Quartenary-if the protein has more than one polypeptide chain, the individual chains bonded together

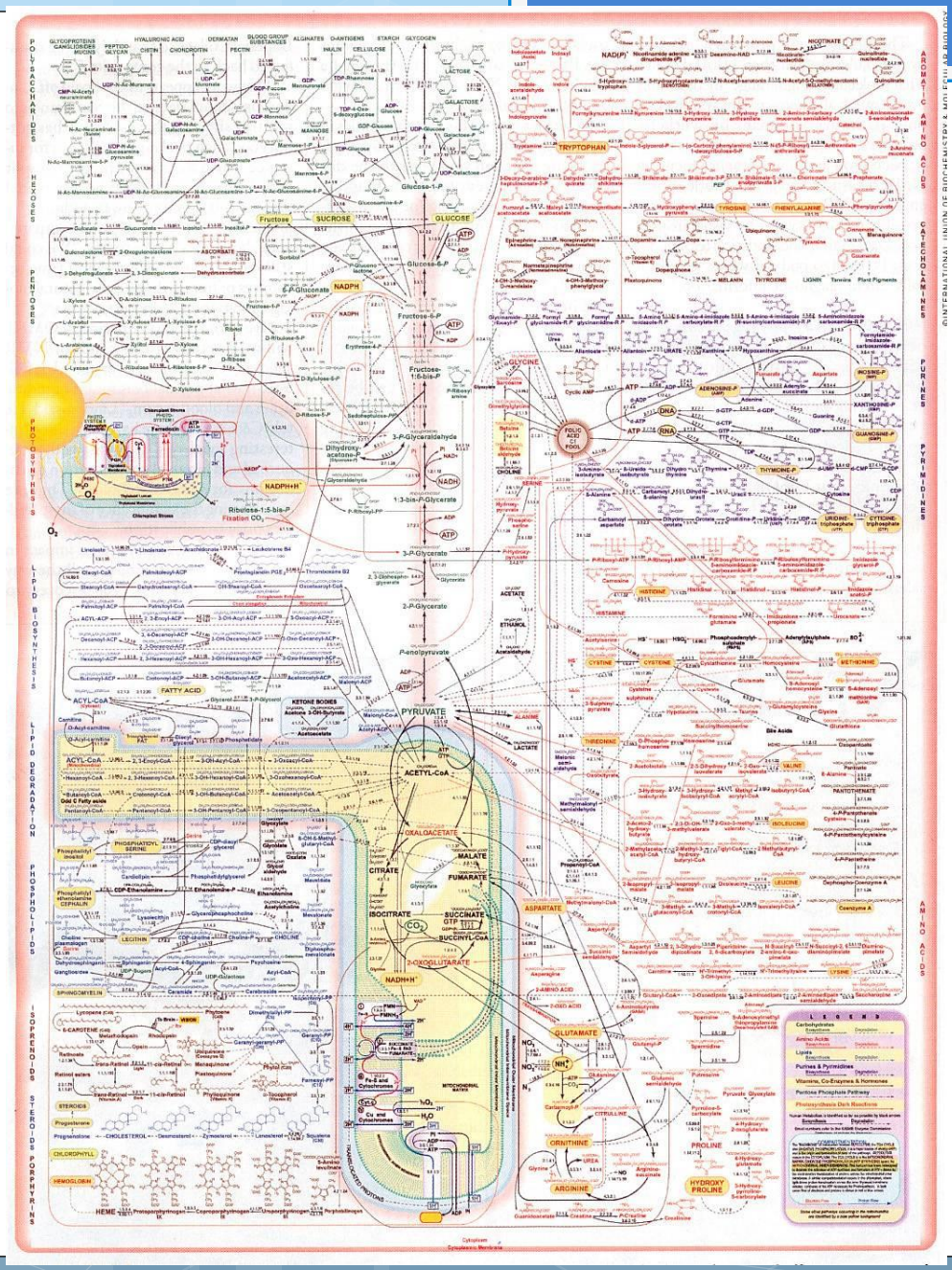
2-3 Carbon Compounds

- Protein structure



2-4 Chemical Reactions and Enzymes

- Every thing that happens in a cell, and therefore an organism, is the result of chemical reactions
- Chemical reactions change one set of chemical into another set of chemicals
- Reactants $\rightarrow$Products

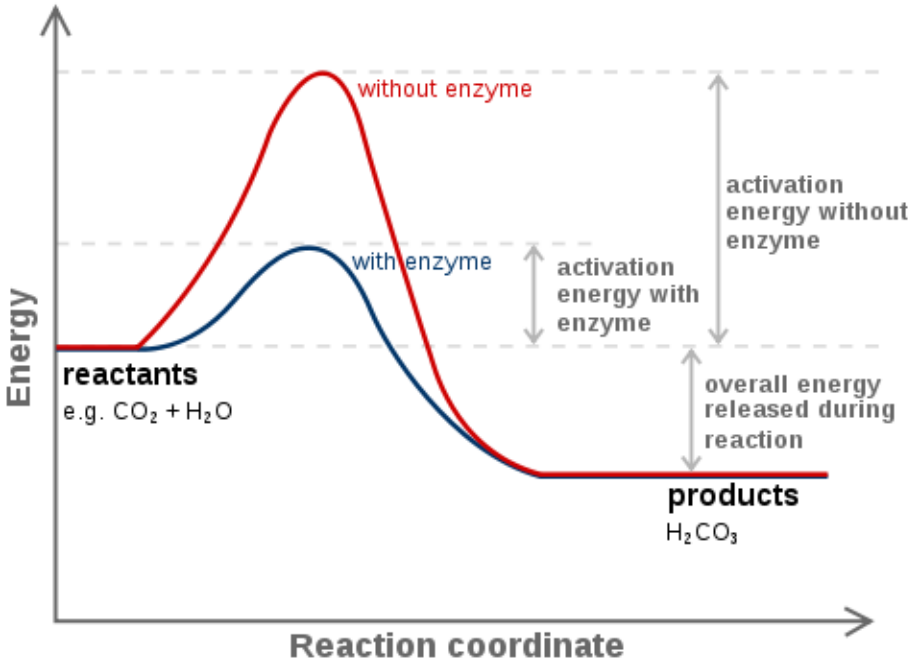

GLUCOSE
SUCROSE
Fructose
Glucose-1-P
Glucose-6-P
Fructose-6-P
Fructose-1:6-bis-P
6-P-Gluconate
NADPH
3-P-Glyceraldehyde
Dihydroxy-acetone-P
1.3-bis-P-Glycerate
3-P-Glycerate
2-P-Glycerate
P-enolpyruvate
PYRUVATE
ACETYL-CoA
OXALOACETATE
CITRATE
ISOCITRATE
SUCCINATE
SUCCINYL-CoA
2-OXOGLUTARATE
MALATE
FUMARATE
ASPARTATE
GLUTAMATE
CITRULLINE
ORNITHINE
ARGININE
PROLINE
HYDROXY PROLINE
GLYCINE
TRYPTOPHAN
TYROSINE
PHENYLALANINE
HISTIDINE
METHIONINE
CYSTEINE
THREONINE
VALINE
LEUCINE
ISOLEUCINE
LYSINE
SERINE
ALANINE
LACTATE
ACETATE
ETHANOL
FATTY ACID
ACYL-CoA
KETONE BODIES
CHOLESTEROL
HEME
CHLOROPHYLL
HEMOGLOBIN
PHOTOSYNTHESIS
LIPID BIOSYNTHESIS
LIPID DEGRADATION
PHOSPHOLIPIDS
ISOPRENOIDS - STEROIDS - PORPHYRINS
POLYSACCHARIDES
HEXOSES
PENTOSES
AROMATIC AMINO ACIDS
CATECHOLAMINES
PURINES
PYRIMIDINES
AMINO ACIDS
LEGEND

2-4 Chemical Reactions and Enzymes

- Energy in reactions
- Chemical reactions either absorb or release energy
- Reactions that release energy are spontaneous
- Those that are not spontaneous require energy
- $2H_2 + O_2 \rightarrow 2H_2O$ releases energy (exothermic)
- $2H_20 \rightarrow 2H_2 + O_2$ absorbs energy(endothermic)
- Organisms need energy for many endothermic reactions
- Activation energy is the energy required to get a reaction started. Amount of activation energy required determines if a reaction will occur

2-4 Chemical Reactions and Enzymes

- Activation energy

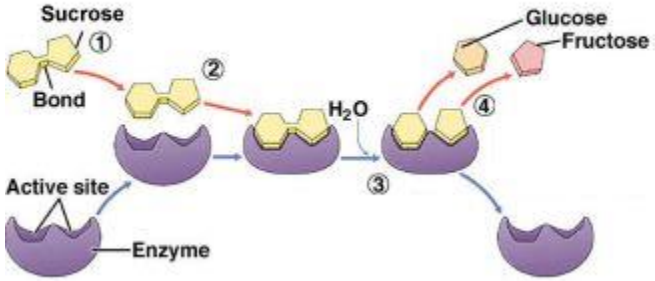


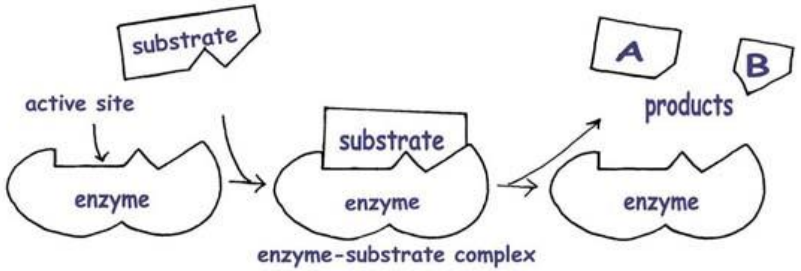
2-4 Chemical Reactions and Enzymes

- Enzymes
- Proteins that catalyze reactions
- Very specific for the substances they act on, substrates
- Enzyme activity is regulated by many factors including cofactors and other things that switch them on and off

2-4 Chemical Reactions and Enzymes

- Enzyme substrate complex





2-4 Chemical Reactions and Enzymes

- Tyrosine Kinase-adds phosphate to a tyrosine in a protein substrate