Madenet Al elm University College
Department of Medical Physics
2nd Year Medical Chemistry 2021 – 2022

CELL BIOLOGY and Molecular Biology

Dr. Hamza Yaseen Isa
Lecture M 8 I 2

Basic Cell Biology

Explain the molecular makeup of cells

Identify the basic structures of cells and their corresponding functions

Review the basic function of the cell

Cell Makeup

- **Cells are composed of molecules**
  - **Lipids**
    - **Fats, a source of high energy**
  - **Phospholipids**
  - **Carbohydrates**
    - **Supply energy and provide structure within the cell –** **Glucose** **is a type of sugar that is routinely measured in blood tests.**
      - » **A high blood sugar can signal** **diabetes**, **which requires**

treatment to lower the blood sugar level.

Cell Makeup

- **Polysaccharides**
  - **Composed of many monosaccharide's.**
    - **Ex: glycogen which is a starch that stores energy within the cell**
- **Protein**
  - **Proteins make up 50% of the dry weight of animals.**
  - **Proteins are made up of amino acids**
    - **22 aa are used to make proteins**
- **Nucleic acids**
  - **Provide plans for protein construction**
    - **RNA and DNA**

Cell Structure

Cell Structure

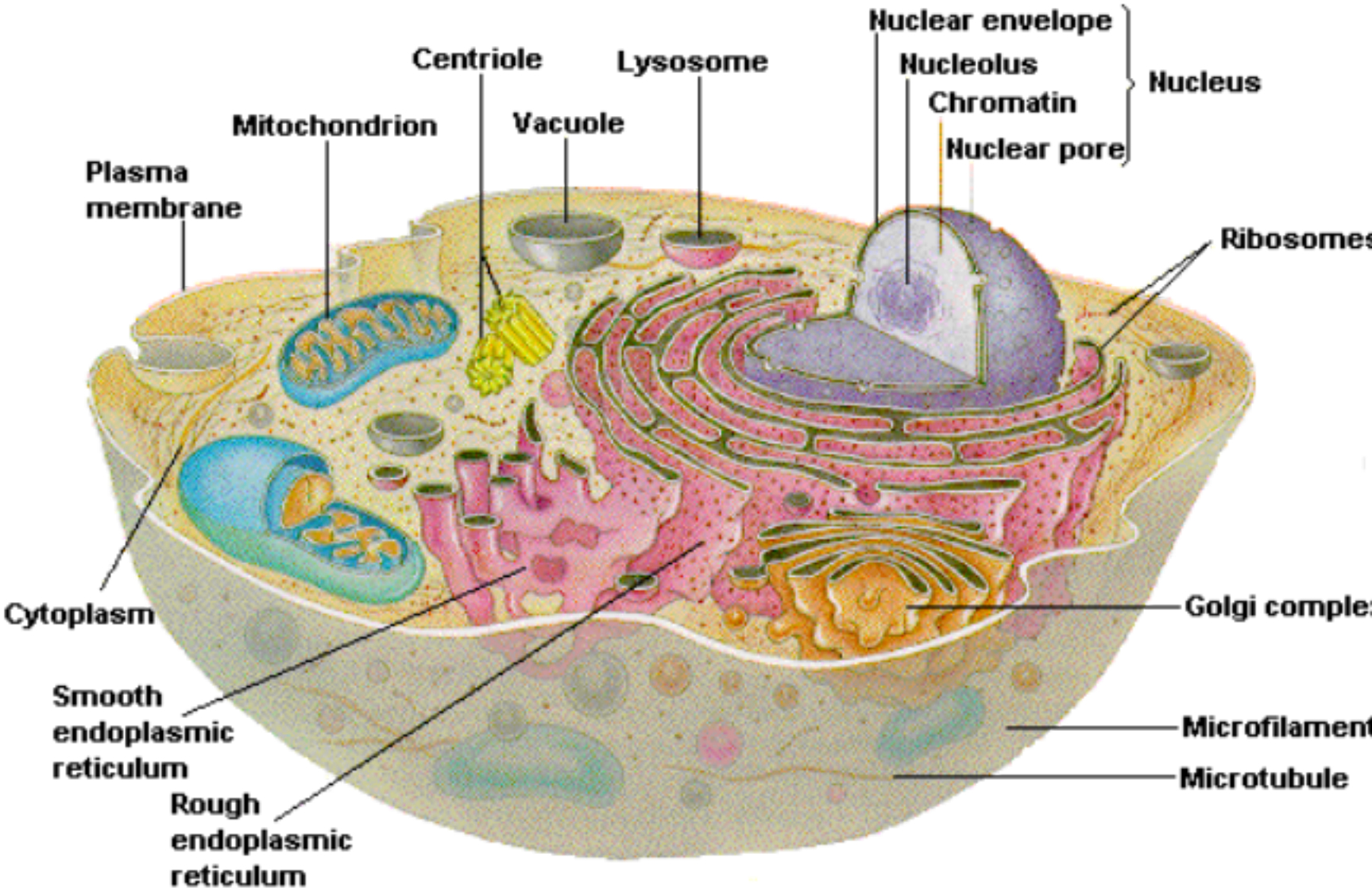
- **Cell membrane – found in all cells, a boundary to keep the inside of a cell contained**
  - **Semi permeable**
- **Cytoplasm – organelles and fluid within the cell**
- **Nucleus – controls the cellular activity and carries genetic material of the cell.**

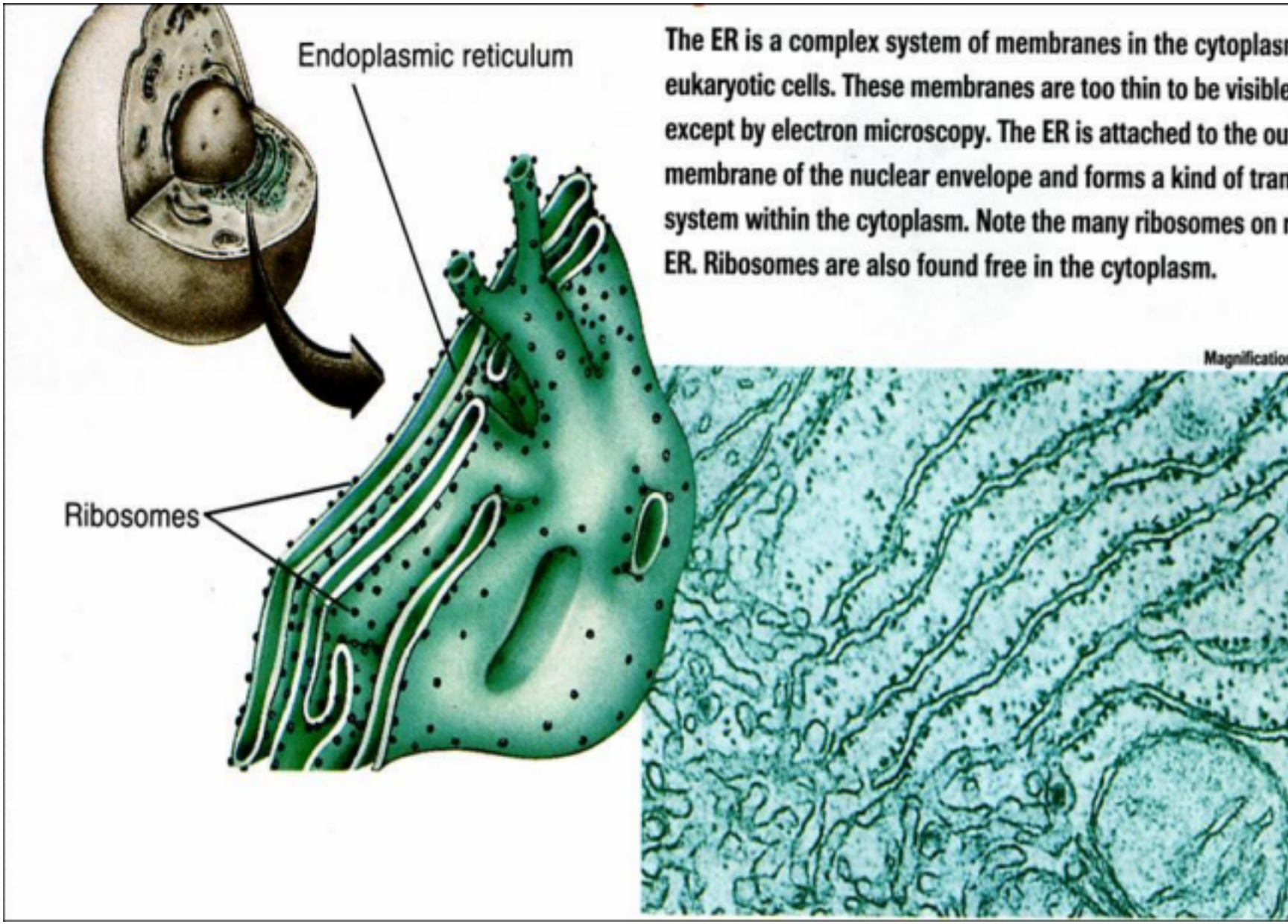
- **Ribosomes – manufacture protein used in the**

cell

- **Endoplasmic reticulum** – converts ribosomal protein or moves the protein to the surface for excretion
- **Golgi apparatus** – produces polysaccharides and lysosomes
- **Lysosomes** – used to digest food taken in by the cell

Cell Structure


Nuclear envelope
Nucleolus
Chromatin
Nuclear pore
Nucleus
Centriole
Lysosome
Mitochondrion
Vacuole
Plasma membrane
Ribosomes
Cytoplasm
Golgi comple
Smooth endoplasmic reticulum
Microfilament
Microtubule
Rough endoplasmic reticulum



Cell Structure

- **Mitochondria – convert food substances into a form of energy that can be used by the cell. Known as the powerhouse of the cell.**

Cell Function

- **The cell constantly reacts with its environment. This can be described as metabolism.**
- **Metabolism can be broken into two categories**
  - **Anabolism**
    - **Smaller molecules are combined into larger ones**

– **Catabolism**

- **Larger molecules are broken down into smaller ones**

Extracellular Fluid (ECF)

- **Surrounds all living cells. Derived from the blood.**
  - **Water**
  - **Dissolved gasses – oxygen and CO2**
  - **Inorganic ions**
    - **Sodium, potassium, chloride, phosphate, calcium (macro minerals)**
    - **Copper, zinc, manganese, cobalt, selenium, iron (trace minerals) –**

    Organic compounds
      - **Proteins, amino acids, lipids, carbohydrates, vitamins**
  - **Hormones**
    - **Compounds produced by glands to influence metabolism of cells**
  - **Waste products**

ECF

- Concentrations must be maintained – Small pupplies can become low in blood sugar (glucose) if they have a lot of parasites robbing them of their nutrients. When the sugar in the ECF becomes too low, the cells do not have adequate energy. The puppy can become weak or develop seizures.
- Homeostasis is the maintenance of the ECF. Allows for normal concentrations despite external conditions.

ECF

- Cells must be able to obtain products from the

ECF.

- Diffusion
  - Molecules move from areas of high concentration to low
- Osmosis
  - Molecules cannot pass, only solvents
- Active transport
  - Pumping of a substance into an area of higher concentration

ECF

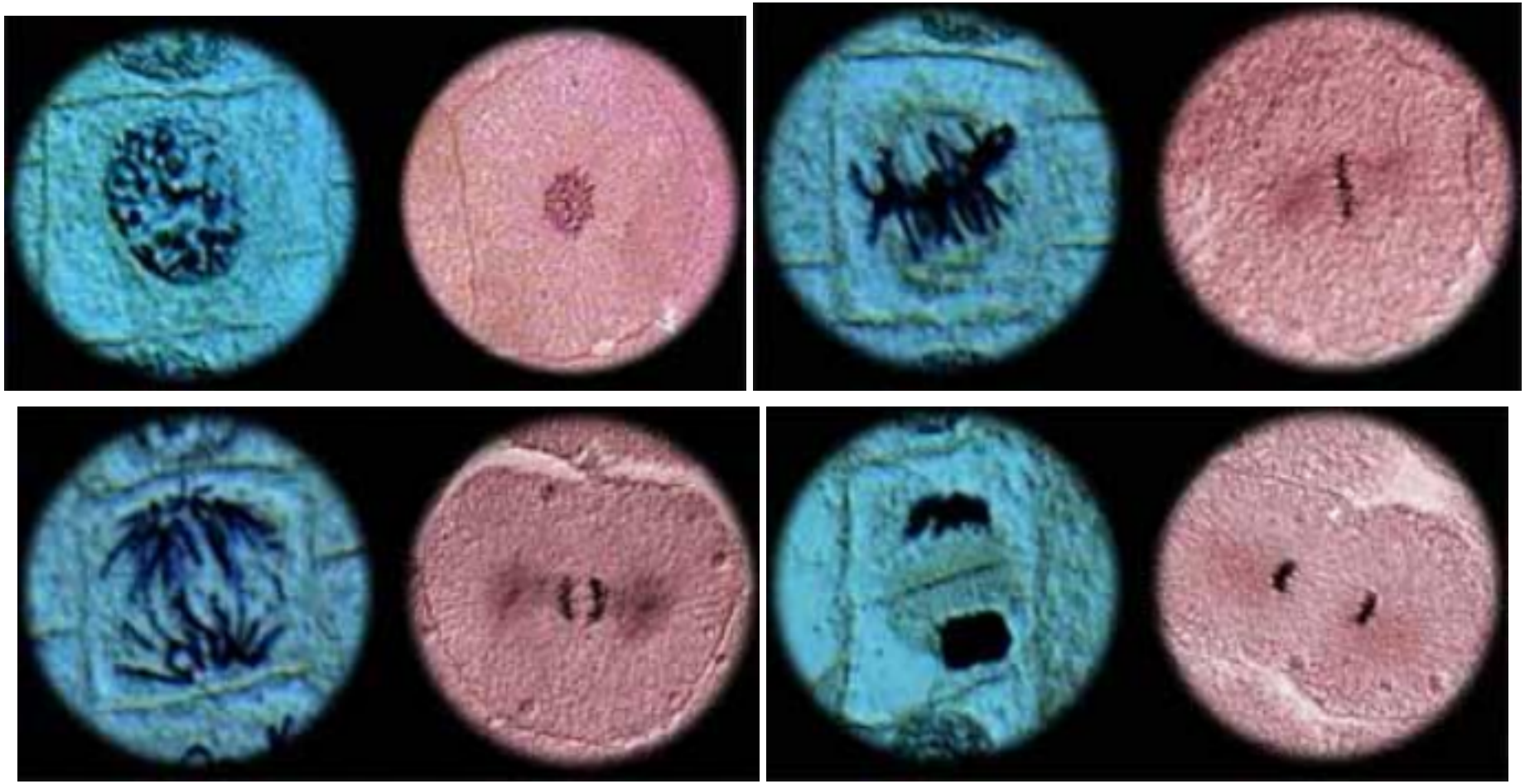
- Endocytosis
  - Cell membrane wraps around a particle, pinches off, then moves into the cytoplasm as a vacuole

- Exocytosis
  - Opposite of endocytosis. The cell membrane releases the protein sac into the ECF

Mitosis and Cancer

- Cells must be capable of reproducing themselves
  - Mitosis is the process in which cells divide, producing two identical cells.
    - Epithelia divide frequently
    - Skeletal do not divide in adults
  - Uncontrolled mitosis can result in

cancer • Mass of rapidly dividing cells is a tumor



Meiosis

- Sexual reproduction
  - Half the genetic material is provided by each cell
- With the variation, no two sperm or egg cells will provide the same genetic material.

Molecular Biology?

- The attempt to understand biological phenomena in molecular terms
- The study of gene structure and function at the molecular level
- It is the study of molecular basics of the process of replication, transcription and translation of the genetic material.

- Understanding of interactions between the various systems of a cell, including the interactions between DNA, RNA and protein biosynthesis
- learning how these interactions are regulated.

Definitions

Nucleic acids are polymers of nucleotides

Nucleotides are carbon ring structures containing nitrogen linked to a 5-carbon sugar (a ribose)

5-carbon sugar is either a ribose or a deoxy-ribose making the nucleotide either a ribonucleotide or a deoxyribonucleotide

In eukaryotic cells nucleic acids are either:

Deoxyribose nucleic acids (DNA)

Ribose nucleic acids (RNA)

Messenger RNA (mRNA)

Transfer RNA (tRNA)

Ribosomal RNA (rRNA)

Nucleic Acid Function

DNA

Genetic material - sequence of nucleotides encodes different amino acids

RNA

Involved in the transcription/translation of genetic material
(DNA) Genetic material of some viruses

Nucleotide Function

Building blocks for DNA and RNA

Intracellular source of energy - Adenosine triphosphate (ATP)

Second messengers - Involved in intracellular signaling (e.g. cyclic adenosine monophosphate [cAMP])

Intracellular signaling switches (e.g. G-proteins)

Nucleotide Structure

Despite the complexity and diversity of life the structure of DNA is dependent on only 4 different nucleotides

Diversity is dependent on the nucleotide sequence

5-carbon sugar : β-D-ribose (RNA)
β-D-deoxyribose (DNA)

All nucleotides are 2 ring structures composed of:

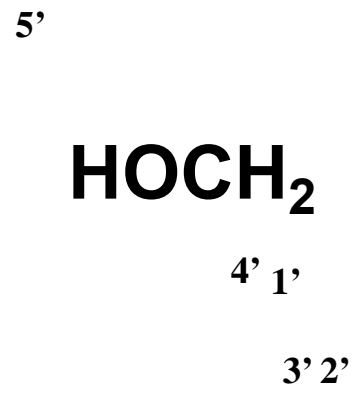
Base Purine
Pyrimidine

Phosphate group A nucleotide **WITHOUT** a phosphate group is a **NUCLEOSIDE**

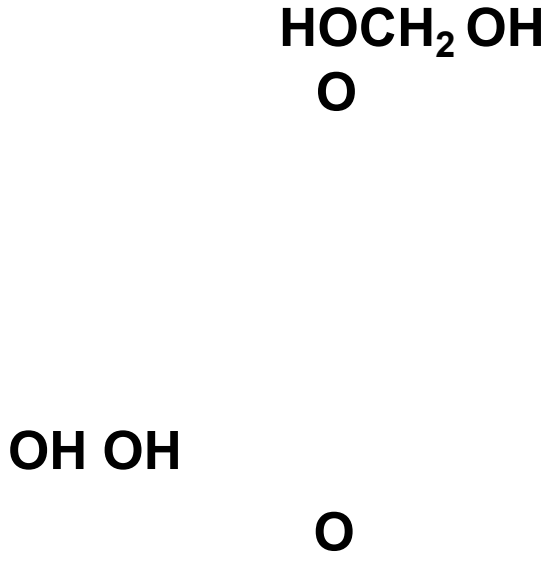
Nucleotide Structure

Sugars

Generic Ribose Structure

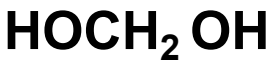


Ribose



Deoxyribose

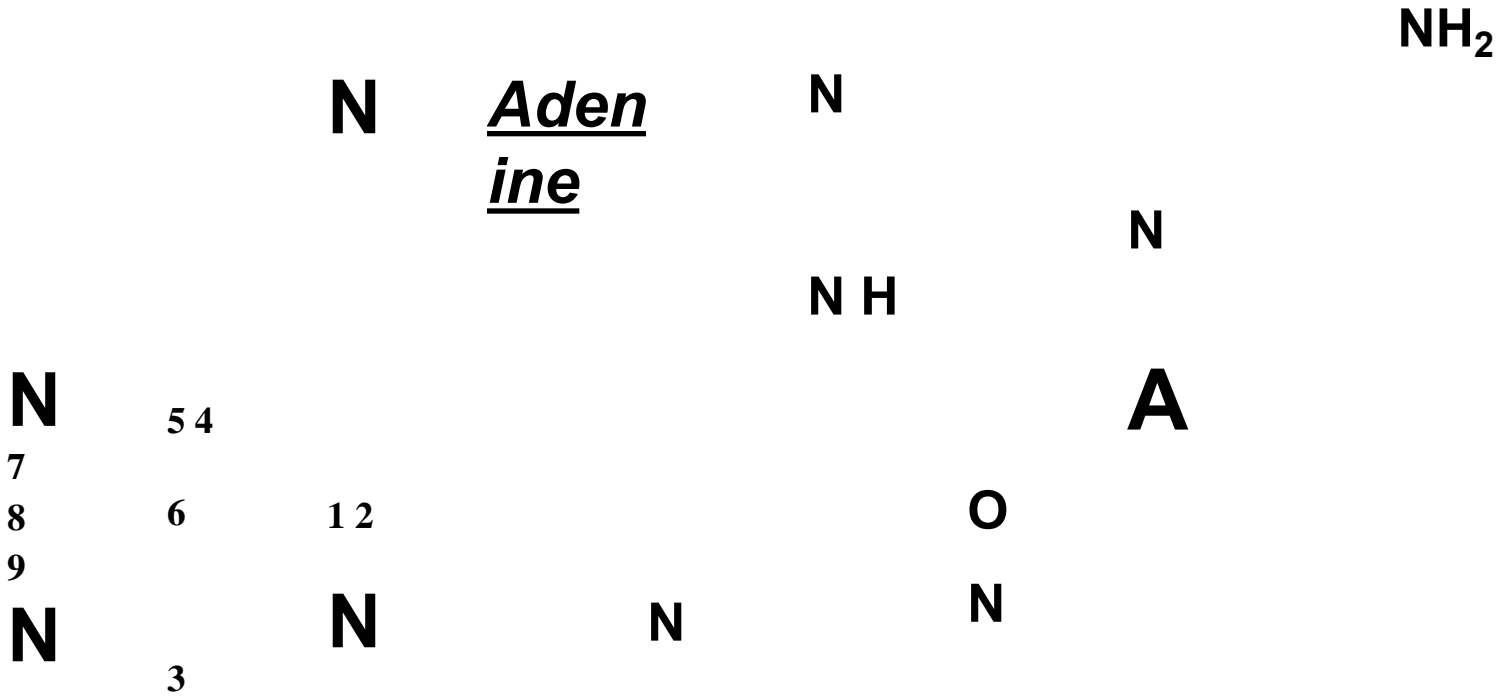
N.B. Carbons are given numberings as a prime



OH H

Nucleotide Structure

Bases - Purines



ne H

N H NH_2

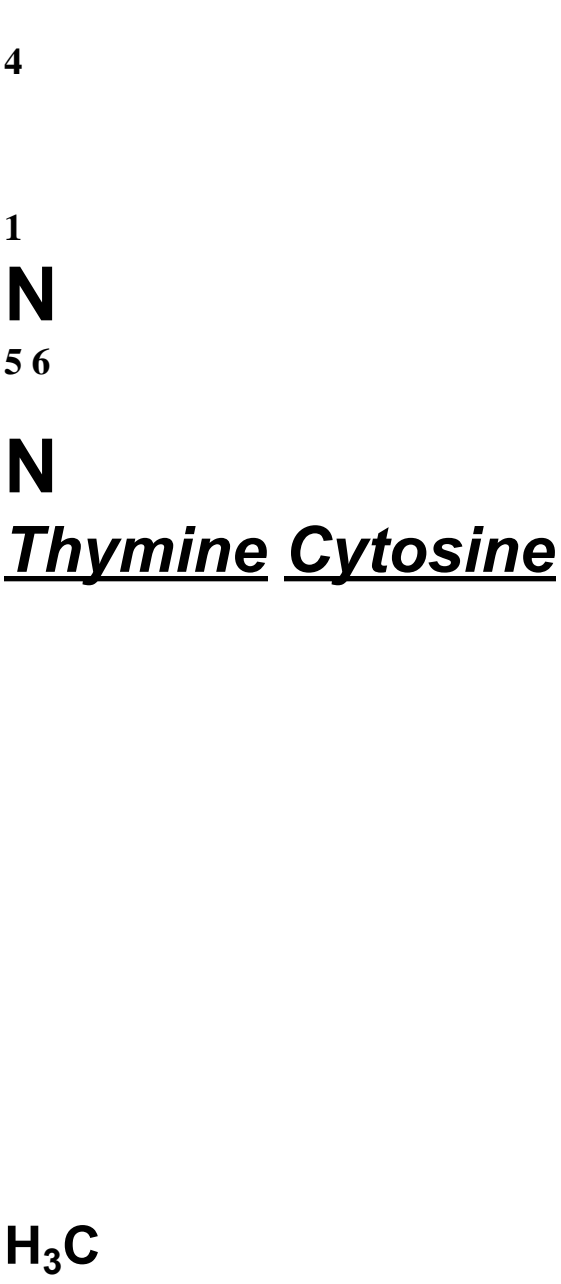
N G

Guani

Nucleotide Structure

Bases - Pyrimidines

O


4
1
N
5 6
N
Thymine Cytosine
H3C


NH2


N
H
N
NH


N
H

C
o
T
o

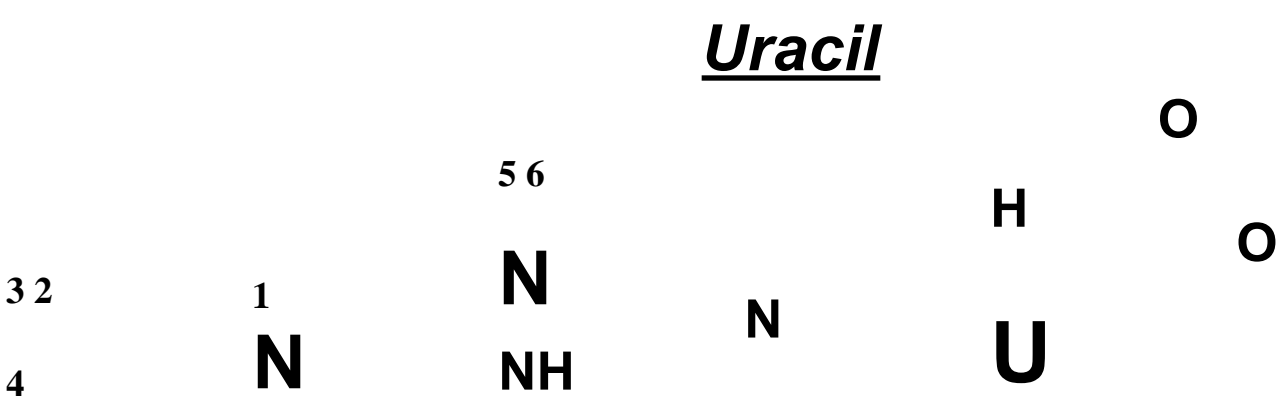
Nucleotide Structure

Bases - Pyrimidines

Thymine is found ONLY in DNA.

In RNA, thymine is replaced by uracil

Uracil and Thymine are structurally similar



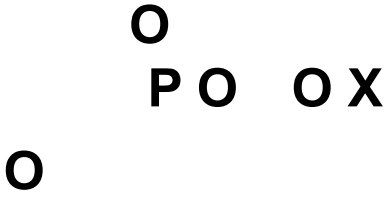
Nucleotide Structure

Phosphate Groups

Phosphate groups are what makes a nucleoside a nucleotide

Phosphate groups are essential for nucleotide polymerization

Basic structure:



Nucleotide Structure

Phosphate Groups

Number of phosphate groups determines nomenclature

Monophosphate e.g. AMP

Free = inorganic phosphate (Pi)

Diphosphate e.g. ADP

Free = Pyro phosphate (PPi)

Nucleotide Structure

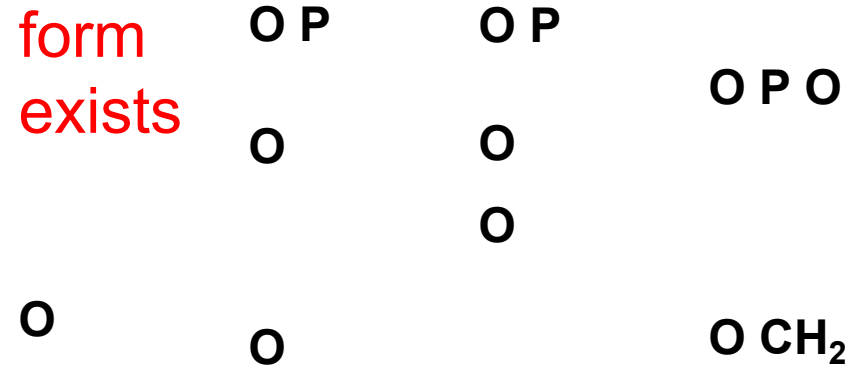
Phosphate Groups

hate
e.g. ATP

form
exists

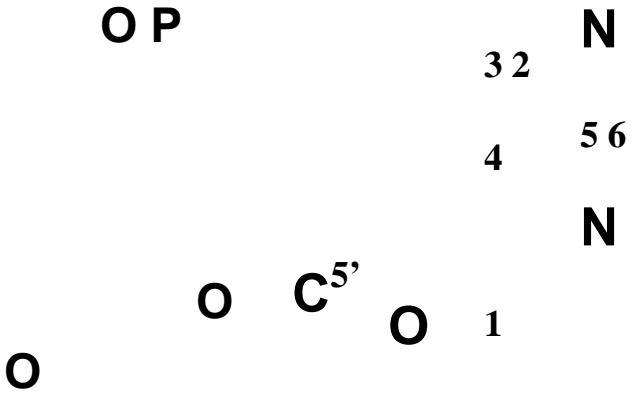
No
Free

Triphosp



Nucleotide Structure

Base-Sugar-PO_4^{2-}



OH

Monophosph
ate

O

4’ 1’

3’ 2’

Nucleic Acid Structure

Polymerization

erase

P P P

C

+

N

S

P P P

C

Phosphodiest

P P

(PPi)

N

S

P

C

S N

P P P

S

N

C

Nucleic Acid Structure

Polymerization

Nucleotide

Sugar Phosphate
“backbone”

Sugar Phosphate “backbone”

Bases

Nucleic Acid Structure

5’ 3’
TAGCAC

Polymerization

Nucleic Acid Structure

“Base Pairing”

RNA [normally] exists as a single stranded

polymer DNA exists as a double stranded polymer

DNA double strand is created by hydrogen bonds between nucleotides

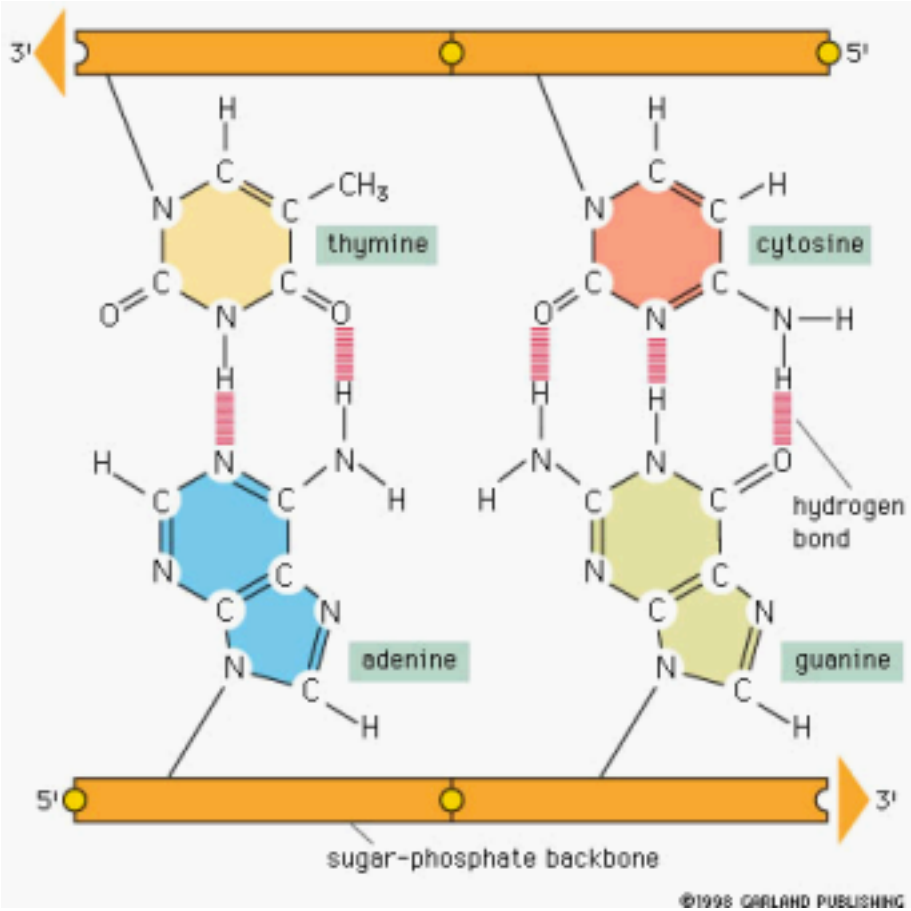
Nucleotides always bind to complementary nucleotides

H-bonds)

A T G C

(2 H-bonds) (3

Nucleic Acid Structure "Base Pairing"



Nucleic Acid Structure

"Base Pairing"

RNA is [usually] single stranded

Base pairing can occur in RNA but is usually within the same strand

Difference between RNA & DNA

RNA	DNA
RNA nucleotides contain ribose sugar	DNA contains deoxyribose
RNA has the base uracil	DNA has the base thymine
presence of a hydroxyl group at the 2' position of the ribose sugar.	Lacks of a hydroxyl group at the 2' position of the ribose sugar.
RNA is usually single-stranded	DNA is usually double stranded

Nucleic Acid Structure

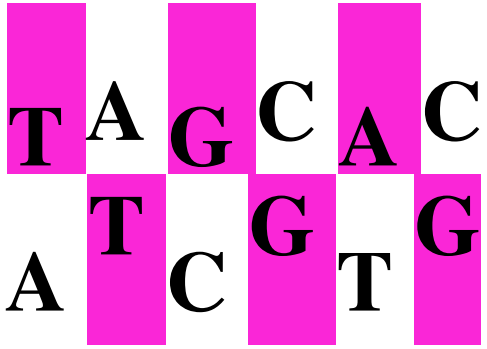
"Base Pairing"

DNA base-pairing is antiparallel

i.e. 5' - 3' (l-r) on top : 5' - 3' (r-l) on bottom

5'

3'



3’ 5’

Nucleic Acid Structure Antiparallel Base Pairing

Why antiparallel DNA base-pairing?

- Need to shield the genetic information

- Is the only conformational structure to allow double helix formation

Nucleic Acid Structure The double helix

First determined by Watson & Crick in 1953

Most energy favorable conformation for double stranded DNA to form

Shape and size is uniform for all life (i.e. DNA is identical)

Without anti-parallel base pairing this conformation could not exist

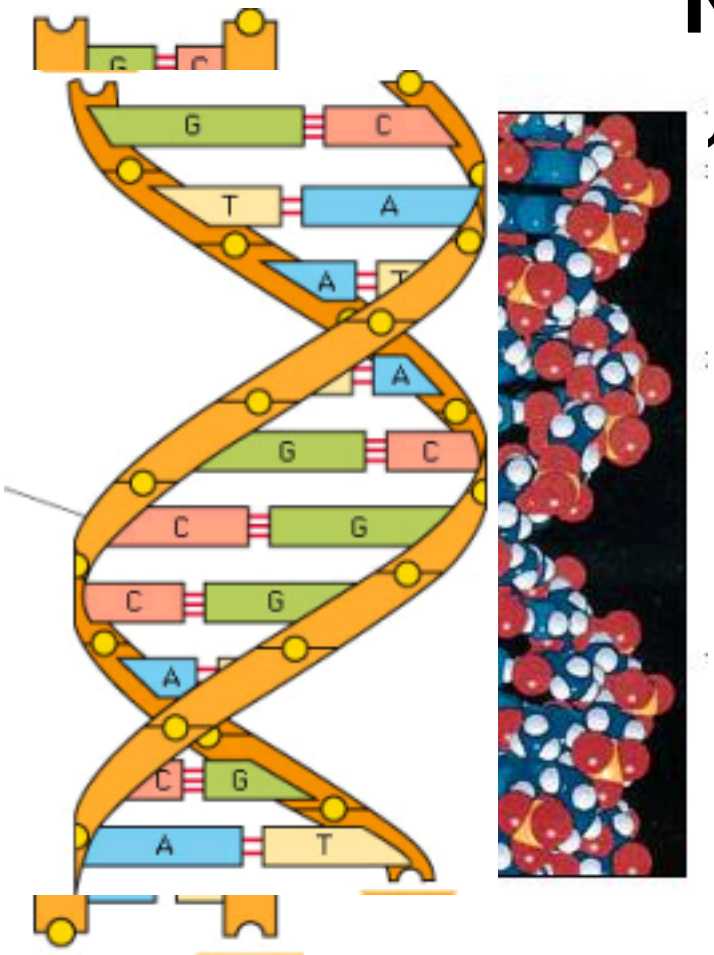
Structure consists of “major” grooves and “minor” grooves

Major grooves are critical for binding proteins that

regulate DNA function

Nucleic Acid

ıcture The double helix



Minor Groove

Major
Groove

Madenat Al elm University College
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Vitamins

Dr. Hamza Yaseen Isa
Lecture M 11 I 2

Vitamins

Definition: Vitamins are organic nutrients that are required in small quantities for a variety of biochemical functions and which,

generally, cannot be synthesized by the body and must therefore be supplied by the diet.

Properties

- Vital to life; are essential
- Organic compounds
- Individual units; not linked in chains
- Do not provide energy
- Assist with release of energy (coenzymes) •

Needed in small amounts: micro/milli grams •

Fruits and vegetables are a primary source

Nomenclature and function

- **Vitamin A: prevent night blindness**
- **Vitamin B: anti-beriberi factor •**

Vitamin C: anti-scurvy factor •

Vitamin D: anti-ricket factor

- **Vitamin E: for reproduce properly •**

Vitamin K: concerned with coagulation

Classification

Water Soluble

- **Vitamin C**
- **B Vitamins**
  - **Thiamine (B_1)**
  - **Riboflavin (B_2)**

Vitamin A • Vitamin D • Vitamin E • Vitamin K

Lipid Soluble •

- **Niacin B 3**
- **Pantothenic Acid B 5**
- **Biotin B7**
- **Pyridoxine (B_6)**
- **Folic Acid B 9**
- **Vitamin B_{12} (cyanocobalamin)**

Energy releasing

Hematopoietic

Function, Deficiency Signs & Sources

Vitamin A

Function: development healthy skin and nerve tissue. Aids in building up resistance to infection. Functions in eyesight and bone formation. ALL ANIMALS require a source of Vitamin A. It is important in the ration of pregnant females.

Deficiency signs: retarded growth in the young, the development of a peculiar condition around the eyes known as Xerophthalmia, night blindness and reproductive disorders.

Sources: whole milk, carotene, animal body oils (cod fish and tuna), legume forages and can be synthetically produced.

Vitamin D

Function: is essential for the proper utilization of

calcium and phosphorus to produce normal, healthy bones.

Deficiency signs: retarded growth, misshapen bones (rickets), lameness and osteoporosis.

Sources: Whole milk, sun-cured hays, forage crops, fish liver oils, irradiated yeast.

types：$VitD_2$（Ergocalciferol）$VitD_3$（Cholecalciferol ）

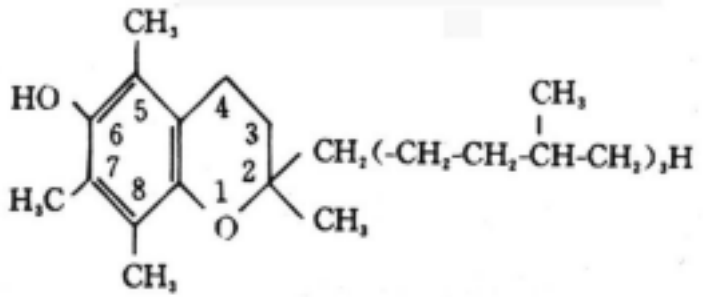
*pro-$VitD_2$：Ergosterol Pro-$VitD_3$： 7-hydro-cholesterol

Ergosterol→$VitD_2$ cholesterol→7-hydro cholesterol→$VitD_3$

*active form of $VitD_3$： 1, 25- $(OH)_2$-VitD

Vitamin E

Function: normal reproduction.



Chemical structure of α- tocopherol

Deficiency signs: poor growth, "crazy chick" disease, Muscular Dystrophy, "white muscle" disease in ruminants and swine and "stiff lamb" disease (affects the nerves and muscles).

Sources: synthetic for poultry and swine, cereal grains and wheat germ oil, green forages, protein concentrates, oil seeds (peanut and soybean oil).

Vitamin E rapidly destroyed in rancid or spoiled fats. That is why these may cause white muscle disease. Utilization of Vitamin E is dependent on adequate selenium.

Vitamin K

Function: necessary for the maintenance of

normal blood coagulation.

Deficiency signs: blood loses its power to clot or the time needed for clotting is longer and serious hemorrhages can result from slight wounds or bruises.

Sources: green leafy forages, fish meal, liver, soybeans, rumen and intestinal synthesis, and the synthetic compounds.

Water-soluble vitamins B+C

Common features:

1.Water soluble

2.Easy to be discharged through urine.

Rarely accumulated to the toxic concentrations.

3.Their storage is limited.

Must be provided regularly.

Vitamin B_{12} is the only water-soluble vitamin that can be stored in the liver for many years.

B Vitamins

1. **Thiamin (B_1)**
2. **Riboflavin (B_2)**
3. **Niacin B3**
4. **Pantothenic Acid B5**
5. **Pyridoxine Vitamin B_6**
6. **Biotin Vitamin B7**
7. **Folic Acid B9**
8. **Cobalamin Vitamin B_{12}**

- **Indispensable for metabolism.**
- **B vitamins help the body to produce**

energy.

• B complex vitamin are necessary for healthy skin, hair, eyes and liver, also help the nervous system function properly.

B-complex VITAMINS

- **B1** – Thiamine
- **B2** – Riboflavin
- **B3** – Niacin
- **B6** – Pyridoxine
- **B12** – Cobalamin
- **B9** - Folate

Share functions, often work together

Cofactors in metabolism

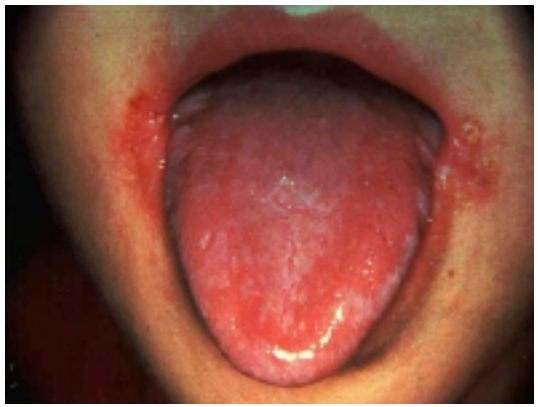
Involved in production & use of energy

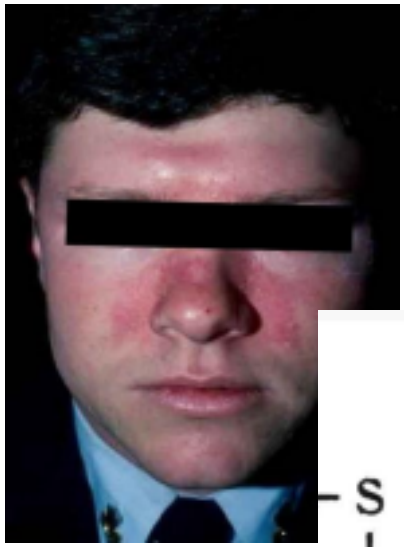
Folate & B12 involved in cell division

Deficiency

Symptoms associated with riboflavin deficiency include

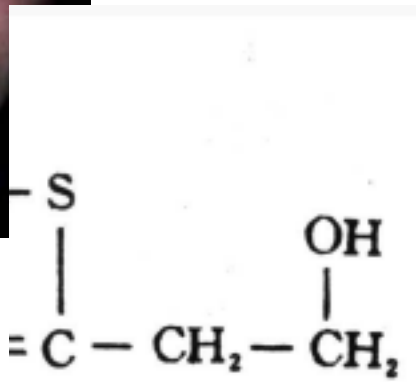
- Glossitis
- Seborrhea
- Angular stomatitis
- Cheilosis
- Scrotitis
- Photophobia





- uncommon

1. Vitamin B_1 (Thiamine)

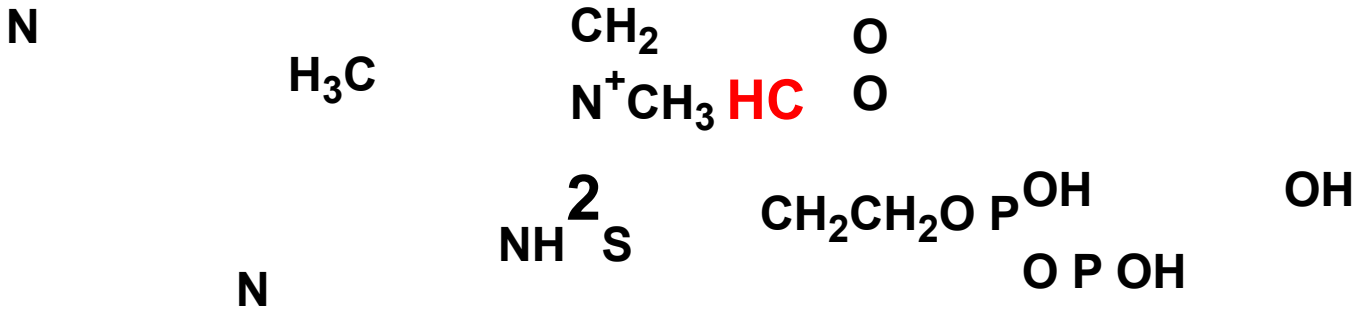


Thiazole ring

Pyrimidine ring

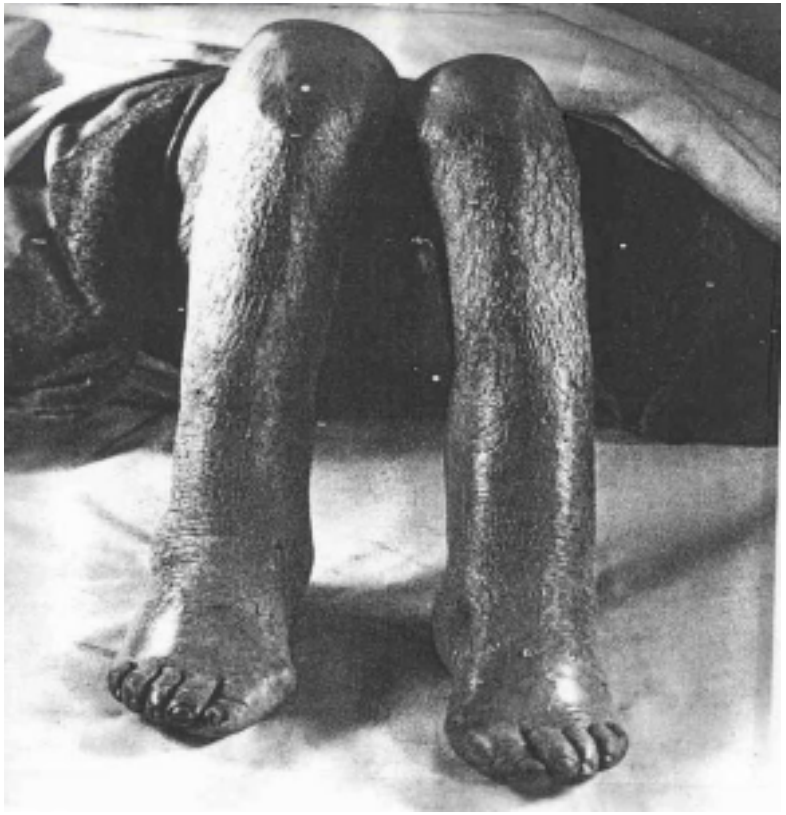
Thiamine: named as the "thio vitamine " ("sulfur containin g vitamin")

Active form :Thiamine pyrophosphate (TPP or cocarboxylase)



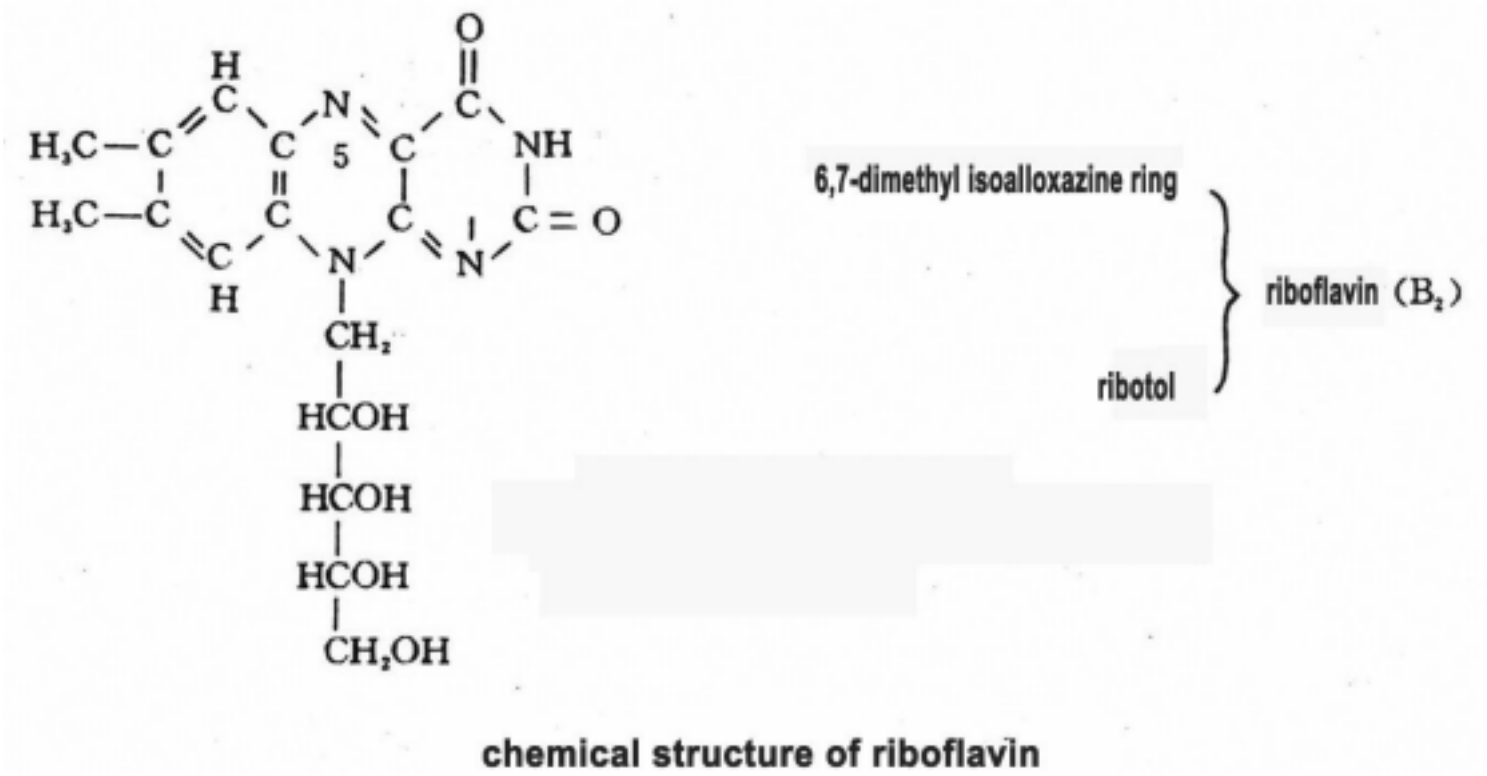
Reactive carbon atom

Beriberi



2. Vitamin B_2 (riboflavin)

• Vitamin B2, also commonly called riboflavin, gets its name from its color. The root of this word is the Latin word "flavus" meaning "yellow."



chemical structure of riboflavin

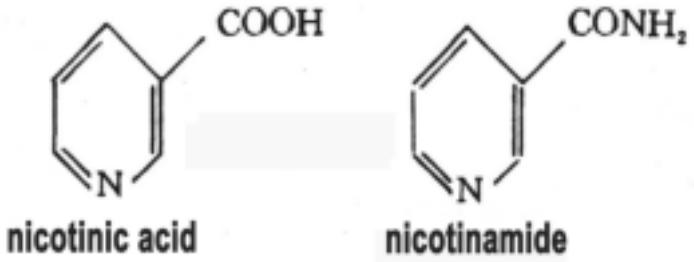
3. Vitamin B3 (niacin, pellagra preventive factor)

Pyridine derivative

* **Vitamin PP**

nicotinic acid

nicotinamide



Chemical structure of nicotinic acid and nicotinamide

- **The name 'niacin' was derived from "nicotinic acid + vitamin"**

* **Active form (coenzyme)**

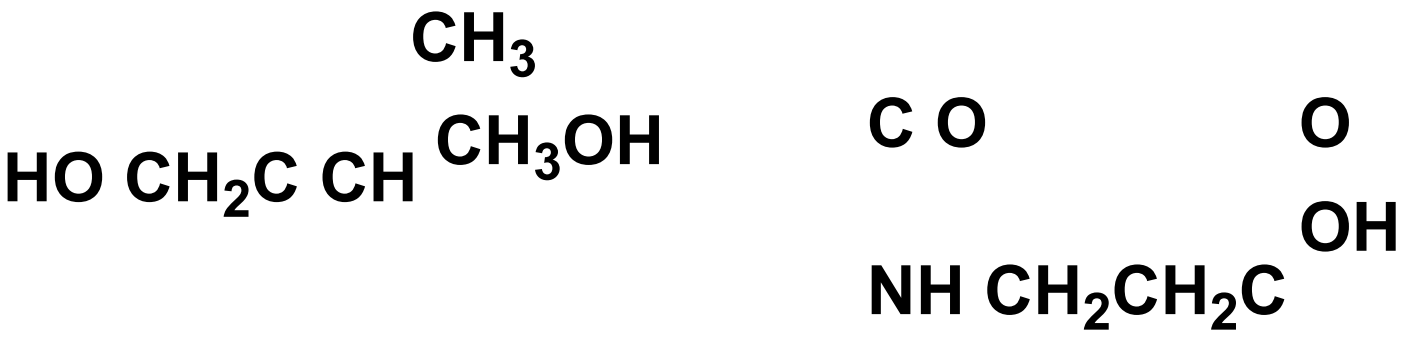
Nicotinamide adenine dinucleotide (NAD^+)

Nicotinamide adenine dinucleotide phosphate ($NADP^+$)

4. Pantothenic acid B5

■ **Its name is derived from the Greek "pantothen" meaning "everywhere". ■ It is found in numerous foods and also is synthesized by intestinal bacteria.**

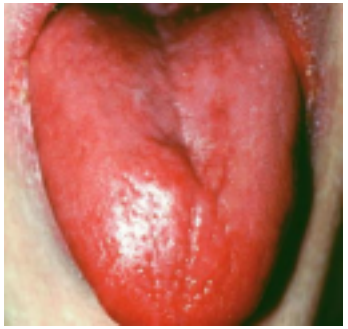
pantoic acid β-alanine

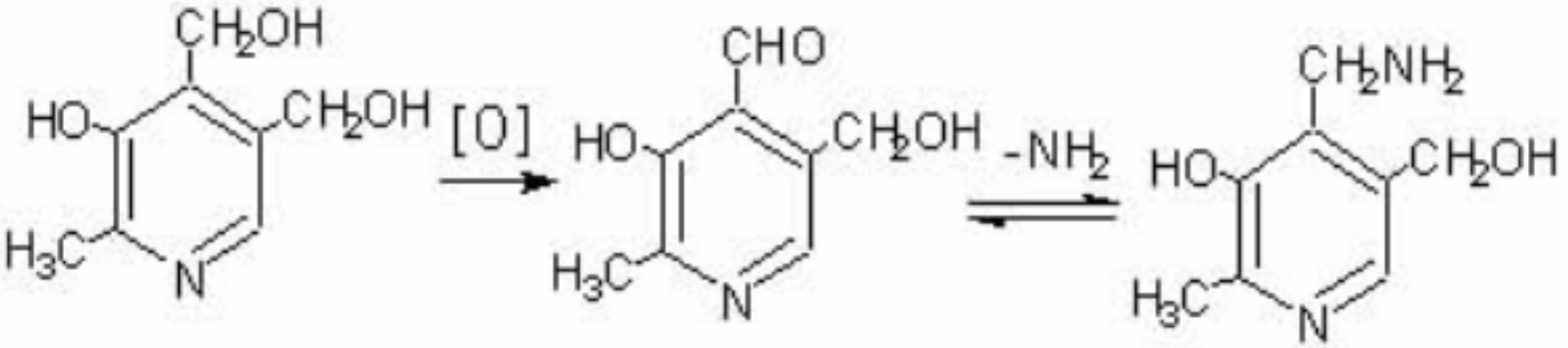


5. Vitamin B_6 (pyridine derivatives)

- **Three forms of vitamin B_6:**

- **Pyridoxine, pyridoxal, pyridoxamine**





pyridoxine **pyridoxal** **pyridoxamine**

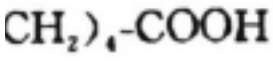
• antituberculosis medication) can induce VitB_6 deficiency.

6. Biotin VitaminB7

• It is necessary for cell growth, the production of fatty acids, and the metabolism of fats and amino acids.

Food Sources ■

ead in food



Imidazole ring

Thiophene ring

Biotin - Food Sources

- Cheese, egg yolk, liver, peanut butter, soybeans, fish

- Synthesized by GI (gastrointestinal) bacteria.

7. Folic acid (or folate) B9

• Folic acid or folate derive their names from the Latin word folium (which means "leaf").

• Obtained from yeasts and leafy vegetables as well as animal liver.

- Major Functions
  - New cell synthesis - GI tract, RBC

- Protein synthesis
- DNA/RNA synthesis
- Increased needs w/ pregnancy

- **It is especially important during periods of rapid cell division and growth.**

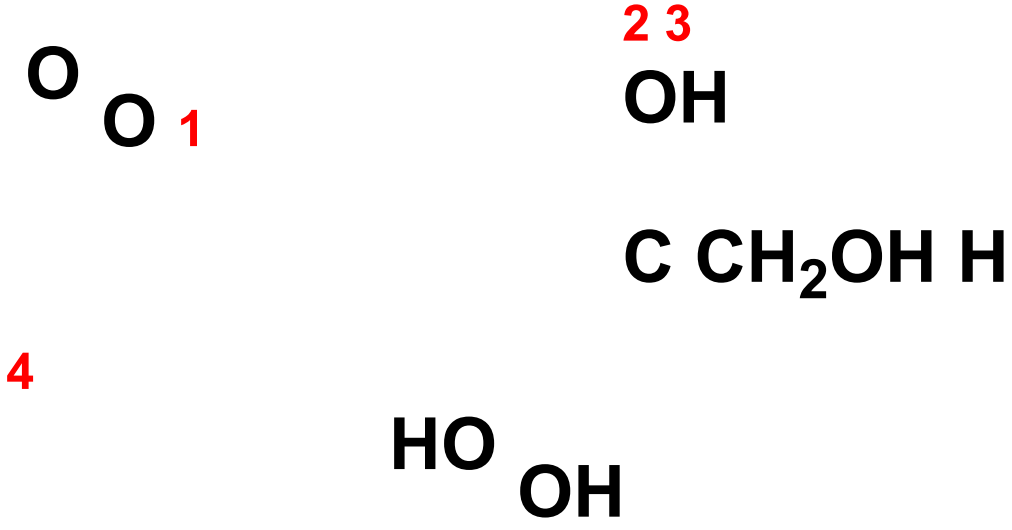
8. Vitamin B_{12}

- **Vitamin B12 is a unique vitamin, synthesized by only microorganisms and not by animals and plants.**
- **Food Sources:**
- **It is naturally found in meat (especially liver and shellfish), milk and eggs. Animals, in turn, must obtain it directly**

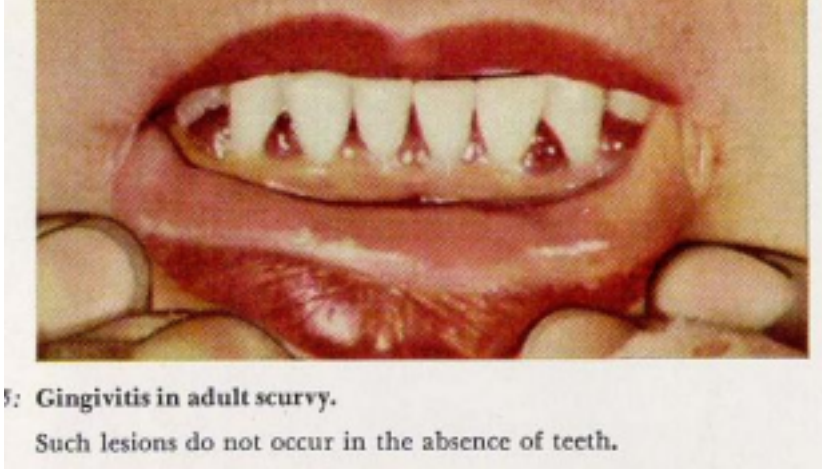
or indirectly from bacteria.

Vitamin C（ascorbic acid）

- **Water soluble**
- **sour taste (acid)**
- **Six-carbon polyhydroxy compound**
- **Strong antioxidant**

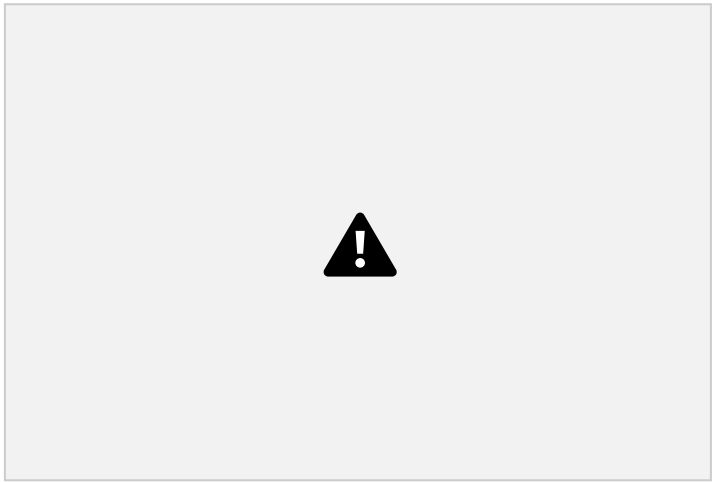


Vitamin C deficiency



5: Gingivitis in adult scurvy.
Such lesions do not occur in the absence of teeth.

- **Scurvy**
  - **Scaly, dry skin**
  - **Edema**
  - **Bleeding gums**
  - **Poor wound healing**
  - **Infection**



  - **Can be destroyed by heat and oxygen**

Madenet Alelm University College
Department of Medical Physics
2nd Year Medical Chemistry 2021 – 2022

Introduction to Pharmacology

Dr. Hamza Yaseen Isa
Lecture M 12 I 2

Introduction

- Pharmacology – Science of drugs
- Medication mistakes can injure or even cause death of a patient.
- This lecture will provide an overview of the role of drugs in ambulatory medical facilities

You will need to have a good working knowledge of the foundations of pharmacology.

Medical Assistant's Role in Pharmacology

- You will need to:

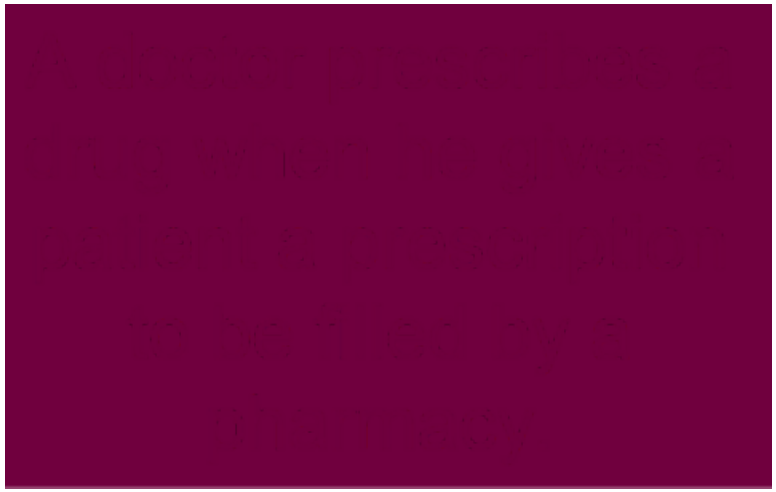
- **You will need to:**
  - Have basic knowledge of medications
  - Be attentive to ensure that the physician is aware of all the medications a patient is taking.
  - Ask patients about use of alcohol, vitamins, herbal

medications, or
recreational drugs

Drugs and Pharmacology

- Drug
- Pharmacologist

❑ **Drug** : chemical compound used to prevent, diagnose or treat a disease or other abnormal condition



❑

Pharmacologist : specialist in pharmacology

You are responsible to administer a drug by giving it directly by injection, by mouth, or by any other route to introduce the drug into a patient's body.[4]

Classifications of Medications

□ Anticoagulants □ Anticonvulsants □ Ant diabetics □ Anti dysrhythmics □ Anti hypertensive's □ Anti infective □ Antipsychotics □ Cardiac Glycosides □ Corticosteroids □ Drotrecogin

- GI Agents
- IV fluids
- Narcotics

• Parenteral Nutrition • Platelet Aggregation Inhibitors
• Respiratory Medications • Sedatives
• Vasoactive agents

Sources of Drugs

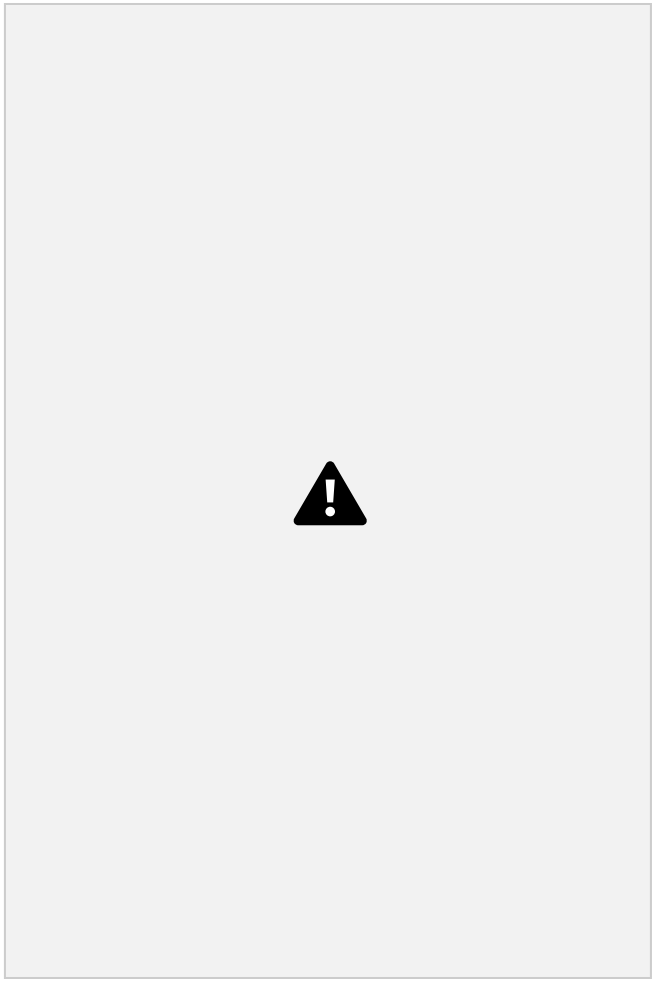
- Many drugs originate as natural products

- Many drugs originate as natural products

  a. Plants

  b. Animals

  c. Minerals



d. Bacteria or fungi **Name this source of drug and the drug it is used to make.**

Categories of Pharmacology

1. Pharmacognosy – study of characteristics of natural drugs and their sources

2. Pharmacodynamics – study of what drugs do to the body

3. Pharmacokinetics –

what the body does to drugs **4. Pharmacotherapeutics** – study of how drugs are used to treat disease

5. Toxicology – study of poisonous effects of drug

Pharmacodynamics

- Study of what a drug does to the body

- Includes interaction between the drug and

target cells or tissues and the body's response to that interaction

Pharmacokinetics

- The study of what the body does to a drug includes:

(i) - Absorbs – converts a drug into

a form the body can use (ii) - Metabolizes – drug molecules are transformed into simpler products

(iii) - Distributes – transporting a drug from its site of administration to its site of action (iv)Excretes –manner in which a drug is eliminated from the body

Pharmacotherapeutic

S

1. Drug

Names: 

(i) - Generic – official name

(ii) - International nonproprietary name (iii) - Chemical name

(iv) - Trade name – brand or proprietary name

You will probably use only generic or trade names.

Apply Your Knowledge

Which of the following is a generic drug name?

- Biocef
- Keflex
- Cephalexin

Cephalexin

Pharmacotherapeutics

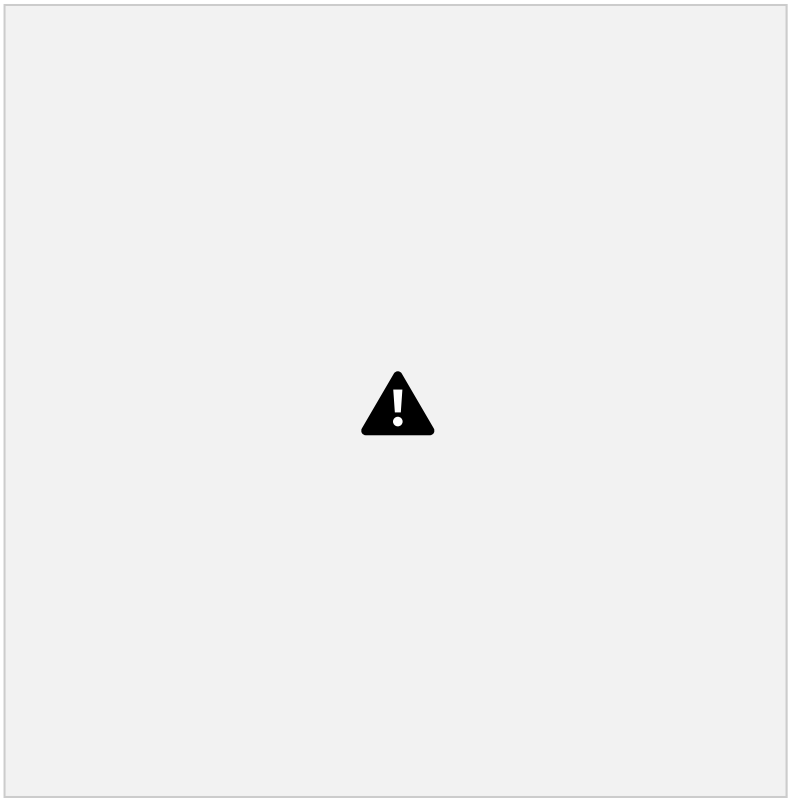
: 2. Drug Categories

⚠ **Categorized by:** ⚠

(i) -Their action on the body

(ii) - General therapeutic effect

(iii) - Body system affected



Example:

Antacid – neutralizes stomach acids

- **Tums**
- **Basaljel**

Pharmacotherapeutics:

3. Indications and Labeling

-

Indications – used to

identify purpose or reason for using a drug.

(i) - approved indications which must be part of labeling

(ii) - Multiple uses of a drug are possible.

(iii) - When a drug is used for multiple indications one or more may not be in its labeling.

- Example: Benadryl can be used for antihistamine or temporary sedative.

Pharmacotherapeutics :

4. Safety and Efficacy

- Safety is how many and what kinds of adverse effects are associated with the drug.

  (i) - An adverse reaction may require immediate action.

  (ii) - Be alert to complaints from patient after starting new drug.

Pharmacotherapeutics

: 5. Kinds of Therapy

(i) - Acute – improve life threatening or serious condition

(ii) - Empiric – give until other tests prove another therapy is appropriate

(iii) - Maintenance – maintain a condition

(iv) - Palliative – reduce the severity of a condition or pain

(v) -

Prophylactic – prevent a disease or condition

(vi) - Replacement – provide chemicals missing by the patient.

Apply Your Knowledge

-Answer What is

Pharmacokinetics?

The study of what the body does to the drug.

6. Toxicology

Study of poisonous effect or toxicity of drugs

- **Toxic effects includes: (i) - Adverse effect on a fetus or infant**

  (ii) - Adverse reactions reported in clinical trials (iii) - Adverse effect in pediatric or elderly patients

Controlled Substances

(i) - A drug that is categorized as potentially dangerous and addictive (ii) - The greater the potential the more severe limitations on prescribing it

Controlled Substances:

1. Schedules

Schedule	Abuse
I	High
II	High
III	Lower than II
IV	Lower than III

Example

I Heroin II Codeine III Butabarbital

IV Chloral hydrate

V Lower than IV Antidiarrheals

Controlled Substances:

2. Drug Security

(i) - Store controlled drugs in a locked cabinet or safe.

(ii) - Double lock opioids (االفيون مشتقات)

Vaccines

❑ Special preparations made from microorganisms ❑ Administered to a person to produce reduced sensitivity to or increased immunity to an infectious disease

Antibody Formation

1. Antigen enters body
2. White cells produce antibodies
3. Combine with antigens to neutralize them
4. This arrests or prevents reaction or disease
5. Vaccines stimulate antibody formation and reduce symptoms if patient is exposed to disease

Patient Education About Over The Counter (OTC) Drugs

- You need to give your attention to all the drugs a patient is taking whether prescription or OTC
- Caution patient not to

treat themselves with OTC drugs

- Inform patient that many OTC medications contain more than one active ingredient.
- Tell the patient that interactions can occur when a person takes more than one OTC at a time or takes one with prescription drugs

Madenet Alelm University College
Department of Medical Physics
2nd Year Medical physics I 2021 – 2022

CHEMISTRY OF BIOMOLECULES

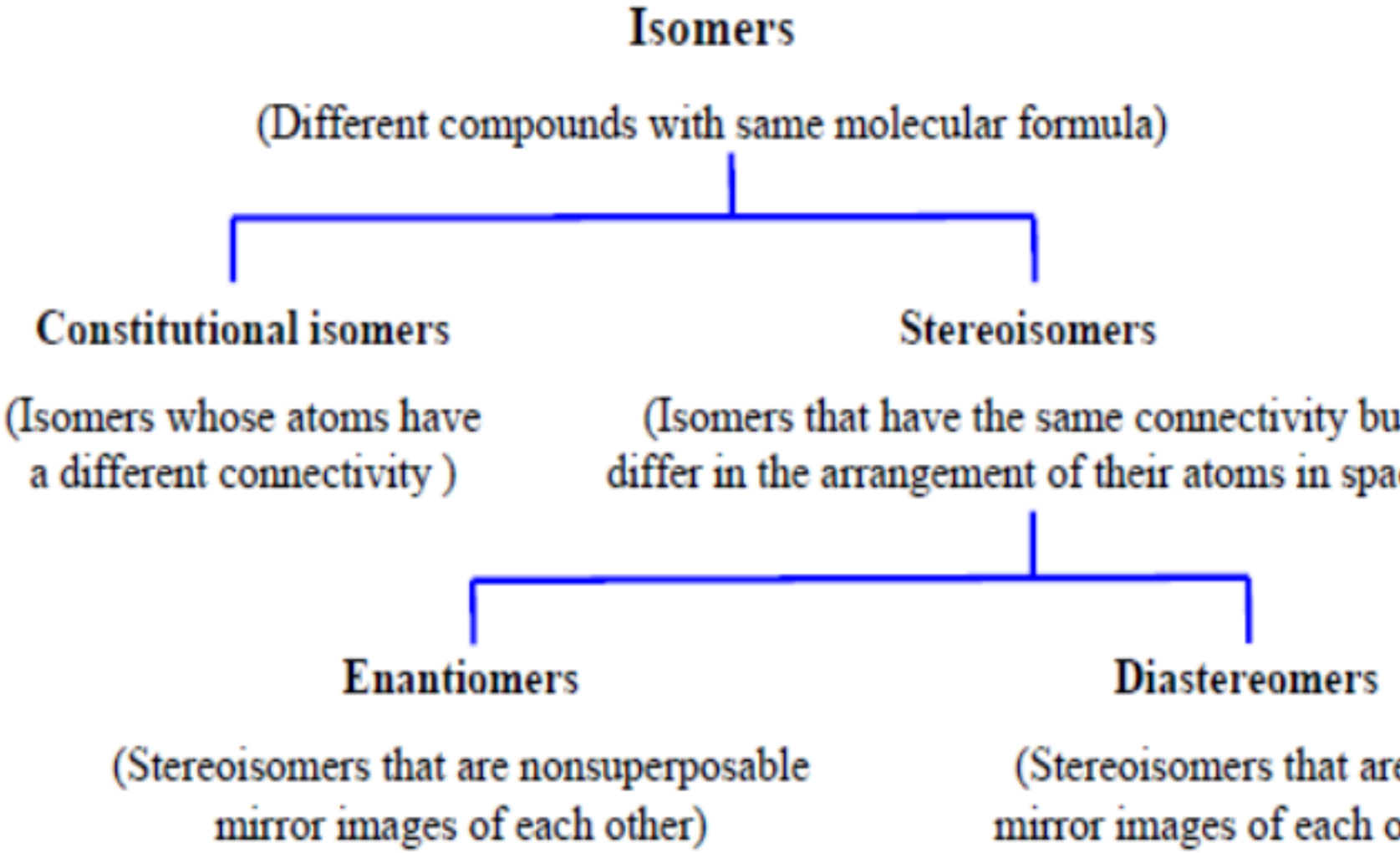
Dr. Hamza Yaseen Isa
Lecture M 4 I 1

Stereochemistry

• Some objects are not the same as their mirror images (technically, they have no plane of symmetry) – A right-hand glove is different than a left-hand glove – The

property is commonly called “handedness” • Organic molecules (including many drugs) **have handedness that results from substitution patterns on *sp*^{3} hybridized carbon**

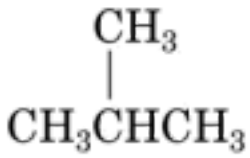
SUBDIVISION OF ISOMERS



Constitutional Isomers

- Different order of connections gives different carbon backbone and/or different functional groups

Different carbon skeletons



and

$CH_3CH_2CH_2CH_3$

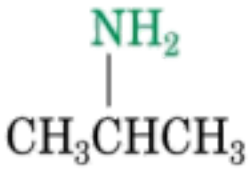
Isobutane **Butane**

Different functional groups

CH_3CH_2OH and CH_3OCH_3

Ethyl alcohol **Dimethyl ether**

Different position of functional groups



and

$CH_3CH_2CH_2NH_2$

Isopropylamine **Propylamine**

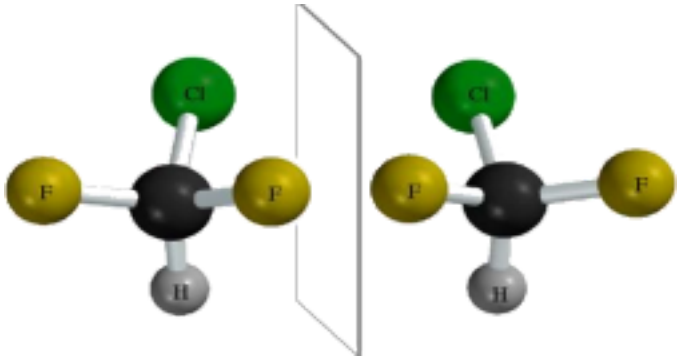
Stereoisomers

1. A **chiral** molecule is one that is *not identical with its mirror image*.

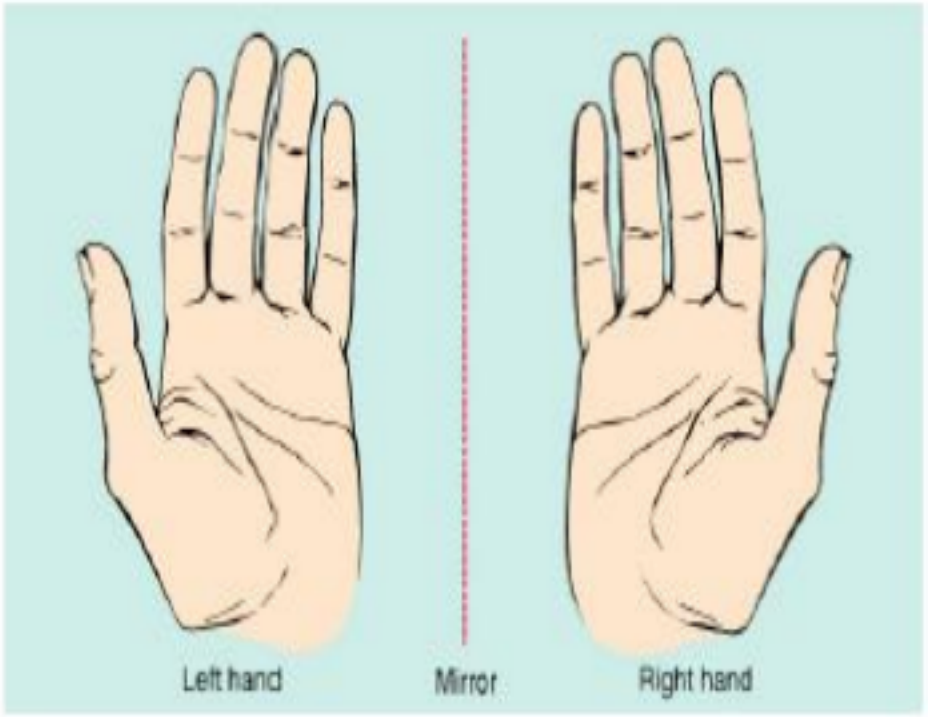
2. Objects (and molecules) that *are* superposable on their mirror images are *achiral*.

Enantiomers and the Tetrahedral Carbon

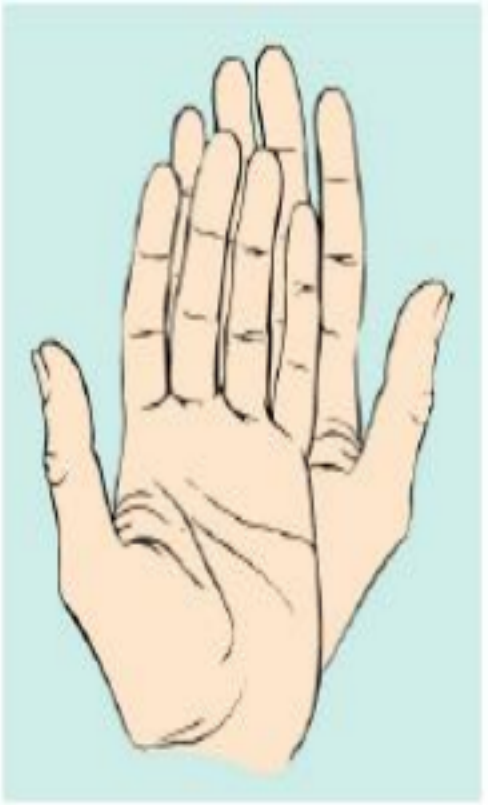
- **Enantiomers** are molecules that are not the same as their mirror image
- They are the "same" if the positions of the atoms can coincide on a one-to-one basis (we test if they are *superimposable*)
- This is illustrated by enantiomers of



bromochlorofluoromethane



The mirror image of a left hand is aright hand.

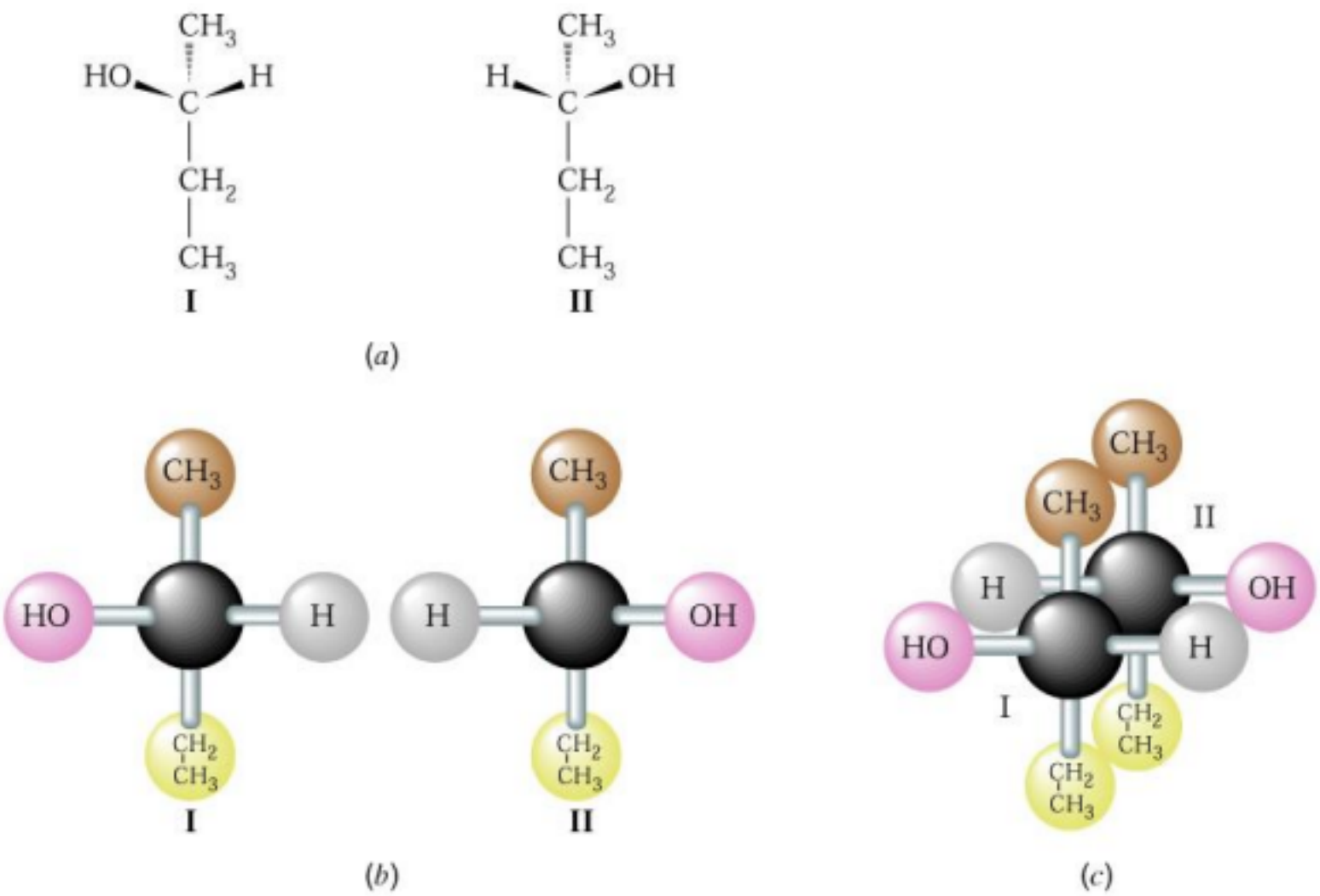


Left and right hands are not superposable

Chirality

- If an object has a plane of symmetry it is necessarily the same as its mirror image

- The lack of a plane of symmetry is called "handedness", **chirality**
- Hands, gloves are prime examples of chiral object
  - They have a "left" and a "right" version

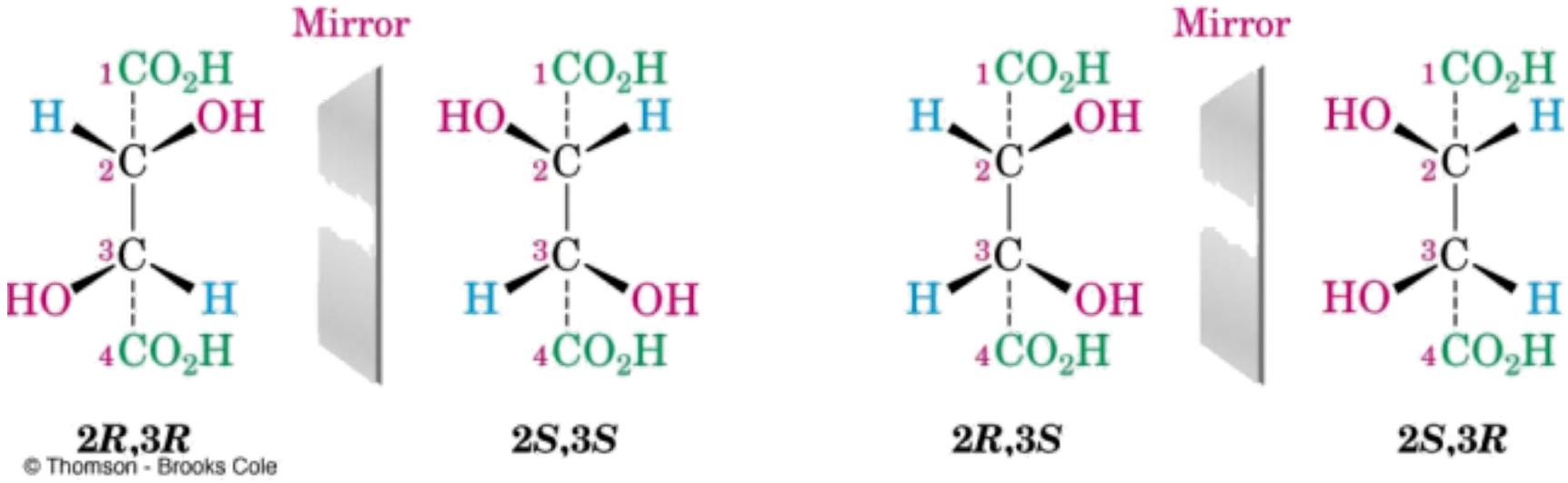


(a)

Three-dimensional drawings of the 2-butanol enantiomers I and II. (b) Models of the 2-butanol enantiomers. (c) An unsuccessful attempt to superpose models of I and II.

Meso Compounds

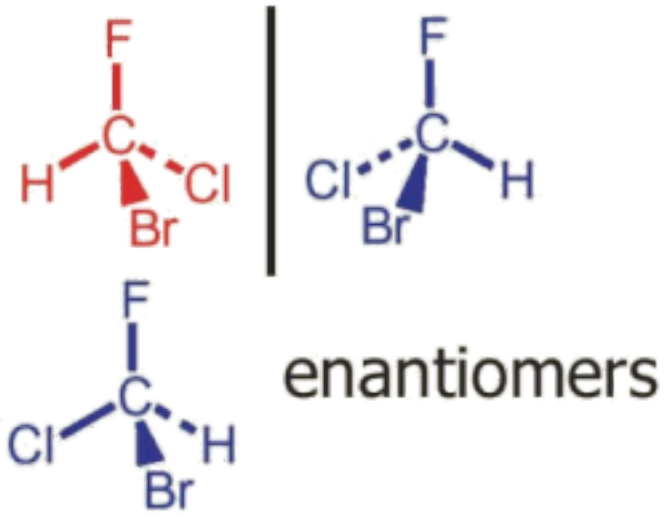
- **Tartaric acid has two chiral carbons and two diastereomeric forms**
- **One form is chiral and the other is achiral, but both have two chiral carbons**
- **An achiral compound with chiral carbons is called a *meso* compound – it has a plane of symmetry**
- **The two structures on the right in the figure are identical so the compound (*2R, 3S)* is achiral**

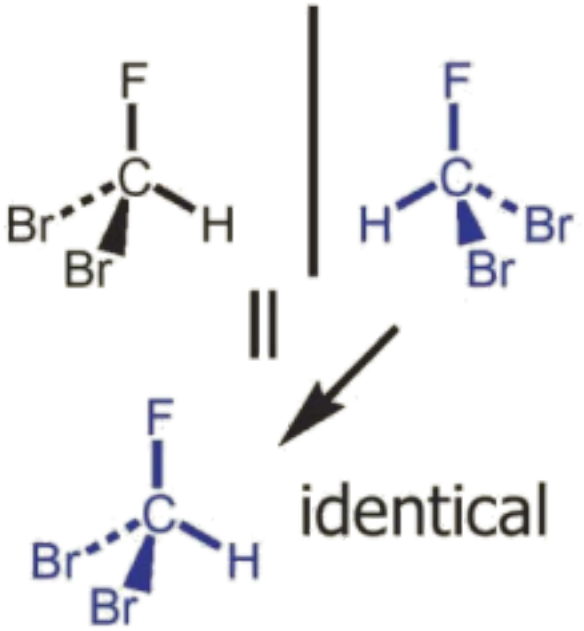


Examples of Enantiomers

- Molecules that have one carbon with 4 (count-em 4) different

substituents have a nonsuperimposable mirror image – enantiomer

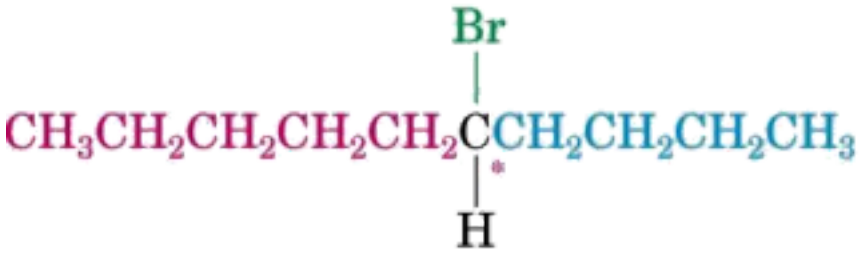




Chiral Carbons

• A point in a molecule where four different groups (or atoms) are attached to carbon is called the **chiral carbon** • There are two nonsuperimposable ways that 4 different groups (or atoms) can be attached to one carbon atom – If two groups are

the same, then there is only one way • A chiral molecule usually has at least one chiral carbon



5-Bromodecane (chiral)

Substituents on carbon 5
—H
—Br
—$CH_2CH_2CH_2CH_3$ (butyl)
—$CH_2CH_2CH_2CH_2CH_3$ (pentyl)

Optical Activity

- Light restricted to pass through a plane is *plane polarized*
- Plane-polarized light that passes through solutions of

achiral compounds remains in that plane

- Solutions of chiral compounds rotate plane-polarized light and the molecules are said to be *optically active*
- Phenomenon discovered by Biot in the early 19th century

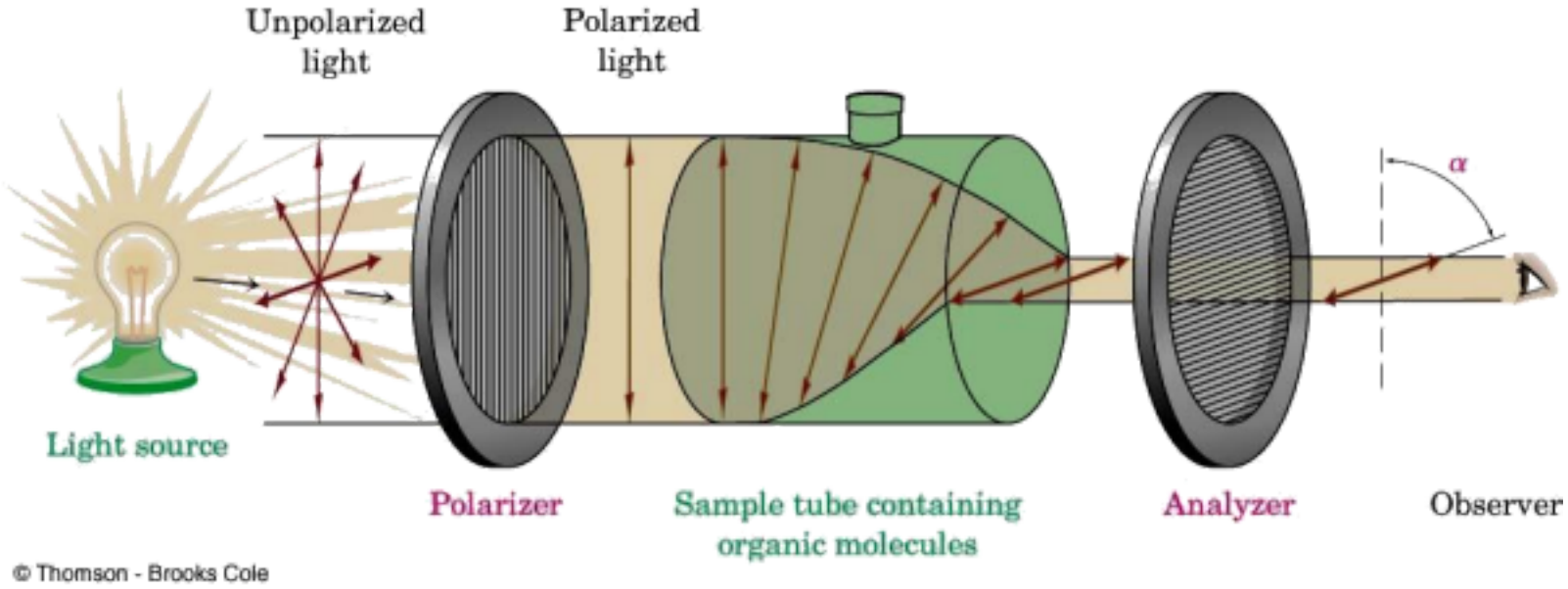
Optical Activity

- Light passes through a plane polarizer • Plane polarized light is rotated in solutions of optically active compounds
- Measured with polarimeter
- Rotation, in degrees, is [α]

- Clockwise rotation is called **dextrorotatory**
- Anti-clockwise is **levorotatory**

Measurement of Optical Rotation

- A *polarimeter* measures the rotation of plane-polarized that has passed through a solution
- The source passes through a *polarizer* and then is detected at a second polarizer
- The angle between the entrance and exit planes is the optical rotation.



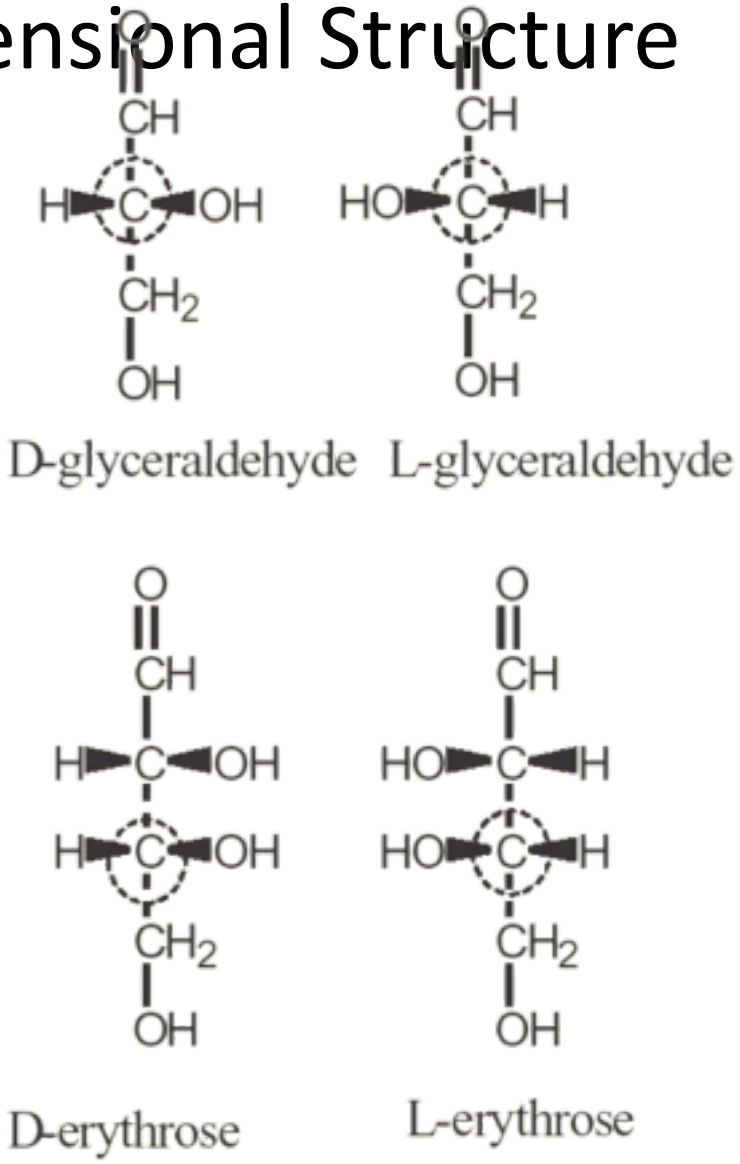
Specific Rotation

- To have a basis for comparison, define **specific rotation, $[\alpha]_D$** for an optically active compound

- $[\alpha]_D$ = observed rotation/(pathlength x concentration)
  = $\alpha/(l \times C)$ = *degrees/(dm x g/mL)*

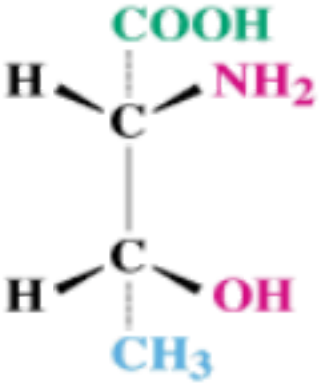
Relative 3-Dimensional Structure

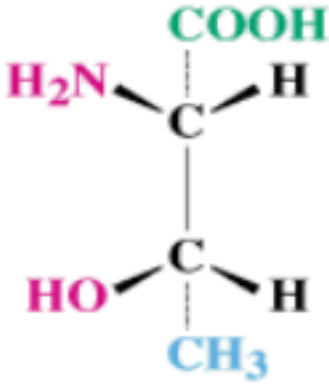
- is the mirror image of L erythrose
- This does not apply in general The original method
  was a correlation system, classifying related molecules into “families” focused on carbohydrates
  - Correlate to D- and L glyceraldehyde
  - D-erythrose



Diastereomers

- Molecules with more than one chiral carbon have mirror image stereoisomers that are enantiomers





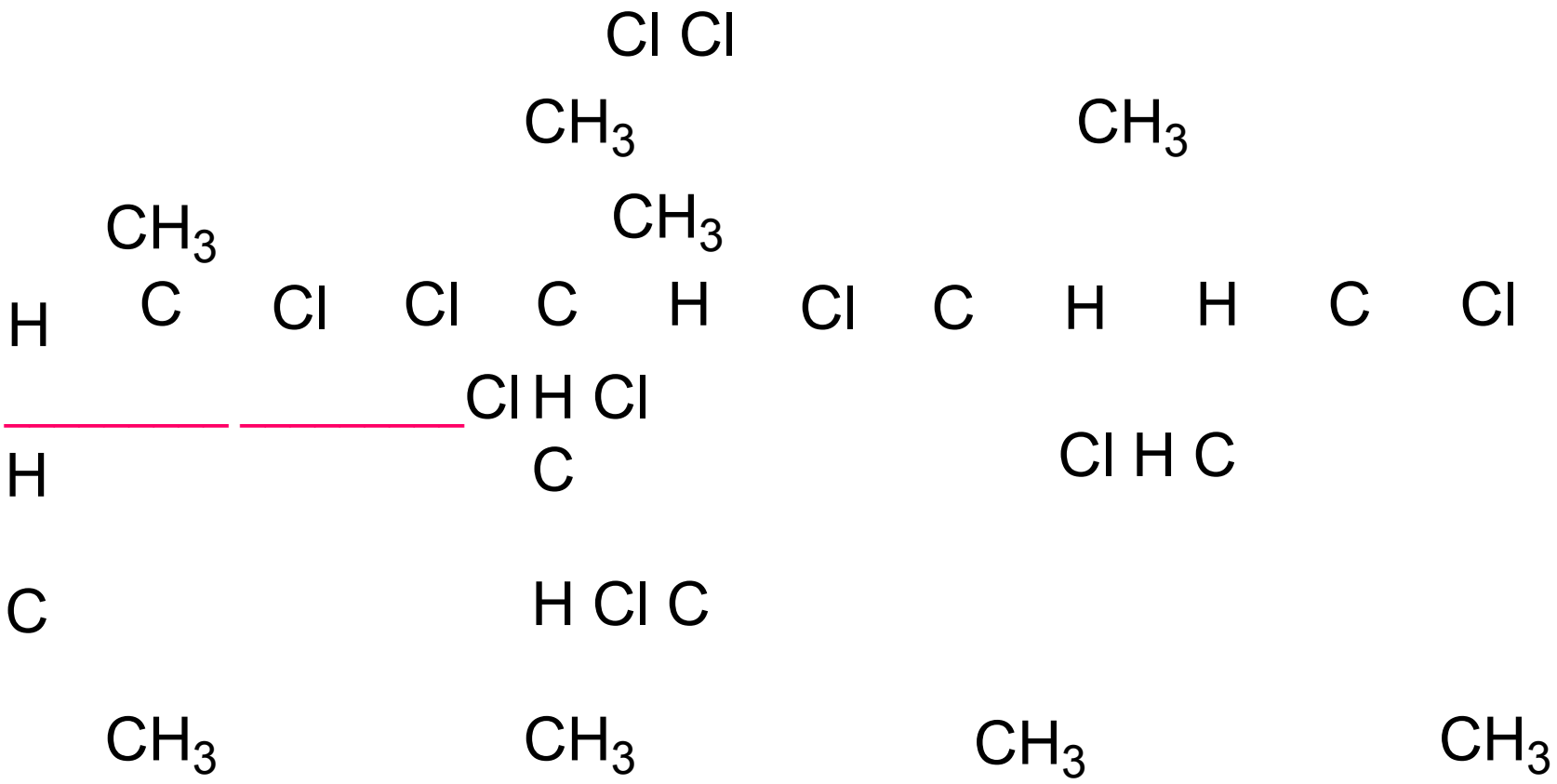
- In addition they can have stereoisomeric forms that are not mirror images, called **diastereomers**

2R,3R
2S,3S

2R,3S
2S,3R

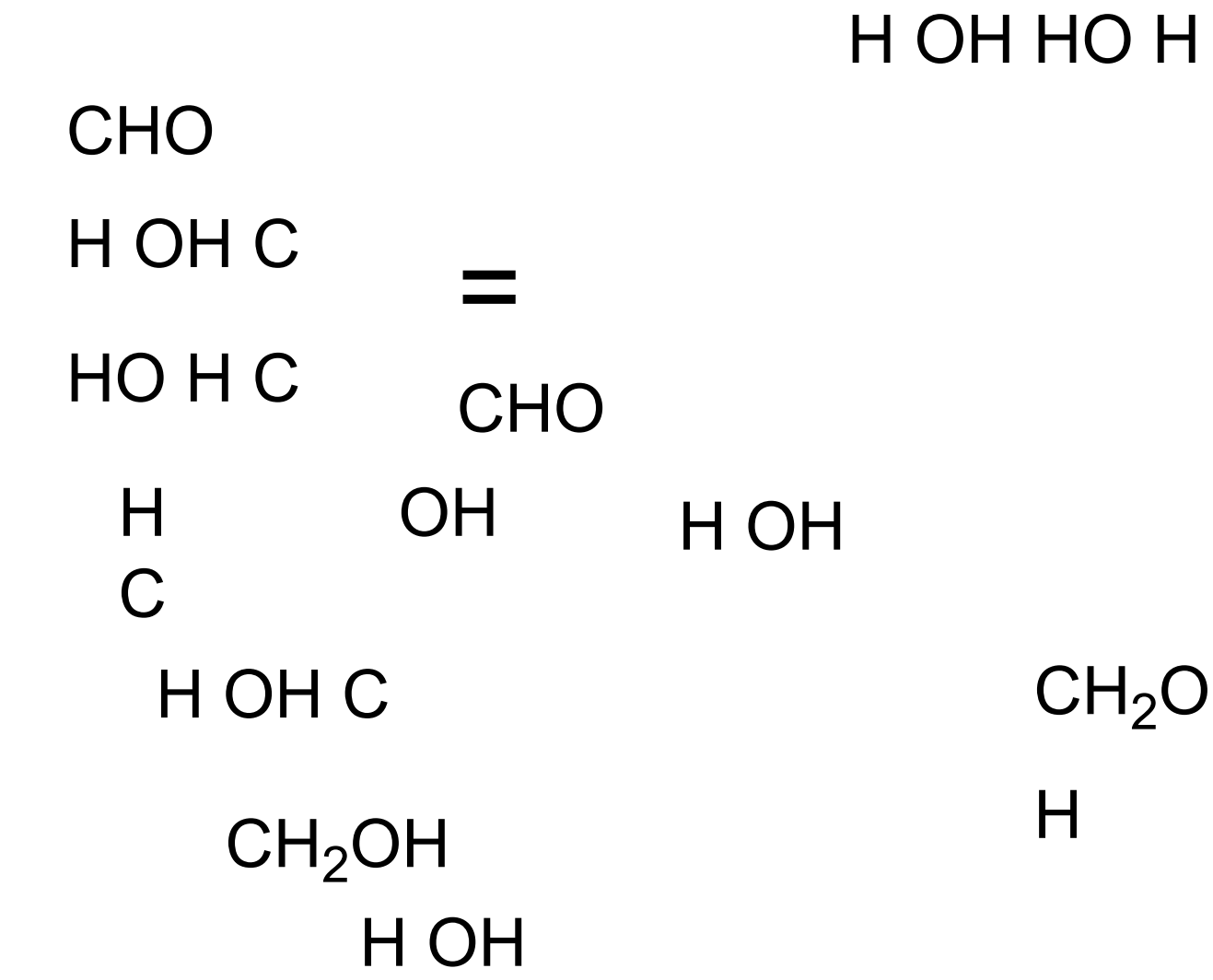
Stereoisomers of

2,3-Dichlorobutane $CH_3CHCHCH_3$



Meso Compound Enantiomers

Fisher Projections



Vertical – Bonds are going away from

you Horizontal – Bond are coming toward

you

Water in Biochemistry

Properties of water

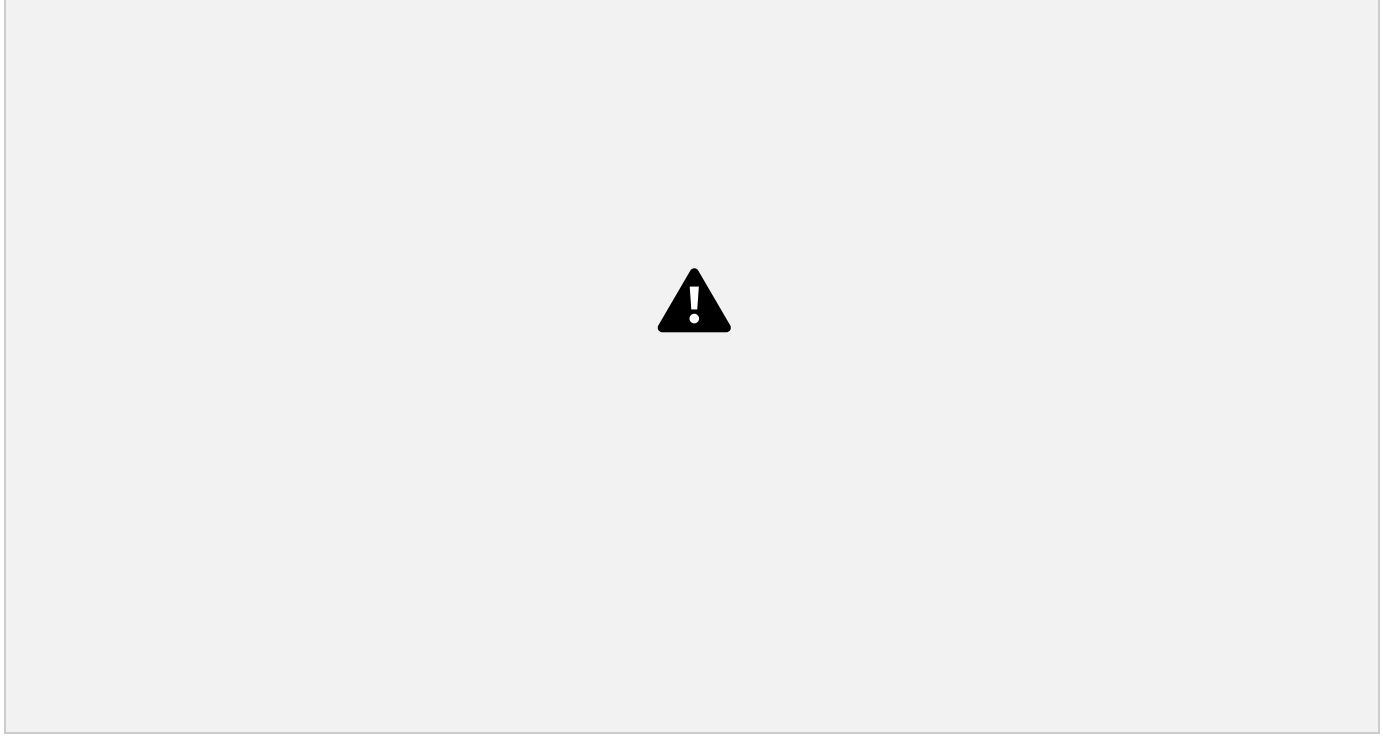
- Very polar

$2\delta^{\ominus}$

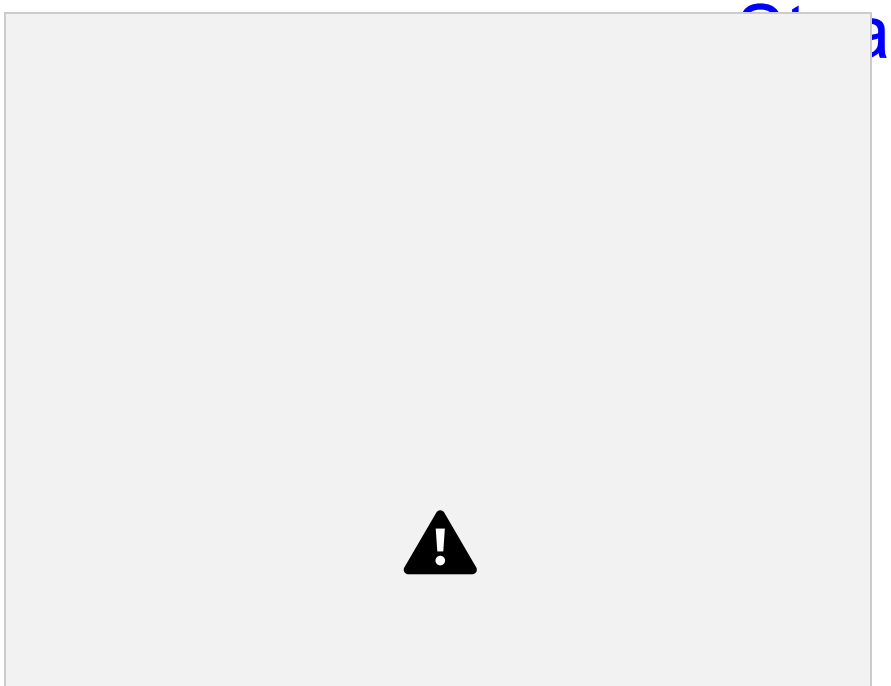
- Oxygen is highly electronegative(electronegativity 3.5)
- H-bond donor and acceptor(electronegativity 2.1)
- High b.p., m.p., heat of vaporization, surface tension
- Water constitutes 65 to 70 % of human body while it constitutes 60 to 95 % of human cells.

Water dissolves polar

solvation shell
or
hydration shell



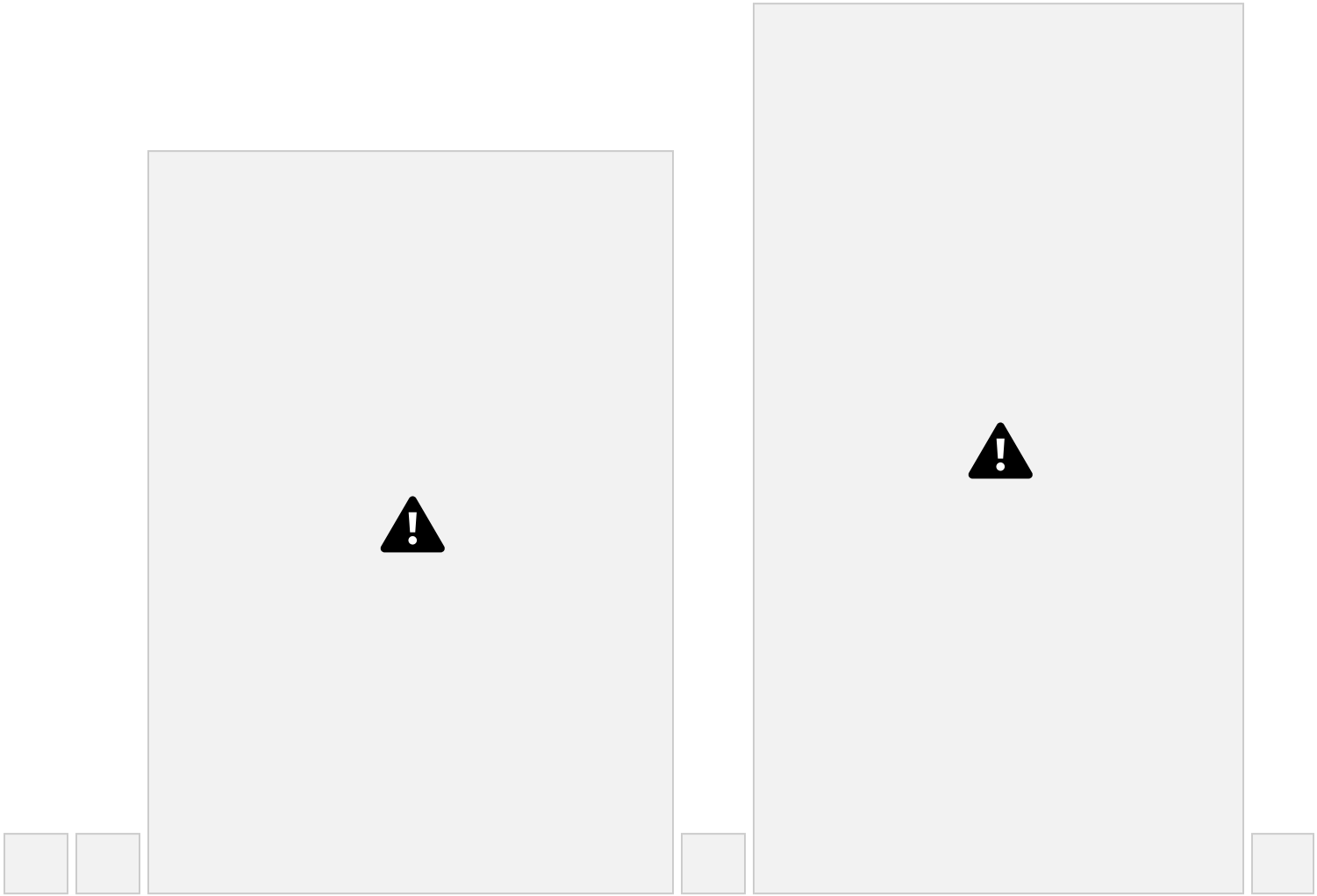
aric acid



The packing of fatty acids depends on their degree of saturation. Stearic acid is shown here in its usual extended conformation. Saturated fatty acids are tightly packed and stabilized by many hydrophobic

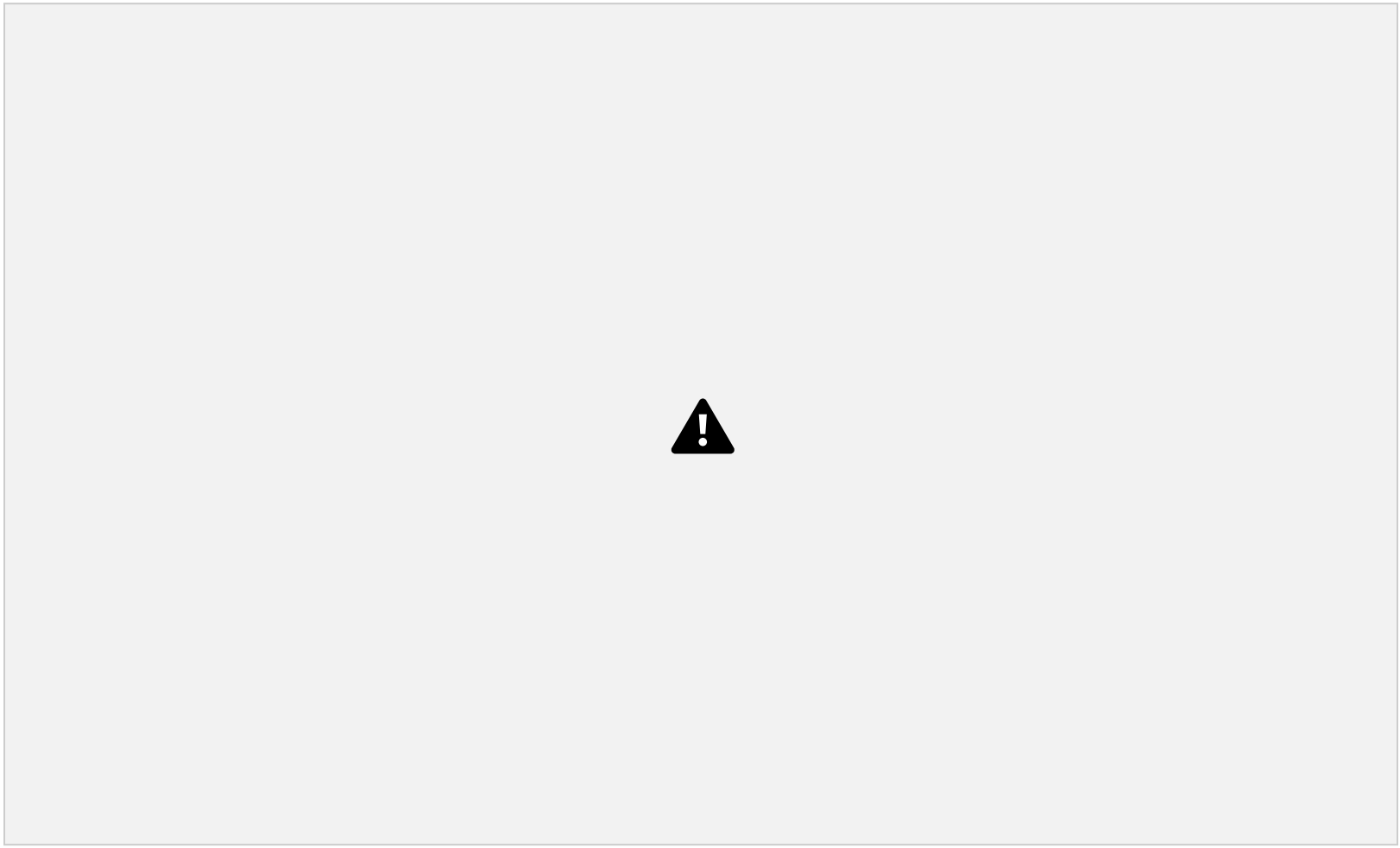
interactions

Non-polar substances are insoluble in water

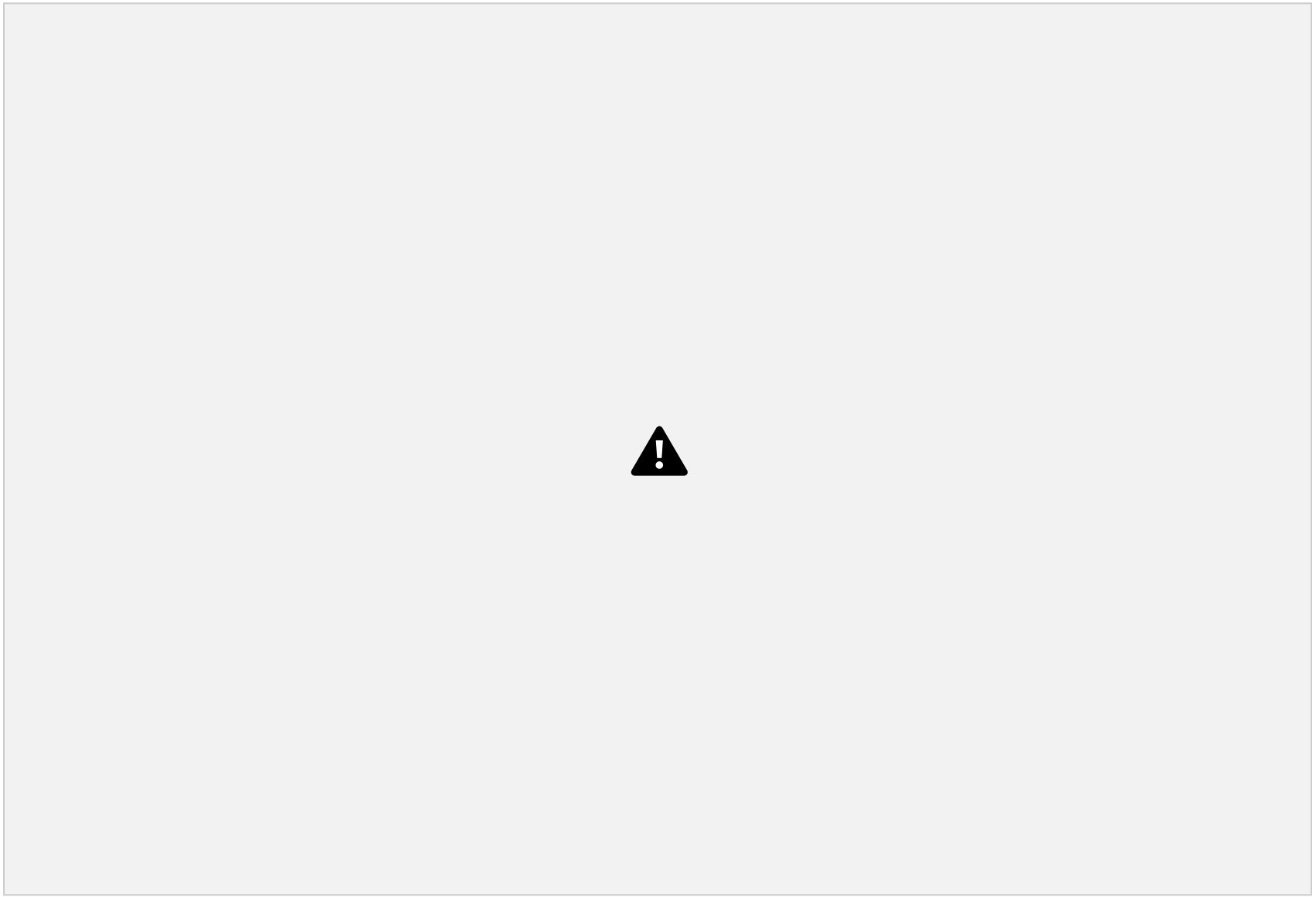


Many lipids are **amphipathic**

The bilayer system of lipids in aqueous solution



How detergents work?



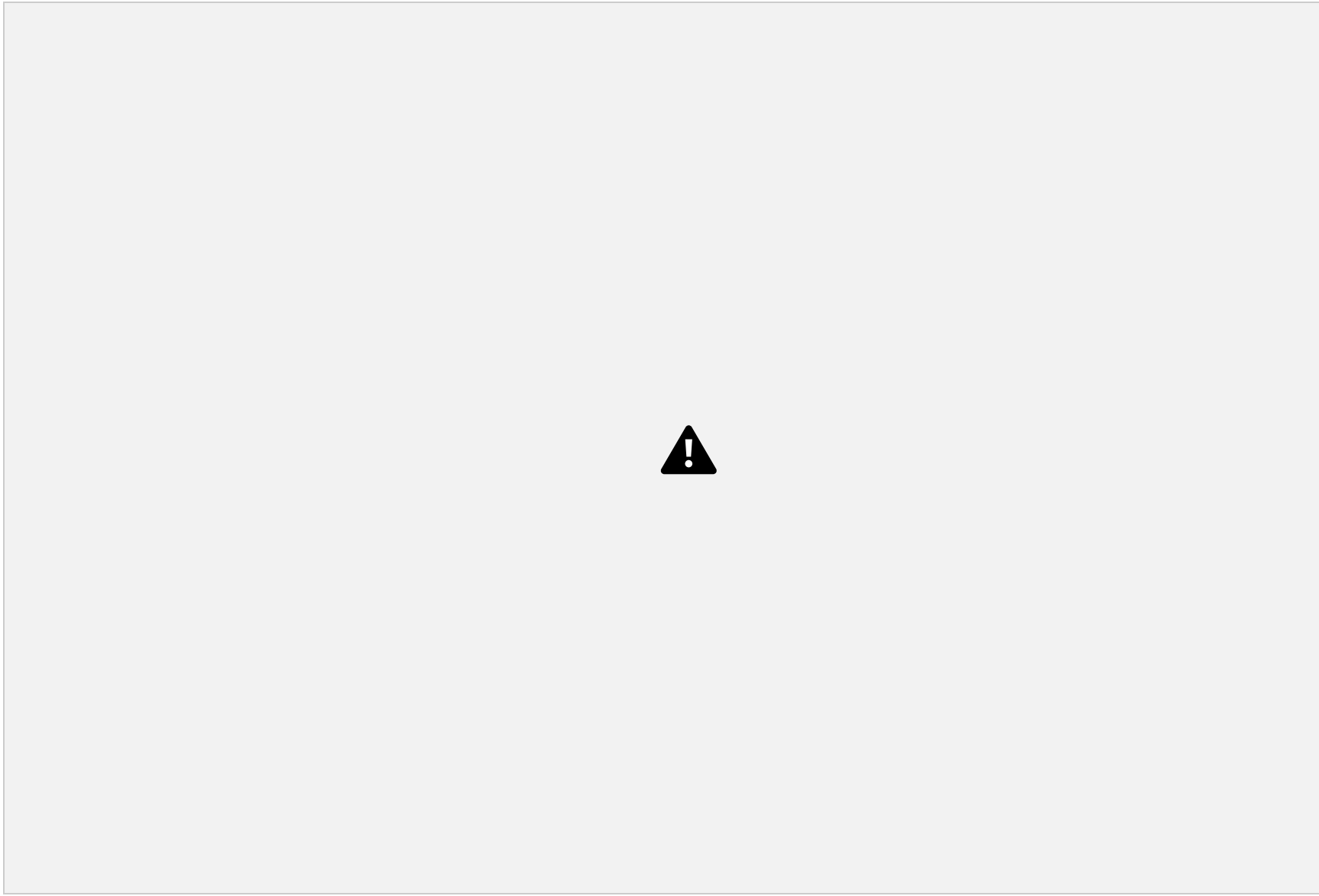
Hydrogen Bonding of Water

One H_2O molecule can associate with 4 other H_20 molecules

- **Ice: 4 H-bonds per water molecule**
- **Water: 2.3 H-bonds per water molecule**

Crystal lattice of ice

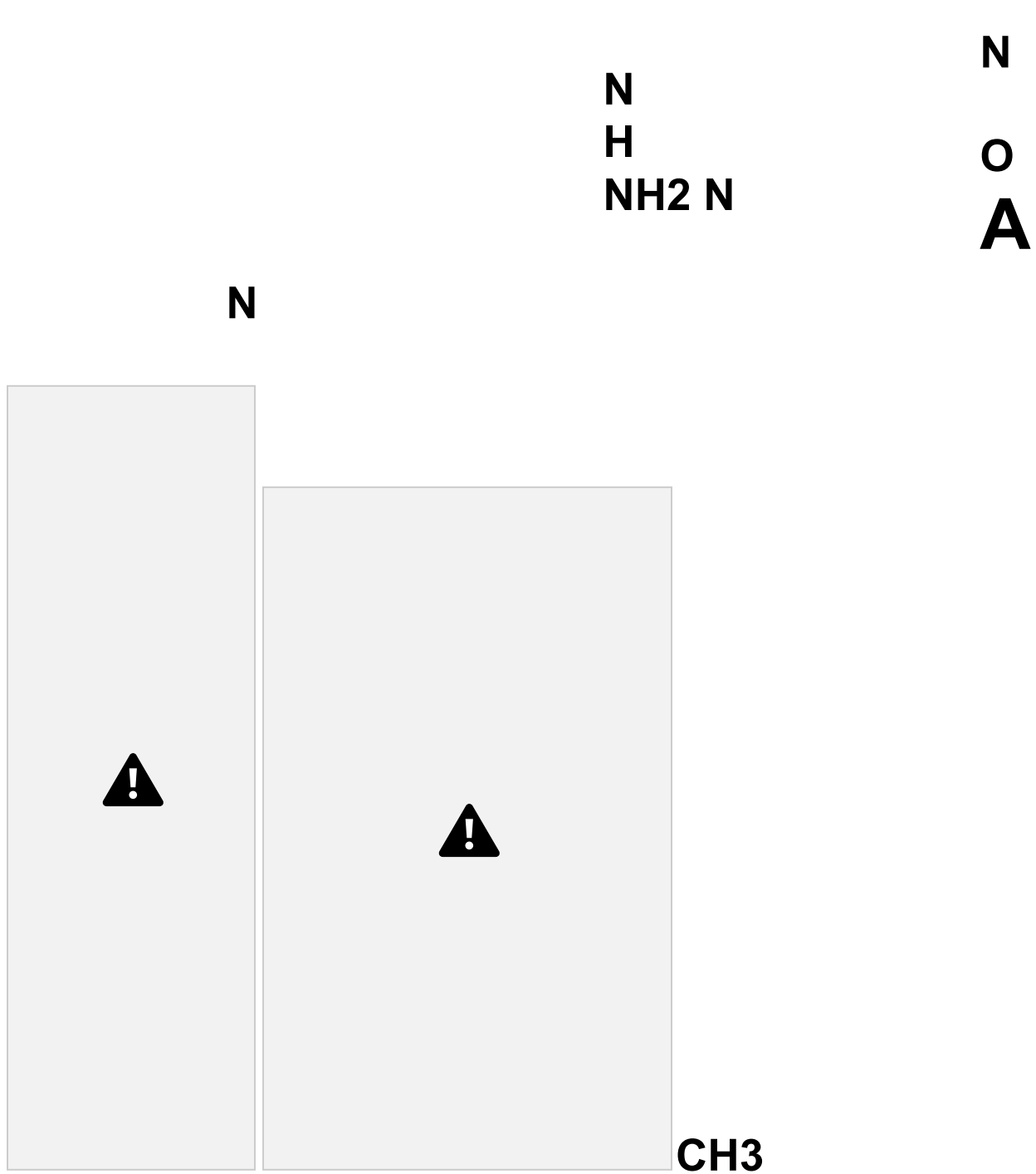
Biological Hydrogen Bonds



Nucleic Acid

Structure helix

The double


N
N
H
NH2 N
N
O
A
CH3

N H
NH O

T

Ionization of Water H_20

+ H_20 H_3O^+ + OH H_20 H^+

+ OH

$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]}$

$K_{eq} = 1.8 \times 10^{-16} M$ $[H_2O] =$ 55.5 M

$[H_2O]\ K_{eq} = [H^+]\ [OH^-]$

$(1.8 \times 10^{-16} M)(55.5\ M) = [H^+]$

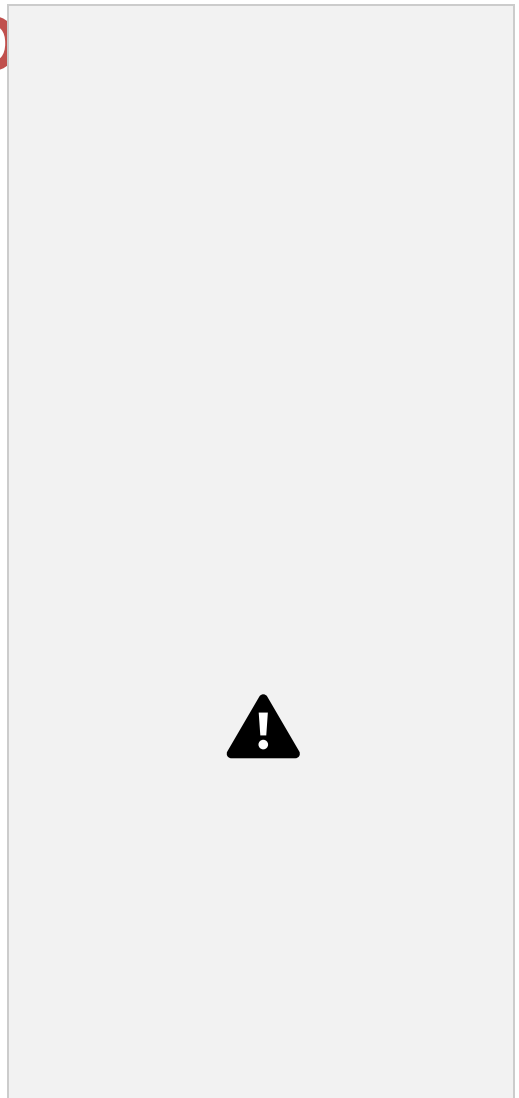
$[OH^-]$ 1.0 X 10^{-14} M^2 = $[H^+]$ $[OH^-]$ =

K_w

If $[H^+]=[O$ 1.0 X 10^{-7}

pH Scale

- Devised by Sorenson (1902)
- [H+] can range from 1M and 1 X 10^{-14}M



- **using a log scale simplifies notation**

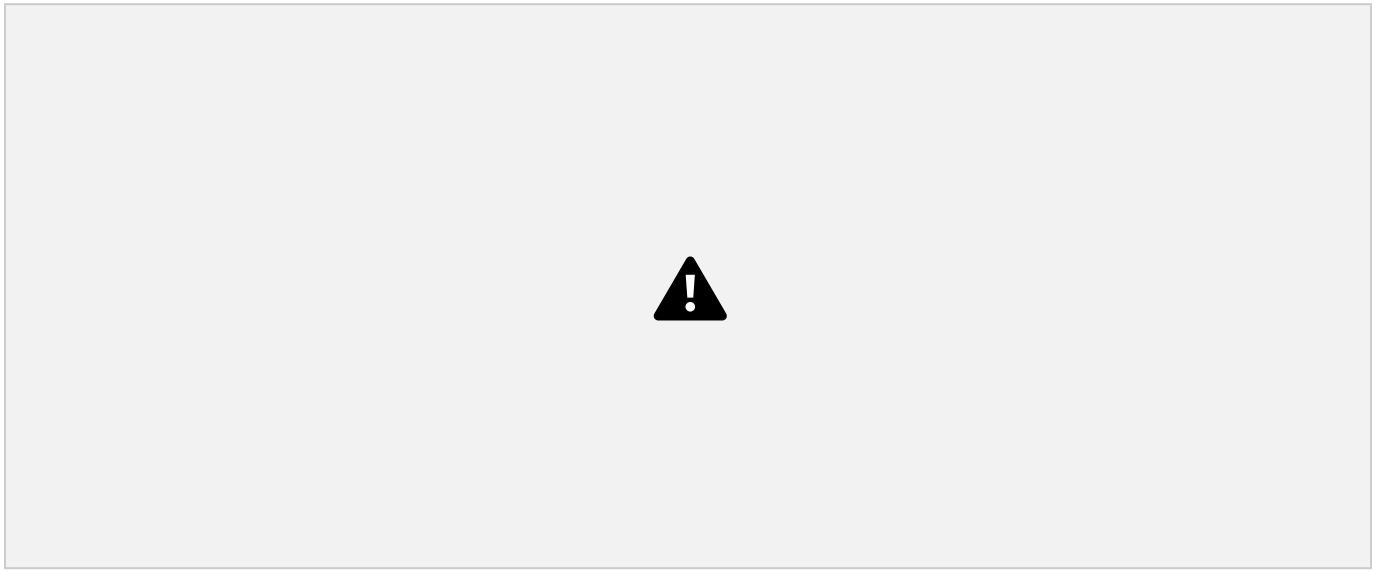
- **pH = -log [H^+]**

- **Neutral pH = 7.0**

Weak Acids and Bases Equilibria

•Strong acids / bases – disassociate completely •Weak acids / bases – disassociate only partially •Enzyme activity sensitive to pH

• weak acid/bases play important role in protein structure/function



Buffers

- **Buffers are aqueous systems that resist changes in pH when small amounts of a strong acid or base are added.**
- **A buffered system consist of a weak acid and its conjugate base.**
- **The most effective buffering occurs at the region of minimum slope on a titration curve**

(i.e. around the pKa).

- **Buffers are effective at pHs that are within +/-1 pH unit of the pKa**

Henderson-Hasselbach Equation

1) $K_a = \frac{[H^+][A^-]}{[HA]}$

2) $[H^+] = K_a \frac{[HA]}{[A^-]}$

3) $-\log[H^+] = -\log K_a - \log \frac{[HA]}{[A^-]}$

4) $-\log[H^+] = -\log K_a + \log \frac{[A^-]}{[HA]}$

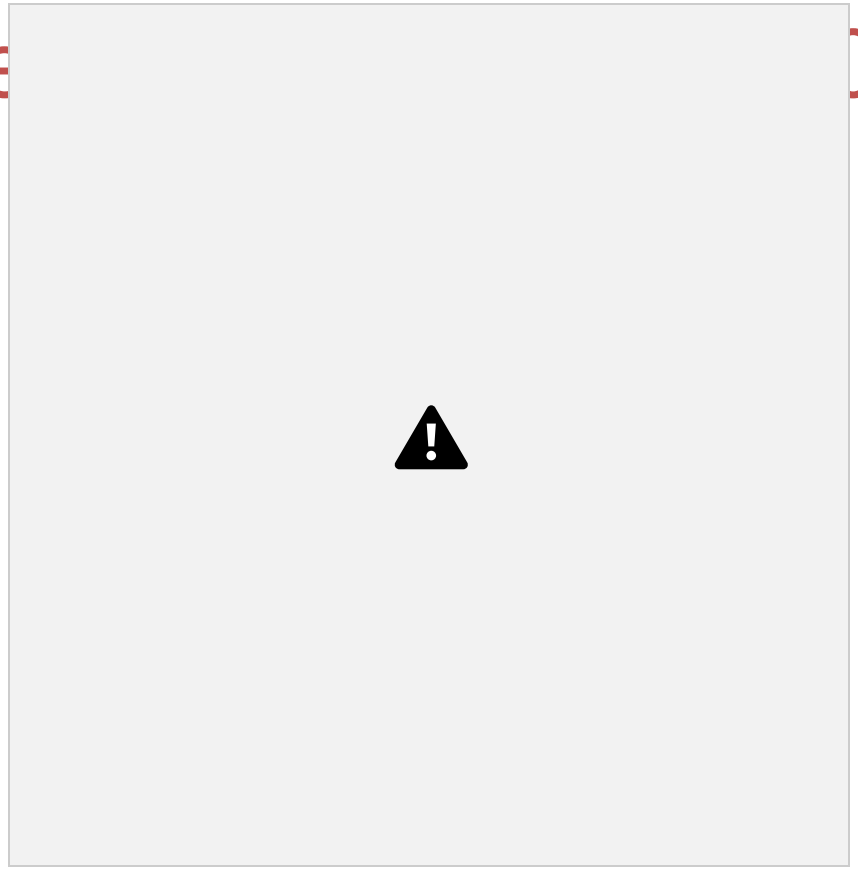
5) $pH = pK_a + \log \frac{[A^-]}{[HA]}$

HA = weak acid A^- = Conjugate base

* H-H equation describes the relationship between pH, pKa and

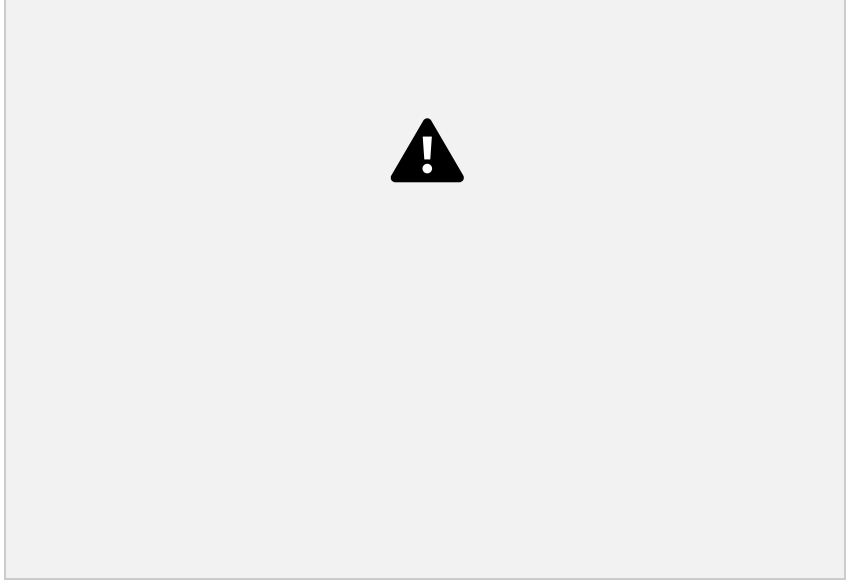
buffer concentration

Case where 0%



- $pH = pK_a + \log_{10} \frac{[0.1]}{[0.9]}$
- $pH = 4.76 + (-0.95)$
- $pH = 3.81$

Case where 90% acetate ion 10% acetic acid



- $pH = pK_a + \log_{10} \frac{[0.9]}{[0.1]}$

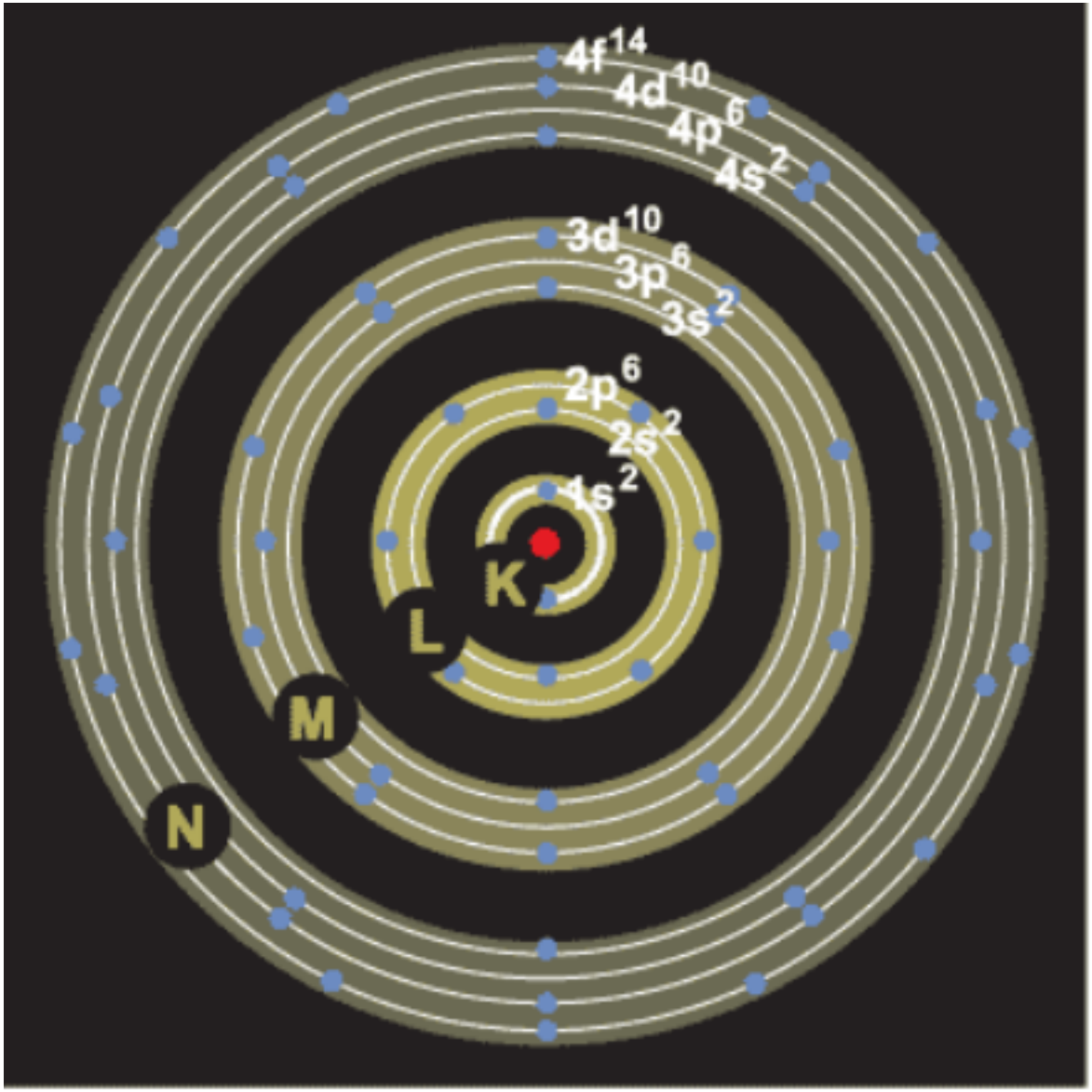
- $pH = 4.76 + 0.95$
- $pH = 5.71$

Madenet Al elm University College
Department of Medical Physics
Second Year 2021 - 2022

Organic Chemistry

Dr. Hamza Yaseen Isa **Lecture M 1 1 2**

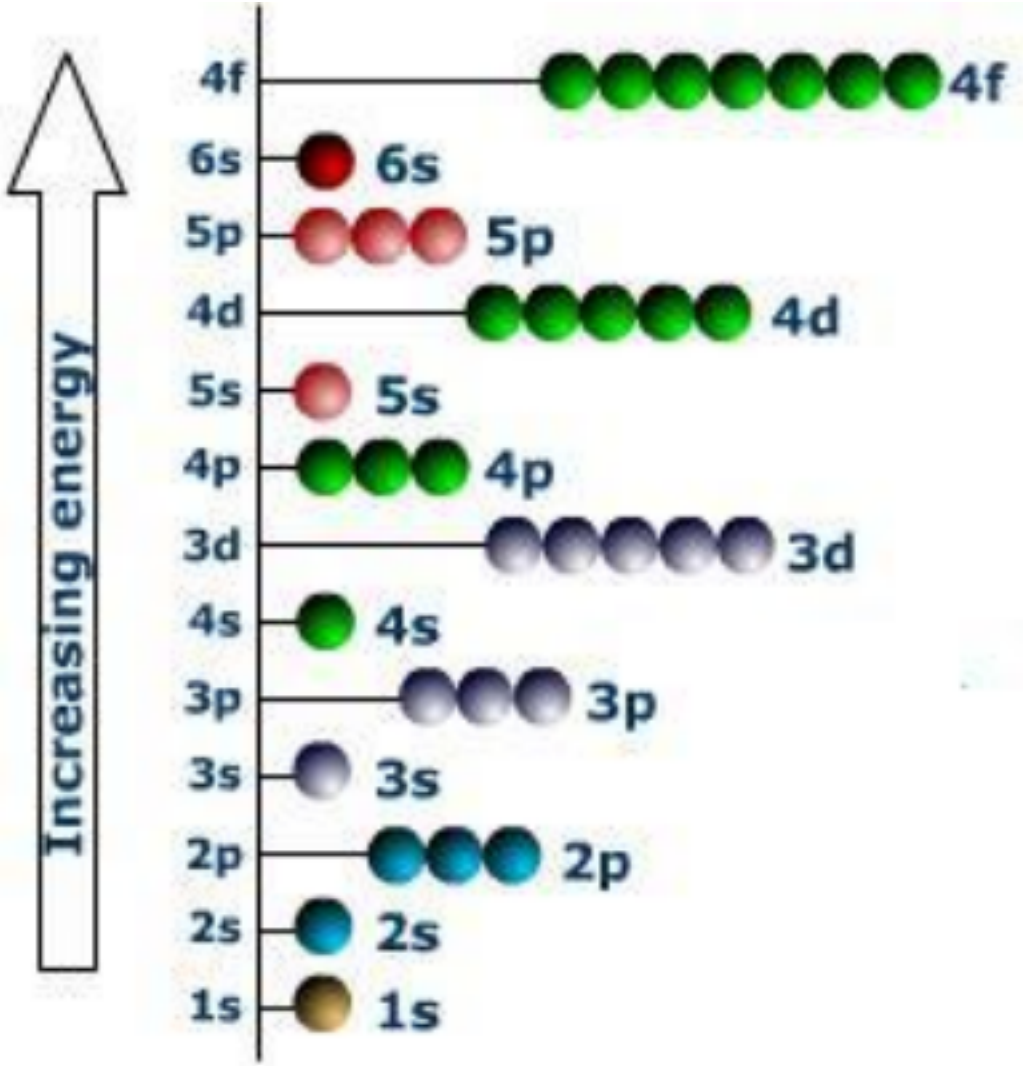
MULTIELECTRON ATOMS



Electron Configuration of Atoms

- Electrons are confined to regions of space called principle energy levels (shells) – each shell can hold $2n^2$ electrons (n = 1,2,3,4.....)

Shell	Number of Electrons Shell Can Hold Relative	Energies of Electrons in These Shells
4		
3		
2	8	
1	2	higher
		lower



Electron Configuration of Atoms

- Shells are divided into subshells called orbitals, which are designated by the letters *s*, *p*, *d*, *f*,..... –

s (one per shell)

– *p* (set of three per shell 2 and higher)

– *d* (set of five per shell 3 and higher) .....

Shell Orbitals Contained in That Shell

3

$3s$, $3p_x$, $3p_y$, $3p_z$, plus five $3d$ orbitals2

$2s$, $2p_x$, $2p_y$, $2p_z$

1 1*s*

Electronegativity

- Electronegativity:

- Electronegativity:

– a measure of an atom's attraction for the electrons it shares with another atom in a

chemical bond

- Pauling scale

– generally increases left to right in a row – generally increases bottom to top in a column

Covalent Bonds

- The simplest covalent bond is that in H_2
  – the single electrons from each atom combine to form an electron pair

$H^+ \bullet H \; H\text{-}H \;\; \Delta H^0$

- **= -435 kJ (-104 kcal)/mol**

– the shared pair functions in two ways simultaneously; it is shared by the two atoms and fills the valence shell of each atom

- The number of shared pairs
  - one shared pair forms a single bond
  - two shared pairs form a double bond
  - three shared pairs form a triple bond

Polar and Nonpolar Covalent Bonds

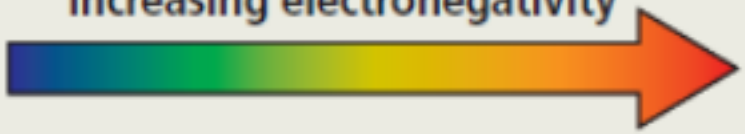
- Although all covalent bonds involve sharing of electrons, they differ widely in the degree of sharing
- We divide covalent bonds into
  - nonpolar covalent bonds
  - polar covalent bonds

Difference in Electronegativity Between Bonded Atoms	Type of Bond
Less than 0.5	
0.5 to 1.9	

Greater than 1.9	**f orm**
Nonpolar covalent	
Polar covalent Ions	

TABLE 1.3 The Electronegativities of Selected Elements[a]

IA	IIA	IB	IIB	IIIA	IVA	VA	VIA	VIIA
H 2.1								
Li 1.0	Be 1.5			B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2			Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0							Br 2.8
								I 2.5



[a]Electronegativity values are relative, not absolute. As a result, there are several scales of electronegativities. The electronegativities listed here are from the scale devised by Linus Pauling.

Polar and Nonpolar Covalent Bonds

- an example of a polar covalent bond is that of H-Cl
- the difference in electronegativity between Cl and H is 3.0 - 2.1 = 0.9
- we show polarity by using the symbols δ+ and δ-, or by using an arrow with the arrowhead pointing toward the negative end and a plus sign on the tail of the arrow at the positive end

Polar Covalent Bonds

- Bond dipole moment (μ):
  - a measure of the polarity of a

covalent bond – the product of the charge on either atom of a polar bond times the distance between the nuclei

– The following table shows average bond dipole moments of selected covalent bonds

Bond	Bond Dipole (D)	Bond	Bond Dipole (D)	Bond	Bond Dipole (D)
H-C	0.3	C-F	1.4	C-O	0.7
H-N	1.3	C-Cl	1.5	C=O	2.3
H-O	1.5				

C-Br C-N

H-S C-I -

1.4 -

0.2

0.7 1.2 C=N 3.5

Formal Charge

- Formal charge: the charge on an atom in a molecule or a polyatomic ion
- To derive formal charge

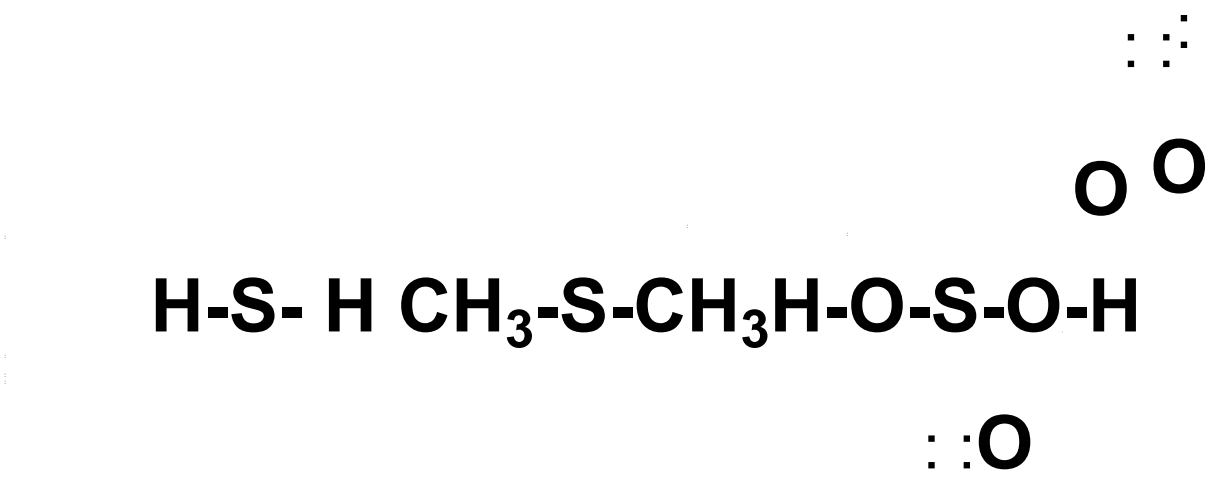
  1. write a correct Lewis structure for the molecule or ion 2. assign each atom all its unshared (nonbonding) electrons and one half its shared (bonding) electrons 3. compare this number with the number of valence electrons in the neutral, unbonded atom

Formal charge= Number of valence electrons in the neutral, unbonded atom − **All unshared electrons** + **One half of all shared**

electrons

Exceptions to the Octet Rule

– sulfur, another third-period element, forms compounds in which its valence shell contains 8, 10, or 12 electrons



e Sulfuri c acid

What is Organic chemistry?

The study of carbon and its compounds.

First we will concentrate on compounds just containing carbon and hydrogen, these compounds are called hydrocarbons.

Hydrocarbon Classification

Hydrocarbons

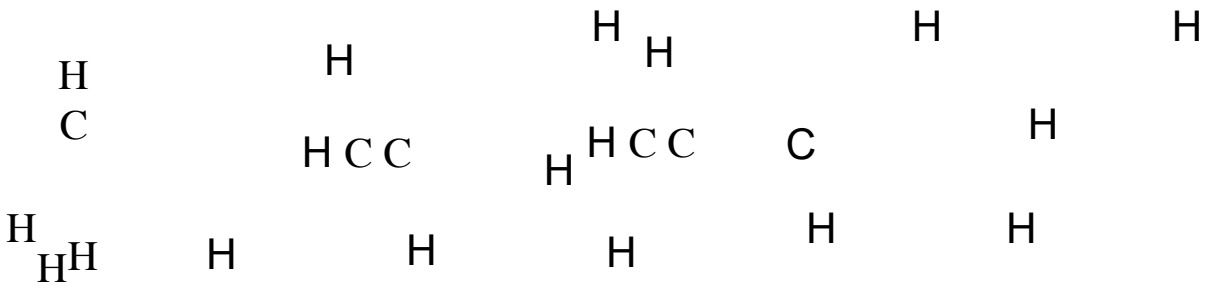
Alkanes Cycloalkanes Alkenes Cycloalkenes Alkynes

1. Alkanes (saturated) hydrocarbons, or aliphatic

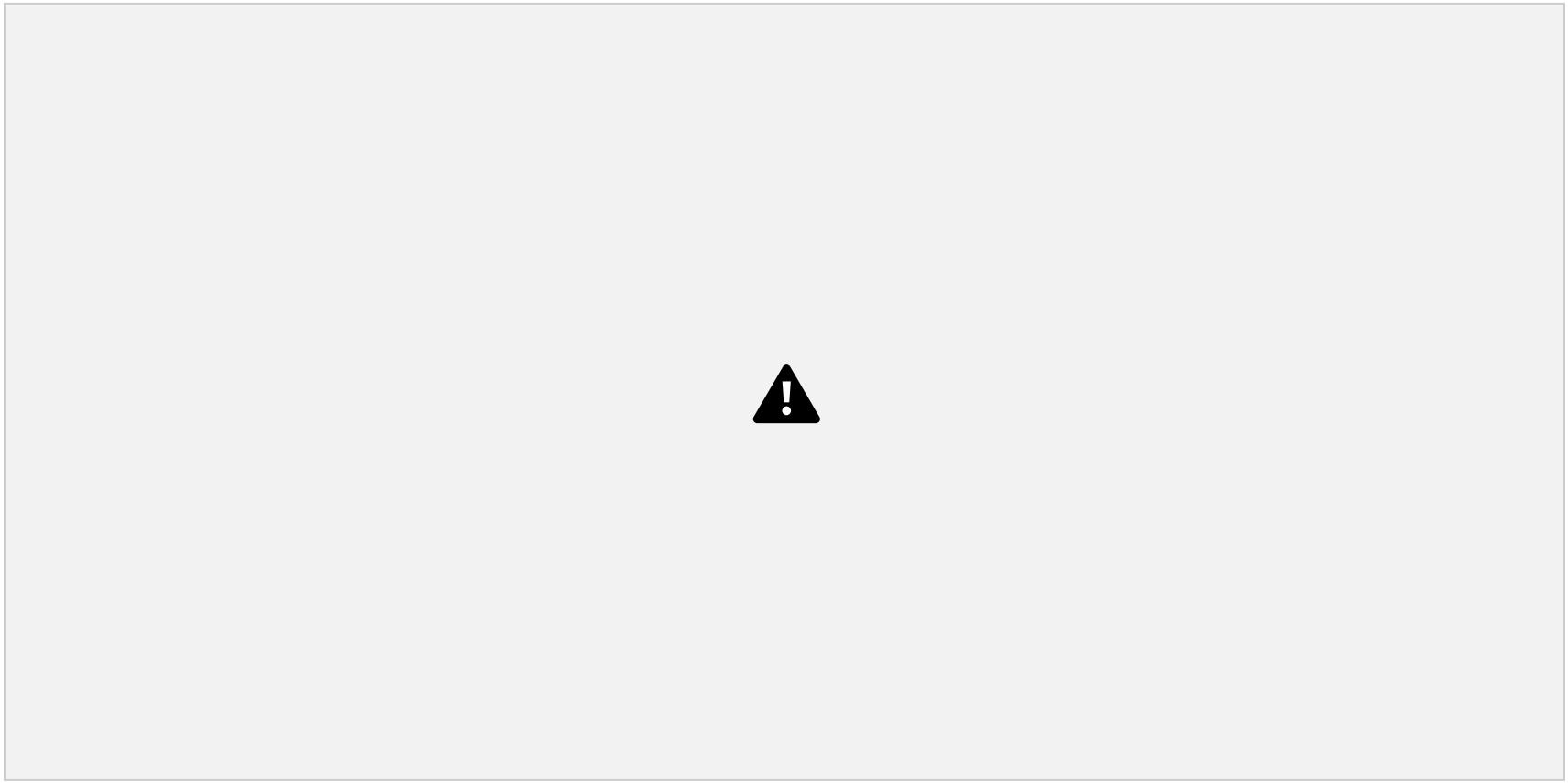
hydrocarbons) A. General formula of C_nH_{2n+2}

B. Examples

a. CH_4 b. C_2H_6 c. C_3H_8 d. C_4H_{10} C. Draw Lewis Structures



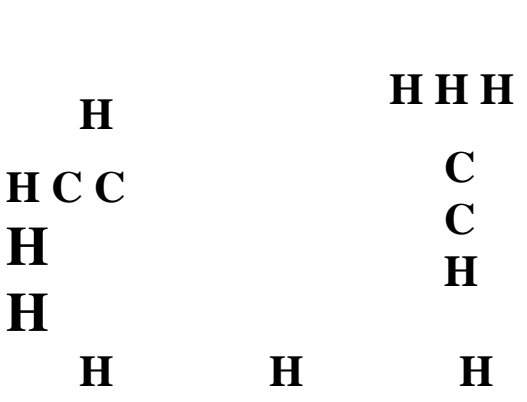
CH^4 C_2H^6 C_3H_8 D. Polarity? Polar or nonpolar? Nonpolar



G. Types of carbon

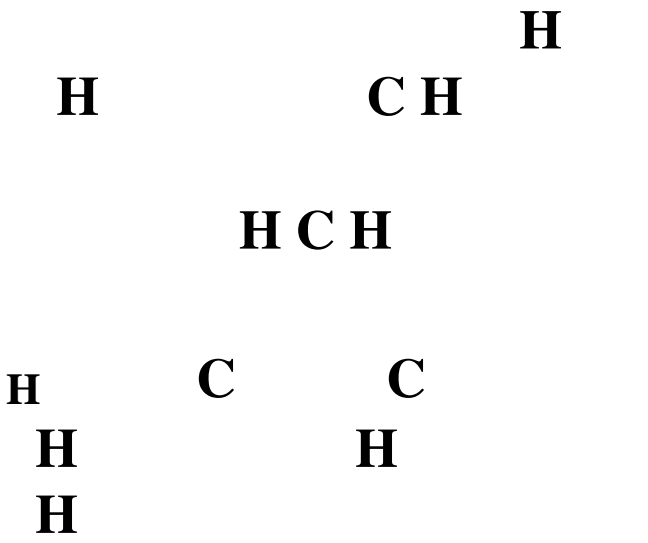
1. Primary (1°) Carbon connected to one carbon atoms. 2. Secondary (2°) Carbon connected to two carbon atoms. 3. Tertiary (3°) Carbon connected to three carbon atoms. 4. How many primary, secondary, and tertiary carbons in the two

different structures of C_4H_{10}



Butane, C_4H_{10}

Primary carbon = 2
Secondary carbon = 2 Tertiary carbon = 0



Primary carbon = 3
Secondary carbon = 0 Tertiary carbon = 1

Isobutane C_4H_{10}

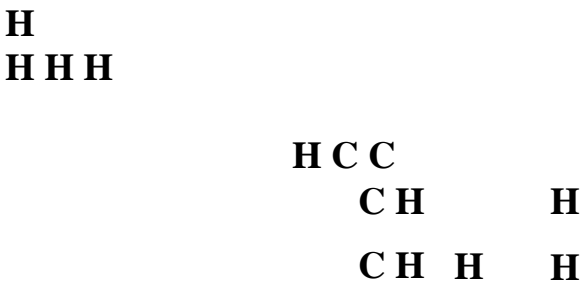
1. Alkanes (Continued)

F. There are two different structures for C_4H_{10} called

isomers, because they contain different types of carbon.

1

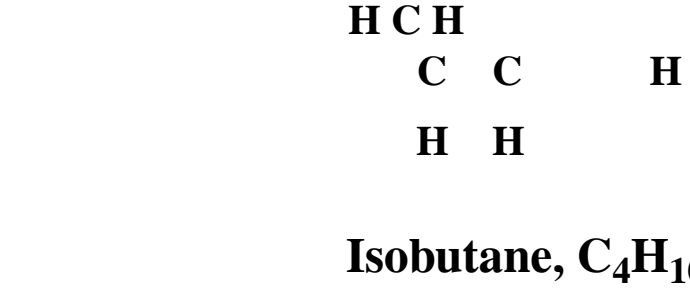
Structure



Butane,

C_4H_{10}

Structure 2



Isobutane, C_4H_{10}

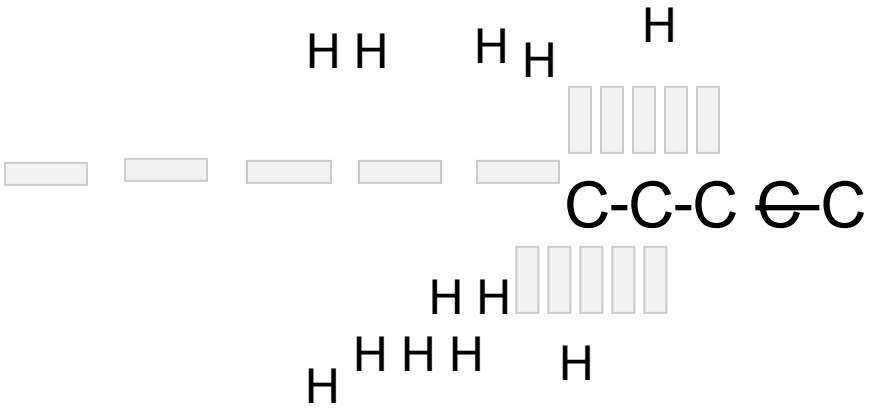
Isomerism

Constitutional Isomers (Structural Isomers) are different compounds of the same formula. The different structures from the previous slide for the formula C_4H_{10} is an example of Constitutional isomers.

How many isomers are there of an alkane containing five carbons (C_5H_{12})?

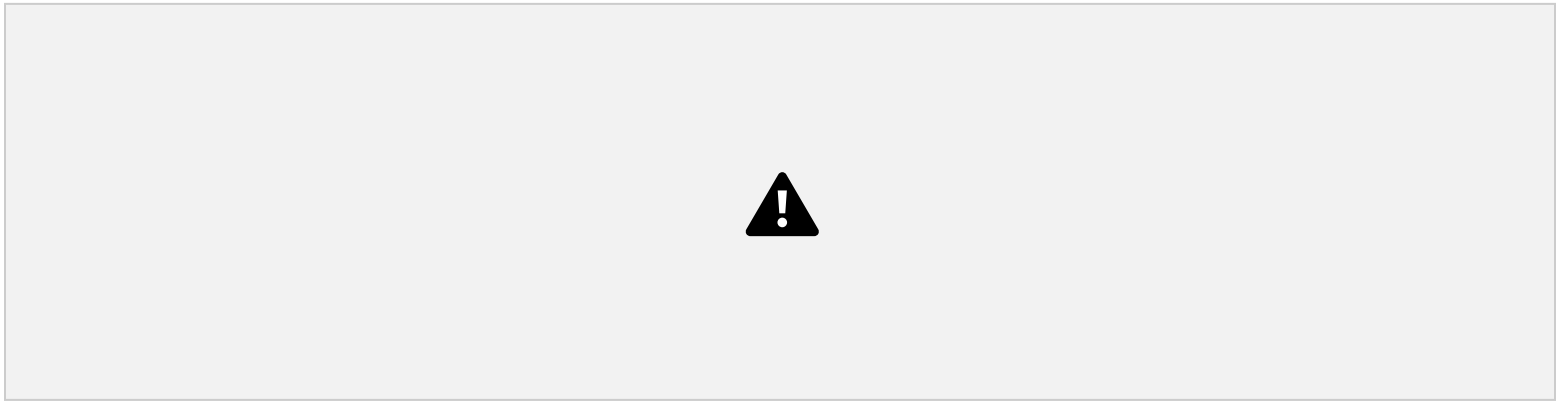
Isomer Strategy – Draw Lewis possible different length chains of carbons atoms connected with a covalent bond.

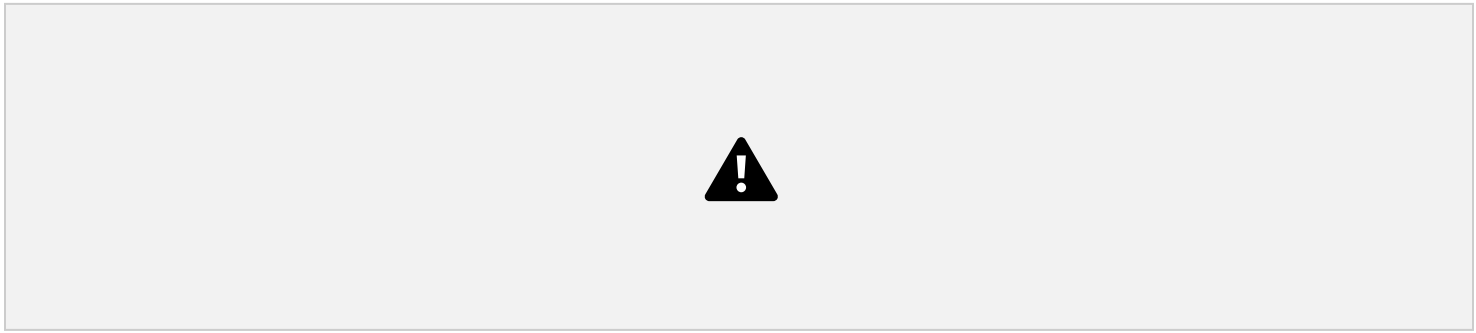
Chains of 5 carbon atoms



Stereoisomers

- Compounds with atoms connected in the same order but which differ in three-dimensional orientation, are stereoisomers
- The terms “cis” and “trans” should be used to specify stereoisomeric ring structures
- Recall that constitutional isomers have atoms connected in different order





NOMENCLATURE

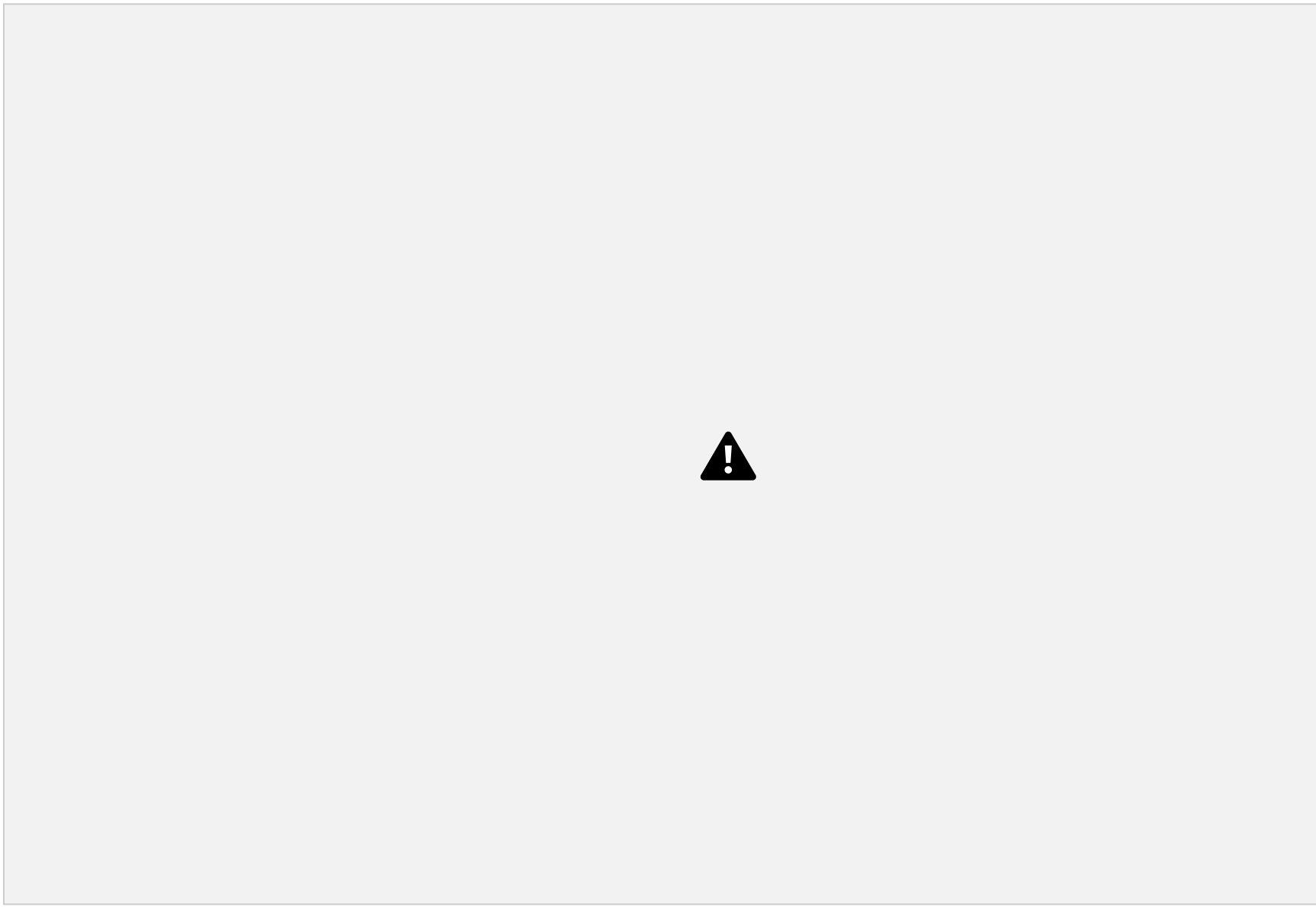
1. Common system
    a. Works best for low molecular weight hydrocarbons
    b. Steps to give a hydrocarbon a common name:
        1. Count the total number of carbon atoms in the molecule.
        2. Use the Latin root from the following slide that corresponds to the number of carbon atoms followed by the suffix "ane".
        3. Unbranced hydrocarbons use the prefix *normal, or n-,*
        4. Branched hydrocarbons use specific prefixes, as shown on a subsequent slide

2. Systematic System of Nomenclature (IUPAC)

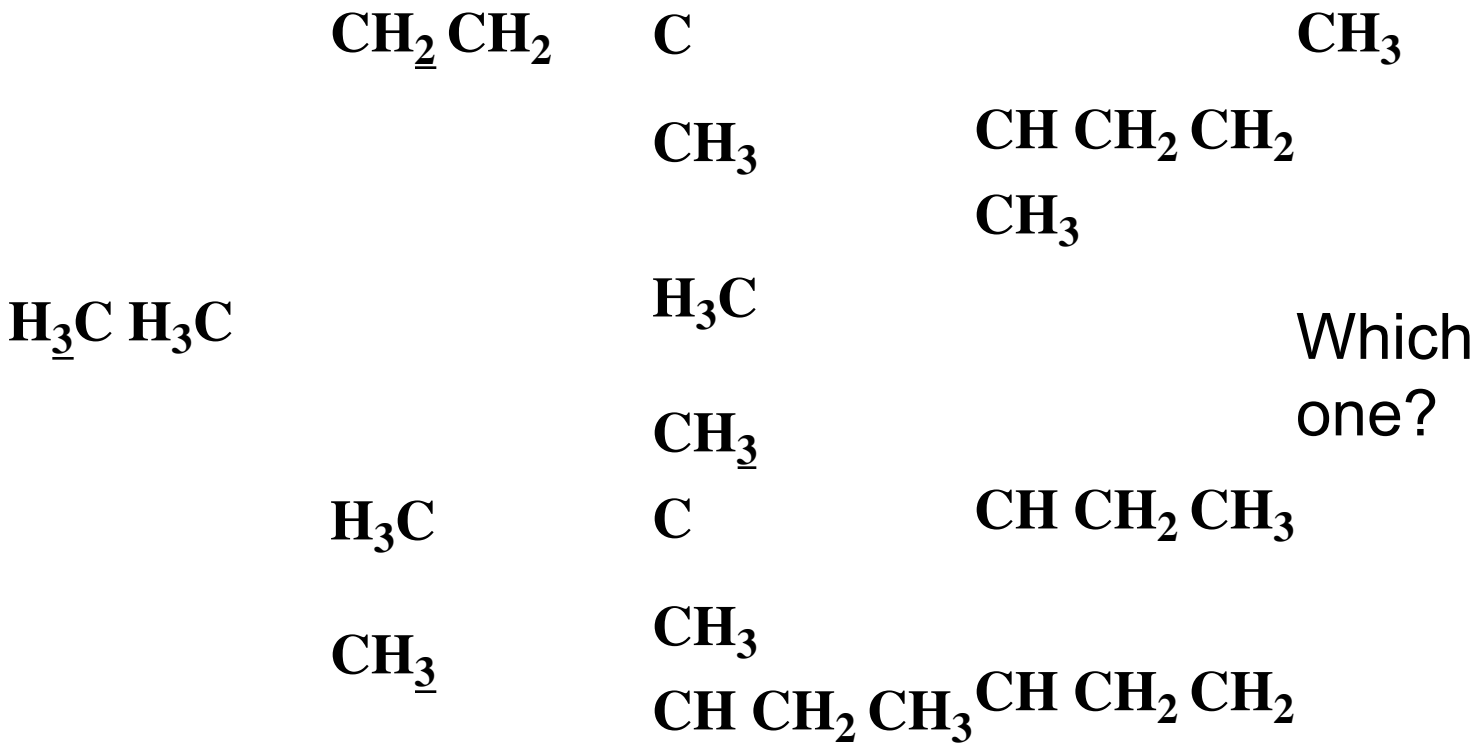
•Find the longest continuous chain of carbon atoms. •Use a Latin root corresponding to the number of carbons in the longest chain of carbons.
•Follow the root with the suffix of "ane" for alkanes •Carbon atoms not included in the chain are named as substituents preceding the root name with Latin root followed by "yl" suffix.
•Number the carbons, starting closest to the first branch.

•Name the substituent's attached to the chain, using the carbon number as the locator in alphabetical order.
•Use di-, tri-, etc., for multiples of same substituent. • If there are two possible chains with the same number of carbons, use the chain with the most substituent's.

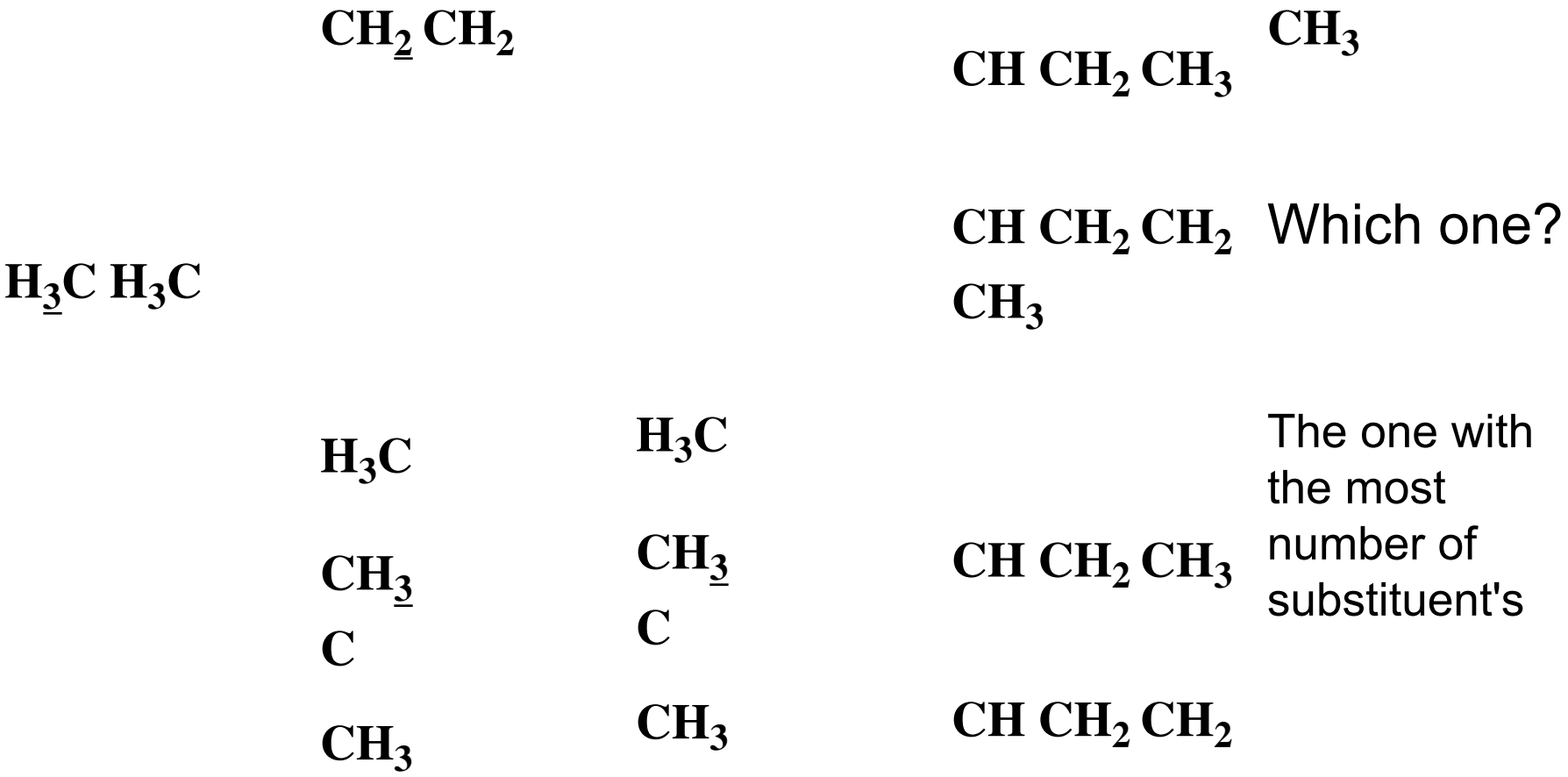
Substituent Names (Alkyl groups)



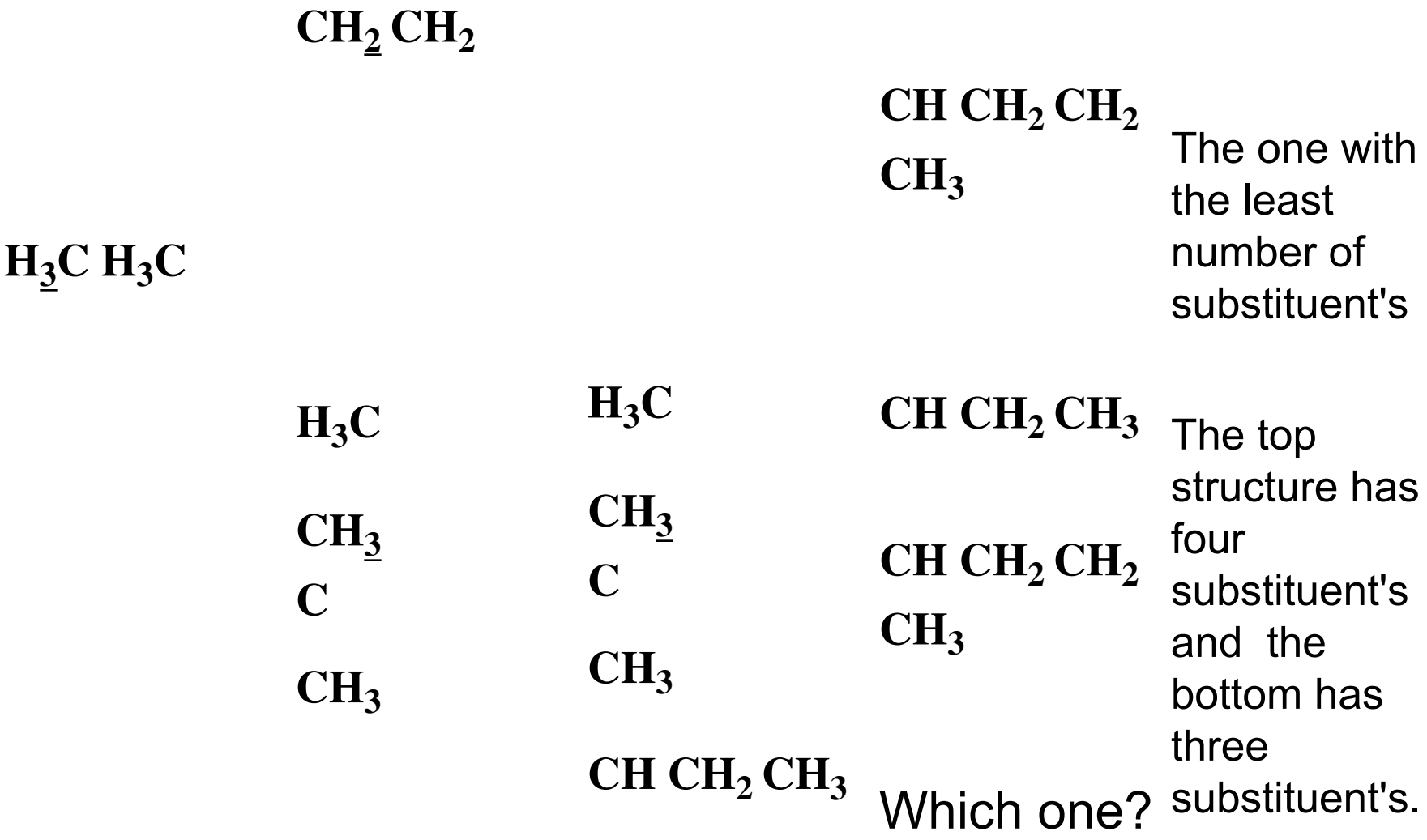
Systematic Nomenclature continued.



Systematic Nomenclature continued.



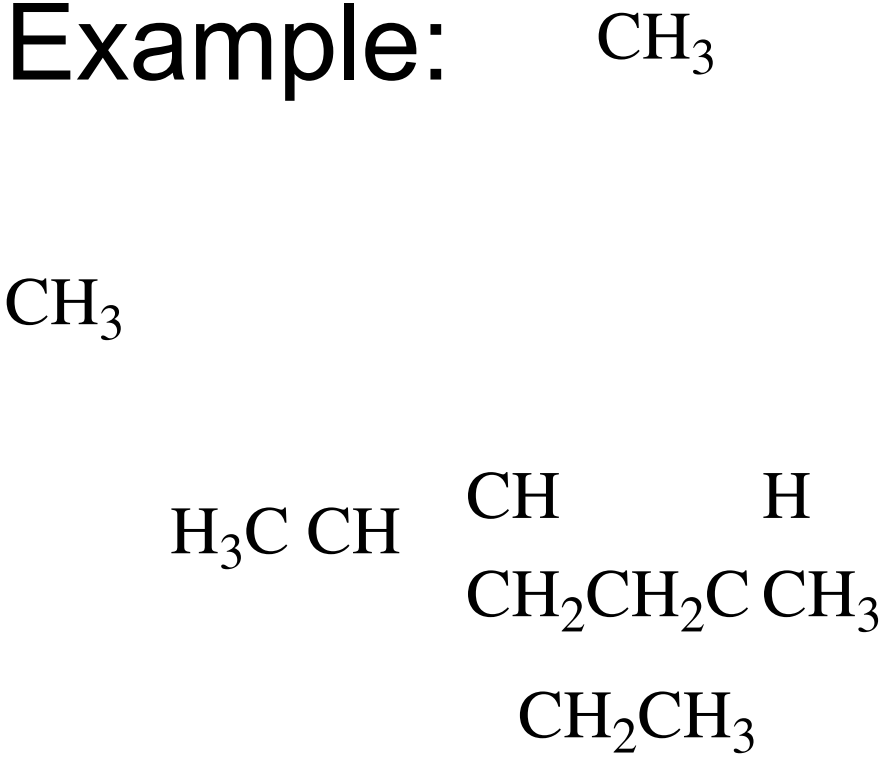
Systematic Nomenclature continued.



Name = 3,3,5-trimethyl-4-propylheptane

Another

Example:



Name = 3-ethyl-2,6-dimethylheptane

Notice substituent's are in alphabetical order; di, tri, etc. do not participate in the alphabetical order

quicker way to write structures'

CH_3

Line Structures

CH_3

A

$H_3C\ CH$ CH CH_3(Condensed Structure)

CH_2CH_2CH

CH_2CH_3

ethyl

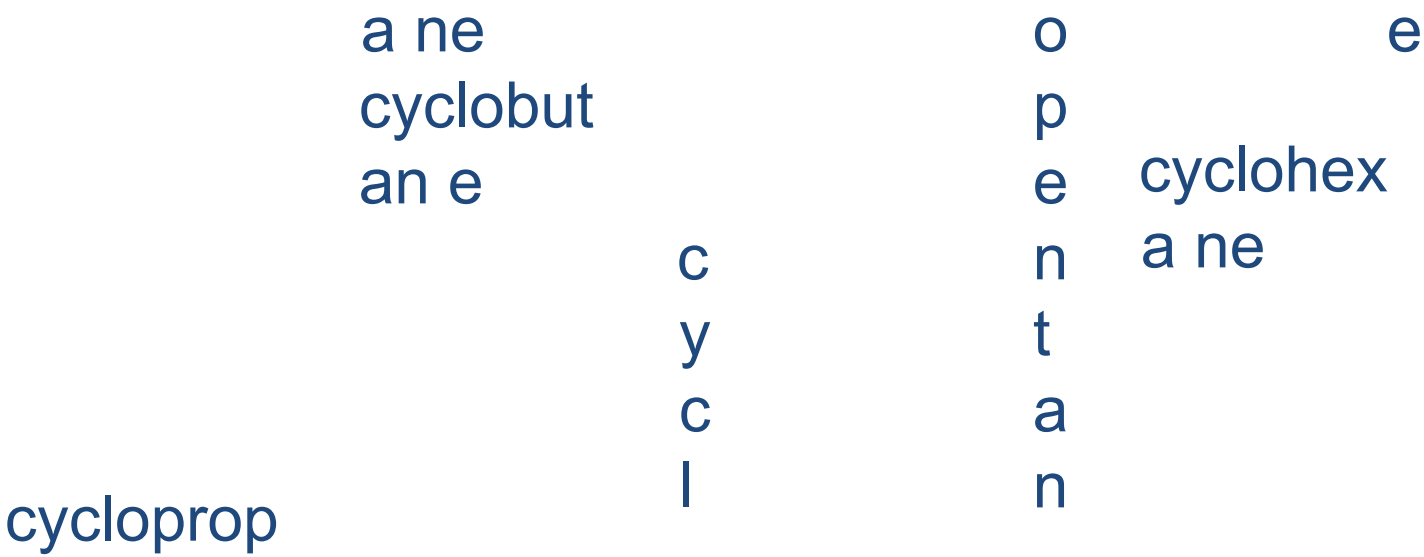
methyl

(A line structure of the above condensed structure)

methyl

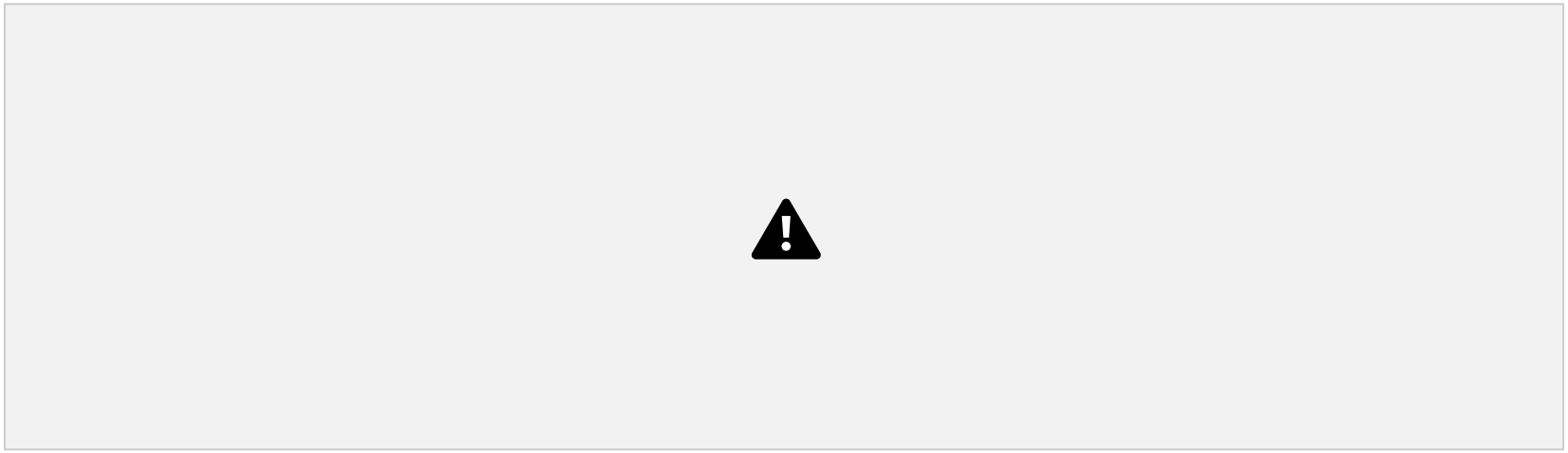
Cycloalkanes

- Cycloalkanes are alkanes that have carbon atoms that form a ring (called alicyclic compounds)
- Simple cycloalkanes rings of —CH2— units, (CH2)*n*, or C*n*H2*n* • Structure is shown as a regular polygon with the number of vertices equal to the number of C's (a projection of the actual structure)



Naming Cycloalkanes

- Count the number of carbon atoms in the ring and the number in the largest substituent chain. If the number of carbon atoms in the ring is equal to or greater than the number in the substituent, the compound is named as an alkyl-substituted cycloalkane
- For an alkyl- or halo-substituted cycloalkane, start at a point of attachment as C1 and number the substituents on the ring so that the *second* substituent has as low a number as possible.
- Number the substituents and write the name
- See text for more details and examples



Alkane Physical Properties

Solubility: hydrophobic (not water soluble)
Density: less than 1 g/mL (floats on water)

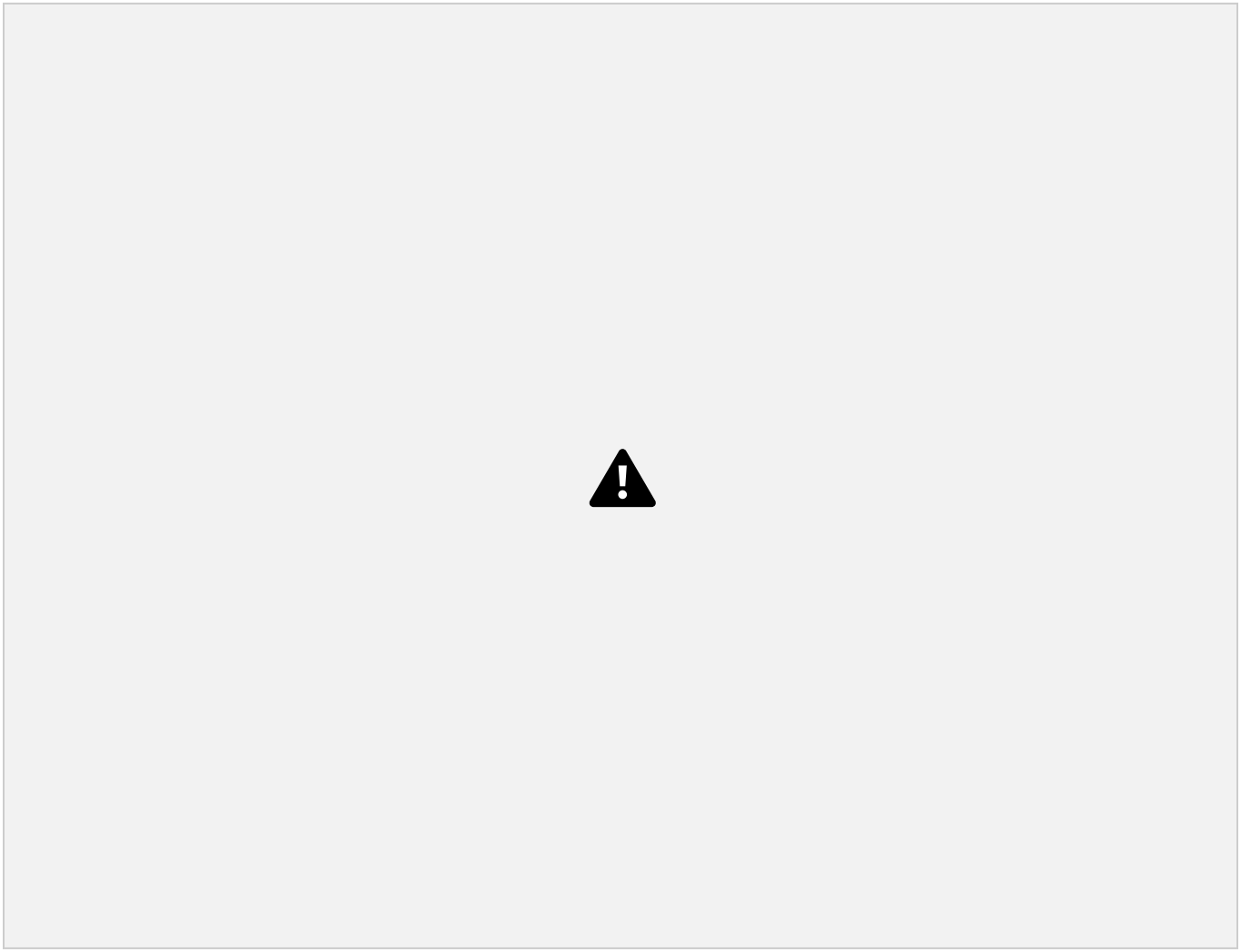
Boiling points increase with increasing carbons (little less for branched chains) due to dispersion forces being larger.

Melting points increase with increasing carbons (less for

odd-number of carbons).

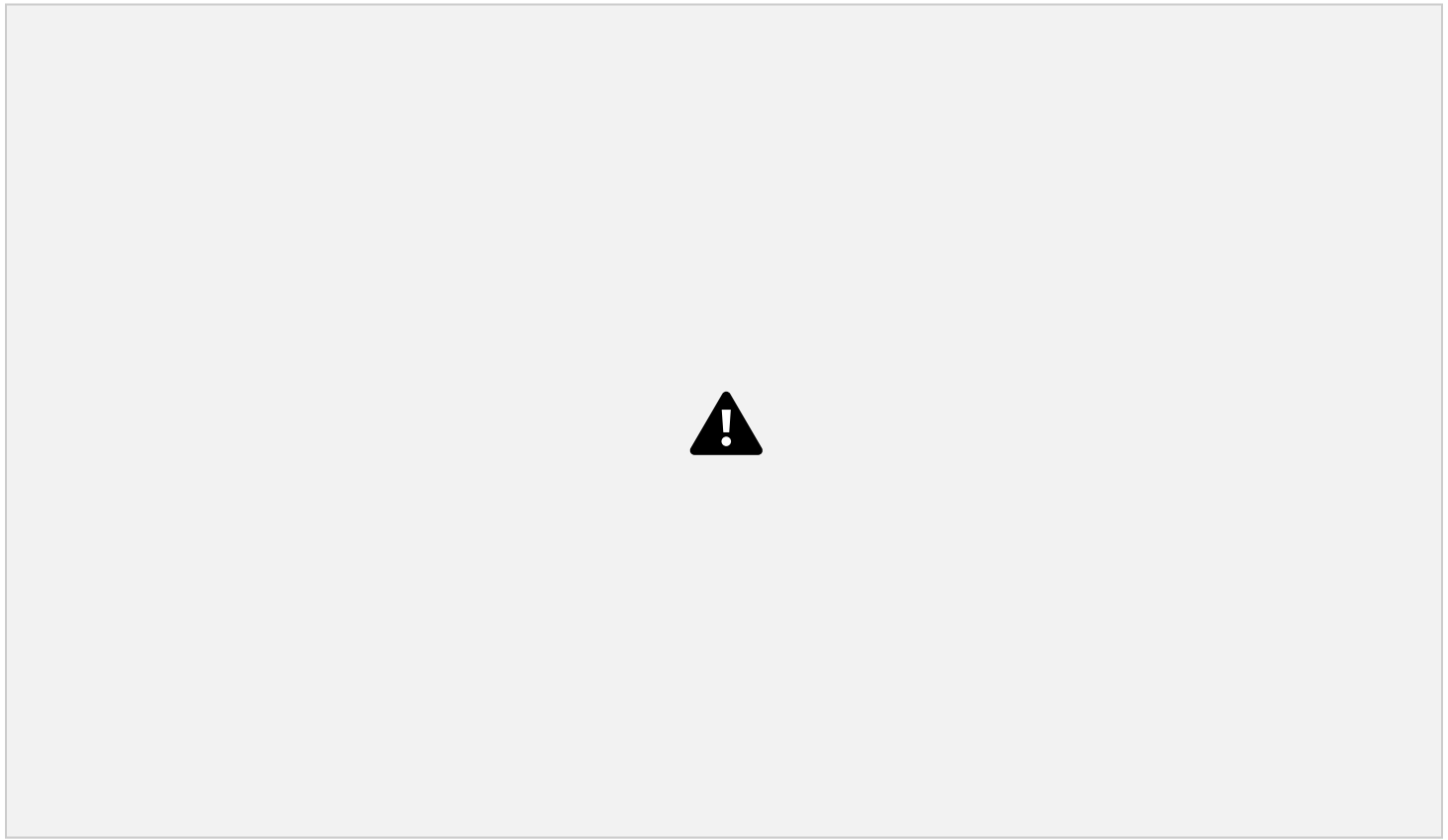
Boiling Points of Alkanes

Branched alkanes have less surface area contact, so weaker intermolecular forces.



Melting Points of Alkanes

Branched alkanes pack more efficiently into a crystalline structure, so have higher m.p.



Reactions of Alkanes

I. Combustion reaction

H

H C H

H + O_2 $\xrightarrow{\text{heat}}$ $CO_2 + H_2O$

$\xrightarrow{\text{heat}}$ $CO_2 + H_2O$

+ O_2

II. Cracking reaction

heat

catalyst+

III. Halogenation reaction (substitution reaction)

sun

Cl Cl

+ Cl_2

+ HCl +

Butane 2-chlorobutane 1-chlorobutane

Madenet Al elm University College
Department of Medical Physics
Second Year 2021 - 2022

Alkenes and Aromatic Compounds

Dr. Hamza Yaseen Isa

Lecture M 2 I 2

Alkenes and Alkynes I: Structure and Preparation

Hydrocarbon with carbon carbon double bond

Also called an olefin but *alkene* is better

Includes many naturally occurring materials Flavors, fragrances, vitamins

Important industrial products

These are feedstocks for industrial processes

Electronic Structure of Alkenes

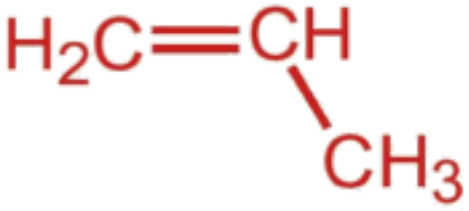
- **Carbon atoms in a double bond are *sp*^{2}-hybridized –**
  - **Three equivalent orbitals at 120º separation in plane –**
  - **Fourth orbital is atomic *p* orbital**
- **Combination of electrons in two *sp*^{2} orbitals of two atoms forms σ bond between them**
- **Additive interaction of *p* orbitals creates a π bonding orbital – Subtractive interaction creates a π anti-bonding orbital • Occupied π orbital prevents rotation about σ-bond • Rotation prevented by π bond - high barrier, about 268 kJ/mole in ethylene**

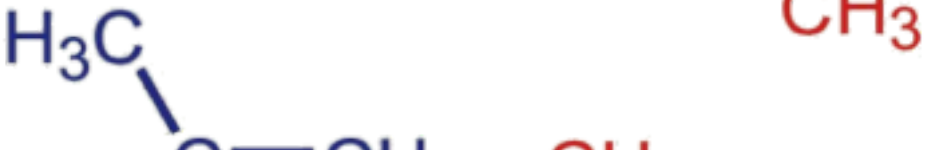
Nomenclature

- **Suffix “-ene”**
- **Find longest continuous carbon chain <u>containing the double bond</u> for root name**
- **Number carbons in chain so that double bond carbons have lowest possible numbers**
- **Rings have “cyclo” prefix**

Many Alkenes Are Known by Common Names

- **Ethylene = ethene**
- **Propylene = propene**

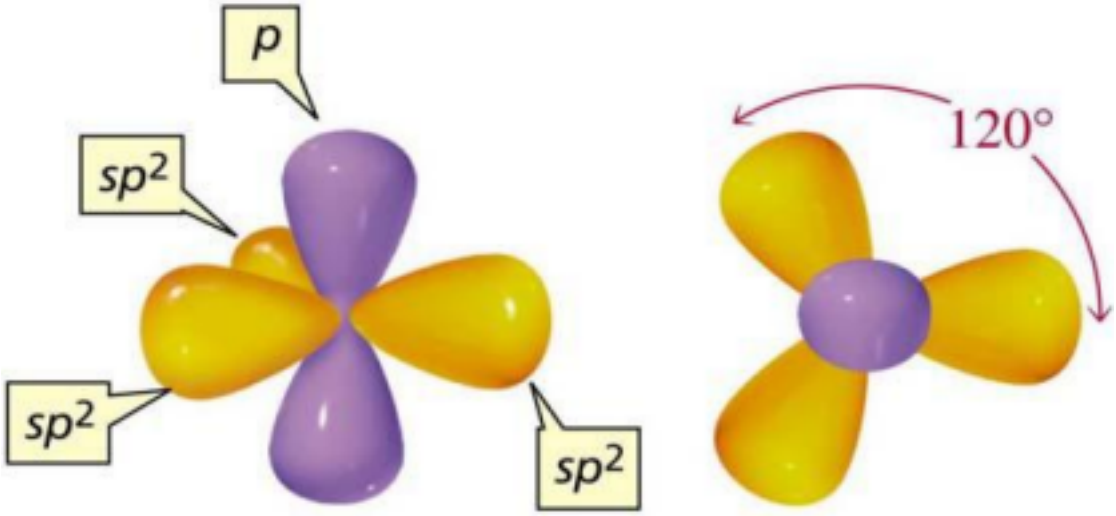




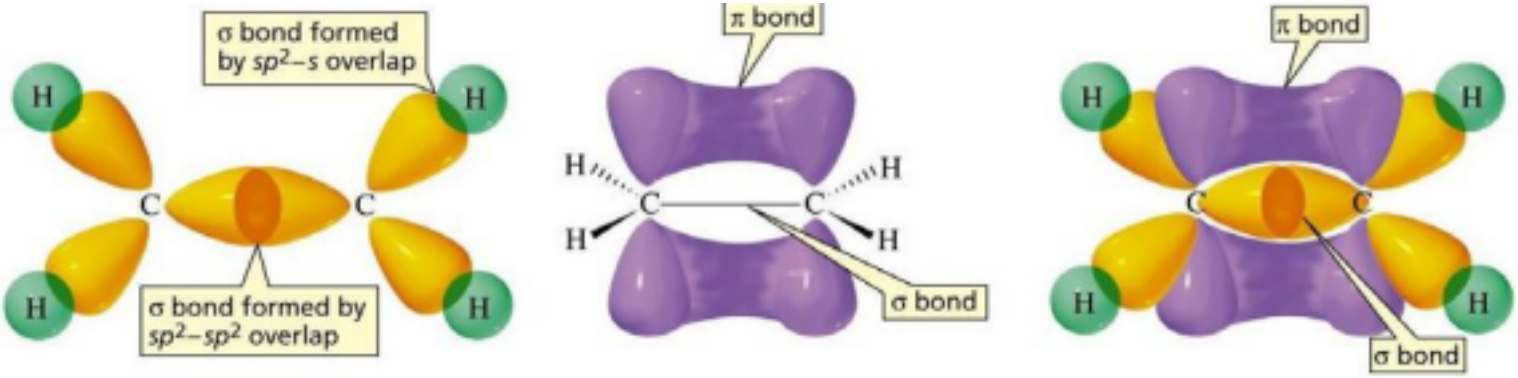
- **Isobutylene = 2-methylpropene**
- **Isoprene = 2-methyl-1,3-butadiene**

Electronic Structure of Alkenes

- Carbon atoms in a double bond are sp^2-hybridized –
  Three equivalent orbitals at 120º separation in plane –
  Fourth orbital is atomic *p* orbital
- Combination of electrons in two sp^2 orbitals of two atoms forms σ bond between them
- Additive interaction of *p* orbitals creates a π bonding orbital – Subtractive interaction creates a π anti-bonding orbital • Occupied π orbital prevents rotation about σ-bond • Rotation prevented by π bond - high barrier, about 268 kJ/mole in ethylene



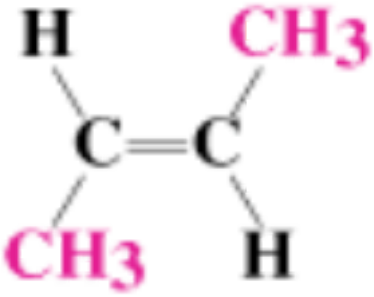
ALL trigonal carbons such as those found in double bonds are sp2 hybridised. The unused p orbital on each carbon overlaps to form the π part of the double bond, e.g. ethene.



Cis-Trans Isomerism in Alkenes

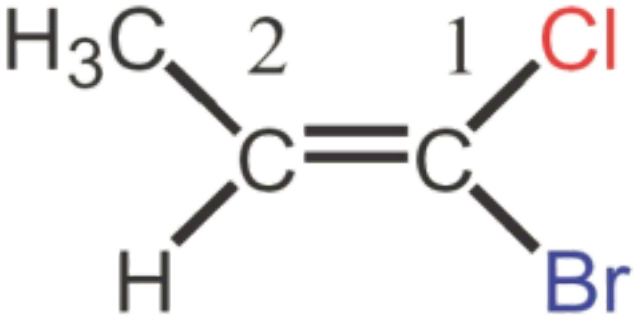
- The presence of a carbon carbon double can create two possible structures
  - *cis* isomer - two similar groups on same side of the double bond
  - *trans* isomer similar groups on opposite sides
- Each carbon must have two different groups for these isomers to occur

cis-2-Butene

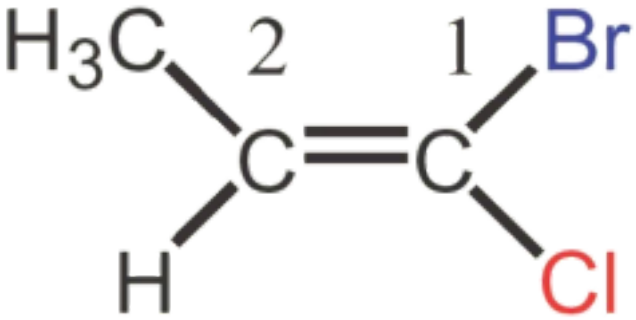


trans-2-Butene

Sequence Rules: The *E,Z* Designation



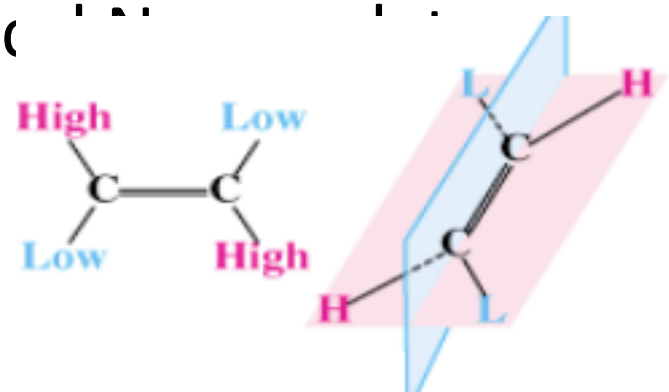
- Neither compound is clearly "*cis*" or "*trans*"
  - Substituents on C1 are different than those on C2
  - We need to define "similarity" in a precise way to distinguish the two stereoisomers



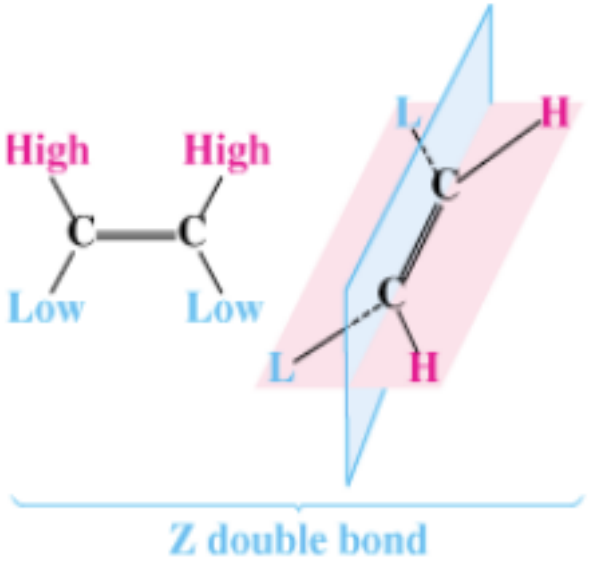
- *Cis, trans* nomenclature only works for disubstituted double bonds

Stereochemic

- Priority rules of Cahn, Ingold, and Prelog



- Compare where higher priority group is with respect to bond and designate as prefix
- E -*entgegen,* opposite sides
- Z - *zusammen,* together on the same side



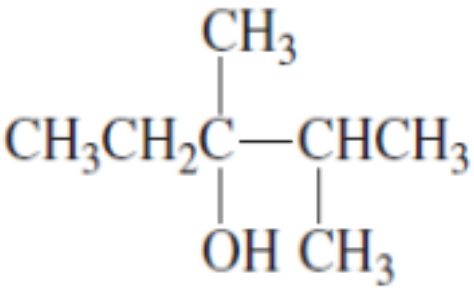
Prepartion of Alkenes1.

Dehydration of an Alcohol CH_3

H_3C C C

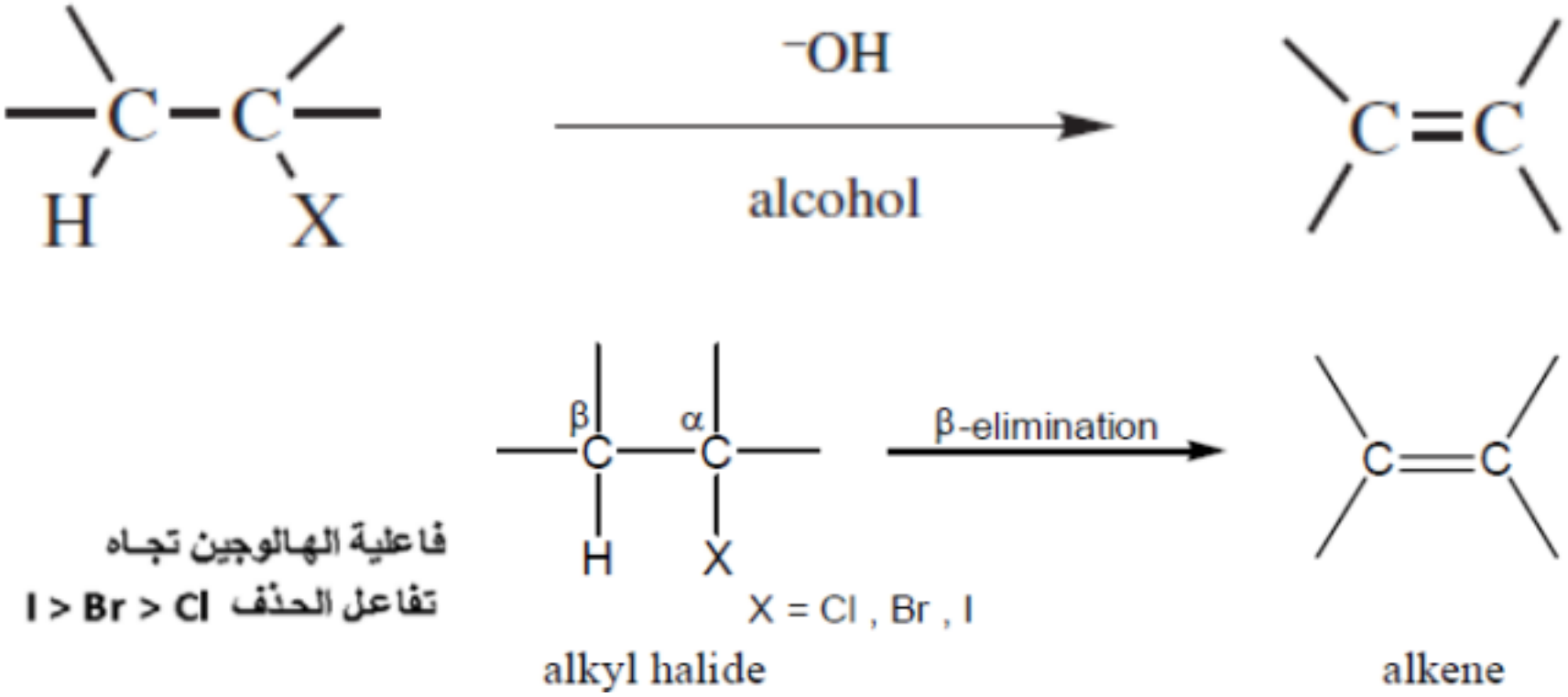
CH_3 + $H_2SO_4CH_2$

C CH_3 OH H_3C

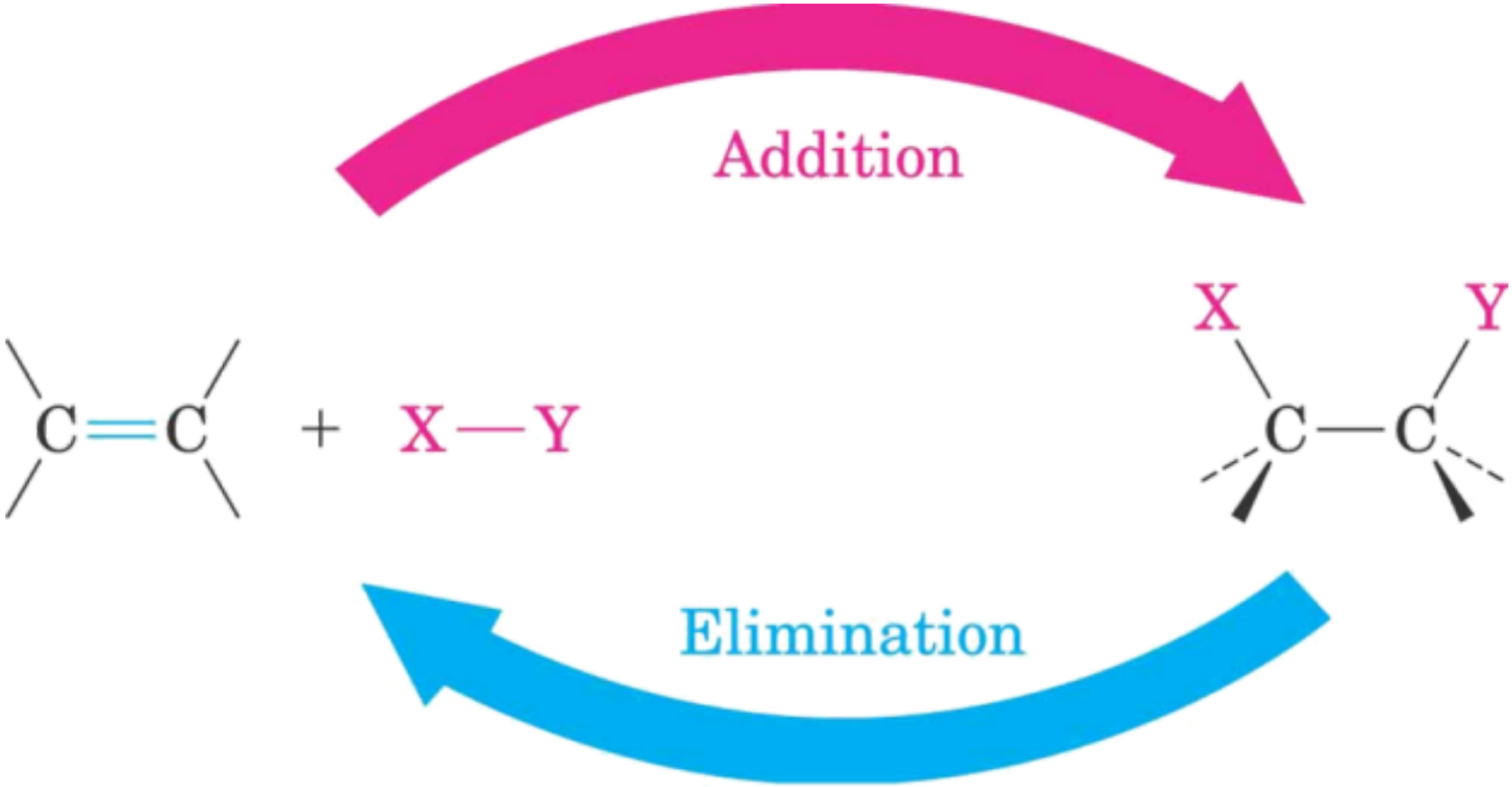


Mechanism of acid-catalyzed dehydration of *tert*-butyl alcohol Figure 5.6

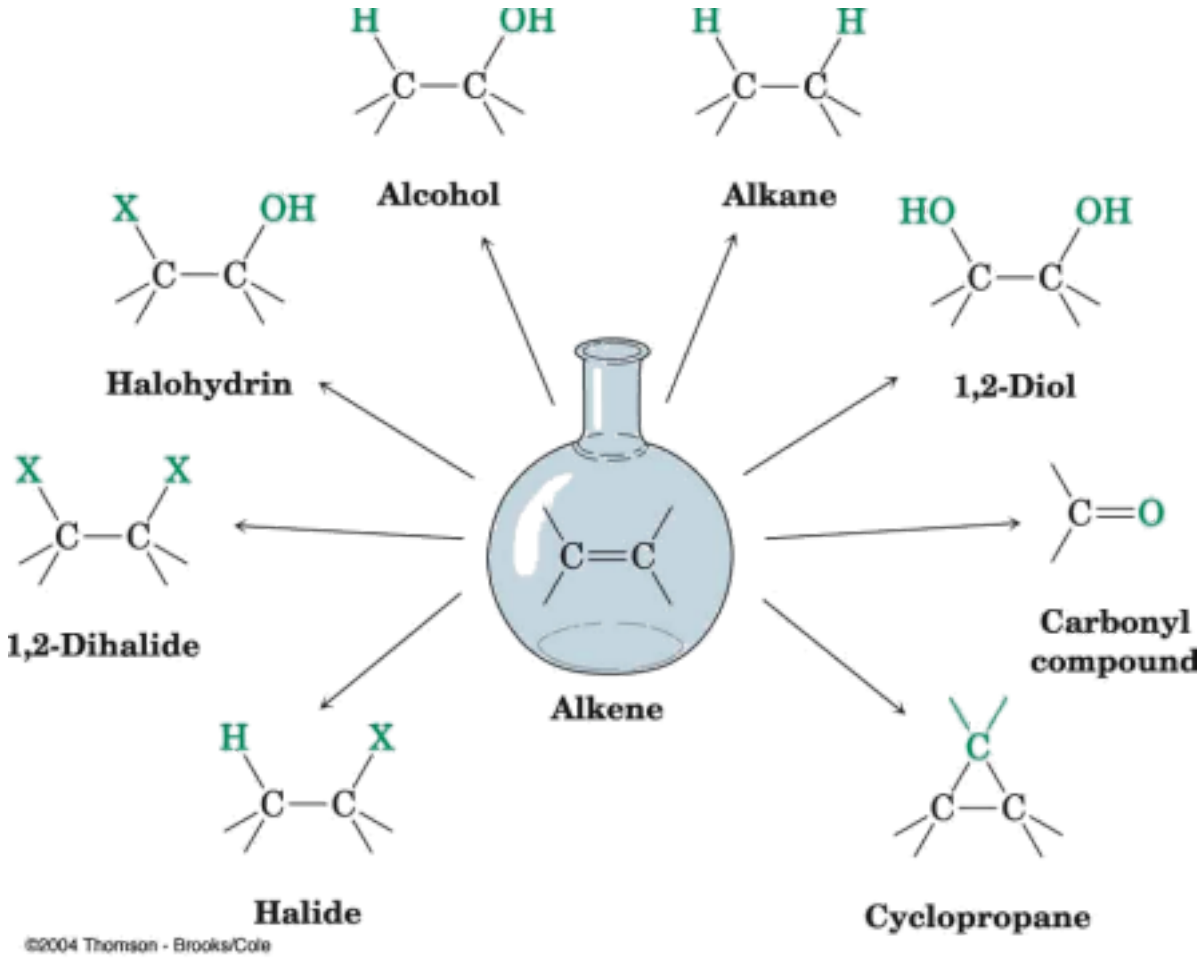
2. Dehydrohalogenation of alkyl halides



Alkenes and Alkynes II: Reactions:

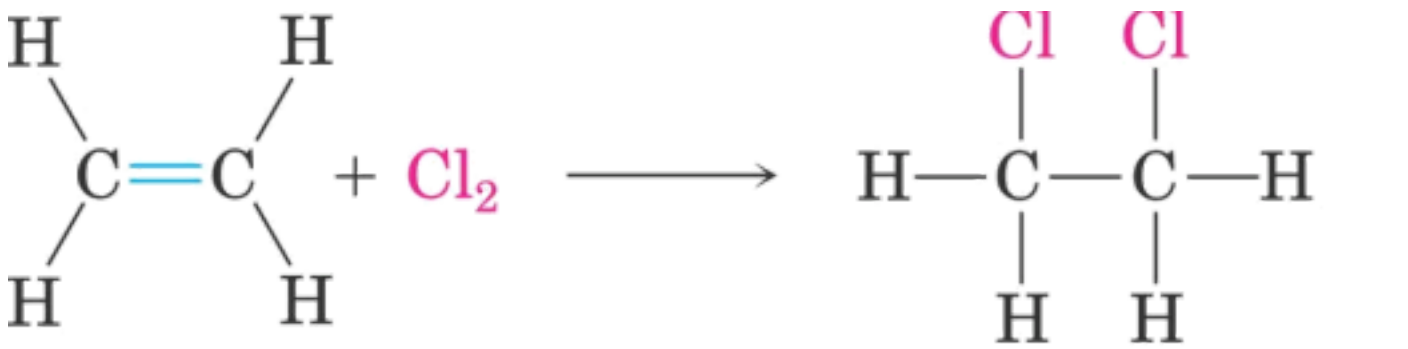


Addition Reactions



Addition of Halogens X

$$\text{C C} + \text{X}_2\,\text{C C X}$$

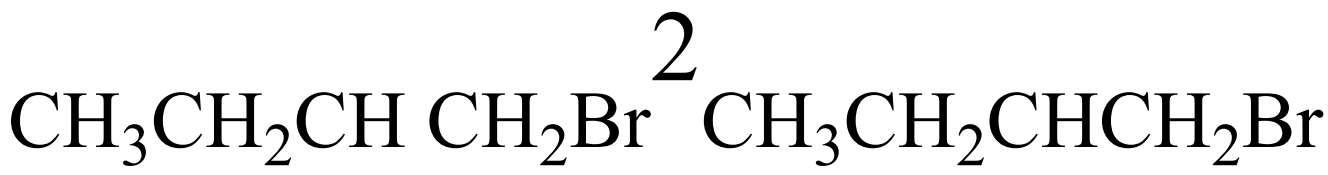


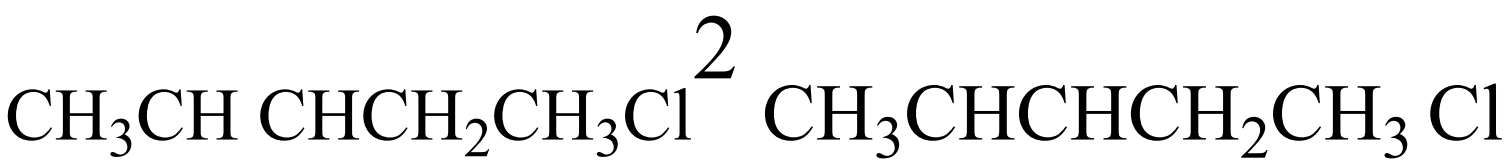
Ethylene

1,2-Dichloroethane (Ethylene dichloride)

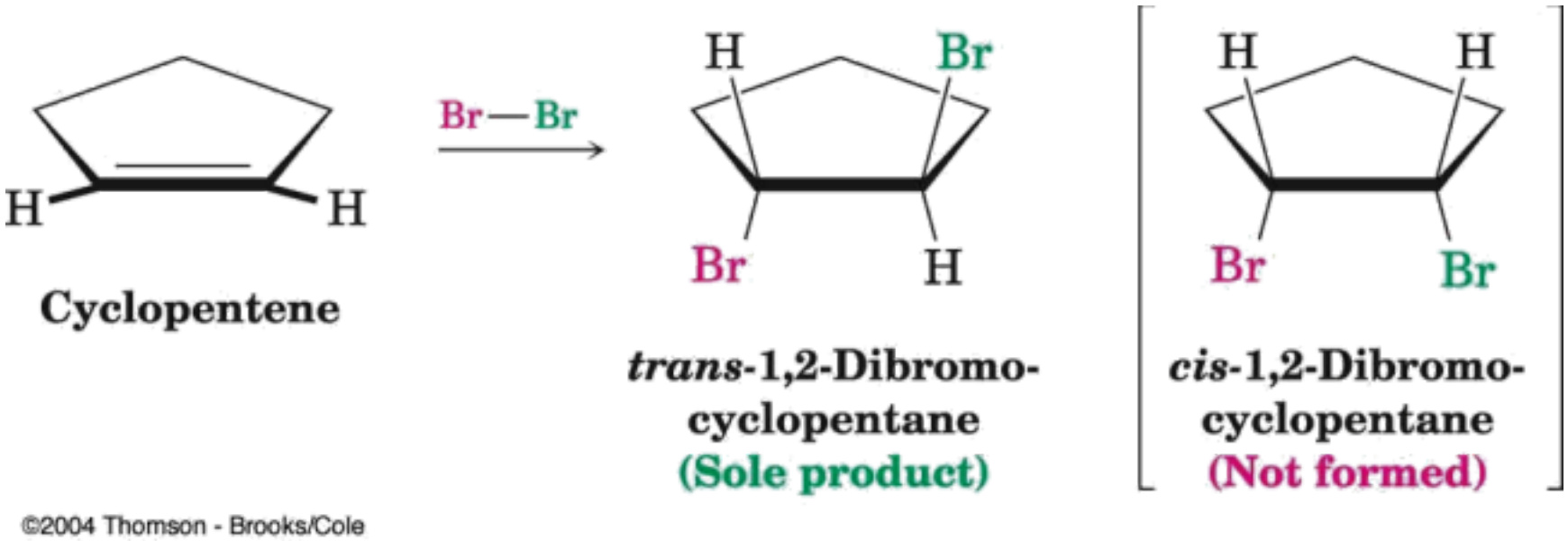
Examples

Br



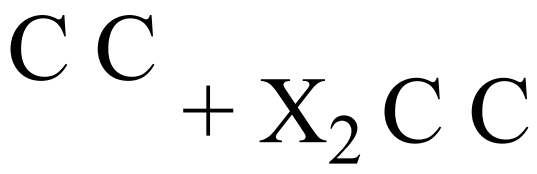


Mechanism



Halohydrin Formation

OH



H_2O

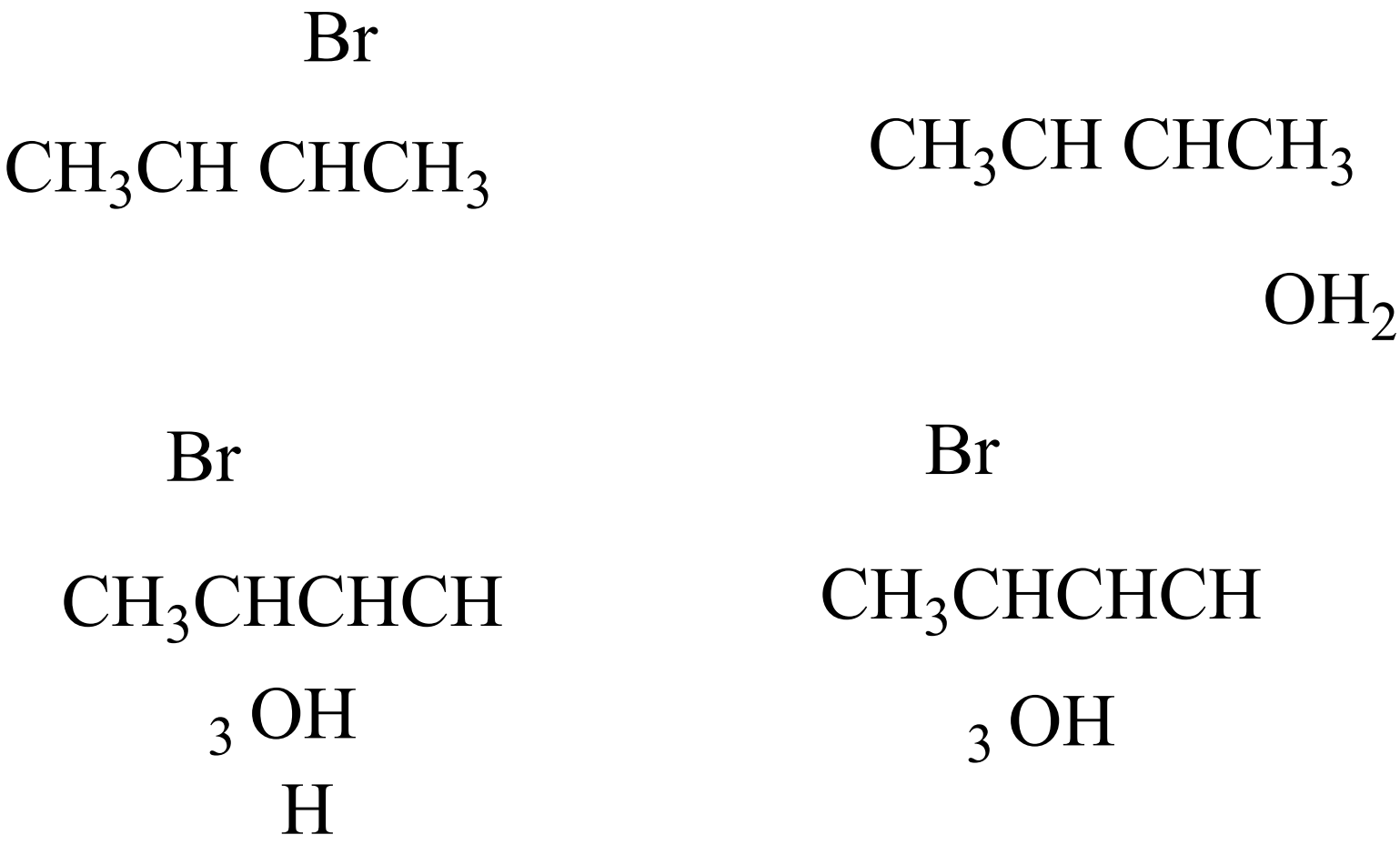
X

OH

$CH_3CH\ CHCH_3Br_2$

$H_2OCH_3CHCHCH_3\ Br$

Mechanis m Br Br

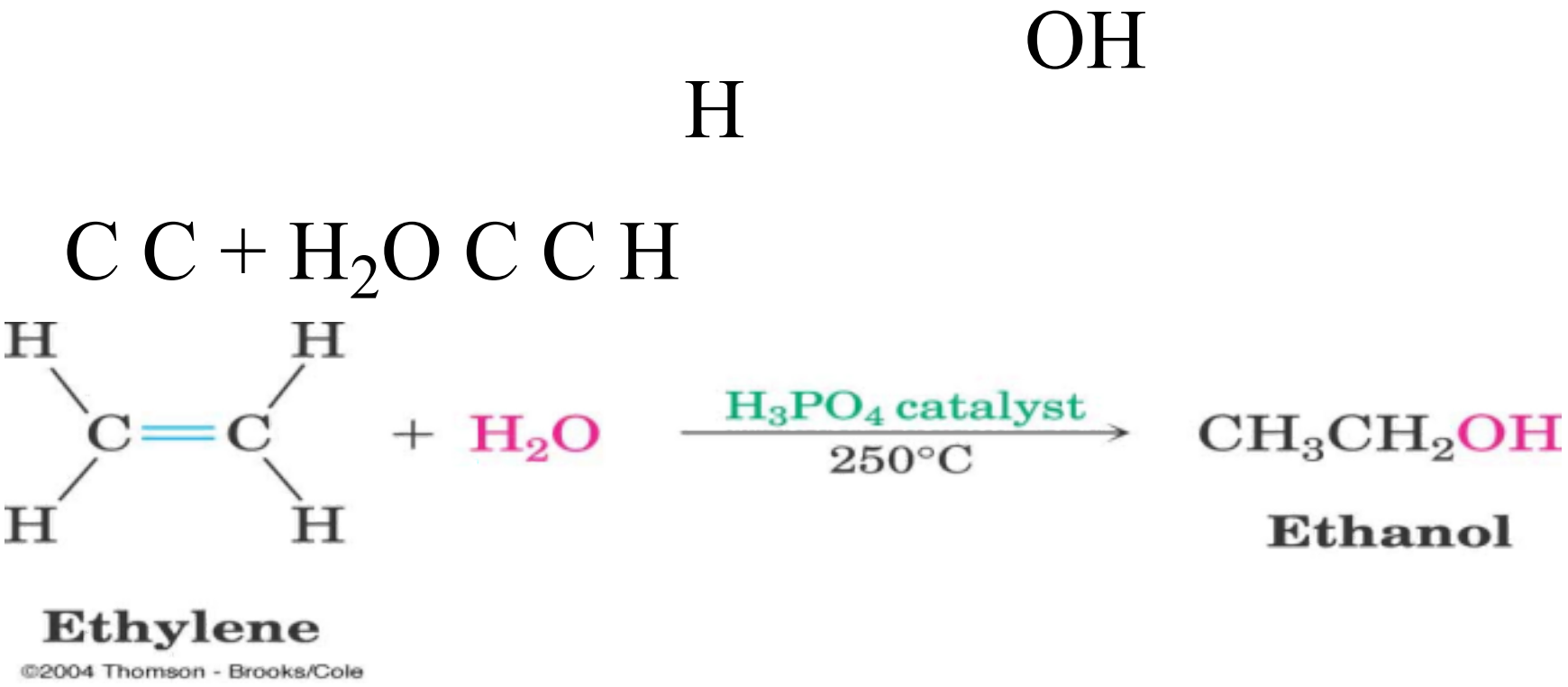


Addition of Water to

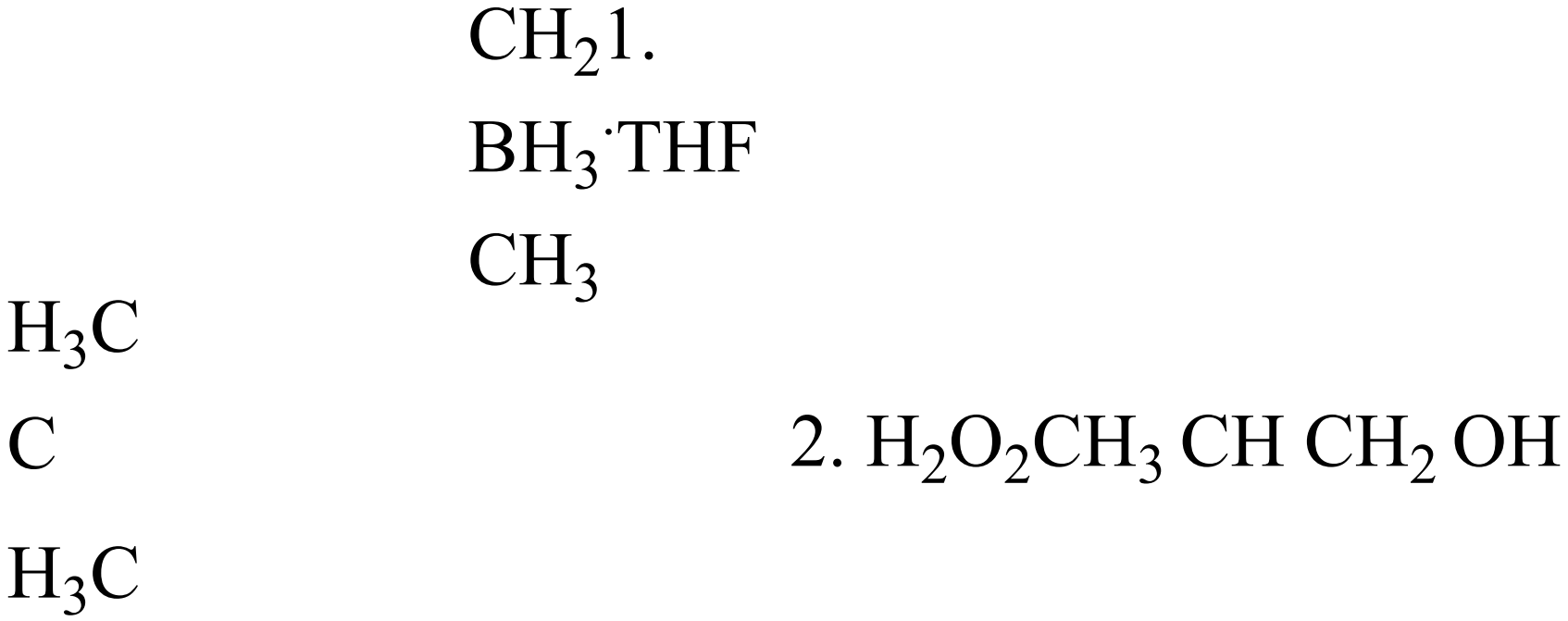
Alkenes • Acid-Catalyzed Hydration

- Oxymercuration-Demercuration
- Hydroboration-Oxydation

Acid-Catalyzed Hydration



Anti-Markovnikov Addition



Benzene and Aromaticity

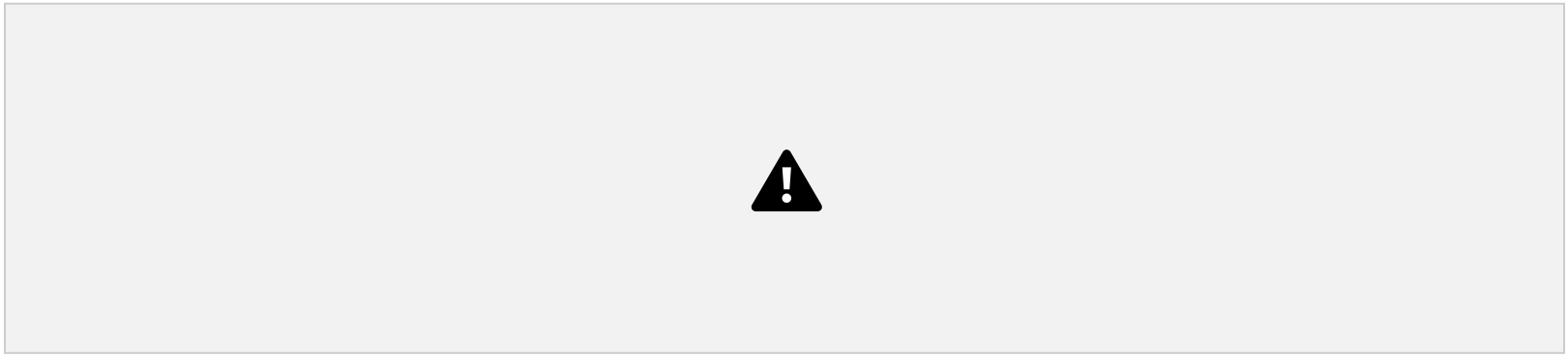
Aromatic Compounds

Aromatic was used to described some fragrant compounds in early 19th century

Not correct: later they are grouped by chemical behavior

(unsaturated compounds that undergo substitution rather than addition)

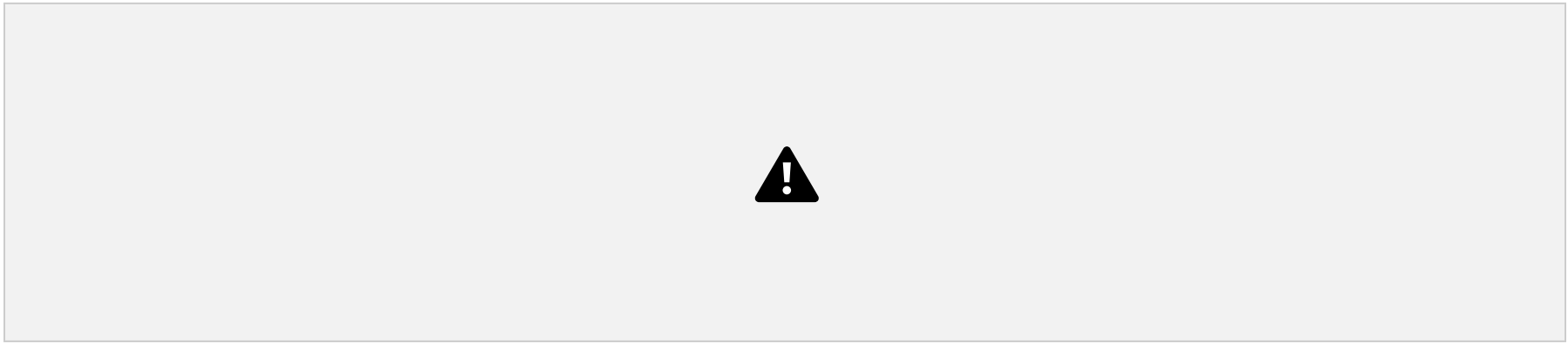
Current: distinguished from *aliphatic* compounds by electronic configuration



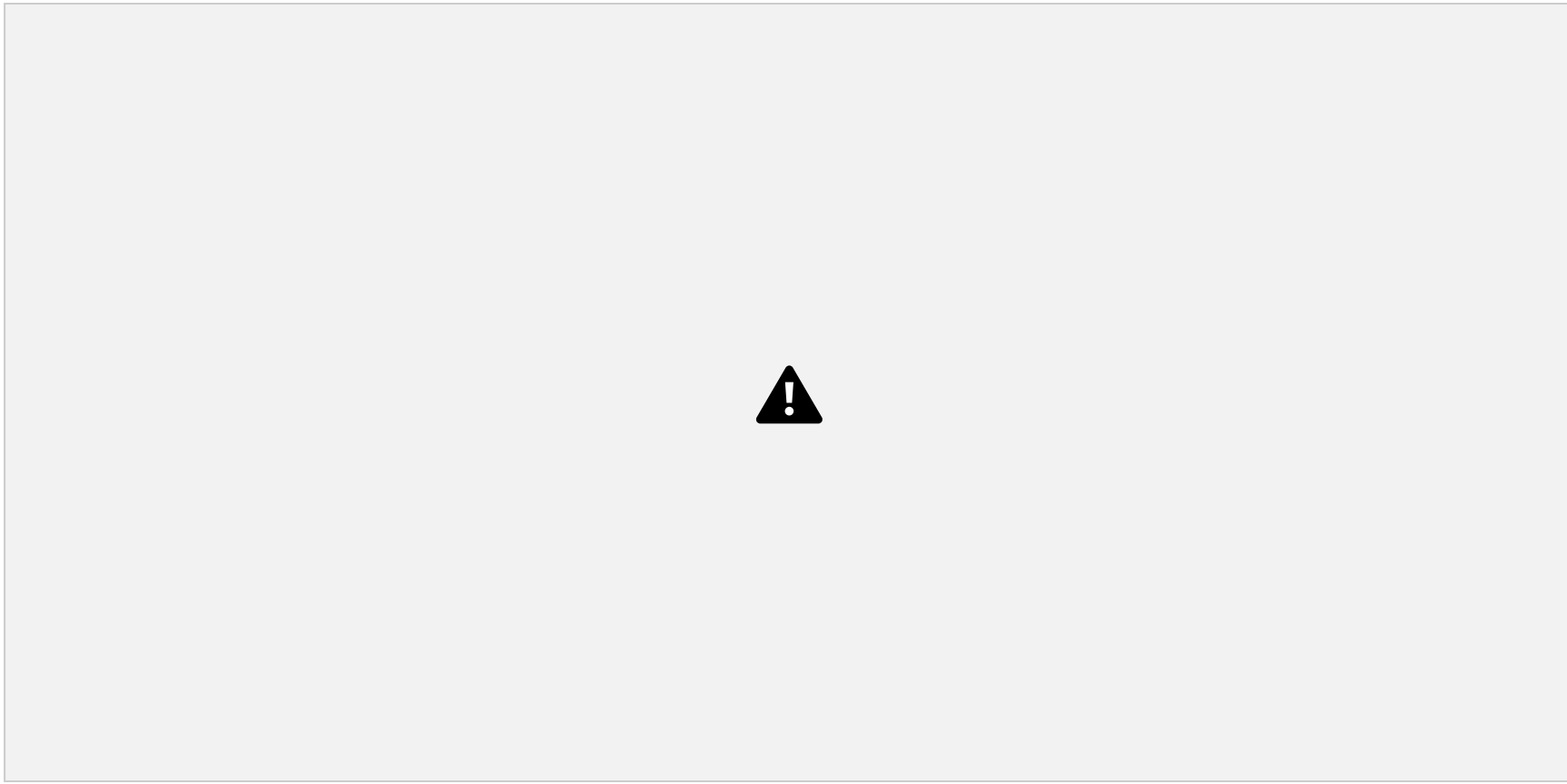
Naming Aromatic Compounds

- Many common names (toluene = methylbenzene; aniline = aminobenzene)
- Monosubstituted benzenes systematic names as hydrocarbons with –*benzene*
  - C_6H_5Br = bromobenzene

– $C_6H_5NO_2$ = nitrobenzene, and $C_6H_5CH_2CH_2CH_3$is propylbenzene



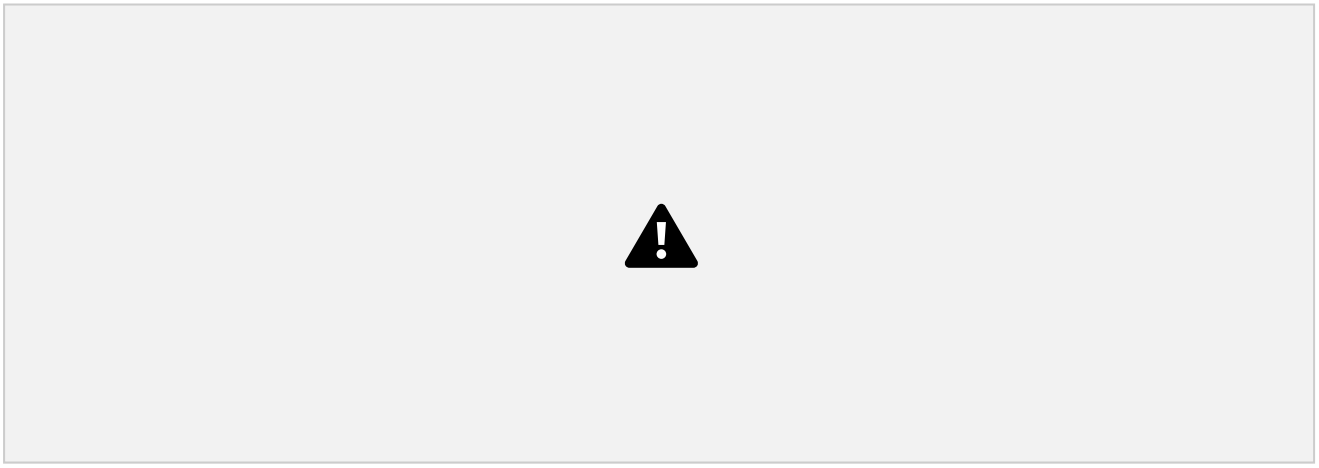
Common Names



Disubstituted Benzenes

- Relative positions on a benzene ring

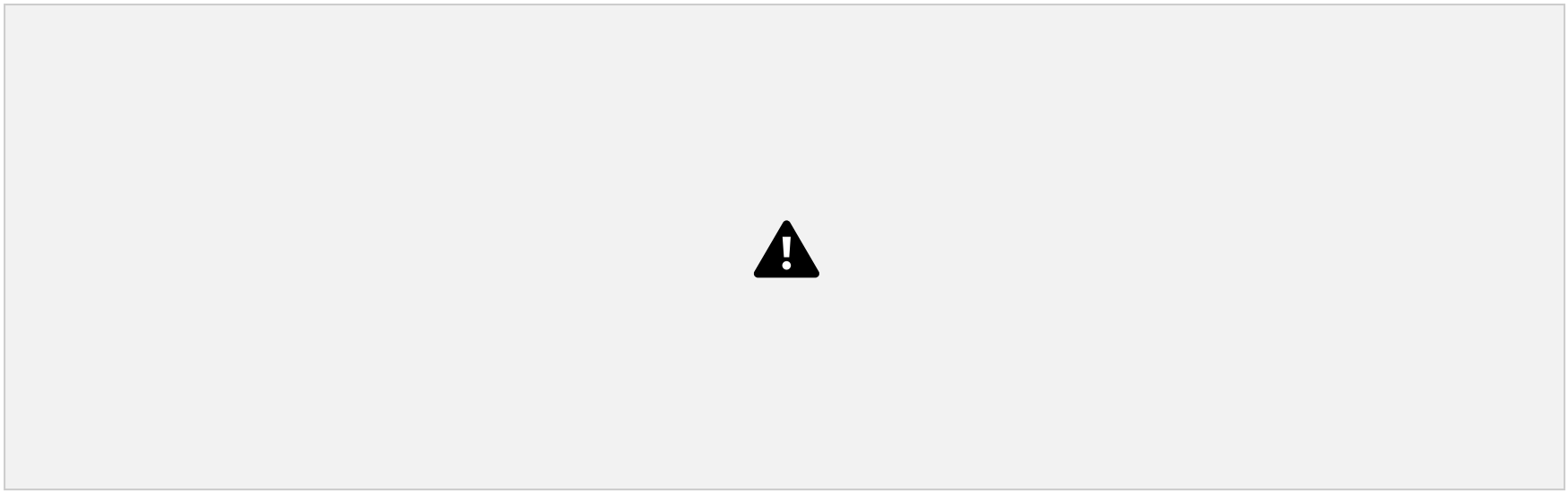
  - *ortho- (o)* on adjacent carbons (1,2)
  - *meta- (m)* separated by one carbon (1,3)
  - *para- (p)* separated by two carbons (1,4)
- Describes reaction patterns (“occurs at the para position”)



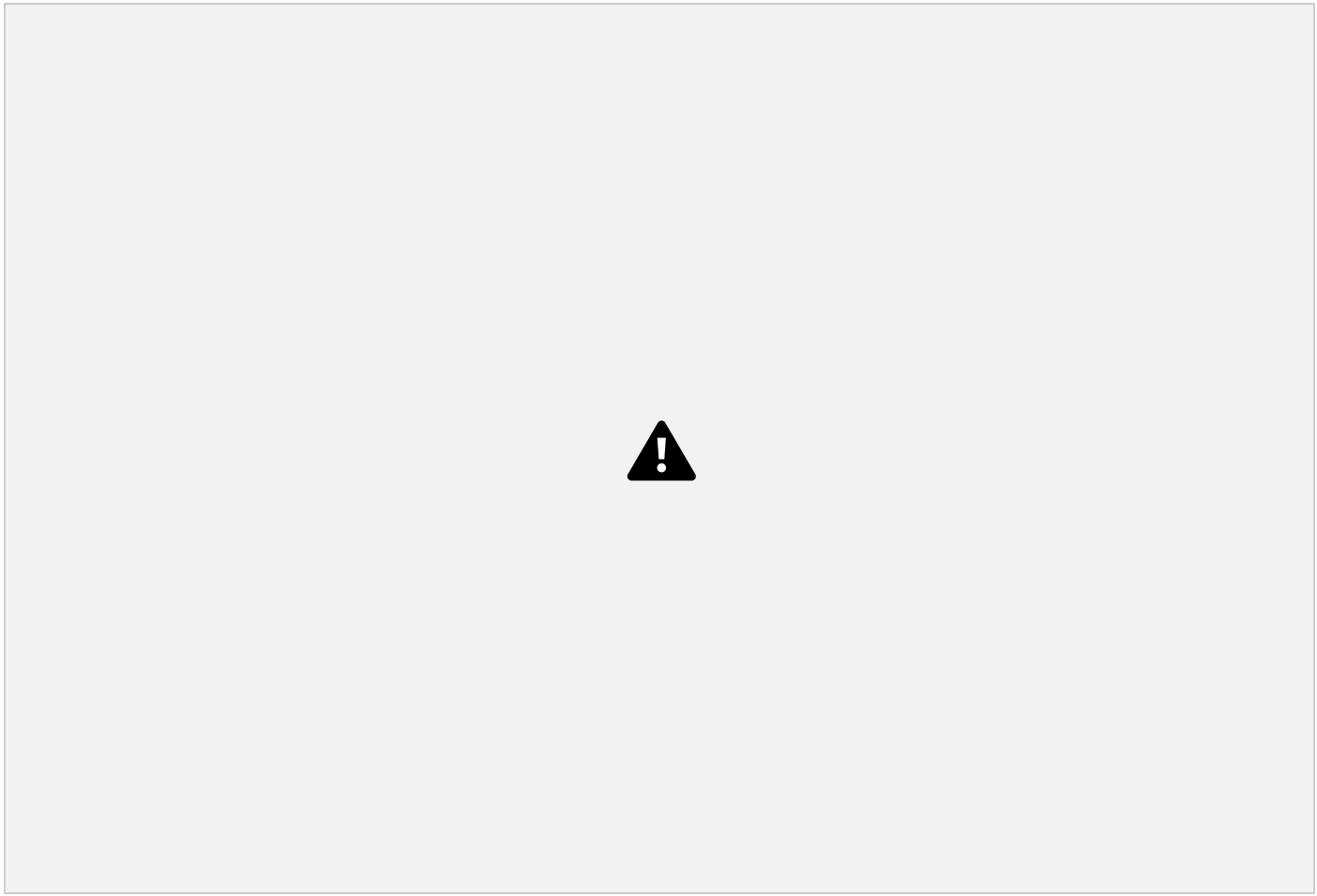
$CH_3\ CH_3$

$H_3C\ CH_3CH_3\ H_3C$

ortho-Xylene *meta*-Xylene *para*-Xylene



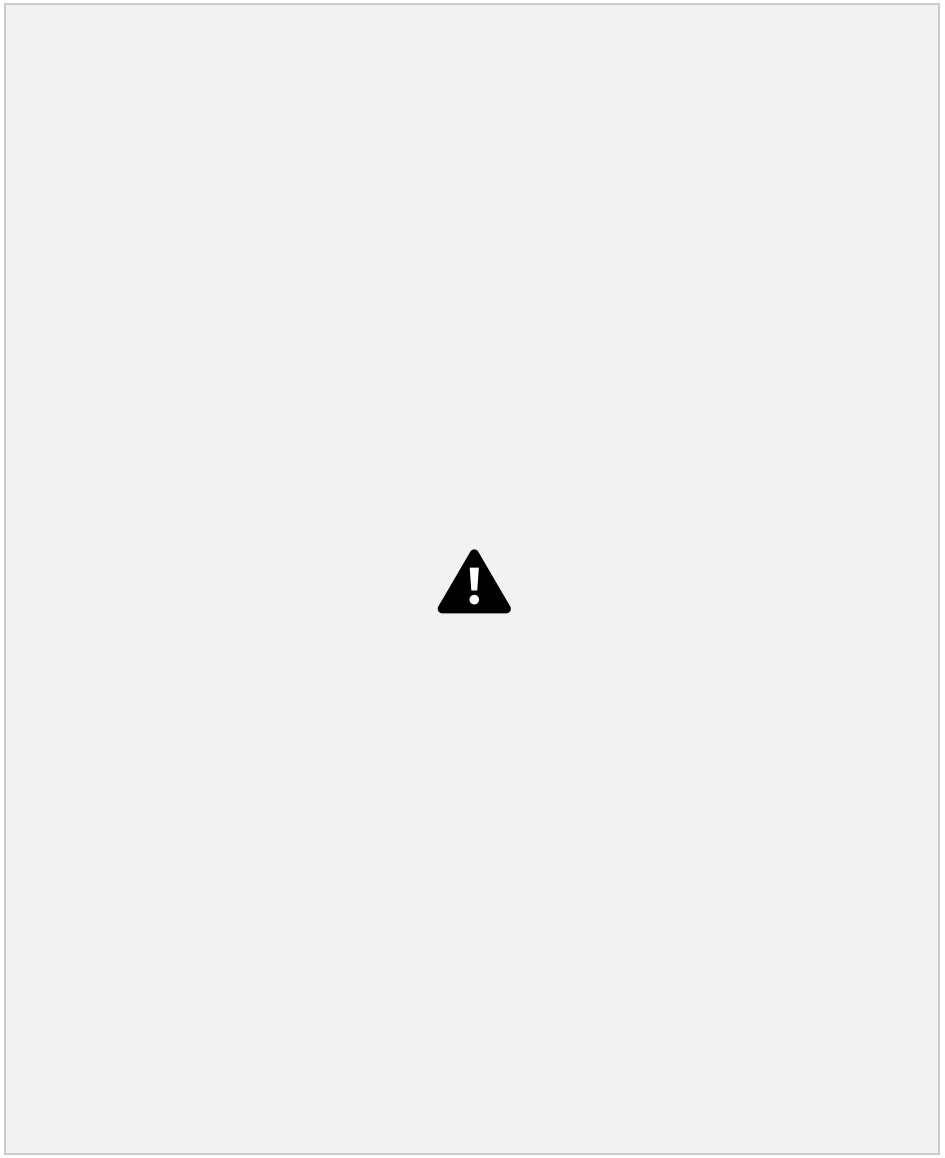
Reactions of Benzene



Aromatic Heterocycles: Pyridine and Pyrrole

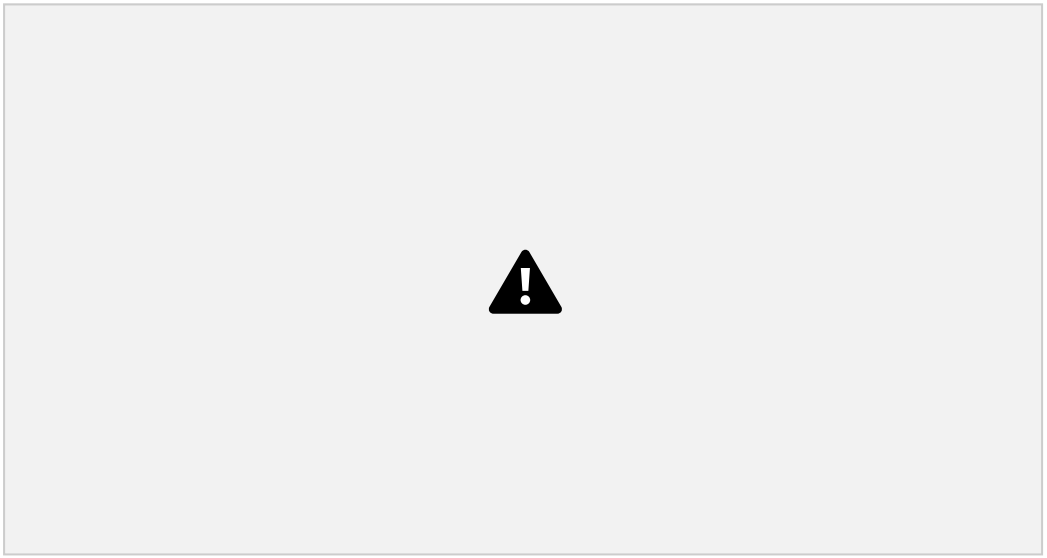
- Heterocyclic compounds contain elements other than carbon in a ring, such as N,S,O,P
- Aromatic compounds can have elements other than carbon in the ring
- There are many heterocyclic aromatic compounds and many are very common
- Cyclic compounds that contain only carbon are called carbocycles (not homocycles)
- Nomenclature is specialized

Pyridine, Pyrrole, & Furan



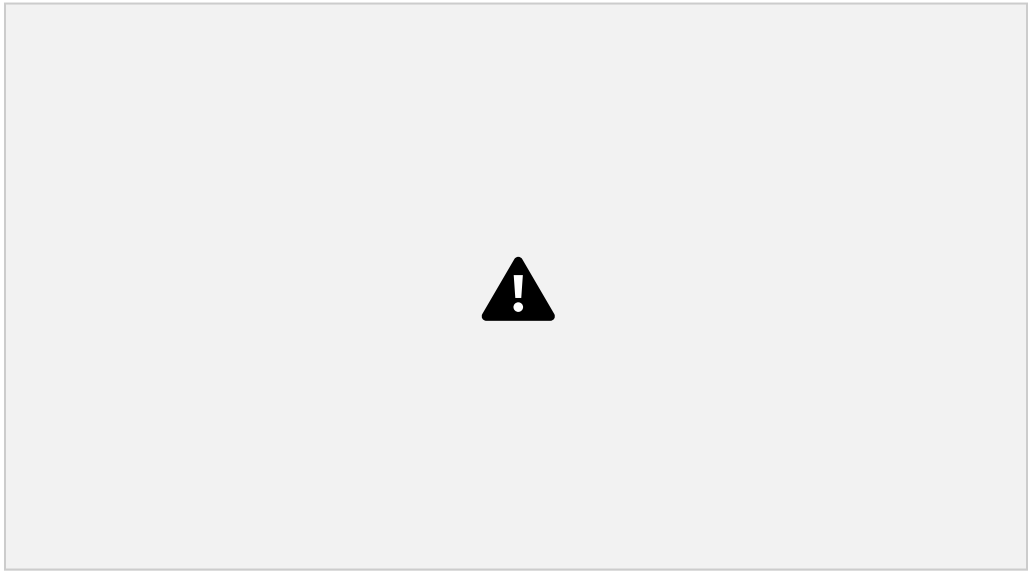
Pyridine

- A six-membered heterocycle with a nitrogen atom in its ring
- π electron structure resembles benzene (6 electrons) • The nitrogen lone pair electrons are not part of the aromatic system (perpendicular orbital)
- Pyridine is a relatively weak base compared to normal amines but protonation does not affect aromaticity



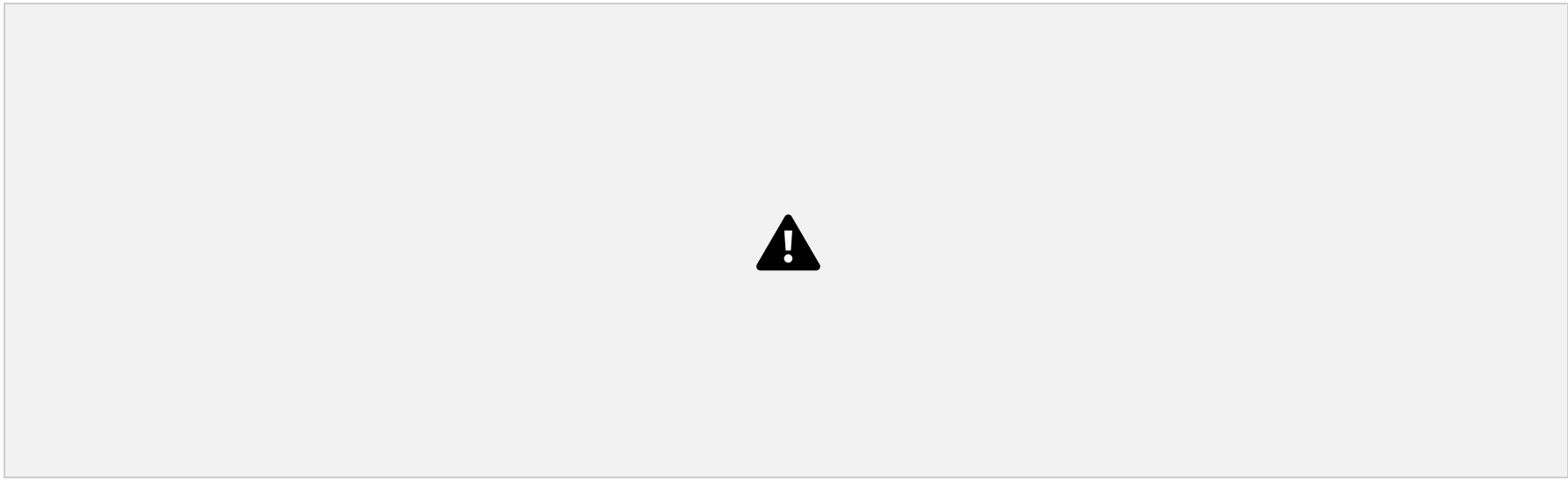
Pyrrole

- **A five-membered heterocycle with one nitrogen**
- **π electron system similar to that of cyclopentadienyl anion • Four *sp*2-hybridized carbons with 4 *p* orbitals perpendicular to the ring and 4 p electrons**
- **Nitrogen atom is sp^2-hybridized, and lone pair of electrons occupies a *p* orbital (6 π electrons)**
- **Since lone pair electrons are in the aromatic ring, protonation destroys aromaticity, making pyrrole a very weak base**



Polycyclic Aromatic Compounds: Naphthalene

- Aromatic compounds can have rings that share a set of carbon atoms (fused rings)
- Compounds from fused benzene or aromatic heterocycle rings are themselves aromatic



Madenet Al elm University College
Department of Medical Physics
Second Year 2021 - 2022

Functional Groups

Dr. Hamza Yaseen Isa

Lecture M 3 I 2

Functional Groups

Functional group:

- **Functional group:** an atom or group of atoms within a molecule that shows a characteristic set of physical and chemical properties

- **Functional groups are important for three reason; they are**

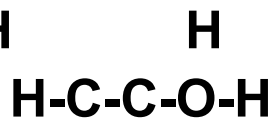
  1. the units by which we divide organic compounds into classes

  2. the sites of characteristic chemical reactions 3. the basis for naming organic compounds

Alcohols

- contain an -OH (hydroxyl hydroxyl) group

-C-O-H



Functional group
Ethanol
(an alcohol)

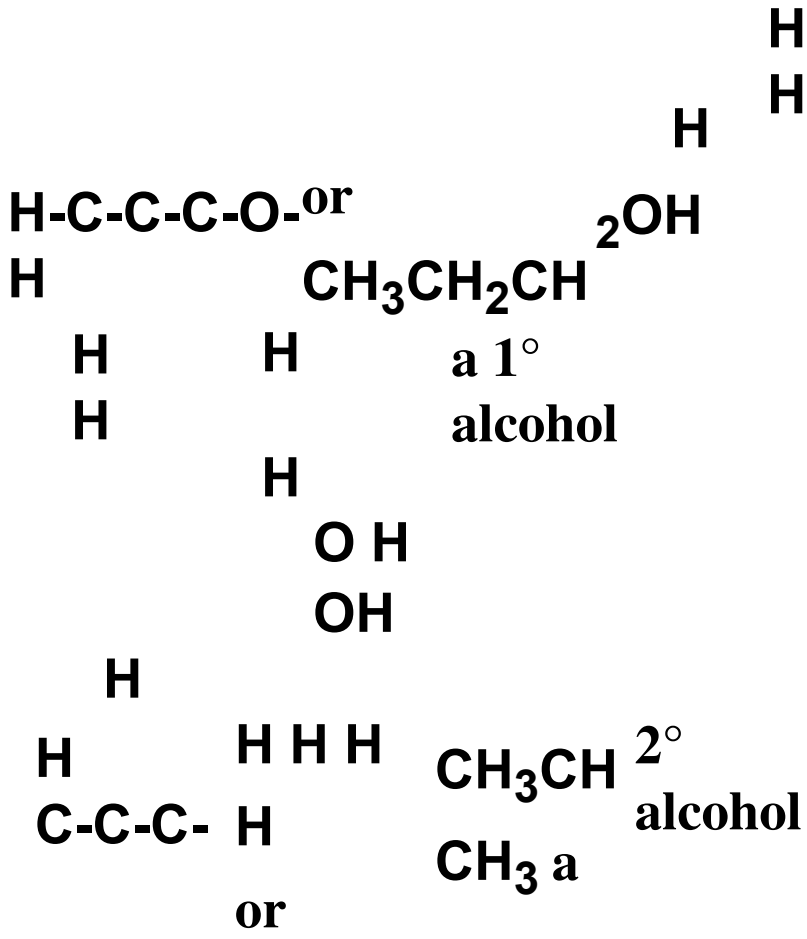
CH_3CH_2OH

CH_3-CH_2-OH **or**

- Ethanol may also be written as a condensed structural formula

Alcohols

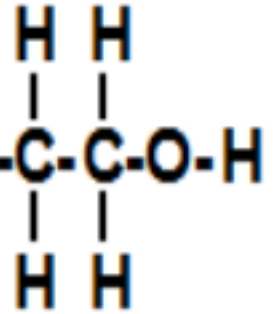
– **there are two alcohols with molecular formula C_3H_8O**



Alcohols

- alcohols are classified as primary (1°), secondary (2°), or tertiary (3°) depending on the number of

carbon atoms bonded to the carbon bearing the - OH group



CH_3

CH_3-C-O

H

CH_3

H

CH_3-C-O

H CH_3

CH_3

CH_3-C-O

H CH_3

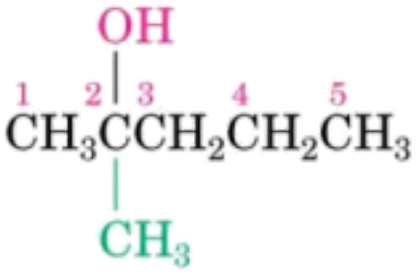
A 1° alcohol A 2° alcohol A 3° alcohol

IUPAC Rules for Naming Alcohols

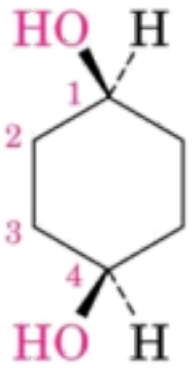
- **Select the longest carbon chain containing the hydroxyl group, and derive the parent name by replacing the -*e* ending of the corresponding alkane with -*ol***
- **Number the chain from the end nearer the hydroxyl group •**

Number substituents according to position on chain, listing

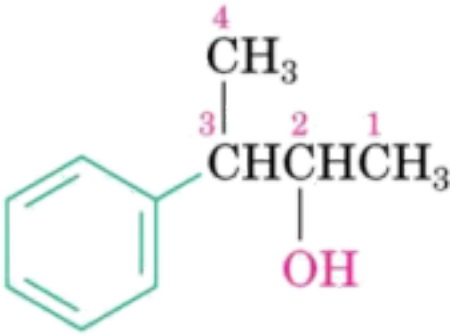
the substituents in alphabetical order



2-Methyl-2-pentanol



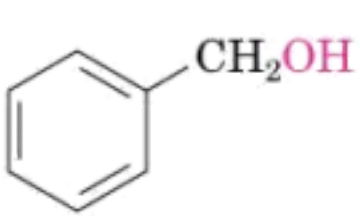
cis-1,4-Cyclohexanediol



3-Phenyl-2-butanol

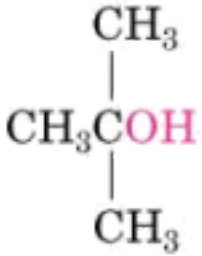
Many Alcohols Have Common Names

- These are accepted by IUPAC



Benzyl alcohol
(Phenylmethanol)

Allyl alcohol
(2-Propen-1-ol)



tert-Butyl alcohol
(2-Methyl-2-propanol)

Glycols

- 1, 2 diols (vicinal diols) are called glycols. • Common names for glycols use the name of the alkene from which they were made.

CH_2CH_2

OH OH

1,2-ethanediol ethylene glycol

$CH_2CH_2CH_3$

OH OH

1,2-propanediol propylene glycol

=>

Properties of Alcohols: Hydrogen

Bonding • **The structure around O of the alcohol or phenol is similar to that in water, sp^3 hybridized**

• **Alcohols and phenols have much higher boiling points than similar alkanes and alkyl halides**

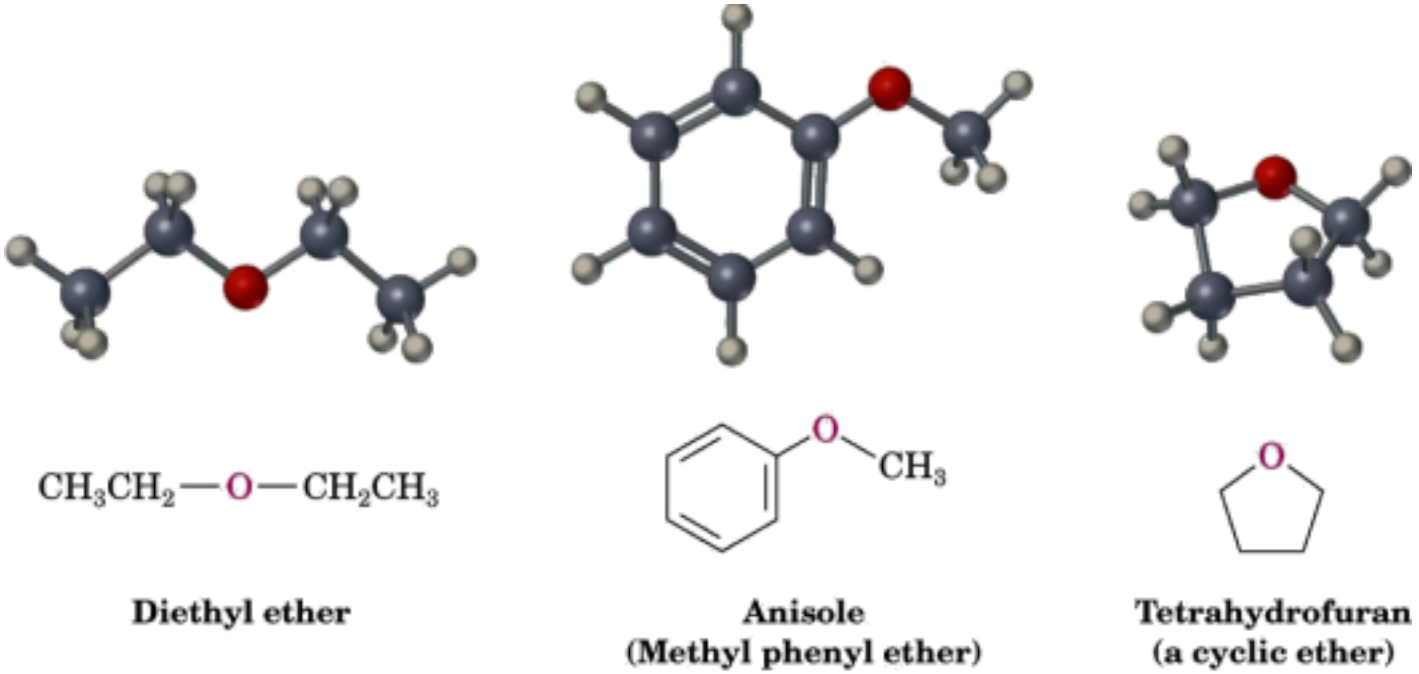
Hydrogen bonding in ethanol

Figure 4.4

Ethers and Their Relatives

- An ether has two organic groups (alkyl, aryl, or vinyl) bonded to the same oxygen atom, R–O–R′
- Diethyl ether is used industrially as a solvent
- Tetrahydrofuran (THF) is a solvent that is a cyclic ether •

Thiols **(R–S–H) and** ***sulfides*** **(R–S–R′) are sulfur (for oxygen) analogs of alcohols and ethers**



Diethyl ether | **Anisole (Methyl phenyl ether)** | **Tetrahydrofuran (a cyclic ether)**

CH_3-O-C(CH_3)$_3$*tert*-butyl methyl ether (MTBE)

If complex, the ether part is named as an "alkoxy" group:

CH_3-O- = methoxy CH_3CH_2-O- = ethoxy, etc.

CH_3-O-$CH_2CH_2CH_2$-O-CH_3 1,3-dimethoxypropane

HO-CH_2CH_2-O-CH_2CH_3 2-ethoxyethanol

Physical properties:

-
-

oxygen is sp^3 hybridized, bond angle ~ 109.5^o

ethers are polar; no hydrogen bonding mp/bp

moderate

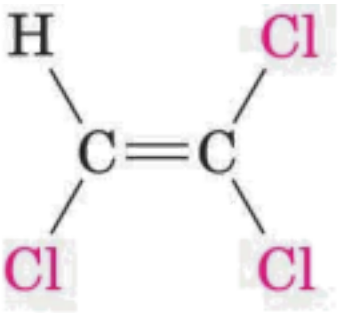
water insoluble

Diethyl ether = very important organic solvent, polar, water insoluble, bp = 35^o. Very flammable & forms explosive peroxides.

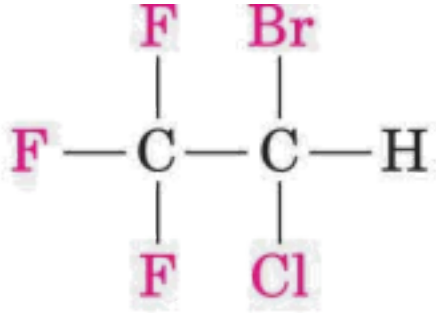
Alkyl Halides

- An organic compound containing at least one carbon-halogen bond (C-X)

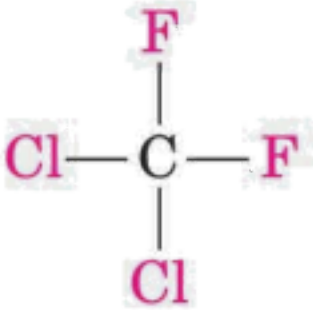
  - X (F, Cl, Br, I) replaces H
- Can contain many C-X bonds
- Properties and some uses
  - Fire-resistant solvents
  - Refrigerants
  - Pharmaceuticals and precursors



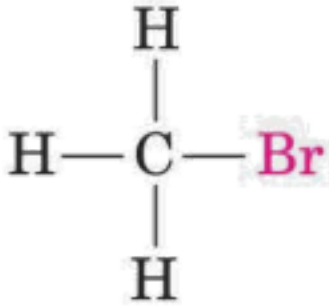
Trichloroethylene
(a solvent)



Halothane
(an inhaled anesthetic)



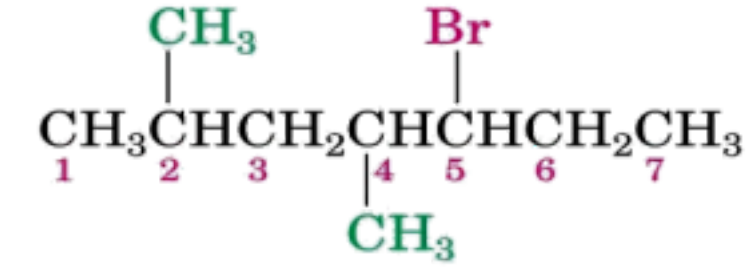
Dichlorodifluoromethane
(a refrigerant)



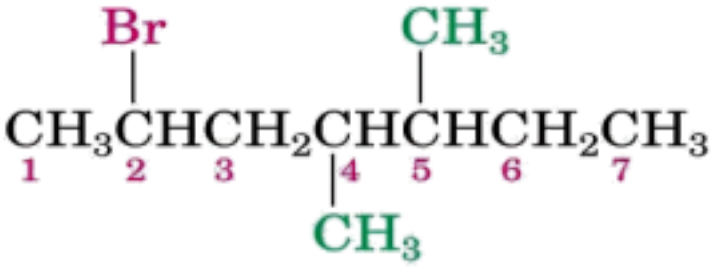
Bromomethane
(a fumigant)

Naming Alkyl Halides

- **Name is based on longest carbon chain**
  - **(Contains double or triple bond if present)**
  - **Number from end nearest any substituent (alkyl or halogen)**



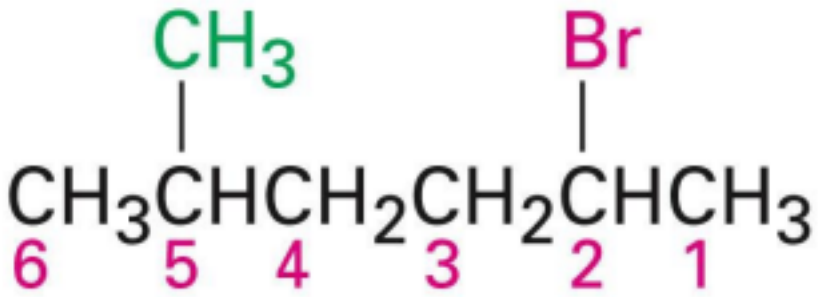
5-Bromo-2,4-dimethylheptane



2-Bromo-4,5-dimethylheptane

Naming if Two Halides or Alkyl Are Equally Distant from Ends of Chain

- **Begin at the end nearer the substituent whose name comes first in the alphabet**

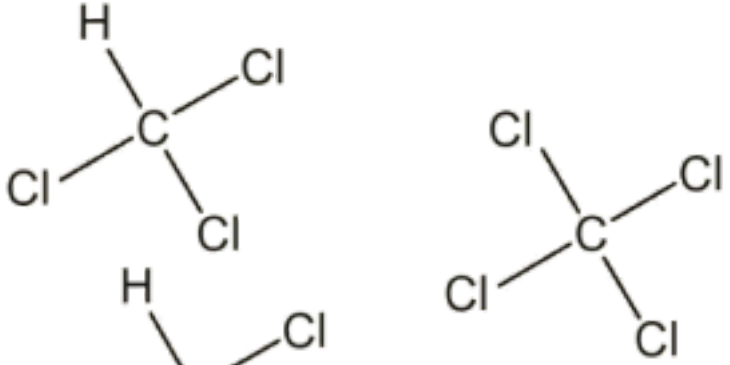


2-Bromo-5-methylhexane

(*NOT* 5-bromo-2-methylhexane)

Many Alkyl Halides That Are Widely Used Have Common Names

- Chloroform
- Carbon tetrachloride



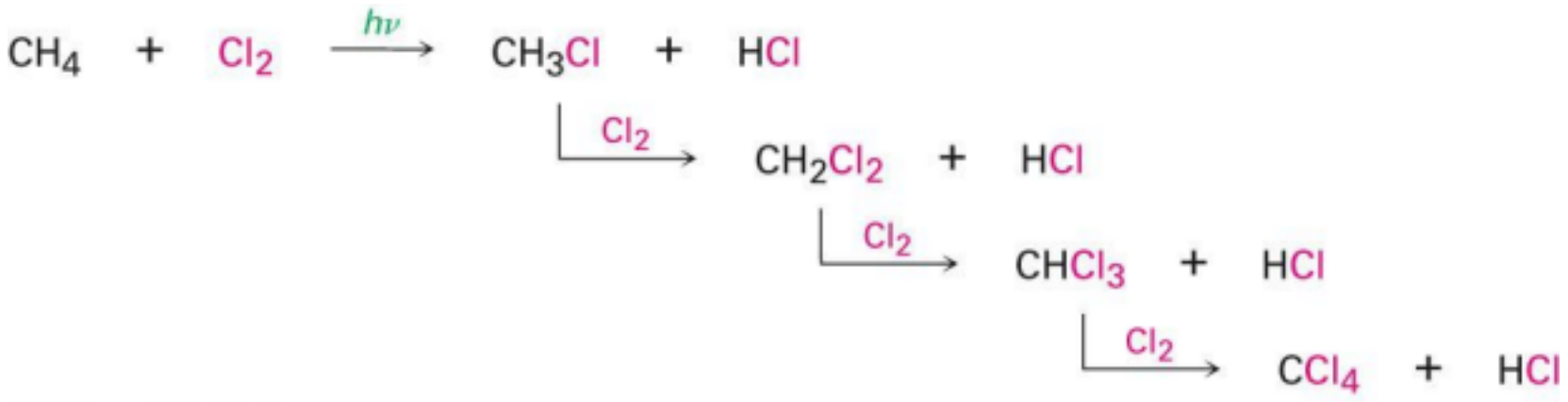
- Methylene chloride
- Methyl iodide
- Trichloroethylene

Preparing Alkyl Halides from Alkanes: Radical Halogenation

- **Alkane + Cl_2 or Br_2, heat or light replaces C-H with C-X but gives mixtures**
  - **Hard to control**

– **Via free radical mechanism**

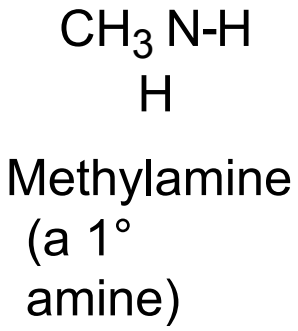
• **It is usually not a good idea to plan a synthesis that uses this method—multiple products**



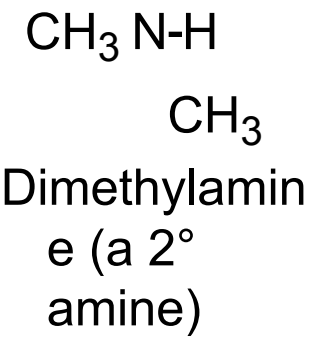
Amines

• contain an amino group; an sp^3-hybridized nitrogen bonded to one, two, or three carbon atoms

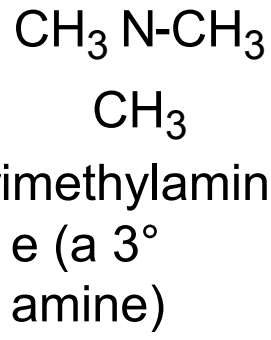
– an amine may by 1°, 2°, or 3°



Methylamine (a 1° amine)



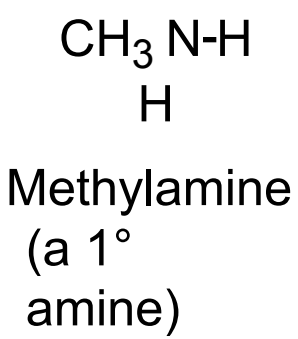
Dimethylamine (a 2° amine)



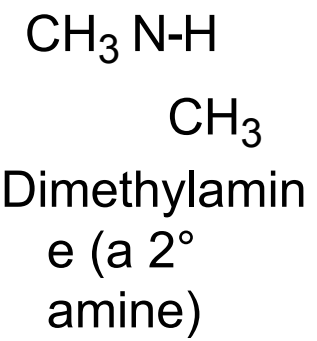
Trimethylamine (a 3° amine)

Amines

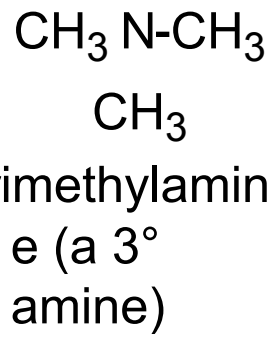
- contain an amino group; an sp^3-hybridized nitrogen bonded to one, two, or three carbon atoms
  - an amine may by 1°, 2°, or 3°



Methylamine (a 1° amine)

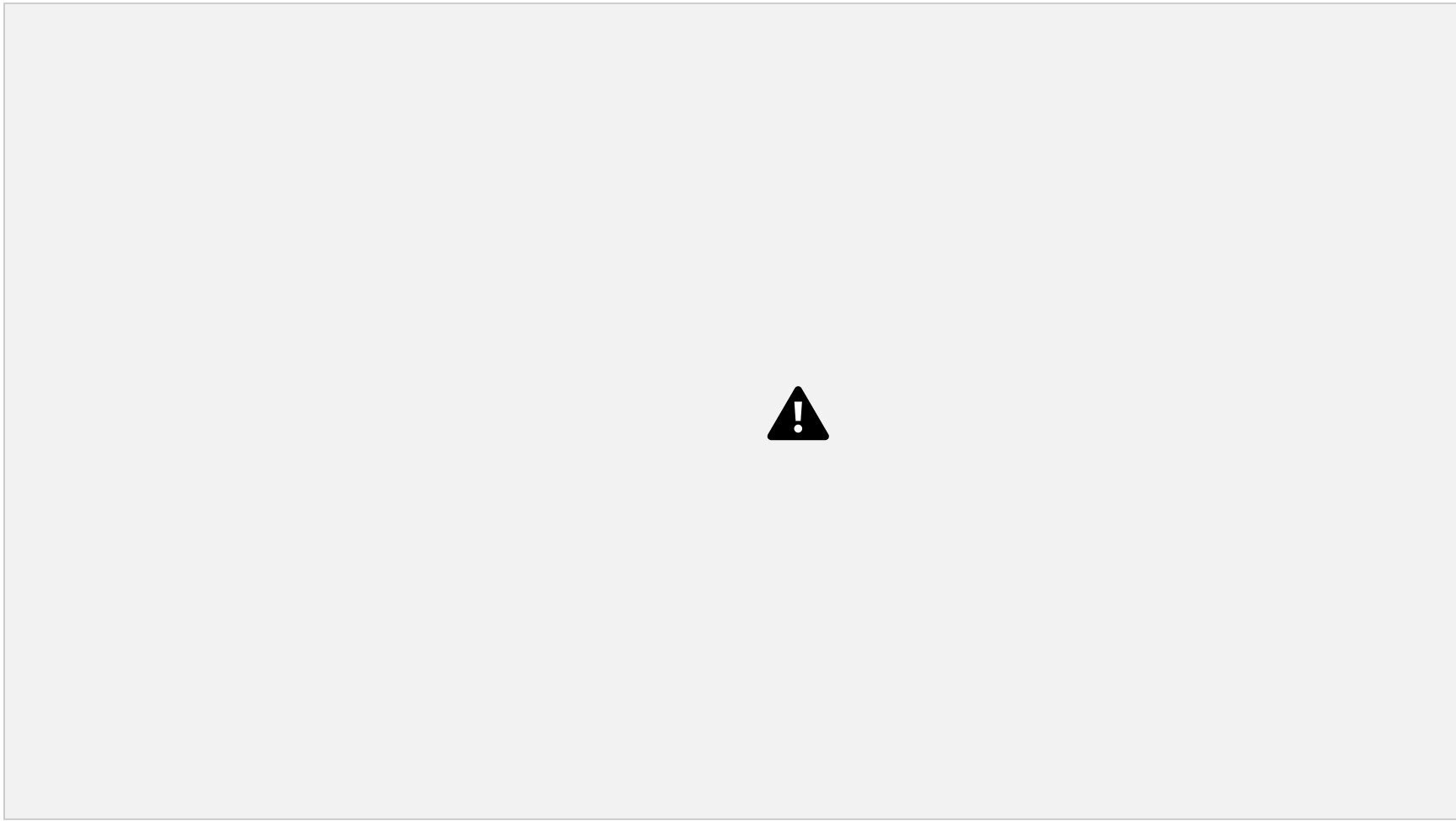


Dimethylamine (a 2° amine)



Trimethylamine (a 3° amine)

- Organic derivatives of ammonia
- Many are biologically active.



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Biological Activity

- Neurotransmitters: dopamine
- Bioregulators: epinephrine
- Vitamins: niacin, B_6
- Alkaloids: nicotine, morphine, cocaine
- Amino acids

=>

Classes of Amines

- Primary (1°): one C-N bond, 2 N-H bonds. •

Secondary (2°): two C-N bonds, 1 N-H bond. •

Tertiary (3°): three C-N bonds, no N-H bond. •

Quaternary (4°): four C-N bonds, nitrogen has a + formal charge.

=>

Aldehydes and

Ketones • contain a

carbonyl (C=O)

group 

O
C H
Functional group
O

CH_3-C-H
Acetaldehyde (an aldehyde)
O

C
Functional group
O

CH_3 -C-CH_3
Acetone (a ketone)

Common Name of Some Simple Aldehydes

Formula Common Name Systematic Name

HCHO Formaldehye Methanal CH_3CHO Acetaldehyde Ethanal

CH_3CH_2CHO Propionaldehyde Propanal $CH_3CH_2CH_2CHO$

Butyraldehyde Butanal $CH_3CH_2CH_2CH_2CHO$ Valeraldehyde

Pentanal

$H_2C=CHCHO$ Acrolein Propenal

Carboxylic Acids

- contain a carboxyl (-COOH) group

: : O

O

C O

Functional group (a carboxylic acid)

Carboxylic acids: R-COOH,

H CH_3-C-O-H

Acetic acid

R-CO_2H,

Common names:

O

R C OH

or or

CH_3COOH CH_3CO_2H

HCO_2H formic acid *L. formica* ant CH_3CO_2H acetic acid *L. acetum* vinegar $CH_3CH_2CO_2H$ propionic acid *G. "first salt"* $CH_3CH_2CH_2CO_2H$ butyric acid *L. butyrum* butter $CH_3CH_2CH_2CH_2CO_2H$ valeric acid *L. valerans*

Carboxylic acids, common names:

…

$CH_3(CH_2)_4CO_2H$ caproic acid *L. caper* goat $CH_3(CH_2)_5CO_2H$

$CH_3(CH_2)_6CO_2H$ caprylic acid

$CH_3(CH_2)_7CO_2H$ ---

$CH_3(CH_2)_8CO_2H$ capric acid

$CH_3(CH_2)_9CO_2H$ ---

$CH_3(CH_2)_{10}CO_2H$ lauric acid oil of lauryl

5 4 3 2 1

C—C—C—C—C=O

δ γ β α used in common names

CH_3

CH_3CHCH_2COOH

Br

$CH_3CH_2CH_2CHCOOH$

α– bromovaleric acid β-methylbutyric acid isovaleric acid

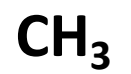
IUPAC nomenclature for carboxylic acids:

parent chain = longest, continuous carbon chain that contains the carboxyl group alkane, drop –e, add –oic acid

HCOOH methanoic acid

CH_3CO_2H ethanoic acid

$CH_3CH_2CO_2H$ propanoic acid



$CH_3CHCOOH$ 2-methylpropanoic acid

$CH_3CH_2CHCO_2H$ 2-bromobutanoic acid

dicarboxylic acids:

HOOC-COOH oxalic acid $HO_2C\text{-}CH_2\text{-}CO_2H$ malonic acid $HO_2C\text{-}CH_2CH_2\text{-}CO_2H$ succinic acid

$HO_2C\text{-}CH_2CH_2CH_2\text{-}CO_2H$ glutaric acid

$HOOC-(CH_2)_4-COOH$ adipic acid

$HOOC-(CH_2)_5-COOH$ pimelic acid

Oh, my! Such good apple pie!

Alpha Hydroxy Acids

Alpha hydroxy acids

(AHAs)

- Occur naturally in fruit, milk, and

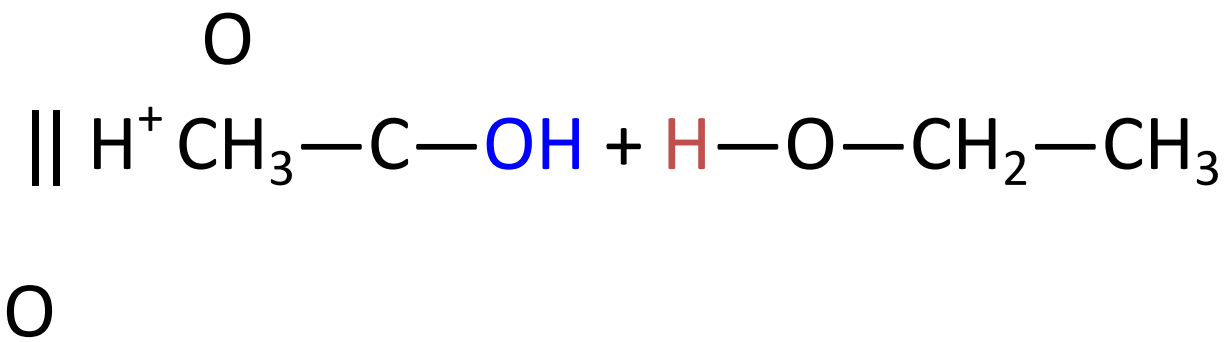
sugarcane.

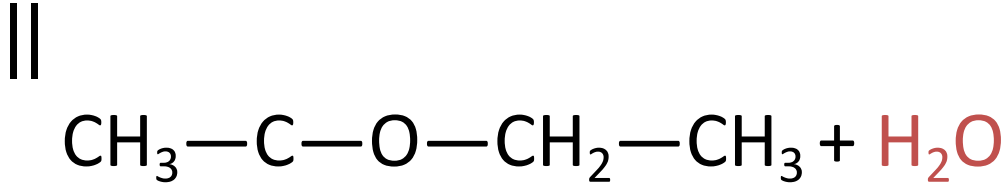
- Are used in skin care products.

Esterification

Esterification is

- **The reaction of a carboxylic acid and alcohol in the presence of an acid catalyst to produce an ester.**





ethyl acetate (an ester)

3

O

C O

Carboxylic Esters

Functional group

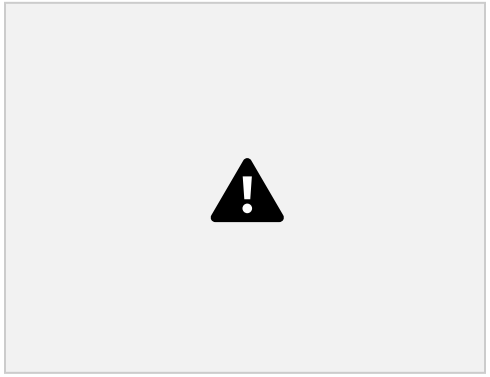
In an ester,

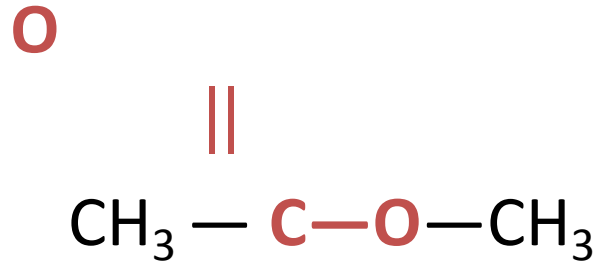
Ethyl acetate (an ester)

:O:

CH_3-C-O-CH_2-CH

- **The H in the carboxyl group is replaced with an alkyl group.**



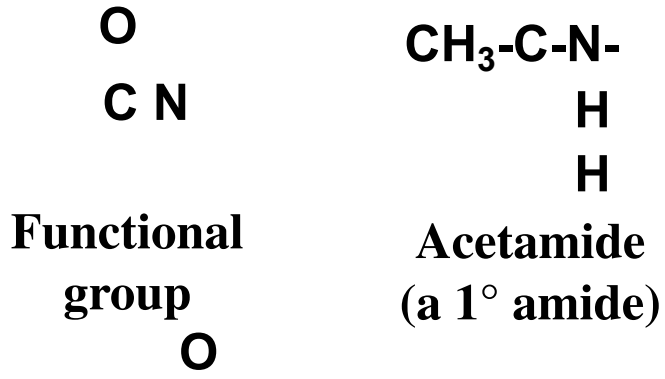


ester group

Carboxylic Amide

- Carboxylic amide, commonly referred to as an amide: a derivative of a carboxylic acid in which the -OH of the -COOH

group is replaced by an amine

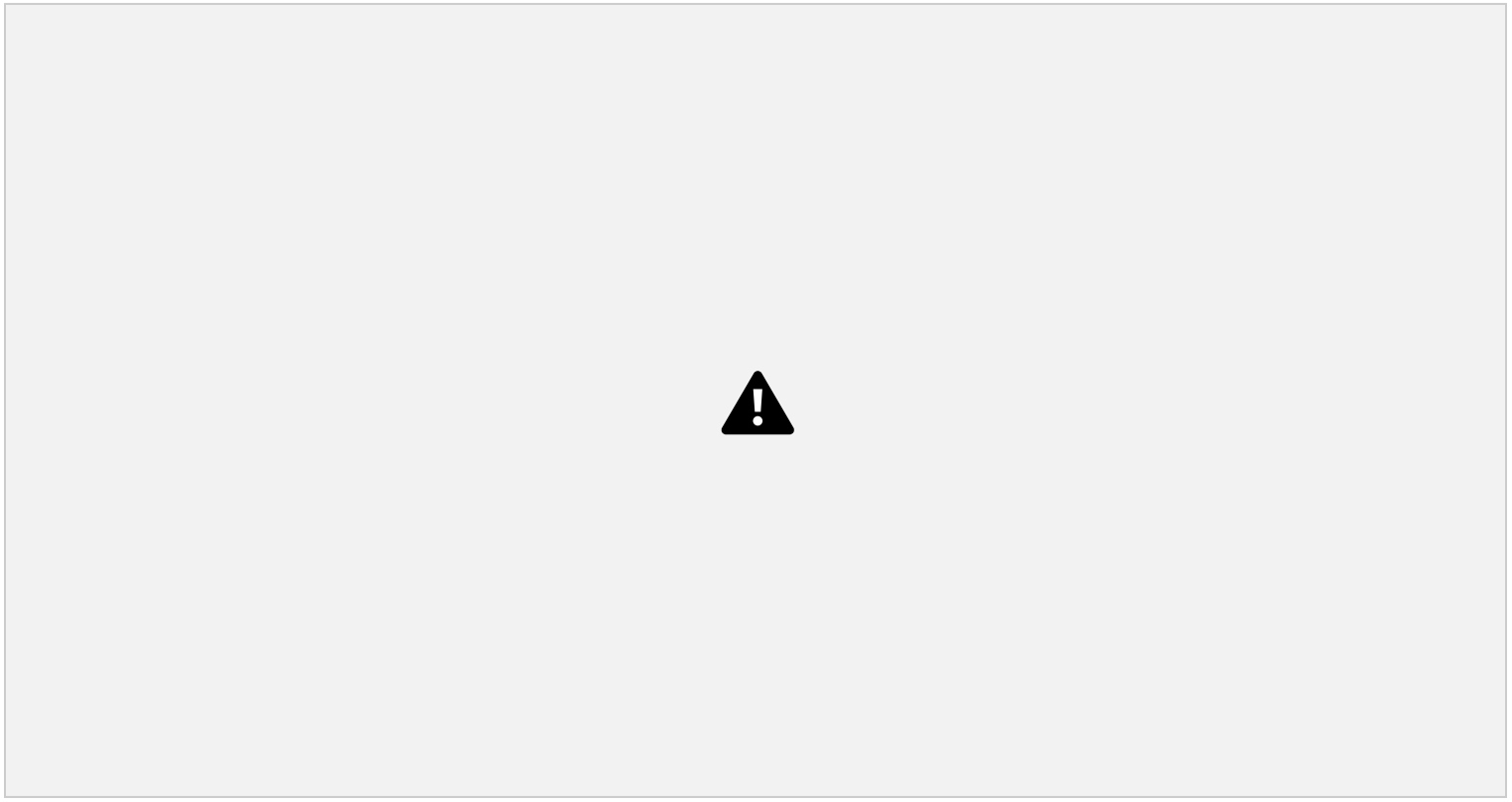


– the six atoms of the amide functional group lie in a plane with bond angles of approximately 120°

Structure and classification of amides •

Amides may be primary, secondary, or teritary:

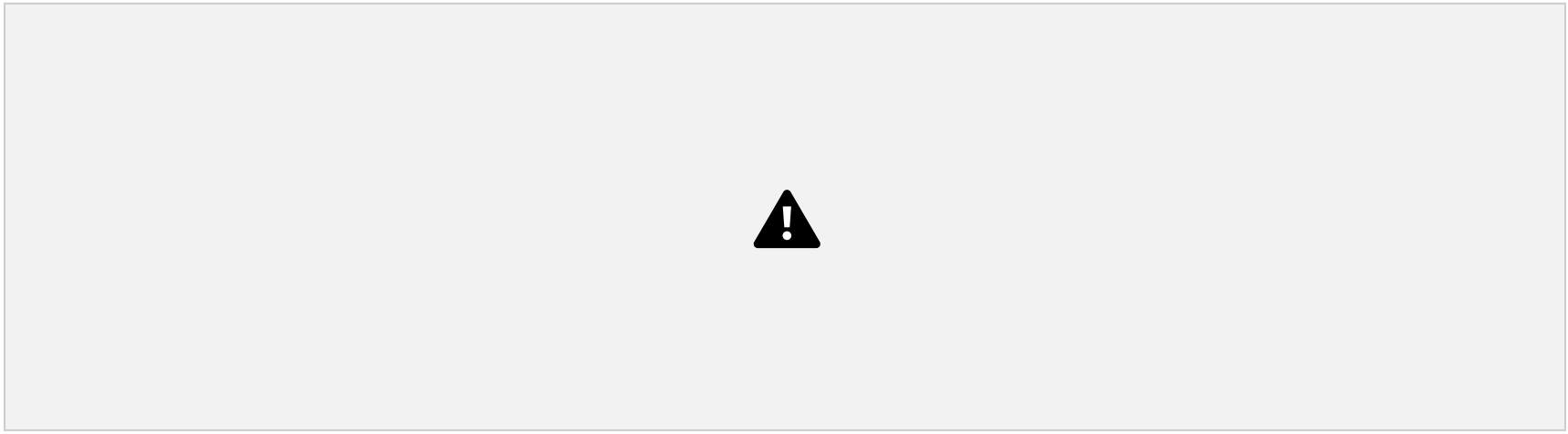
1° amine 2° amine 3° amine



Thiols and Sulfides

- **Thiols (RSH), are sulfur analogs of alcohols**
  - **Named with the suffix -*thiol***

– **SH group is called “mercapto group” (“capturer of mercury”)**



Sulfides

- **Sulfides (RSR′), are sulfur analogs of ethers – Named by rules used for ethers, with *sulfide* in place of *ether* for simple compounds and *alkylthio* in place of *alkoxy***

Naming Priority

- Acids
- Amides • Esters
- Aldehydes • Ketones • Alcohols • Amines
- Alkenes
- Alkynes
- Alkanes

- **Ethers**
- **Halides**

=>

Madenet Al elm University College
Department of Medical Physics
2nd Year Biochemistry 2021 – 2022

BIOCHEMISTRY/CARBOHYDRATE

Dr. Hamza Yaseen Isa
Lecture M 5 I 1

1. Biochemistry

- Definition: The chemistry of life
  - – The science concerned with the chemical basis of life. – The science concerned with the various molecules that occur in living cells and organisms and

with their chemical reaction.

– Anything more than a superficial comprehension of life – in all its diverse manifestation - demands a knowledge of biochemistry.

2. Why biochemistry is important

- Significant: because it is essential to all life sciences as the common knowledge – Genetics; Cell biology; Molecular biology – Physiology and Immunology
  – Pharmacology and Pharmacy
  – Toxicology; Pathology; Microbiology
  – Zoology and Botany

3.What dose the Biochemistry discuss?

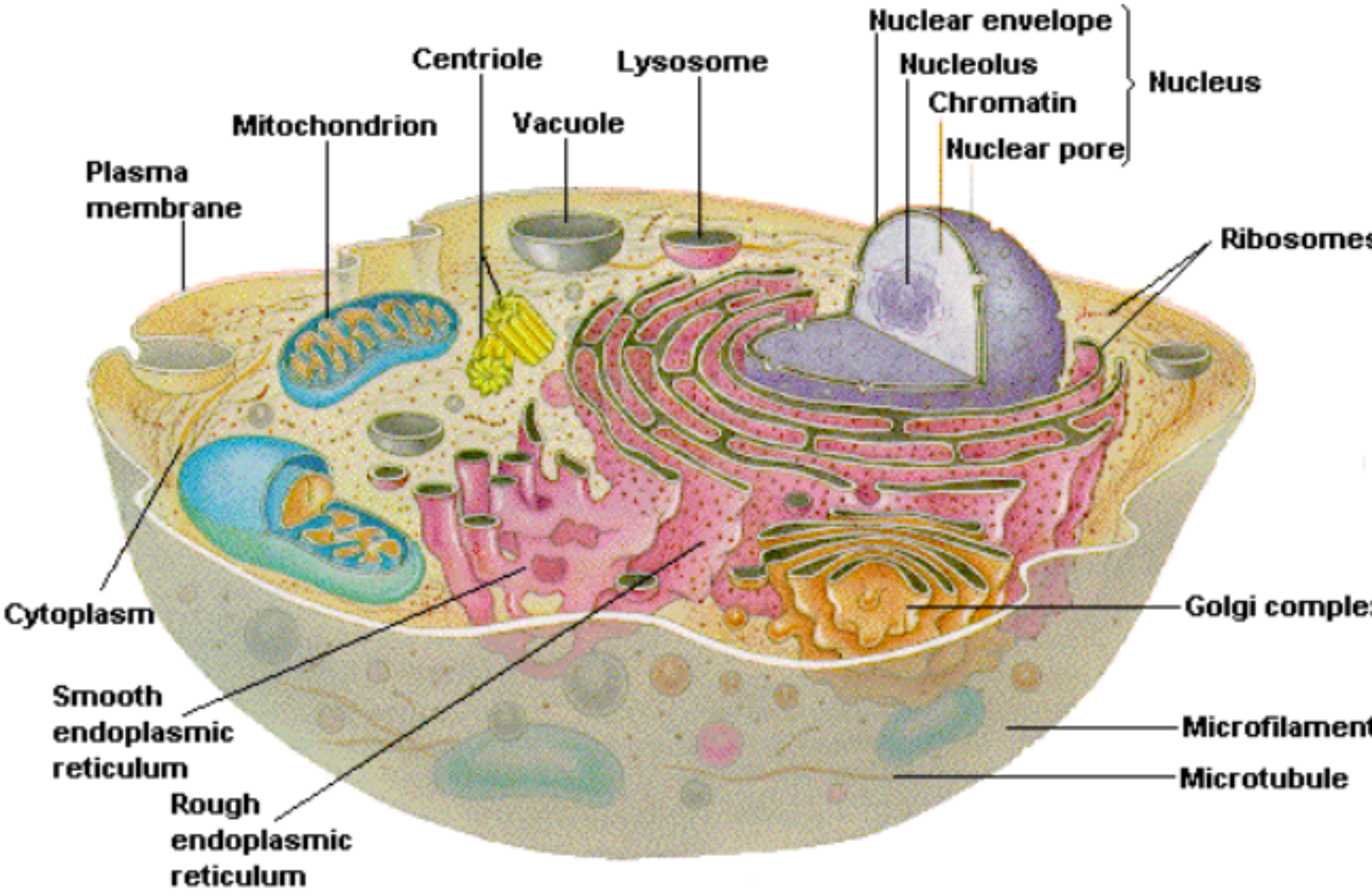
a. structure and function of cellular components.
   – proteins, carbohydrates, lipids, nucleic acids and other biomolecules

b. Metabolism and Regulation.

c. Gene expression and modulation.

DNA RNA Protein

Cell Structure



Bio

Bio –

1 Carbohydrates

organic compounds

1.Carbohydrates.

2.Lipids.

3. Nucleic acids.

4. Amino acids.

5. Proteins.

6. Enzymes.

7. Hormones.

8.Vitamines.

9. Inorganic minerals.

Polymers and Monomers

- Each of these types of molecules are polymers that are assembled from single units called

monomers.

- Each type of macromolecule is an assemblage of a different type of monomer.

Anabolic

- Building block
  - – Simple sugar –
    Amino acid
    - – Nucleotide
    - – Fatty acid

- Macromolecule –
  Polysaccharide –
  Protein (peptide) –
  RNA or DNA
  - – Lipid

Catabolic

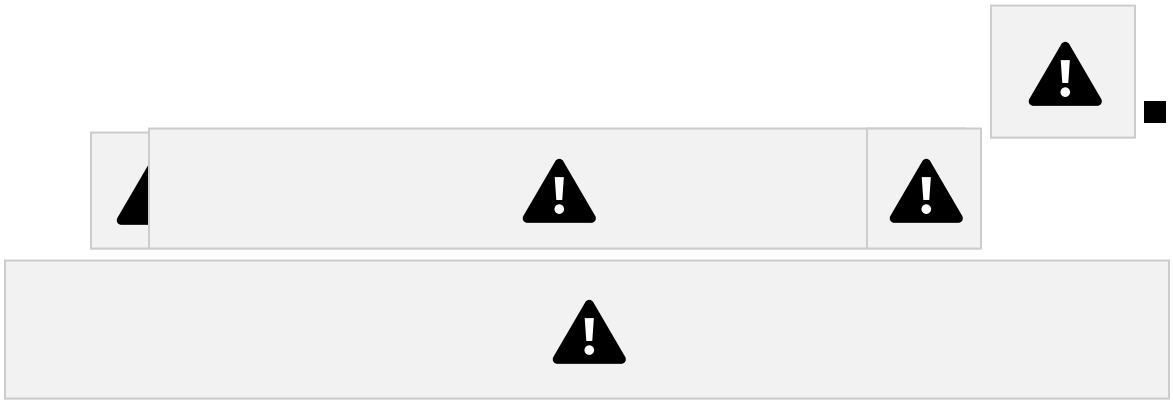
CARBOHYDRATES

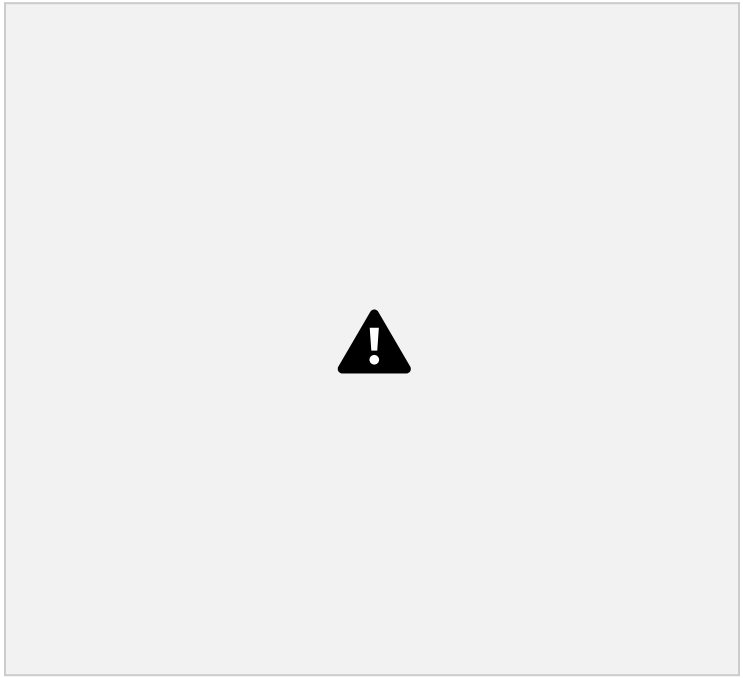
- Living things use carbohydrates as a key source of ENERGY!
- Plants use carbohydrates for structure (CELLULOSE)

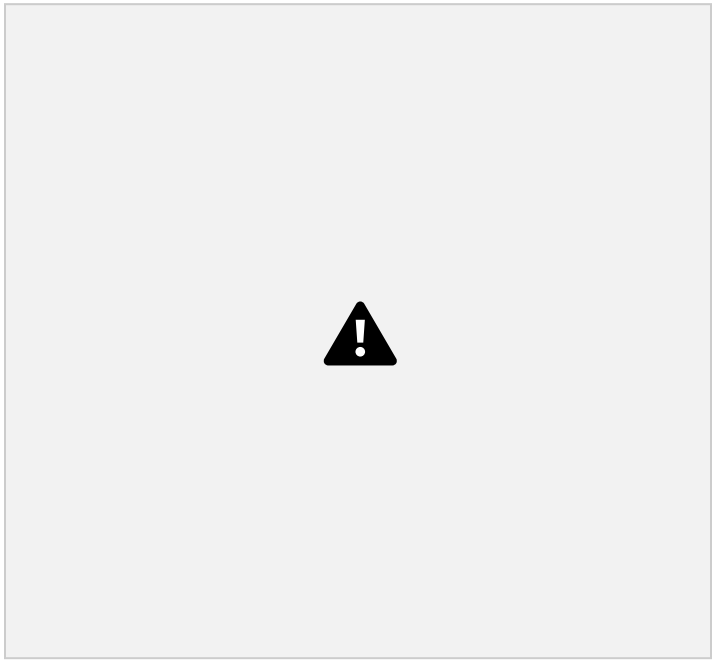
include sugars and complex carbohydrates (starches)

contain the elements carbon, hydrogen, and oxygen (the hydrogen is in a 2:1 ratio to oxygen)

Monosaccharides (simple sugars)

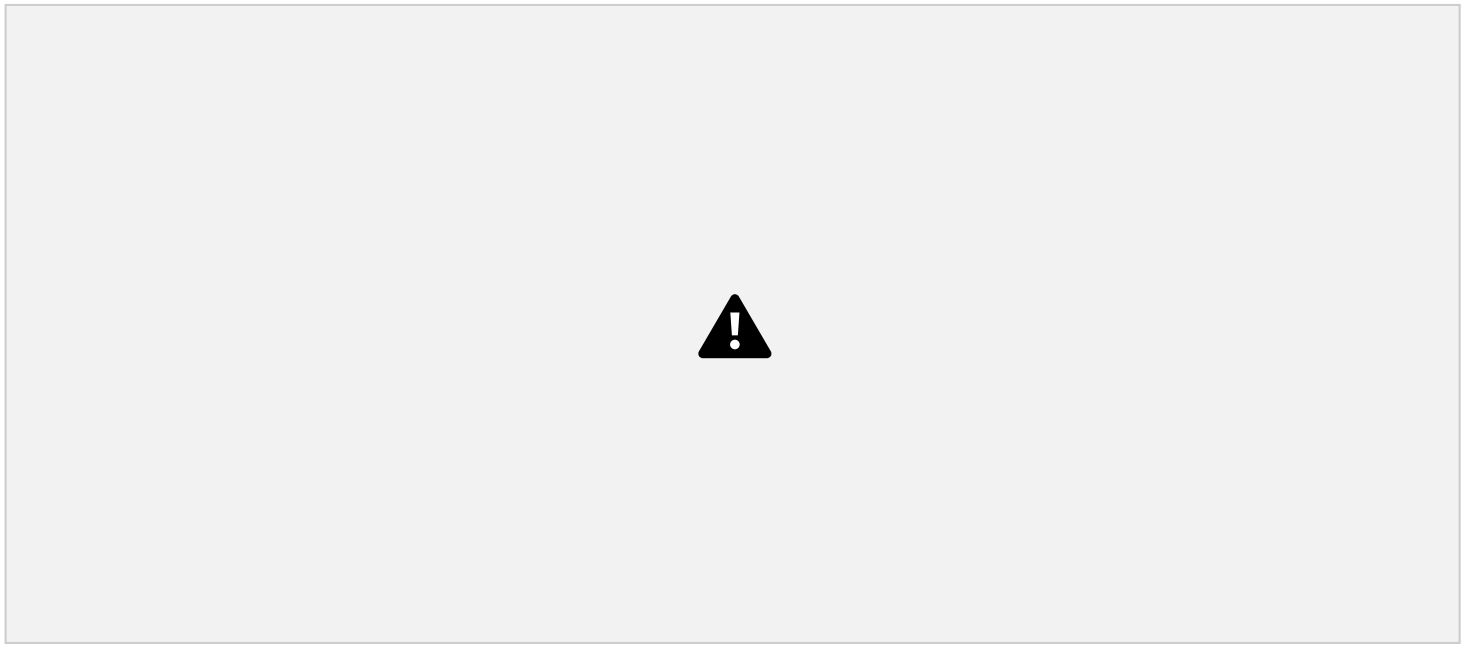
- all have the formula C6 H12 O6
- 
all have a single ring structure 
(glucose is an example)





Disaccharides (double sugars)

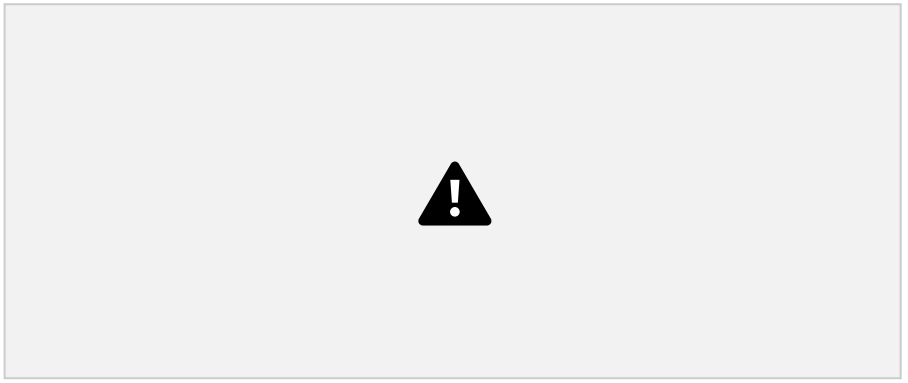
- all have the formula C12 H22 O11
  - sucrose (table sugar) is an example



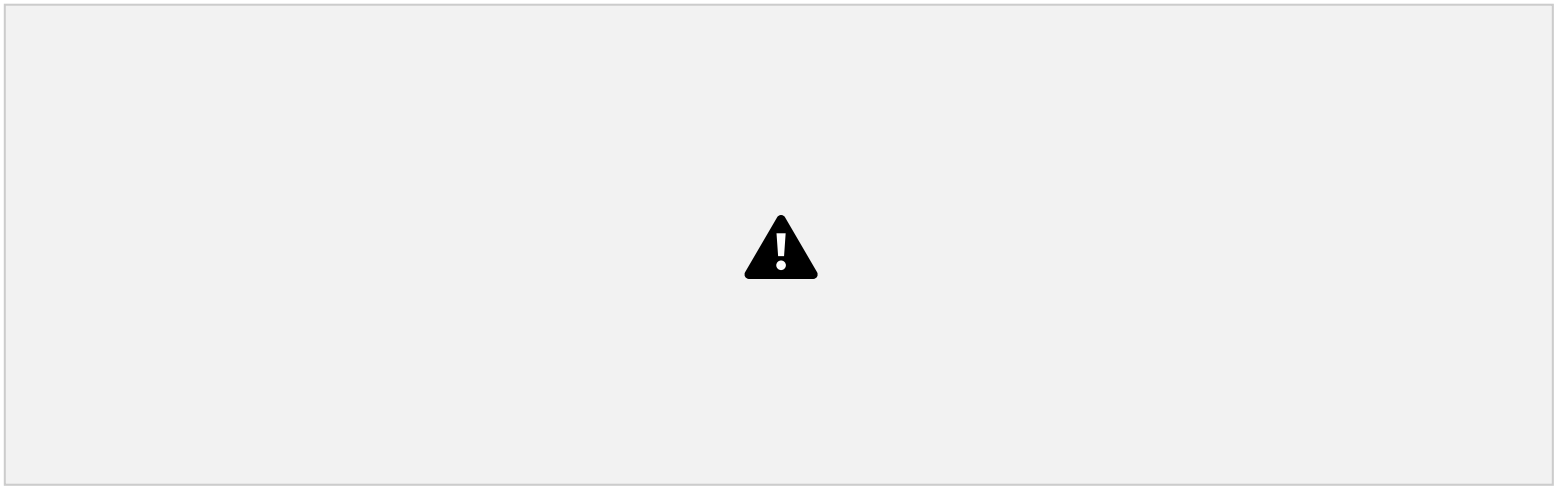
Lipids (Fats)

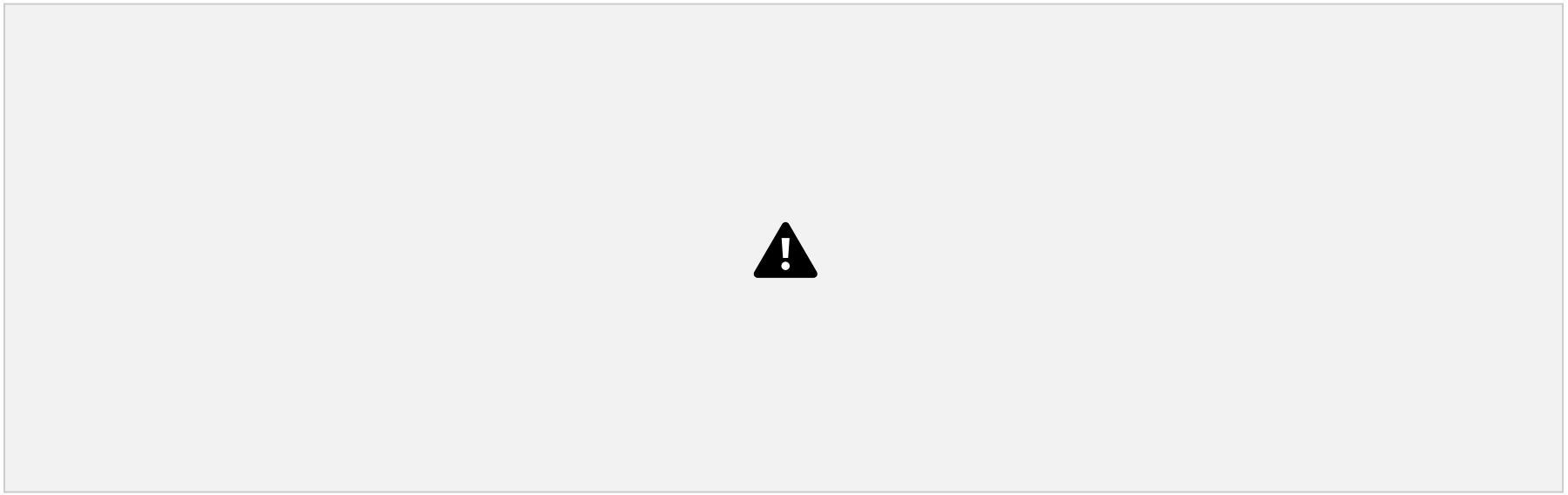
- Fats, oils, waxes, steroids
- Chiefly function in energy storage, protection, and insulation
- Contain carbon, hydrogen, and oxygen but the H:O is not in a 2:1 ratio

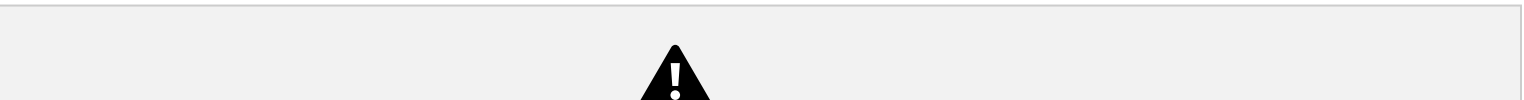
- Tend to be large molecules -- an example of a neutral lipid is below



[Amino acids]





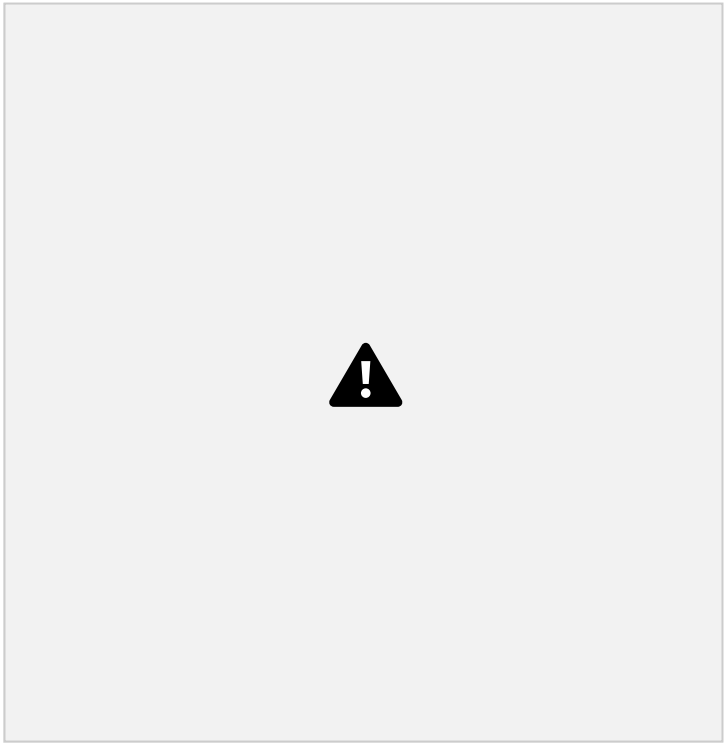


DNA (deoxyribonucleic acid)

contains the genetic code of instructions that direct a cell's behavior through the synthesis of proteins

found in the chromosomes of the nucleus (and a few other

organelles)



Cells

- Basic building blocks of life
- Smallest living unit of an organism
- Cell volume is 10 microns and its weight is one Nano gram.
- A cell may be an entire organism (unicellular) or it may be one of billions of cells that make up the organism

(multicellular).

- Grow, reproduce, use energy, adapt, respond to their environment

- Many cannot be seen with the naked eye
  - a typical cell size is 10µm; a typical cell mass is 1 nano gram.)

Biomolecules

- Just like cells are building blocks of tissues, biomolecules are building blocks of cells.
- Animal and plant cells contain approximately 10,000 kinds of biomolecules.
- Water constitutes 60-95% of cells content by weight. •

Ions like Na^+, K^+ and Ca^{2+} may account for another 1%.

- Almost all other kinds of biomolecules are organic (C, H,

N, O, P, S).

- Organic compounds are compounds composed primarily of a Carbon skeleton.

Chemical composition of a normal man (weight 65 kg)

Constituent	Percent (%)	Weight (kg)
	61.6	
	17.0	
	13.8	
	1.5	

Water 40 Protein 11 Lipid 9

Carbohydrate 1 Minerals 6.1 4

Carbohydrates

Carbohydrates (glycans) have the following basic composition: $(CH_2O)_n$ or H - C - OH

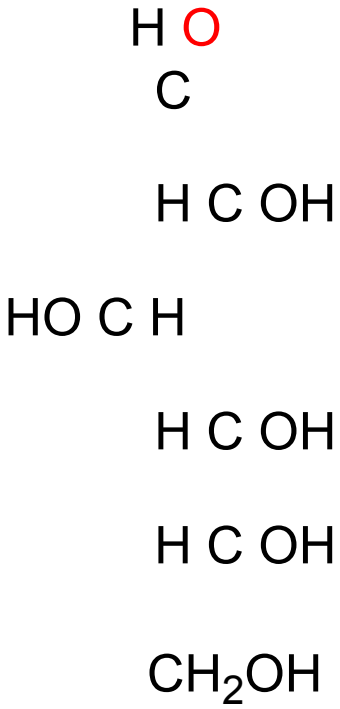
I I

- **Monosaccharides** - simple sugars with multiple OH groups. Based on number of carbons (3, 4, 5, 6), a monosaccharide is a **triose**, **tetrose**, **pentose** or **hexose**.
- **Disaccharides** - 2 monosaccharides covalently linked.
- **Oligosaccharides** - a few monosaccharides covalently linked.
- **Polysaccharides** - polymers consisting of chains of

monosaccharide or disaccharide units.

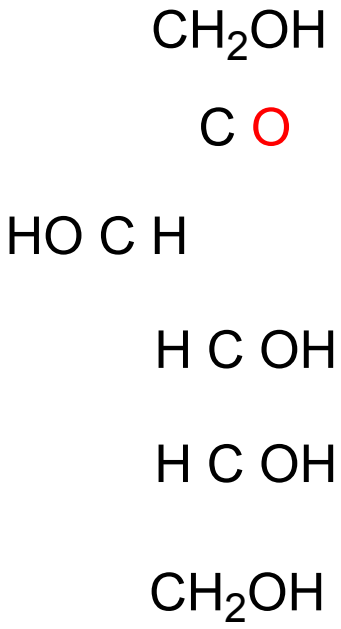
Monosaccharides

Aldoses (e.g., glucose) have an aldehyde group at one end.



D-glucose

Ketoses (e.g., fructose) have a keto group, usually at C2.



D-fructose

aldotetroses $CH_2CHCHCH$ CH_2OH

O

* *

OH OHOH

CHO

HO H HO H CH_2OH

CHO

H OH

H OH

D-erythrose L-erythrose

CHO

HO H H OH

CH_2OH

CHO

H OH HO H

CH_2OH

L-threose D-threose

Glucose (a monosaccharide)

Plants:

photosynthesis

chlorophyll

$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$ sunlight (+)-glucose

(+)-glucose starch or cellulose

respiration

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + energy

Animals

plant starch (+)-glucose

(+)-glucose glycogen

glycogen (+)-glucose

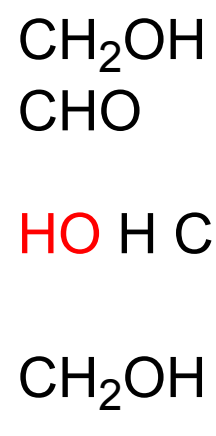
(+)-glucose fats or aminoacids

respiration

(+)-glucose + 6 O_2 6 CO_2 + 6 H_2O + energy

D vs L Designation

D & L designations are based on the configuration about the single asymmetric C in glyceraldehyde.



D-glyceraldehyde

L-glyceraldehyde

The lower representations are **Fischer Projections.**

CHO
H OH C
CH_2OH

CHO
HO H C
CH_2OH

D-glyceraldehyde L-glyceraldehyde

Sugar Nomenclature

For sugars with more than one chiral center, **D** or **L** refers to the asymmetric **C** farthest from the aldehyde or keto group.

Most naturally occurring sugars are D isomers.

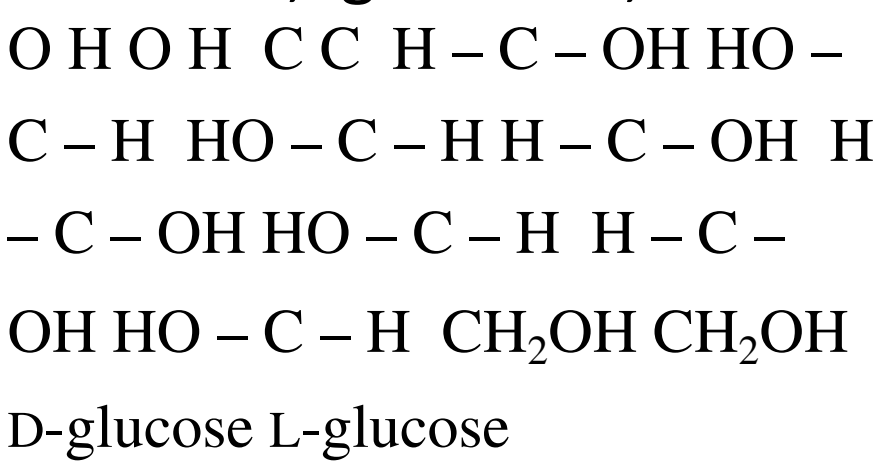
O H O H C C H – C – OH HO –
C – H HO – C – H H – C – OH H
– C – OH HO – C – H H – C –
OH HO – C – H CH_2OH CH_2OH

D-glucose L-glucose

D & L sugars are mirror images of one another.

They have the same name, e.g., D-glucose & L-glucose.

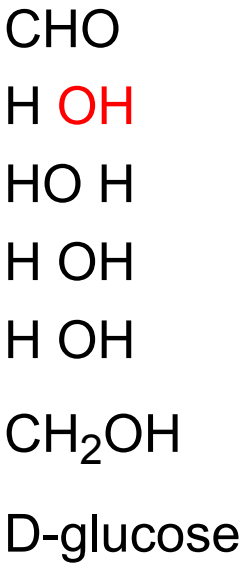
Other stereoisomers have unique names, e.g., glucose, mannose, galactose, etc.



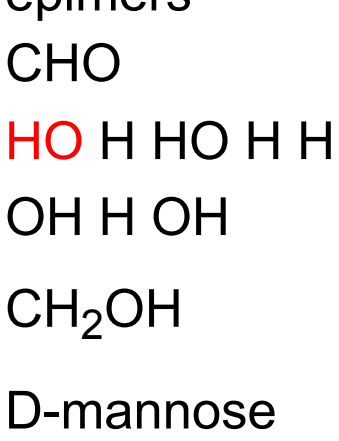
The number of stereoisomers is 2^n, where n is the number of asymmetric centers.

The 6-C aldoses have 4 asymmetric centers. Thus there are 16 stereoisomers (8 D-sugars and 8 L sugars).

Epimers – stereoisomers that differ only in configuration about one chiral center.

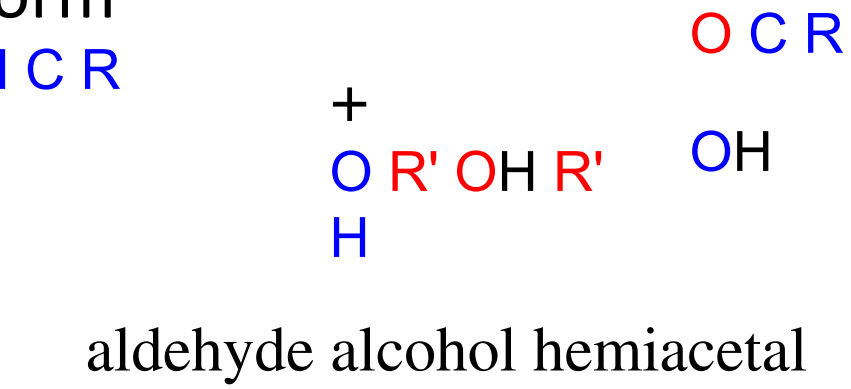

CHO
H OH
HO H
H OH
H OH
CH2OH
D-glucose

epimers


CHO
HO H HO H H
OH H OH
CH2OH
D-mannose

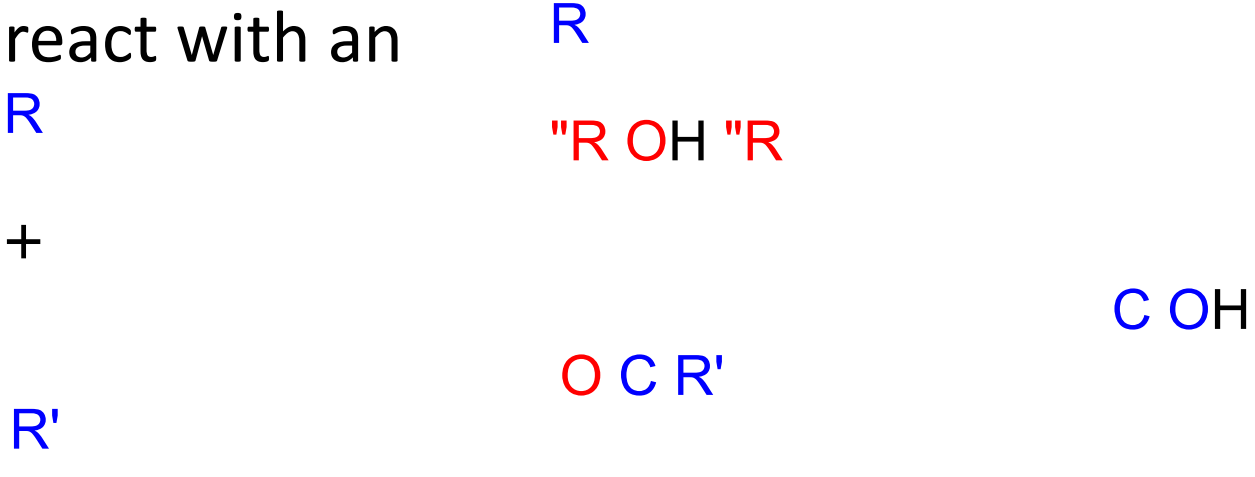
Hemiacetal & hemiketal formation

An aldehyde can react with an alcohol to form a hemiacetal.



aldehyde alcohol hemiacetal

A ketone can react with an alcohol to form a hemiketal.



ketone alcohol hemiketal

Pentoses and hexoses can cyclize

CHO

H C OH

2

as the ketone or aldehyde reacts with a distal OH.

Glucose forms an

HO C H 3

H C OH 4

hemiacetal, as the intra-molecular C1 aldehyde & 6-member C5 OH react, to form a

6

CH_2OH

CH_2OH

6

H C OH 5

D-glucose (linear form)

6

CH_2OH

HO H

5

H HO H

5

OH

4

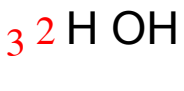
OH H

4

OH H

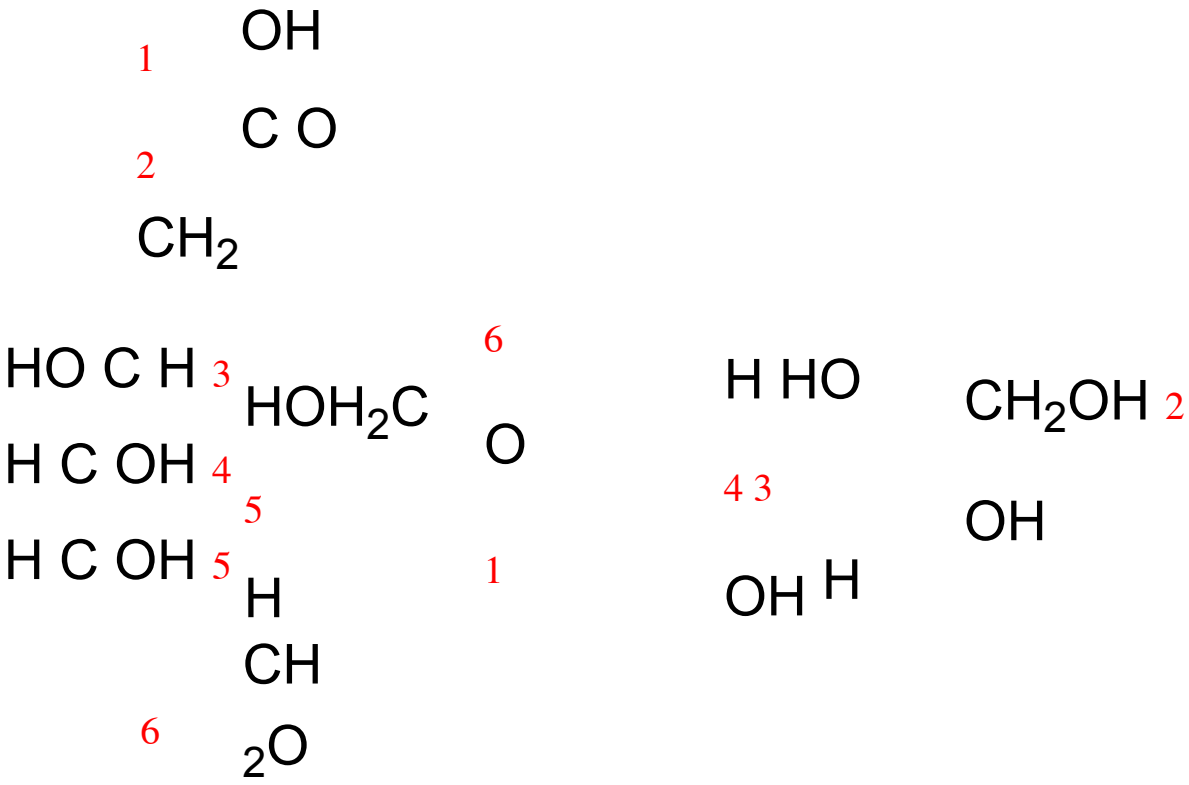
1 1

pyranose ring, named after pyran.



α-D-glucose β-D-glucose

These representations of the cyclic sugars are called **Haworth** projections.

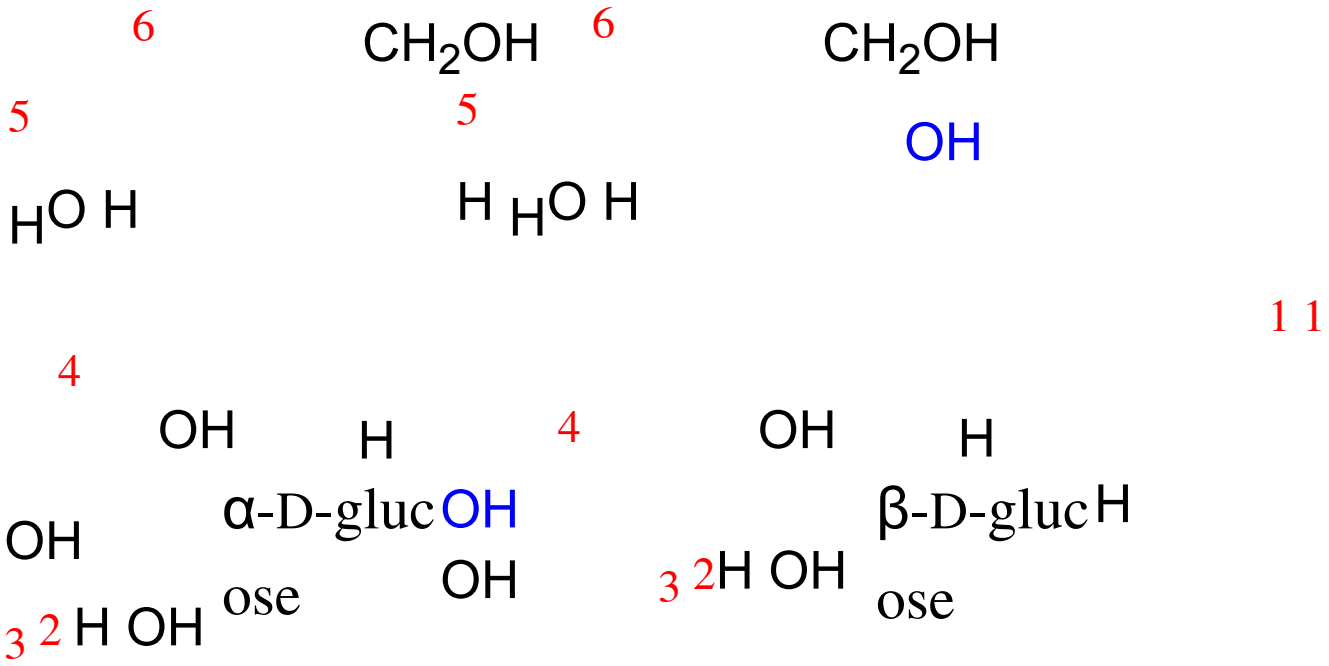


H

D-fructose (linear) α-D-fructofuranose

Fructose forms either

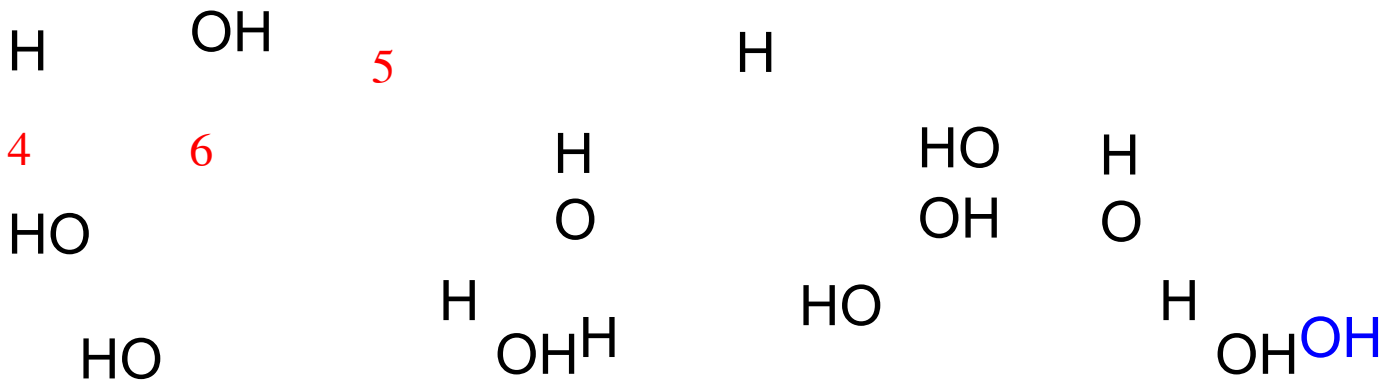
- a 6-member pyranose ring, by reaction of the C2 keto group with the OH on C6, or
- a 5-member furanose ring, by reaction of the C2 keto group with the OH on C5.



Cyclization of glucose produces a new asymmetric center at C1. The 2 stereoisomers are called **anomers**, α & β.

Haworth projections represent the cyclic sugars as having essentially planar rings, with the OH at the anomeric C1:

- α (OH below the ring)
- β (OH above the ring).



α-D-glucopyranose β-D-glucopyranose

Because of the tetrahedral nature of carbon bonds, pyranose sugars actually assume a "chair" or "boat" configuration, depending on the sugar.

The representation above reflects the chair configuration of the glucopyranose ring more accurately than the Haworth projection.

Reducing sugar – a carbohydrate that is oxidized by Tollen's, Fehling's or Benedict's solution.

Tollen's: Ag^+ Ag (silver mirror)

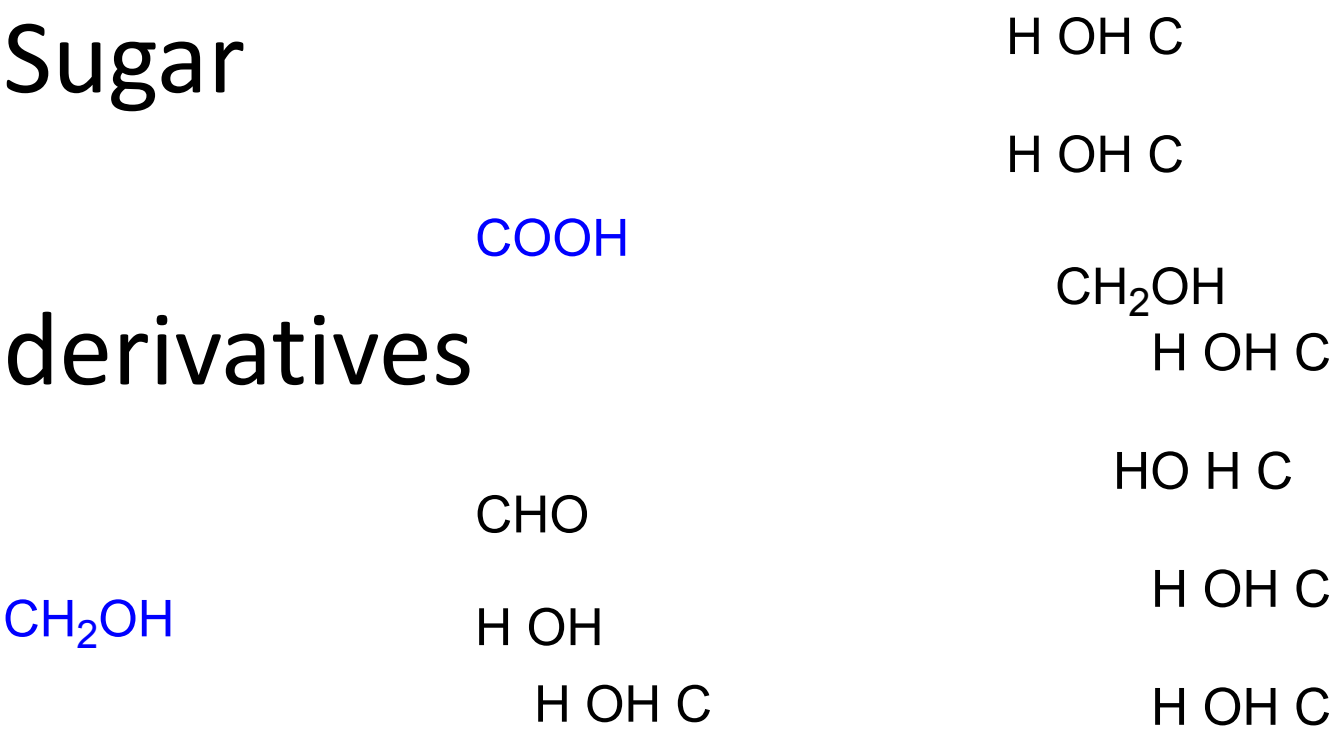
Fehling's or Benedict's: Cu^{2+} (blue) Cu^{1+} (red ppt.) These are reactions of aldehydes and alpha-hydroxyketones.

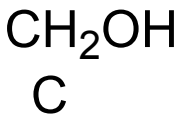
<u>All</u> monosaccharides (both aldoses and ketoses) and **most* disaccharides** are reducing sugars.

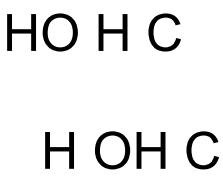
*Sucrose (table sugar), a disaccharide, is <u>not</u> a reducing sugar.

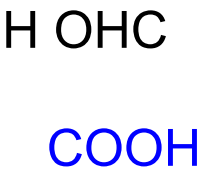
Sugar

derivatives







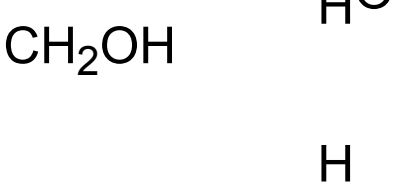


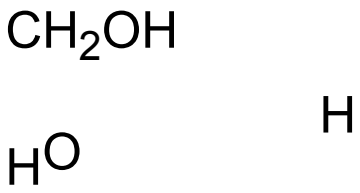
D-ribitol
D-gluconic acid

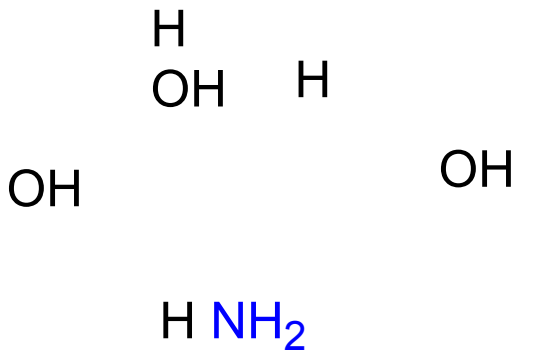
D-glucuronic acid

- sugar alcohol - lacks an aldehyde or ketone; e.g., ribitol.
- sugar acid - the aldehyde at C1, or OH at C6, is oxidized to a carboxylic acid; e.g., gluconic acid, glucuronic acid.

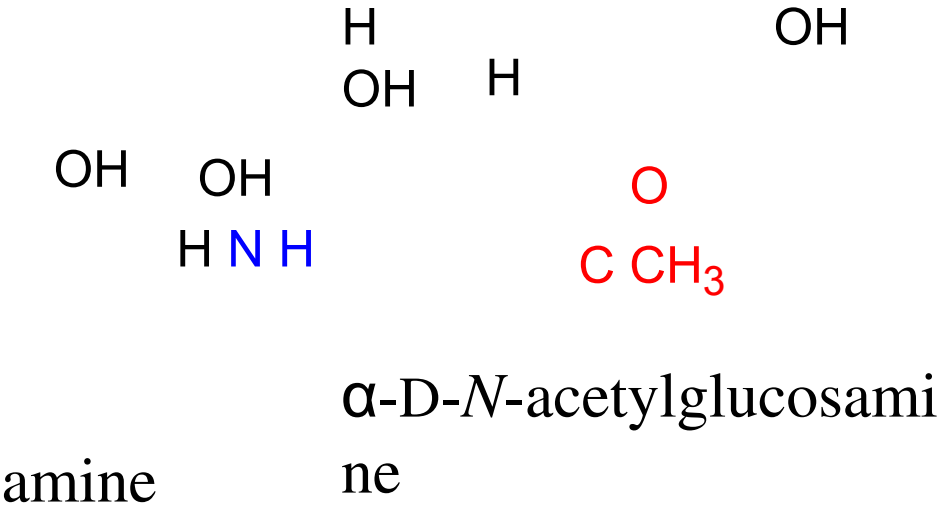
Sugar derivatives







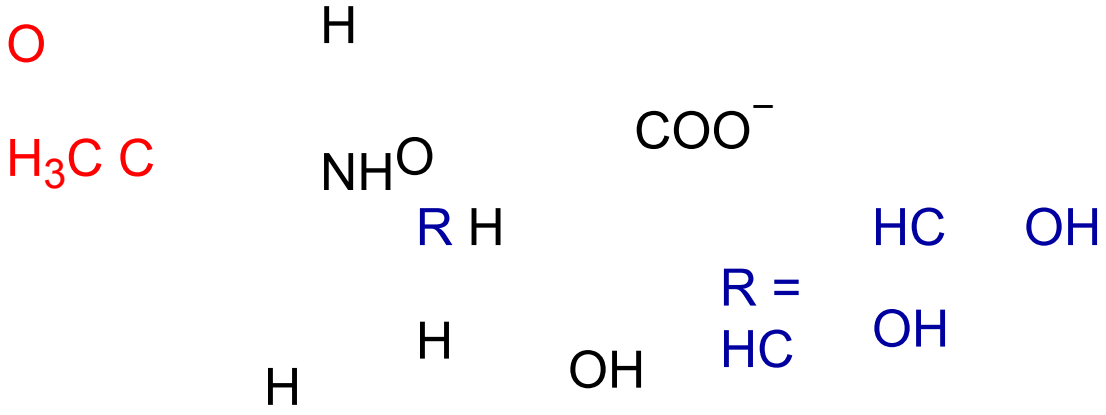
α-D-glucosamine



α-D-*N*-acetylglucosamine

amino sugar - an amino group substitutes for a hydroxyl. An example is glucosamine.

The amino group may be acetylated, as in *N* acetylglucosamine.



N-acetylneuraminate (N-acetylneuraminic acid, also called sialic acid) is often found as a terminal residue of oligosaccharide chains of glycoproteins.

Sialic acid imparts negative charge to glycoproteins, because its carboxyl group tends to dissociate a proton at physiological pH, as shown here.

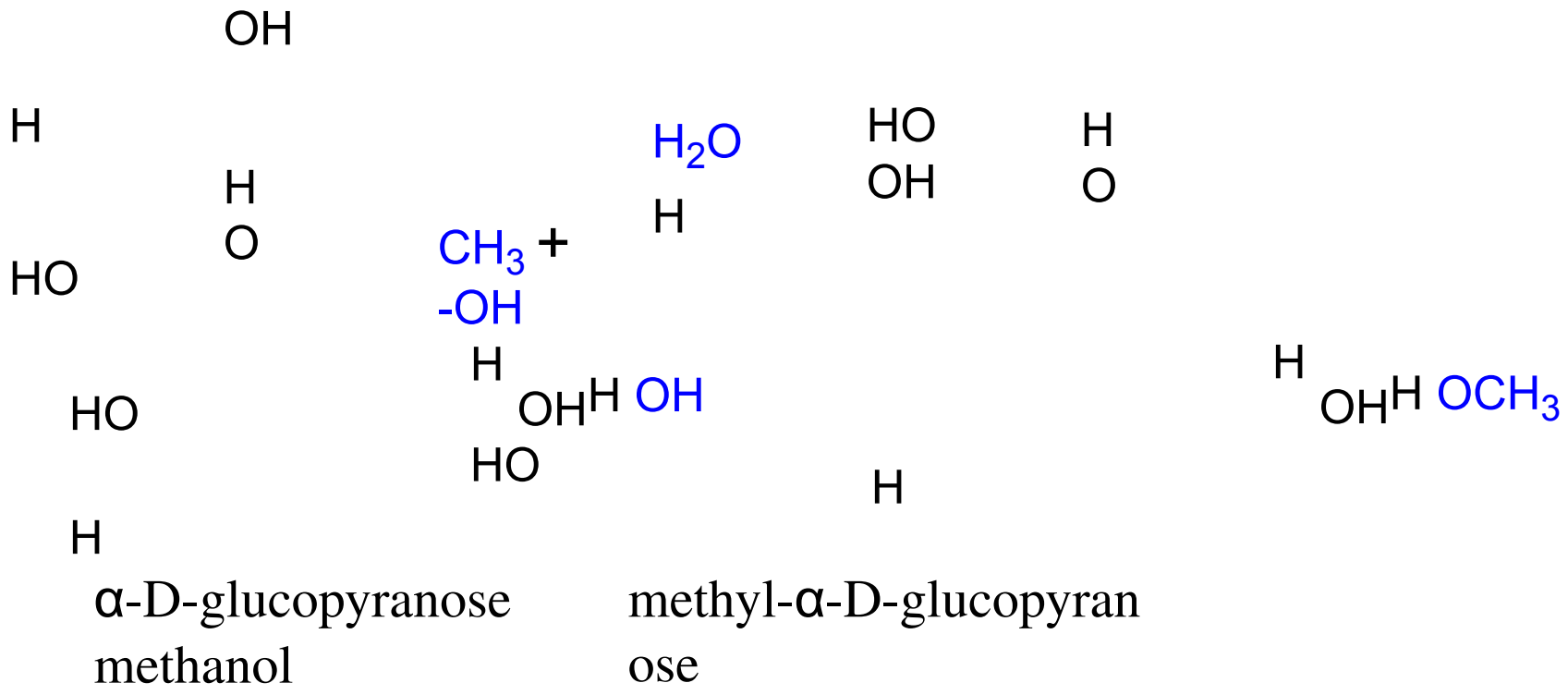
Glycosidic Bonds

The anomeric hydroxyl and a hydroxyl of another sugar

or some other compound can join together, splitting out water to form a glycosidic bond:

R-OH + HO-R' → R-O-R' + H_2O

E.g., methanol reacts with the anomeric OH on glucose to form methyl glucoside (methyl-glucopyranose).



6

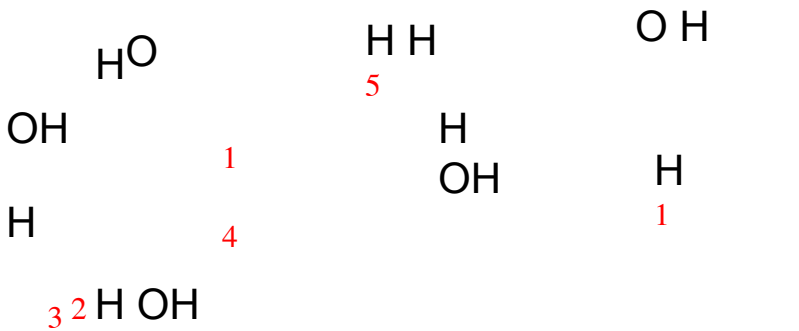
Disaccharides:

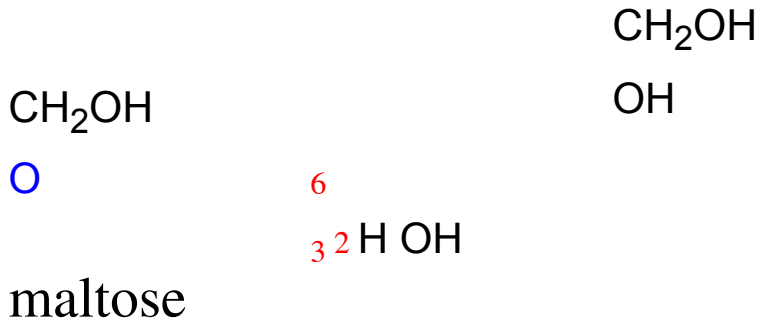
CH_2OH

6

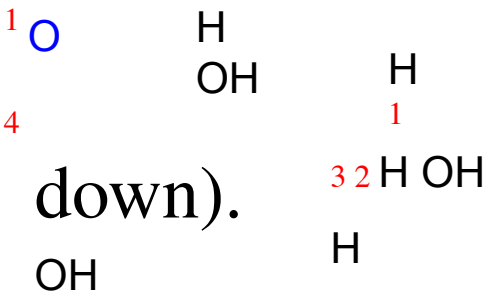
CH_2OH

Malto se, a cleava ge product of starch (e.g., amylose), is a disacchar c ide with an α(1→4) glycosidi link between C1 - C4 OH of[2] gluco ses.

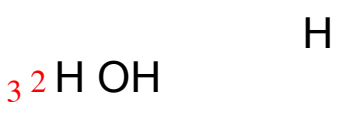




It is the α anomer (C1 O points down).



cellobiose



Cellobiose, a product of cellulose breakdown, is the otherwise equivalent β anomer (O on C1 points up).

The β(1 → 4) glycosidic linkage is represented as a zig-zag, but one glucose is actually **flipped over** relative to the other.

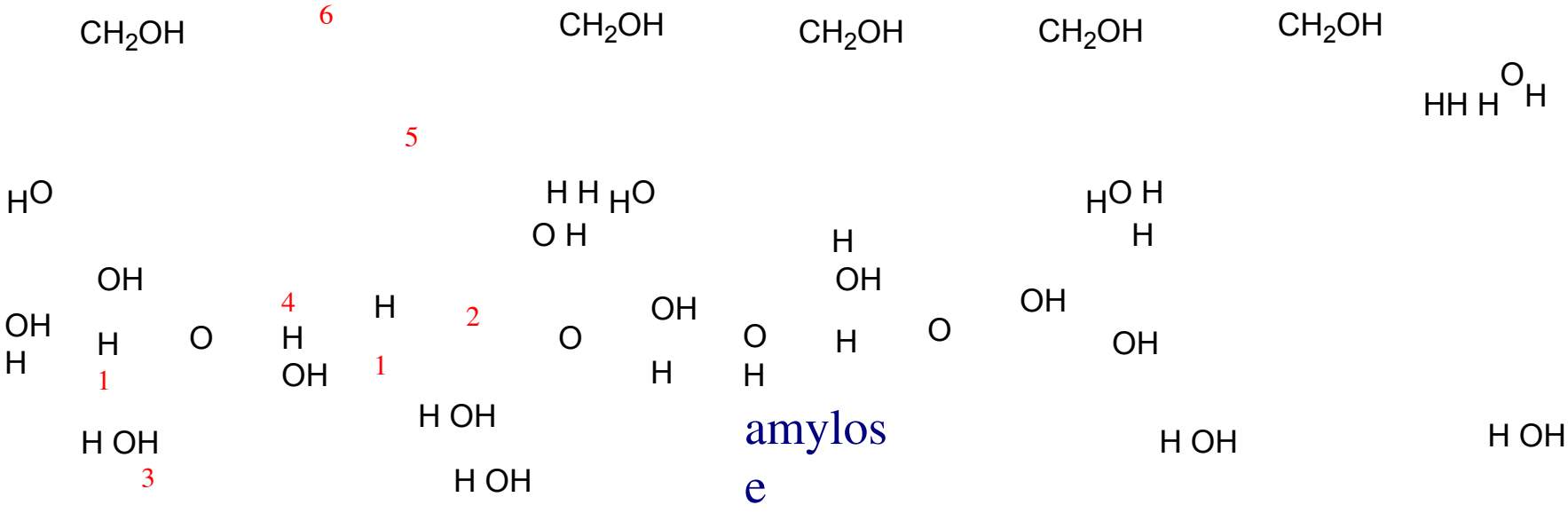
Other **disaccharides** include:

- **Sucrose**, common table sugar, has a glycosidic bond linking the anomeric hydroxyls of glucose & fructose.

Because the configuration at the anomeric C of glucose is α (O points down from ring), the linkage is α(1 → 2).

The full name of sucrose is α-D-glucopyranosyl-(1 → 2)-β-D-fructopyranose.)

- **Lactose**, milk sugar, is composed of galactose & glucose, with $\beta(1 \rightarrow 4)$ linkage from the anomeric OH of galactose. Its full name is β-D-galactopyranosyl-(1 → 4)-α-D glucopyranose



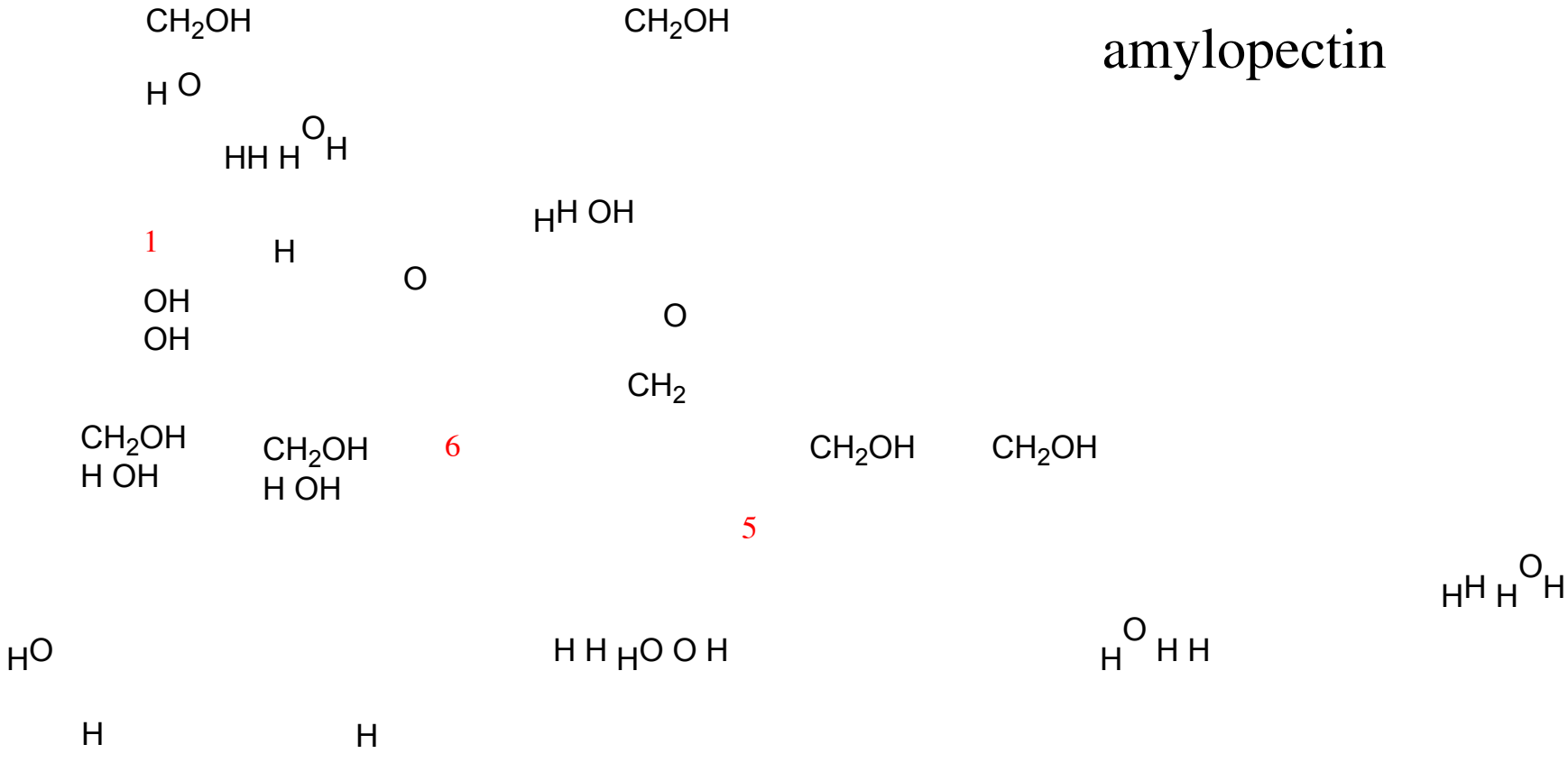
Polysaccharides:

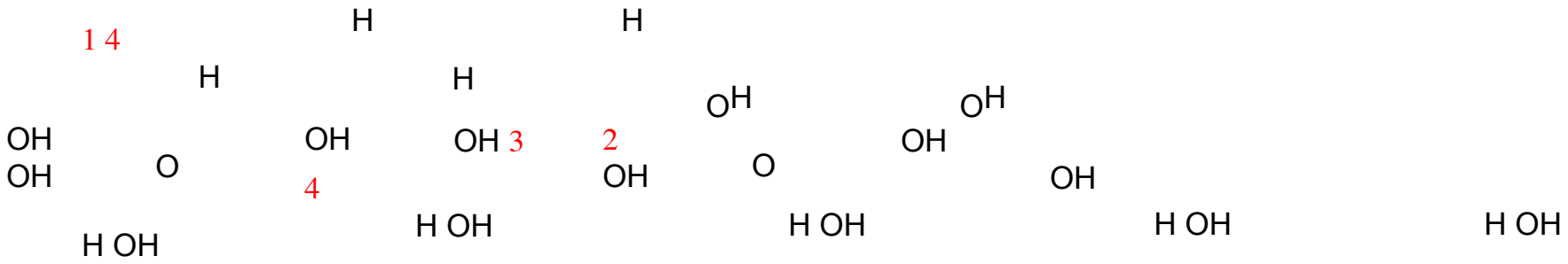
Plantsstore glucose as **amylose** or **amylopectin**, glucose polymers collectively called starch.

Glucose storage in **polymeric** form **minimizes osmotic effects**.

Amylose is a glucose polymer with **α(1 → 4)** linkages.

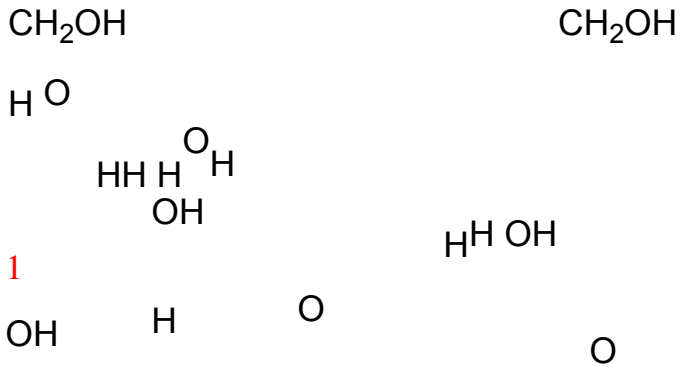
The end of the polysaccharide with an anomeric C1 not involved in a glycosidic bond is called the **reducing end**.



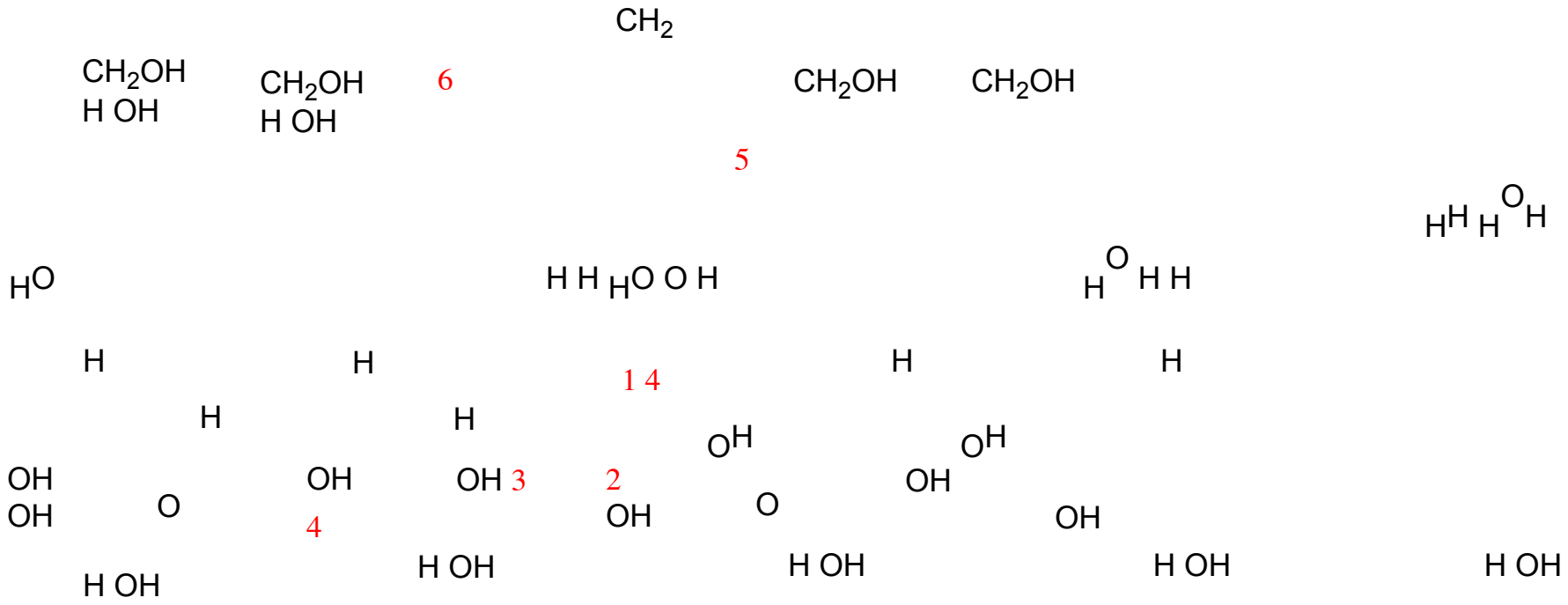


Amylopectin is a glucose polymer with mainly $\alpha(1 \rightarrow 4)$ linkages, but it also has **branches** formed by $\alpha(1 \rightarrow 6)$ linkages. Branches are generally longer than shown above.

The branches produce a compact structure & provide multiple chain ends at which enzymatic cleavage can occur.



glycogen

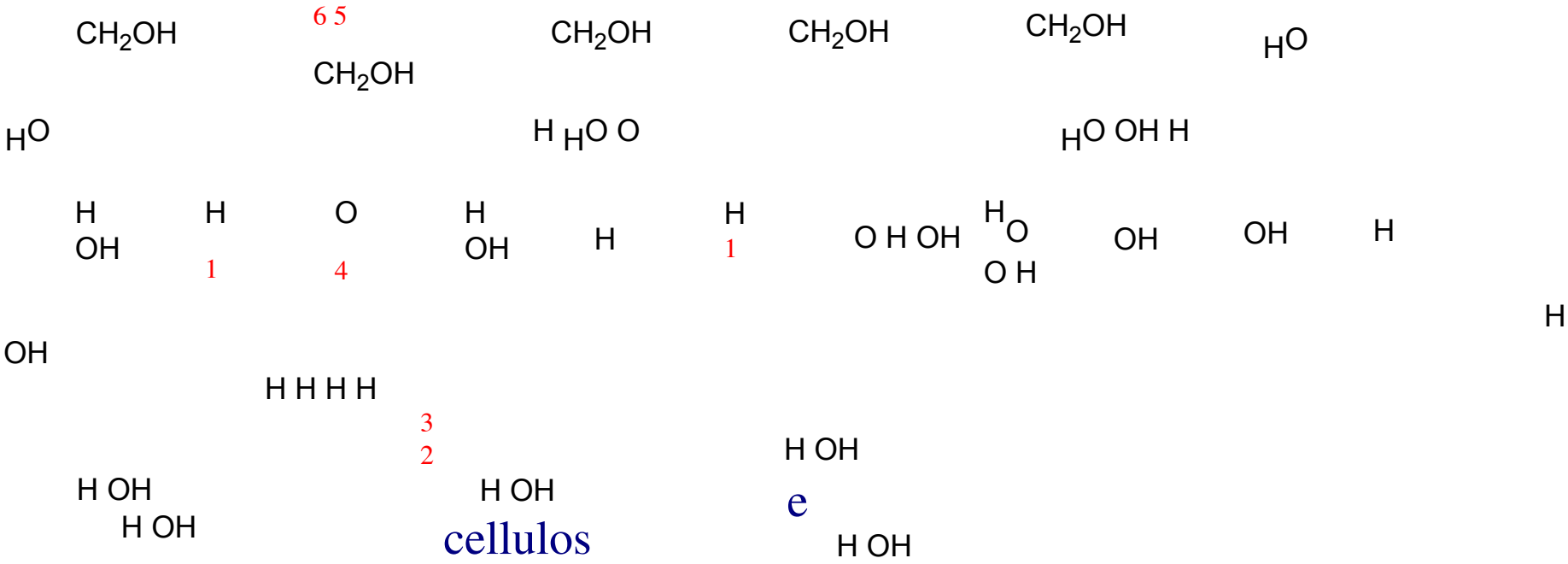


Glycogen, the glucose storage polymer in **animals**, is similar in structure to amylopectin.

But glycogen has **more** $\alpha(1 \rightarrow 6)$ **branches**.

The highly branched structure permits rapid glucose release from glycogen stores, e.g., in muscle during exercise.

The ability to rapidly mobilize glucose is more essential to animals than to plants.



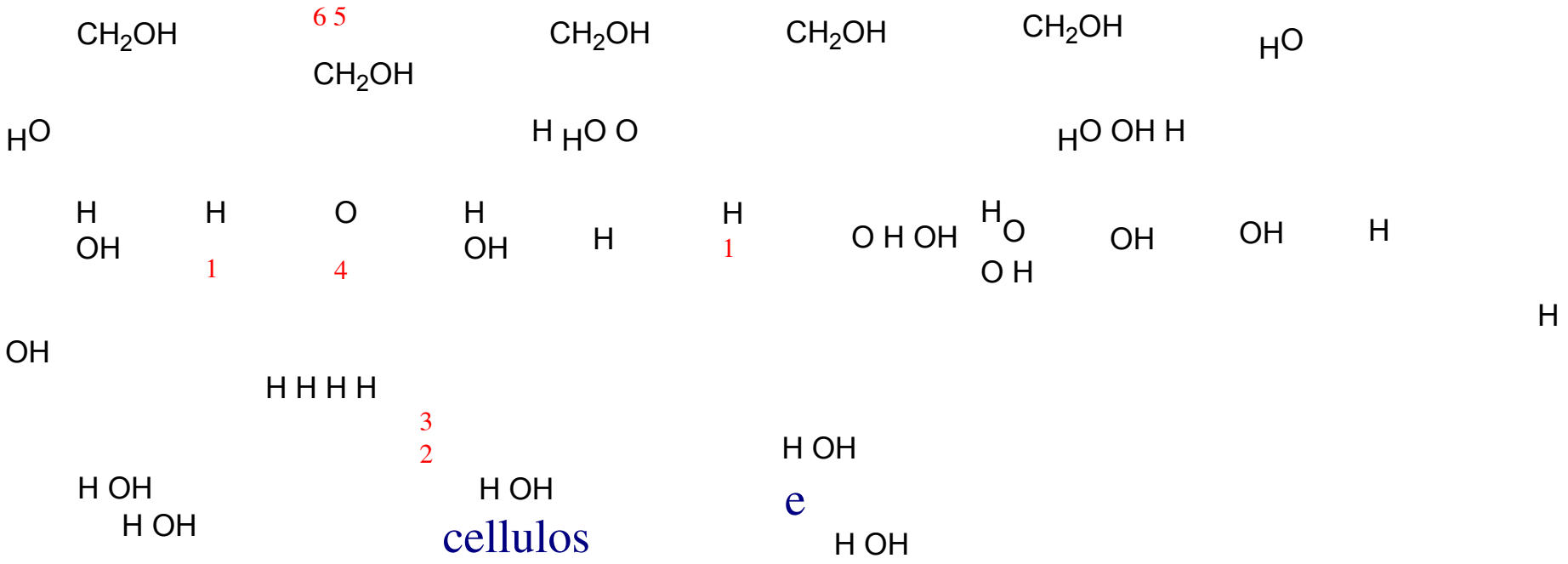
Cellulose, a major constituent of plant cell walls, consists of long linear chains of glucose with β(1 → 4) linkages.

Every other glucose is flipped over, due to β linkages.

This promotes intra-chain and inter-chain H-bonds and

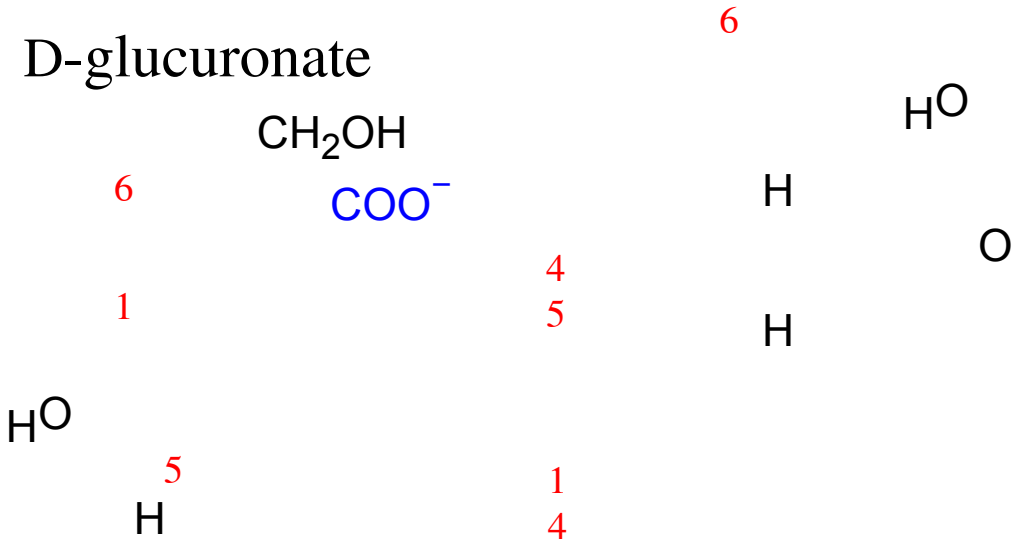
van der Waals interactions, that cause cellulose chains to be straight & rigid, and pack with a crystalline arrangement in thick bundles - microfibrils.

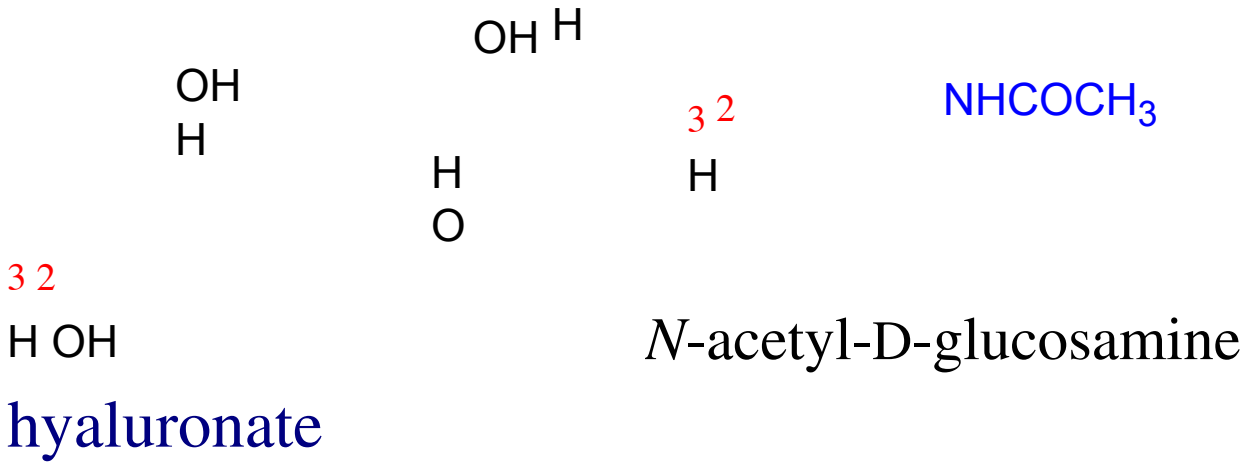
Schematic of arrangement of cellulose chains in a microfibril.



Multisubunit **Cellulose Synthase** complexes in the plasma membrane spin out from the cell surface microfibrils consisting of 36 parallel, interacting cellulose chains. These **microfibrils** are very **strong**.

The **role** of cellulose is to impart strength and rigidity to plant cell walls, which can withstand high hydrostatic pressure gradients. Osmotic swelling is prevented.



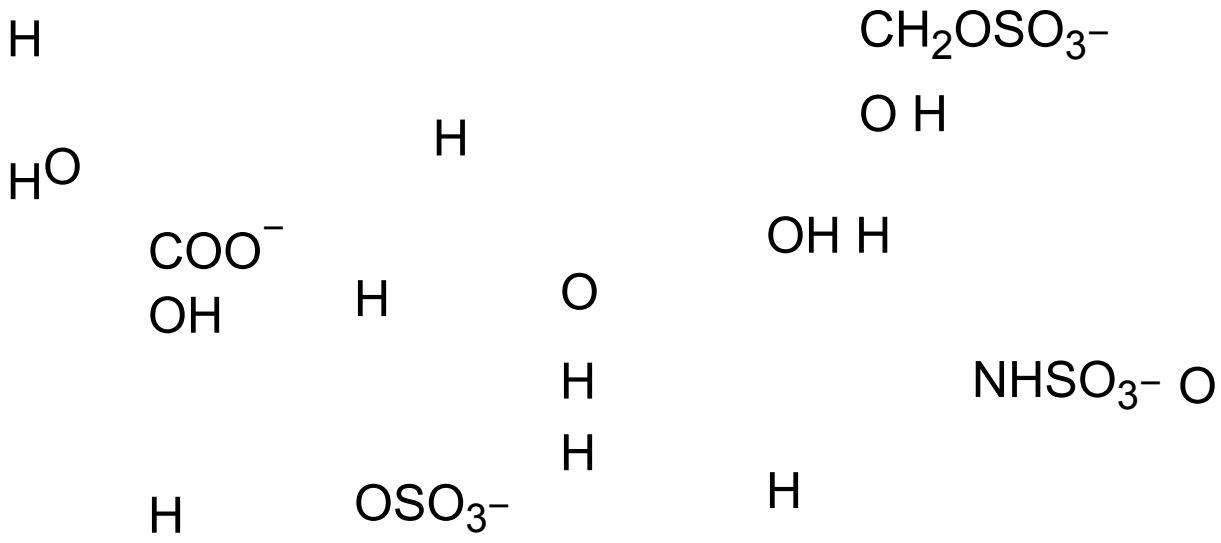


Glycosaminoglycans(mucopolysaccharides) are linear polymers of **repeating disaccharides**.

The constituent monosaccharides tend to be **modified**, with acidic groups, amino groups, sulfated hydroxyl and amino groups, etc.

Glycosaminoglycans tend to be **negatively charged**, because of the prevalence of acidic groups.

iduronate-2-sulfate *N*-sulfo-glucosamine-6-sulfate



heparin or heparan sulfate - examples of residues

Heparan sulfate is initially synthesized on a membrane embedded core protein as a polymer of alternating ***N*-acetylglucosamine** and **glucuronate** residues. Later, in segments of the polymer, glucuronate residues may be converted to the sulfated sugar **iduronic acid**, while

N-acetylglucosamine residues may be deacetylated and/or sulfated.

Madenet Al elm University College
Department of Medical Physics
2nd Year Medical Chemistry I 2021 – 2022

CARBOHYDRATE METABOLISM

Dr. Hamza Yaseen Isa
Lecture 6 M I 2

CELL RESPIRATION

THE CONCEPT OF 'RESPIRATION' IS CENTRAL TO ALL LIVING PROCESSES

All living cells are made up of **chemical substances**

The processes of living involve **reactions** between the substances.

For example, a reaction between carbon and oxygen (such as burning coal in air) changes the carbon in the coal, and oxygen in the air into carbon dioxide

The reaction between carbon and oxygen also releases **energy** in the form of heat and light (flames)

Living organisms get their energy from reactions like this (but not reactions which are violent enough to produce flames)

One of the energy-producing reactions is called **respiration**(Respiration is not the same thing as breathing) The chemical reactions of respiration take place in all living cells

The reaction takes place between oxygen and a substance which contains carbon. The reaction produces carbon dioxide and water, and releases energy

The carbon-containing substances come from **FOOD**

The oxygen comes from the **AIR** (or water) The **energy** is used to drive other chemical reactions taking place in cells

One example of this is the release of energy in muscle cells to make them contract and produce movement

One example of an energy-producing reaction in cells is the breakdown of sugar when it combines with oxygen

This can be represented by the equation

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \textbf{energy}$$

(glucose) sugar; oxygen; carbon dioxide; water

This means that one molecule of sugar reacts with six molecules of oxygen to produce six molecules of

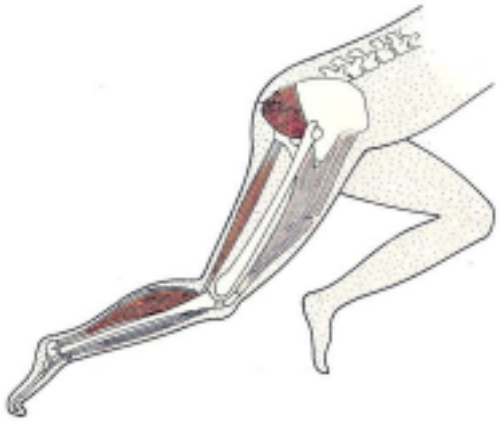
carbon dioxide and six molecules of water.

Energy is released during this process

supplies

Some examples of the use of energy in organisms

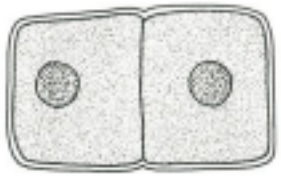
8

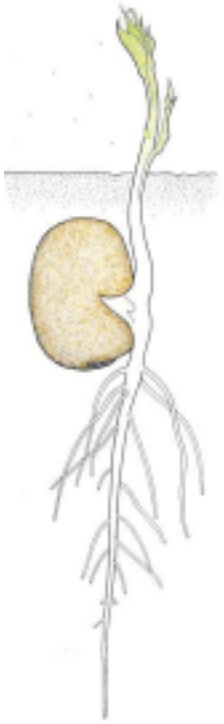


muscle

contraction

Respiration





the energy for

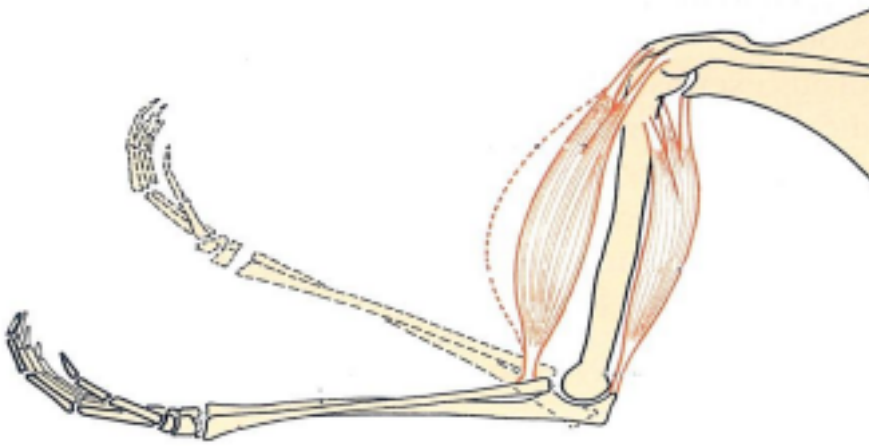
germination

chemical changes in cells cell division

9

.....makes the muscle contract and pull the lower arm up

The blood stream brings food and oxygen to the muscle cells.



lower arm bones

upper arm bone

Respiration occurs in the cells and releases energy which**……**

One example of respiration in ourselves

1. Air taken in

2. The lungs absorb oxygen from the air

1.Food taken in intestine digest food. One of the products

2.The stomach and

is glucose **3.**The blood stream carries glucose
and
oxygen to the muscles

4 RESPIRATION **5** Carbon dioxide

Glucose and
oxygen react to
produce energy for
muscle contraction

is carried to the
lungs by the blood

The process of respiration described so far has been defined as the release of **energy** when foodstuffs such as glucose react with oxygen to produce carbon dioxide and water.

This form of respiration, which needs oxygen, is called **aerobic** respiration.

There is another form of respiration which does not need oxygen and is called **anaerobic** respiration.

In anaerobic respiration, glucose is still broken down to carbon dioxide with the release of **energy**, but without the involvement of oxygen

The glucose is not completely broken down to CO_2 and H_2O but to CO_2 and alcohol (ethanol).

Anaerobic respiration can be represented by the equation

$$C_6H_{12}O_6 \xrightarrow{\text{energy}} 2C_2H_5OH + 2CO_2$$

glucose → alcohol

The energy released by anaerobic respiration is considerably less than the energy from aerobic respiration.

Anaerobic respiration takes place at some stage in the cells of most living organisms.

For example, our own muscles resort to anaerobic respiration when oxygen is not delivered to them fast enough.

Micro-organisms

Anaerobic respiration is widely used by many micro-organismssuch as **bacteria** and **yeasts**.

Bacteria and yeasts are microscopic single-celled organisms.

Bacteria are to be found everywhere, in or on organisms, in water, air and soil

Yeasts are usually found in close association with vegetable matter such as fruit

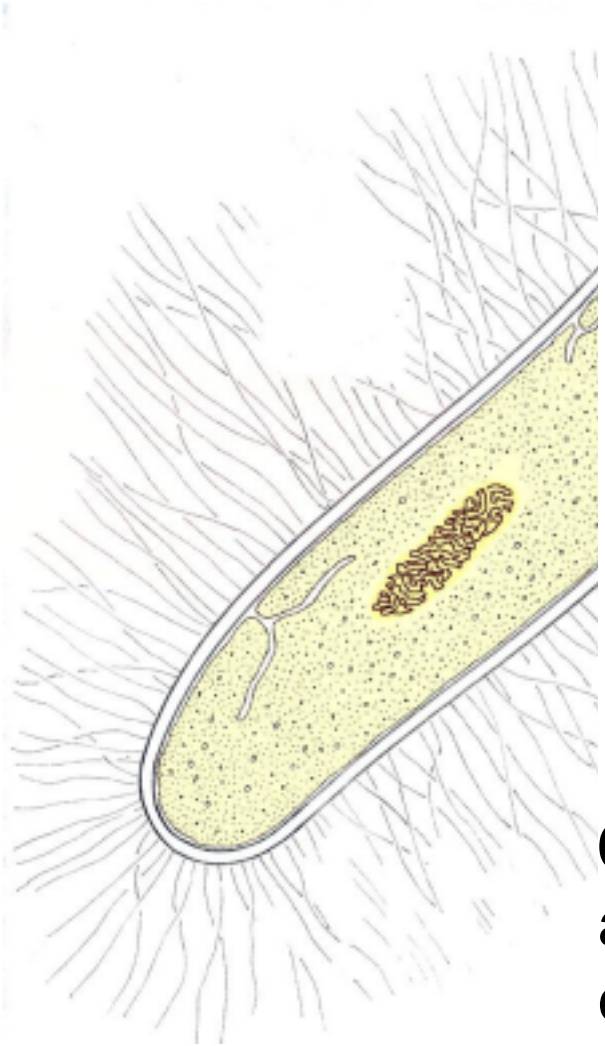
Bacteria

cell wall

there are many species of bacteria

nucleus

cytoplasm



a single bacterium

0.002mm
and they have different shapes and sizes

Aerobic and anaerobic bacteria

Bacteria which need oxygen in order to respire are called **aerobic bacteria**.

Aerobic bacteria are likely to be found in the air, water and soil where oxygen is available

Bacteria which can respire without needing oxygen are called anaerobic bacteria

Anaerobic bacteria are to be found in situations where

oxygen is lacking, such as in stagnant water, waterlogged soils or the intestines of animals

Fermentation

One form of anaerobic respiration in bacteria and yeasts is called fermentation.

During fermentation, sugar is broken down to alcohol and carbon dioxide

The reaction described in previous slide is an example of fermentation

Fermentation is involved in brewing and wine-making

Metabolism

1. Digestion of Food:

Digestion in Mouth

The major carbohydrates present in our diet are starch, glycogen, sucrose, lactose , maltose and very little concentrations of fructose and pentose. Milk and other fluid items like juices escape digestion in the mouth as they do not reside in the mouth for a longer time, whereas, starch and glycogen containing solid foods are masticated with saliva thoroughly.

Saliva contains ptyalin, an alpha amylase, which attacks the alpha **1-4 linkages resulting in the formation of monosaccharide**

glucose,
disaccharide maltose and Trisaccharide maltotriose. The optimum pH for salivary amylase is pH 6.7. Ptyalin needs chloride ions for their effective action

Digestion in Stomach

Ptyalin is inactivated due to low pH. There are no enzymes to act upon carbohydrates in the stomach. Dietary sucrose may be hydrolyzed to equimolar quantities of glucose and fructose by the HCl present.

Digestion in duodenum

When the food bolus reaches the duodenum, it is mixed with the pancreatic juice, which contains amylase. Its action is similar to that of the ptyalin, but it is more powerful . The optimum pH of pancreatic amylase

ranges between 6.9 –
7.1 and it needs chloride ions for its action

Digestion in small intestine

Five enzymes are present in small intestine to hydrolyze the carbohydrates completely to mono saccharides.Only monosaccharides can be absorbed by the intestinal mucosa. The absorption rate of the monosaccharides is in the following order: Galactose > Glucose > Fructose > Mannose > Xylose > Arabinose

2. Carbohydrate as a source of energy

The major function of carbohydrate in metabolism is to serve as fuel and get oxidized to provide energy for other metabolic processes. The metabolic intermediates are

used for various biosynthetic reactions. For this purpose, carbohydrate is utilized by the cells mainly in the form of glucose. A major part of dietary glucose is converted to glycogen for storage in liver. Glucose is degraded in the cell by way of a series of phosphorylated intermediates mainly via two metabolic pathways and other minor path.

2.1. Glycolysis

2.2. Tricarboxylic acid cycle

2.3.HMP shunt

2.1- Glycolysis

Oxidation of glucose to pyruvate is called

glycolysis. It was first described by Embden Meyerhof and Parnas. Hence it is also called as Embden-Meyerhof pathway.

Glycolysis occurs virtually in all tissues. Erythrocytes and nervous tissues derive the energy mainly from glycolysis. This pathway is unique in the sense that it can proceed in both aerobic (presence of O2) and anaerobic (absence of O2) conditions.

All the enzymes of glycolysis are found in the extra mitochondrial soluble fraction of the cell, the cytosol.

2.1.1 Reactions of glycolytic pathway(Aerobic Glycolysis):

Series of reactions of glycolytic pathway which degrades glucose to pyruvate are represented below. The sequence of reactions occurring in glycolysis may be considered under four stages.

2.1.1.1 Stages of Reactions:

Stage I

This is a *preparatory phase*. Before the glucose molecule can be split, the rather asymmetric glucose molecule is converted to almost symmetrical form, fructose 1,6-diphosphate by donation of two phosphate groups from ATP.

1. Uptake of glucose by cells and its phosphorylation **Glucose is freely permeable to liver cells, intestinal mucosa and kidney tubules where glucose is taken up by 'active' transport. In other tissues insulin**

facilitates the uptake of glucose. Glucose is phosphorylated to form glucose 6-phosphate. The enzyme involved in this reaction is glucokinase. This reaction is irreversible.

2. Conversion of glucose 6-phosphate to fructose 6-phosphate

3. Conversion of fructose 6-phosphate to fructose 1,6 diphosphate.

Fructose 6-phosphate is phosphorylated irreversibly at 1 position catalyzed by the enzyme phosphofructokinase to produce fructose

1,6- diphosphate

Stage II

1. Actual splitting of fructose 1,6 diphosphate

Fructose 1,6 diphosphate is split by the enzyme aldolase into two molecules of triose phosphates, an aldotriose-glyceraldehyde 3-phosphate and one ketotriose - dihydroxy acetone phosphate. The reaction is reversible. There is neither expenditure of energy nor formation of ATP.

2. Interconvertion of triose phosphates

Both triose phosphates are interconvertible

Stage III

It is the energy yielding stage. Reactions of this type in which

a aldehyde group is oxidised to an acid are accompanied by liberation of large amounts of potentially useful energy. 1. Oxidation of glyceraldehyde 3-phosphate to 1,3-bisphosphoglycerate

2. Conversion of 1,3-bisphosphoglycerate to 3-phosphoglycerate

Stage IV

It is the recovery of the phosphate group from 3- phosphoglycerate..

1. Conversion of 3-phosphoglycerate to 2-phosphoglycerate. .

2. Conversion of 2-phosphoglycerate to phosphoenol pyruvate

3. Conversion of phosphoenol pyruvate to pyruvate

Phosphoenol pyruvate is converted to pyruvate, the reaction is catalysed by the enzyme pyruvate kinase. The high energy phosphate group of phosphoenol pyruvate is directly transferred to ADP, producing ATP. The reaction is irreversible.

2.1.1.2 Energy yield per glucose molecule oxidation:

During glycolysis ATP molecules are used and formed in the following reactions (aerobic phase)

2.1.2 Anaerobic phase

In the absence of O2, reoxidation of NADH at glyceraldehydes 3-phosphate dehydrogenase stage cannot take place in respiratory chain. But the cells have limited coenzyme. Hence to continue the glycolysis, NADH must be reoxidized to NAD+. This is achieved by reoxidation of NADH by conversion of pyruvate to lactate (without producing ATP).

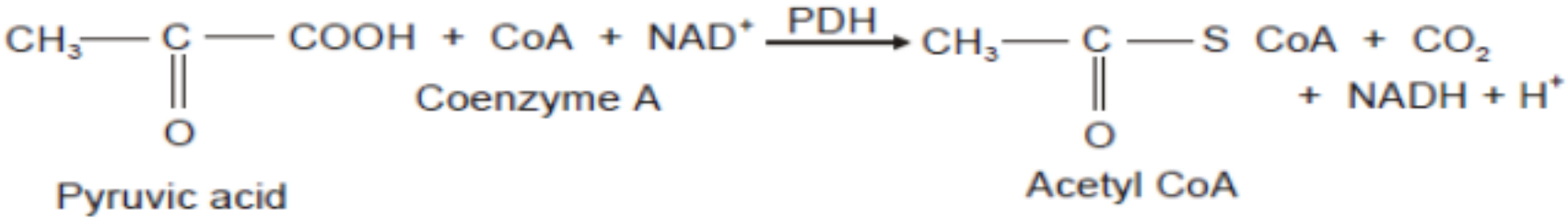
It is to be noted that in the reaction catalyzed by glyceraldehyde 3-phosphate dehydrogenase, therefore, no ATP produced. In the anaerobic phase oxidation of one glucose molecule produces 4 - 2 = 2 ATP.

2.2. Tricarboxylic acid cycle (TCA cycle)

This cycle is the aerobic phase of carbohydrate metabolism and follows the anaerobic pathway from the stage of pyruvate and is called as citric acid cycle or TCA cycle. The name citric acid cycle stems from citric acid which is formed in the first step of this cycle. This cycle is also named "Krebs cycle" after H.A. Krebs, an English biochemist who worked on it. Under aerobic conditions, pyruvate is oxidatively decarboxylated to acetyl coenzyme A (active acetate) before entering the citric acid cycle.

This occurs in the mitochondrial matrix and forms a

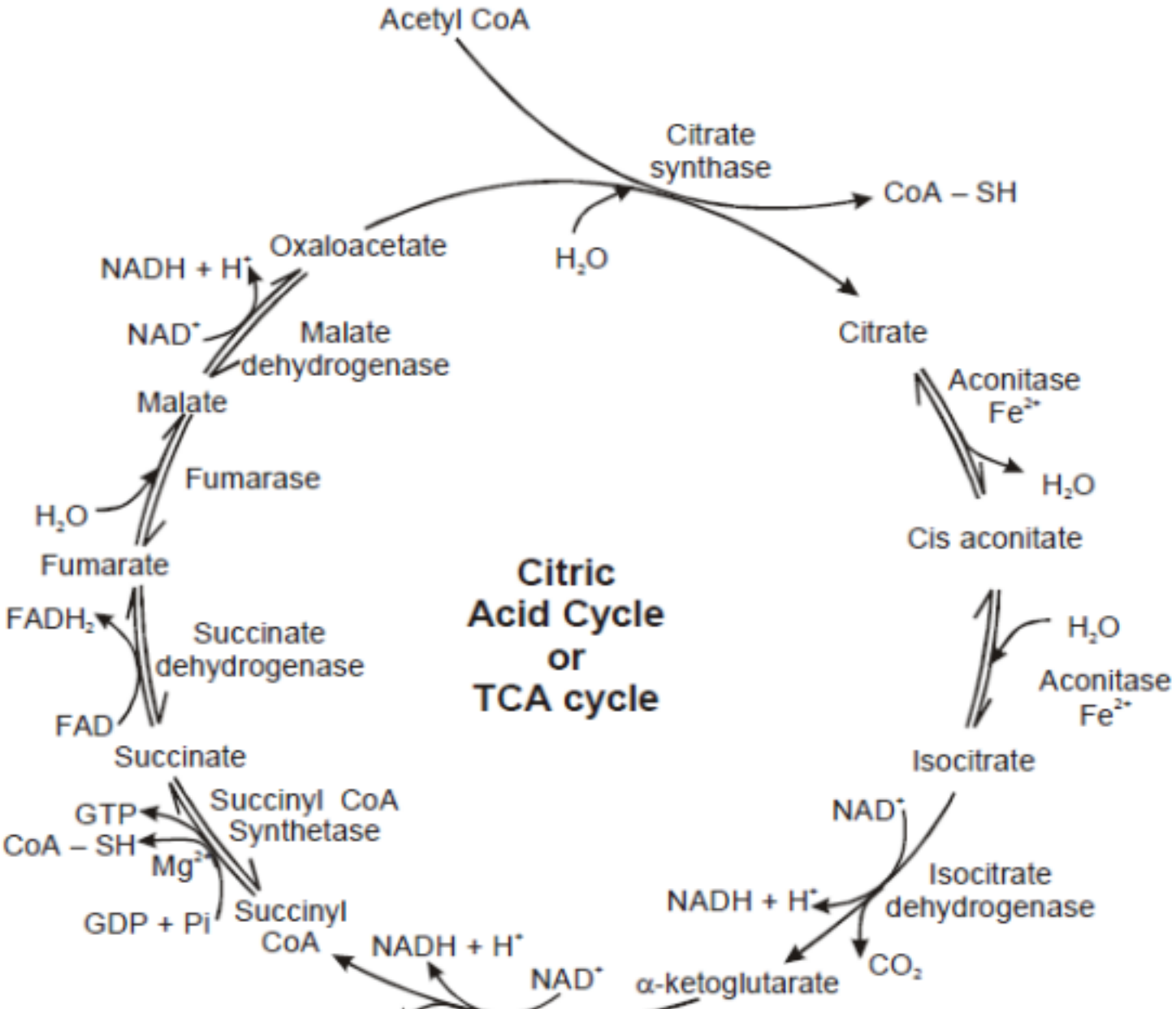
link between glycolysis and TCA cycle



2.2.1 Reactions of the citric acid cycle:

There are eight steps in the cycle and the reactions are as follows: 1. Formation of citrate

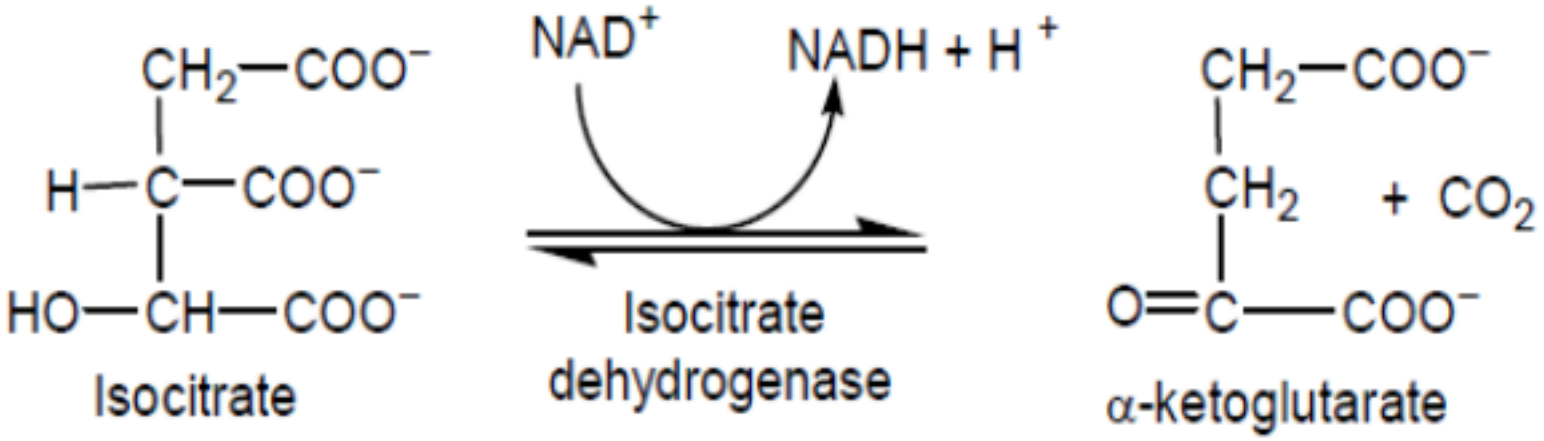
The first reaction of the cycle is the condensation of acetyl CoA with oxaloacetate to form citrate, catalyzed by citrate synthase. This is an irreversible reaction.


Acetyl CoA
Citrate synthase
CoA – SH
H2O
Oxaloacetate
NADH + H+
NAD+
Malate dehydrogenase
Malate
Fumarase
H2O
Fumarate
FADH2
Succinate dehydrogenase
FAD
Succinate
Succinyl CoA Synthetase
GTP
CoA – SH
Mg2+
GDP + Pi
Succinyl CoA
NADH + H+
NAD+
α-ketoglutarate
CO2
Isocitrate dehydrogenase
NADH + H+
NAD+
Isocitrate
H2O
Aconitase Fe2+
Cis aconitate
H2O
Aconitase Fe2+
Citrate
Citric Acid Cycle or TCA cycle

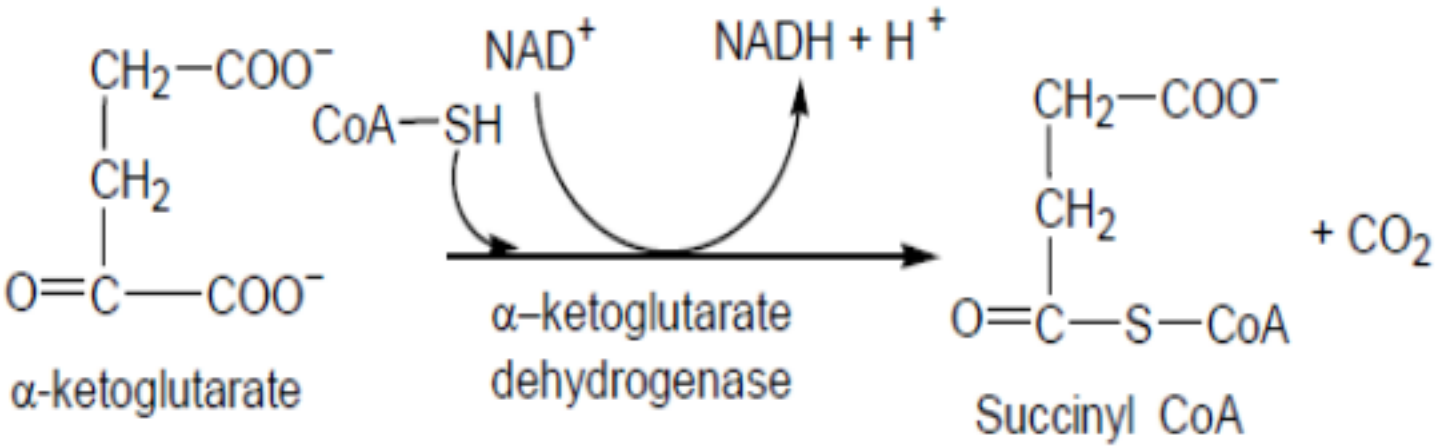
2. Formation of isocitrate via cis aconitate

The enzyme aconitase catalyzes the reversible transformation of citrate to isocitrate, through the intermediary formation of cis aconitate.

3. Oxidation of isocitrate to a-ketoglutarate and CO2 In the next step, isocitrate dehydrogenase catalyzes oxidative decarboxylation of isocitrate to forma-ketoglutarate.



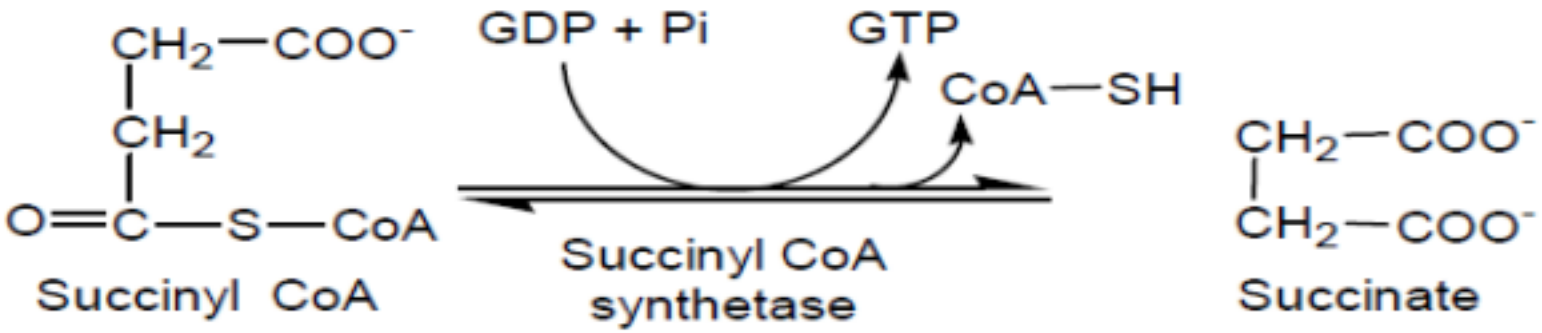
4. Oxidation of a-keto glutarate to succinyl CoA and CO2 The next step is another oxidative decarboxylation, in which a ketoglutarate is converted to succinyl CoA and CO2 by the action of the a-ketoglutarate dehydrogenase complex. The reaction is irreversible



5. Conversion of succinyl CoA to succinate

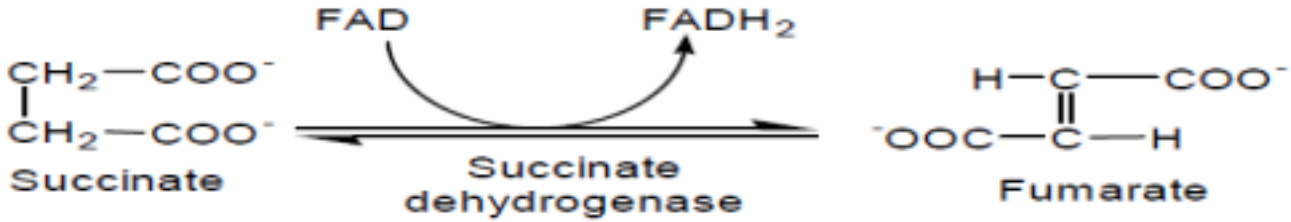
The product of the preceding step, succinyl CoA is converted to succinate to continue the cycle. GTP is formed in this step (substrate level phosphorylation).

The enzyme that catalyzes this reversible reaction is called succinyl CoA synthetase or succinic thiokinase.



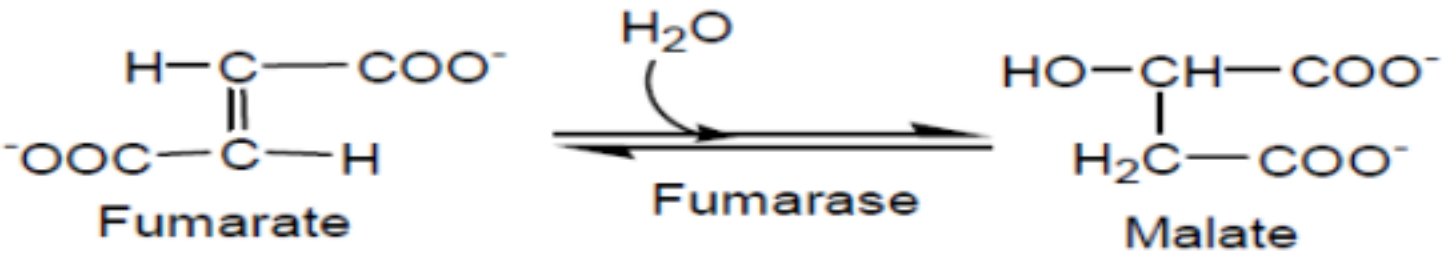
6. Oxidation of succinate to fumarate

The succinate formed from succinyl CoA is oxidized to fumarate by the enzyme succinate dehydrogenase



7. Hydration of fumarate to malate

The reversible hydration of fumarate to malate is catalyzed by fumarase.



8. Oxidation of malate to oxaloacetateThe last reaction of the citric acid cycle is, NAD linked malate - dehydrogenase which catalyses the oxidation of malate to oxaloacetate.

2.2.2 Energy yield from TCA cycle

2.3. HMP shunt pathway of metabolism

Although glycolysis and citric acid cycle are the common pathways by which animal tissues oxidize glucose to CO_2 and H_2O with the liberation of energy in the form of ATP, a number of alternative pathways are also discovered. The most important one is Hexose Monophosphate Shunt Pathway (HMP shunt). The pathway occurs in the extra mitochondrial soluble portion of the

cells-Cytosol.

Unlike glycolysis and Krebs cycle which are primarily concerned with the generation of ATP, HMP shunt generates a different type of metabolic energy - the reducing power. Some of the electrons and hydrogen atoms of fuel molecules are conserved for biosynthetic purposes rather than ATP formation. This reducing power of cells is NADPH (reduced nicotinamide adenine

dinucleotide phosphate).

Oxidative reactions of the hexose mono-phosphate pathway

Glycogen:

Glycogen is the major storage form of carbohydrate in animals and corresponds to starch in plants. It occurs mainly in liver.

Glycogen biosynthesis:

The process of biosynthesis of glycogen from glucose is known as glycogenesis. This occurs in all the tissues of the body but the major sites are liver and muscles. A considerable amount is synthesized in kidney also. Glycogenesis is a very essential process since the excess of glucose is

converted and stored up as glycogen which could be utilized at the time of requirement. In the absence of this process the tissues are exposed to excess of glucose immediately after a meal and they are starved of it at other times. The following are the various reactions of glycogenesis.

Gluconeogenesis:

The synthesis of glucose from non carbohydrate precursors is known as gluconeogenesis. The major site of gluconeogenesis is liver. It usually occurs

when the carbohydrate in the diet is insufficient to meet the demand in the body, with the intake of protein rich diet and at the time of starvation, when tissue proteins are broken down to amino acids.

Madenet Alelm University College
Department of Medical Physics
2nd Year Medical Chemistry 2021– 2022

Amino Acids , Proteins, and Lipids

Dr. Hamza Yaseen Isa
Lecture M 7 I 2

- **Proteins are linear copolymers built from**

monomeric units called amino acids.

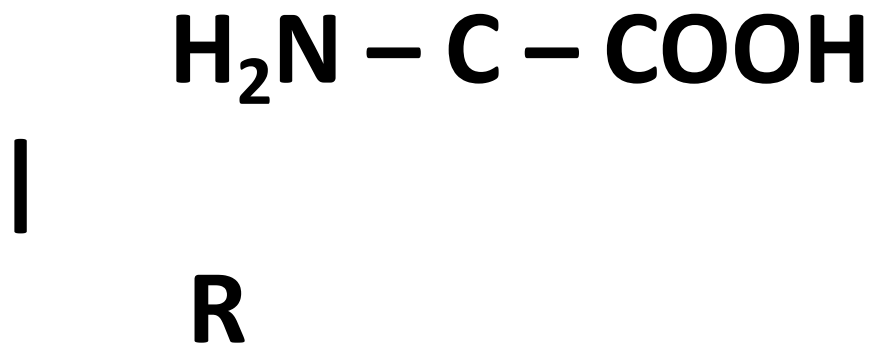
- **Twenty amino acids are commonly found in proteins.**
- These amino acids contain a variety of different functional groups:
  - Alcohols (R-OH)
  - Phenols (Ph-OH)
  - Carboxylic acids (R-COOH)
  - Thiols (R-SH)
  - Amines ($R\text{-}NH_2$)
  - *and others…*

- **Protein function depends on both**
  - amino acid content, and

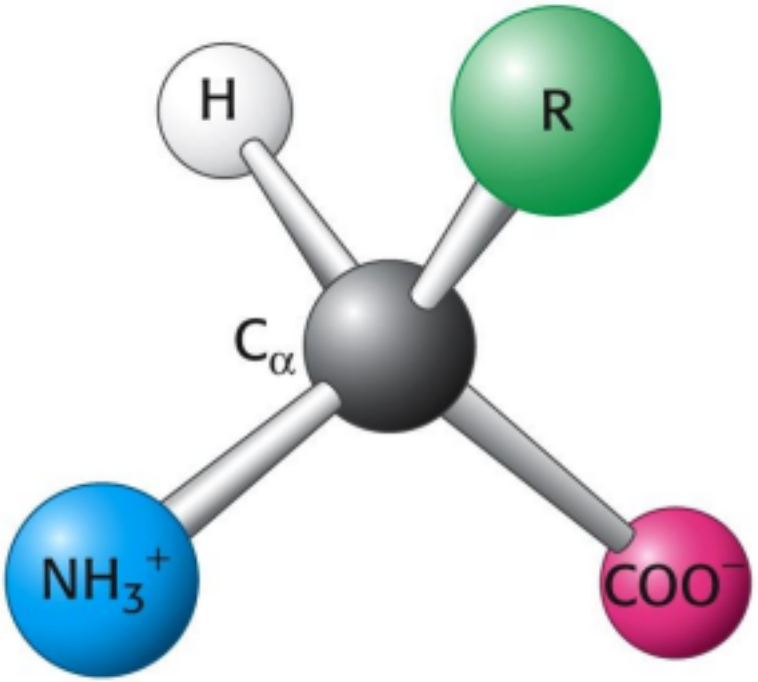
- amino acid sequence.

- **Protein fold into diverse shapes such as**
  - **spherical**
  - **elipsoidal**
  - **long strands, etc.**
- **All information for 3-D structure is contained in the linear sequence of amino acids.**

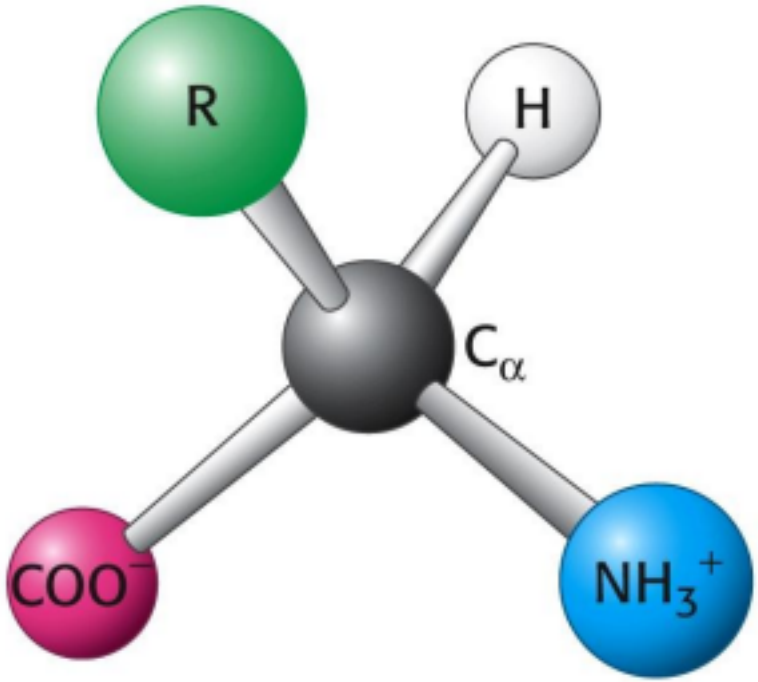
- **To understand protein function, we must first understand the nature of amino acids.**
- **Amino acids are essentially α-amino acids:** **alpha carbon (IUPAC #2 position)**



- **When R is not H, the alpha carbon is asymetric, giving rise to isomers.**



L isomer



D isomer

Only L-amino acids are constituents of proteins.

"L" and "D" isomeric nomenclature is similar to the "R" and "S" utilized in modern organic chemistry.

- **<u>Carboxylic acids</u> are traditional Bronsted-Lowery acids, donating a proton in aqueous solution.**

- **The pKa for caroboxylic acids is normally around 2 to 5. That is, the pH at which these acids are 50% ionized:**

- **R-COOH R-COO$^-$ + H$^+$**

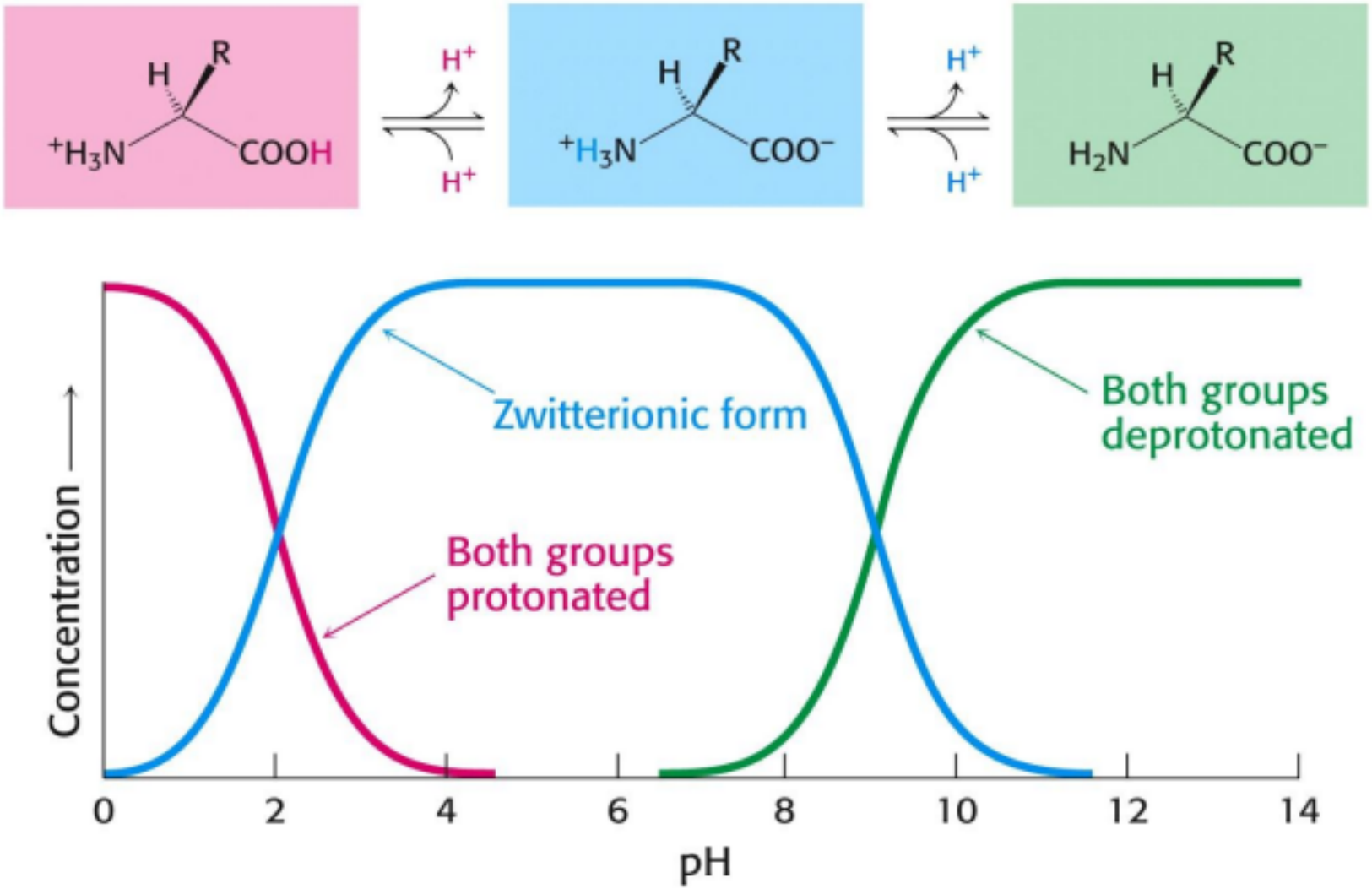
pH= [less than 2] [above 5]

- **<u>Amino groups</u> function as bases, accepting a proton. • The pKa for amino groups is usually around 9 – 10. Again, at the pKa these groups are 50% ionized:**

R-NH$_3^+$ R-NH$_2$ + H$^+$

pH= [below 8] [above 9]

- **Even though both acids and amines are present in the same molecule, they mostly behave as though they were separate entities:**



- **“Zwitter” Ions:**
- **Ions bearing two charges were named zwitter**

ions by German scientists; the name still applies today, especially for amino acids at neutral pH:

$$^{+}H_3N - CH_2 - COO^{-}$$

Acid-Base Properties of Amino Acids

Draw the following chemical structures for glycine:

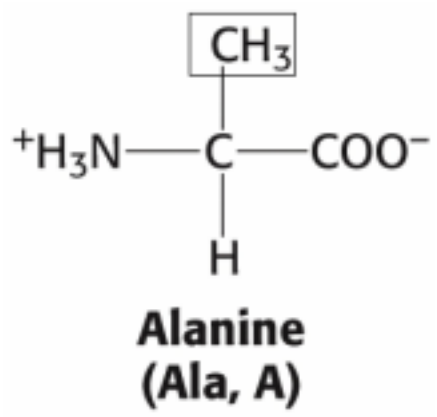
***(Non-existent form*:) $H_2N - CH_2 - COOH$**

<u>pH=1:</u> $^{+}H_3N - CH_2 - COOH$

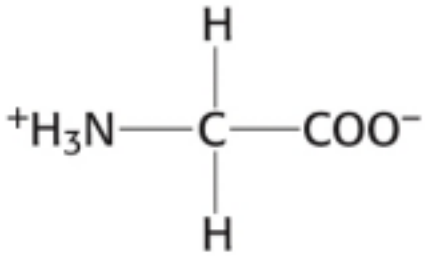
pH=7: $^{+}H_3N - CH_2 - COO$

pH=12: $H_2N - CH_2 - COO^{-}$

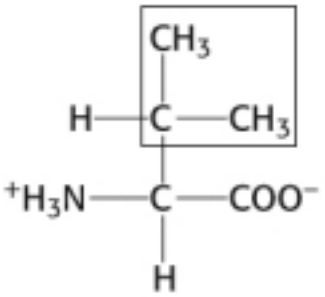
Amino acids: (*Aliphatic*)



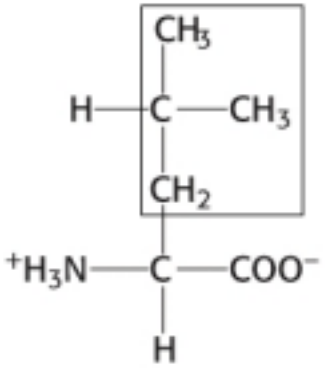
Alanine
(Ala, A)



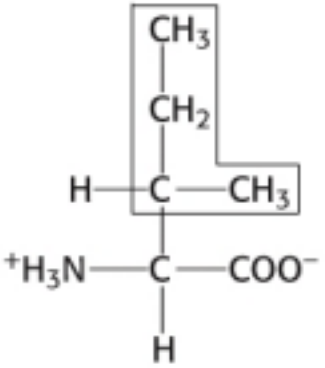
Glycine
(Gly, G)



Valine
(Val, V)



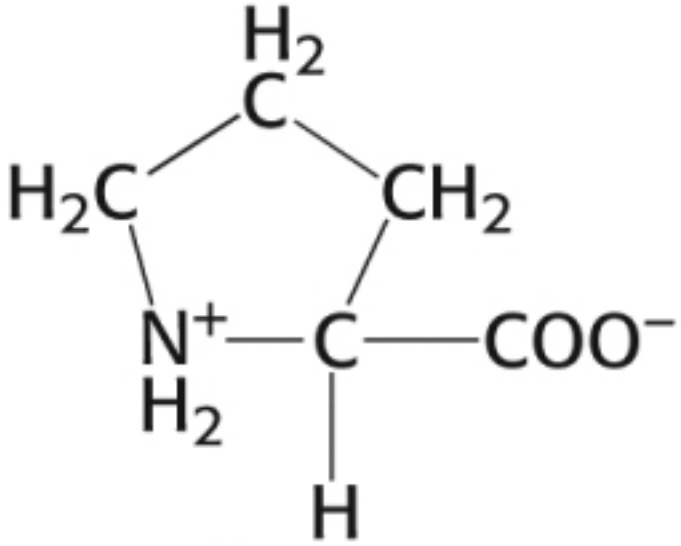
Leucine
(Leu, L)



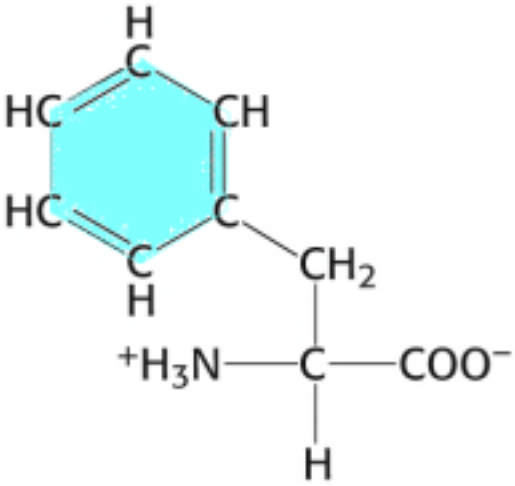
Isoleucine
(Ile, I)

- **Amino acid Proline**

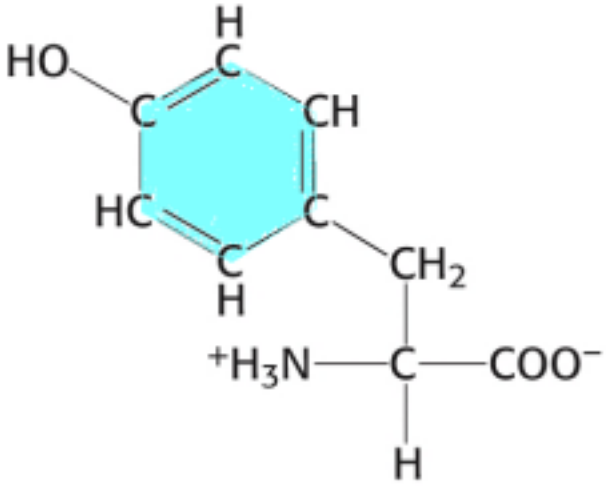
(The only secondary (2°) amino acid or ("imino" acid.)



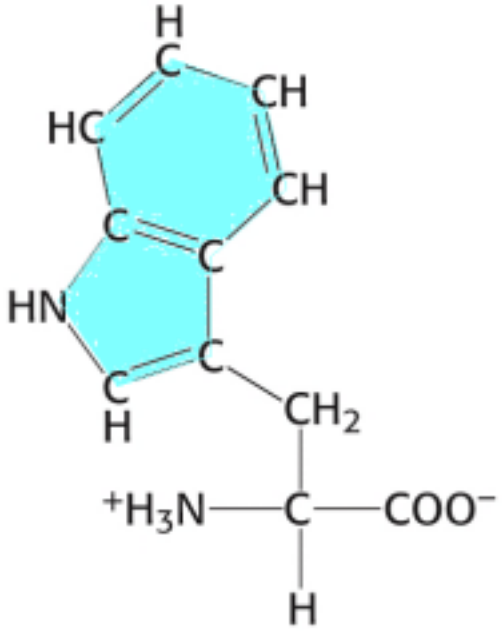
Proline
(Pro, P)



Phenylalanine (Phe, F)

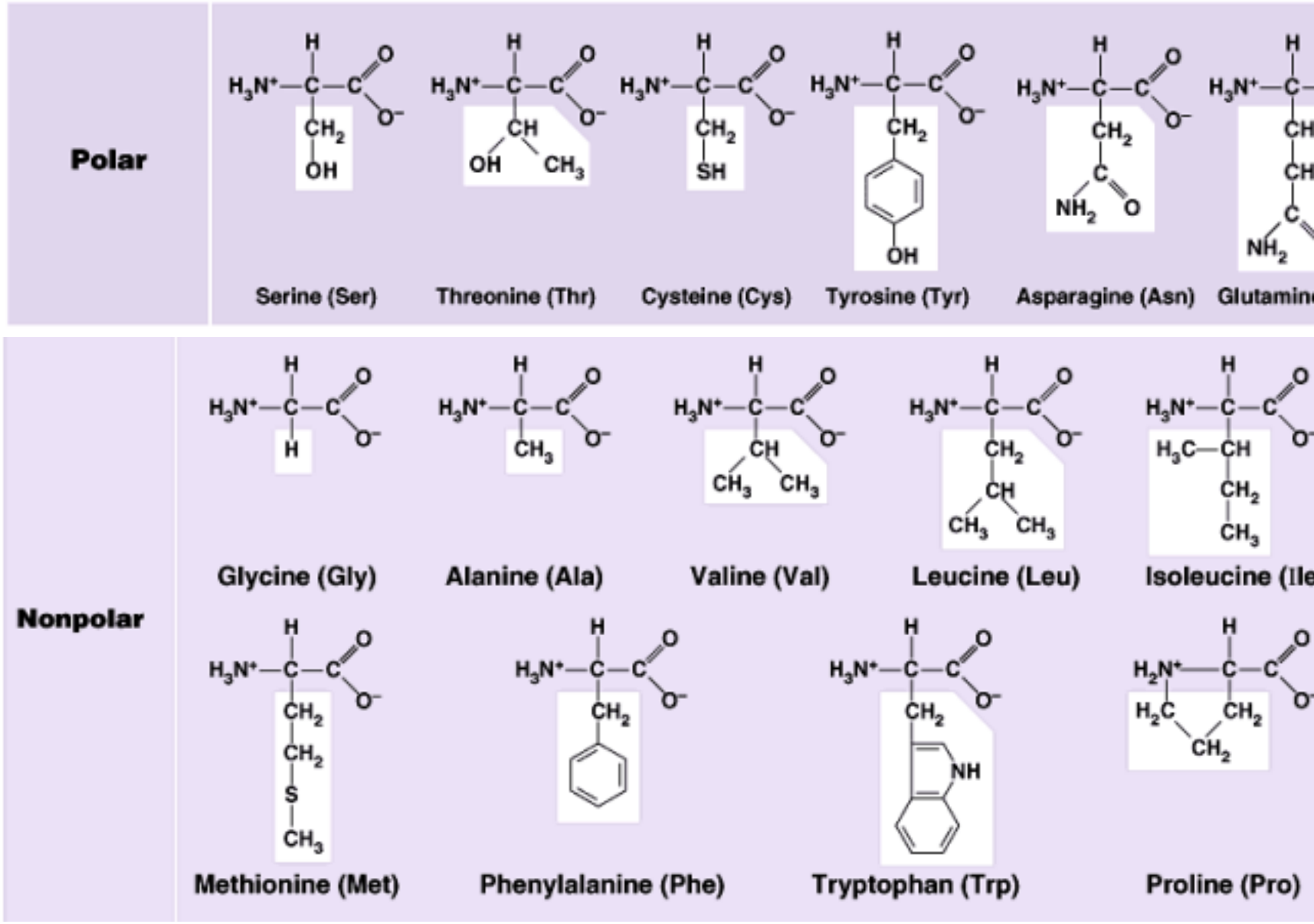


Tyrosine (Tyr, Y)

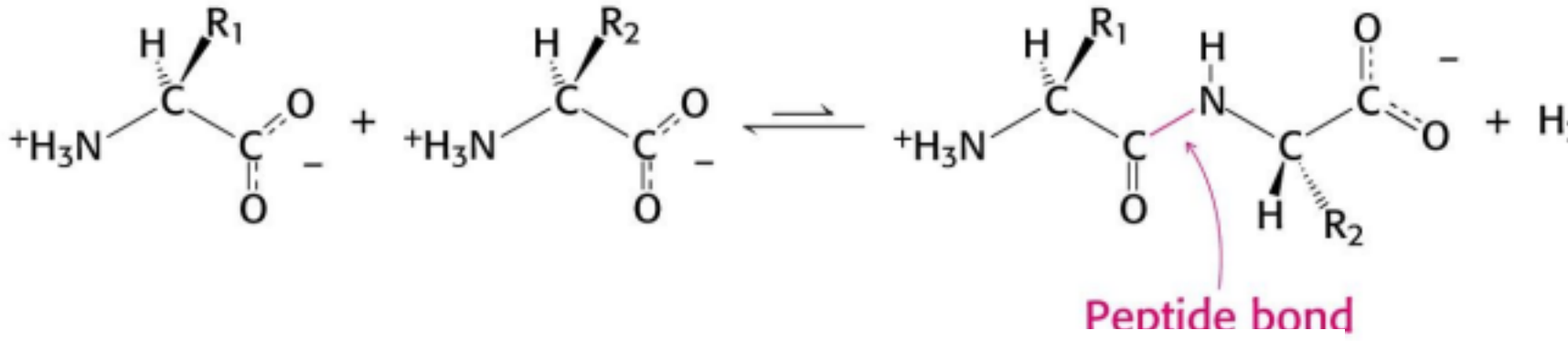


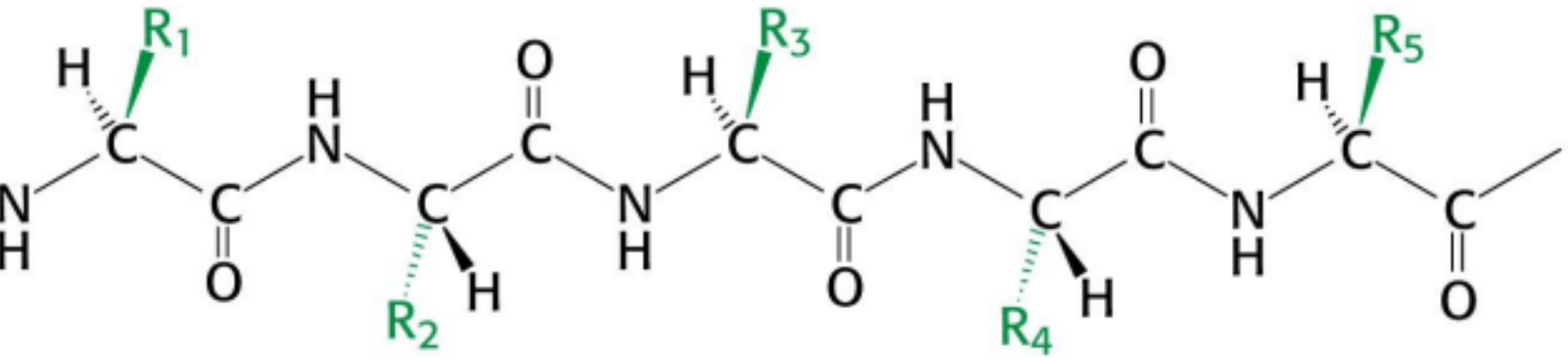
Tryptophan (Trp, W)

- Amino acids (*Aromatic*)



- **Amino acids are polymerized via amide or "peptide" bonds:**





- Copolymer of amino acids:

  – a “<u>polypeptide</u>”

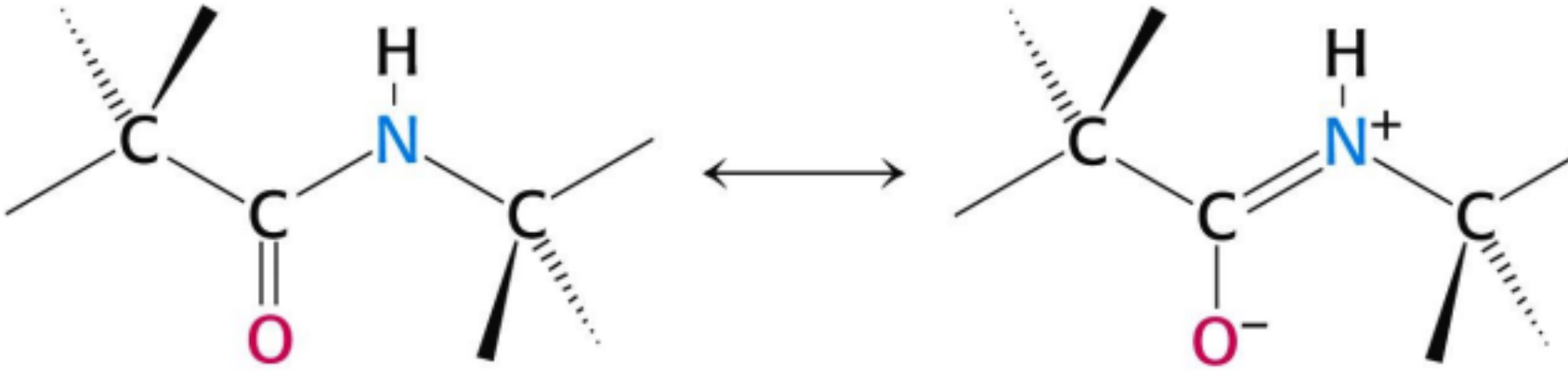
Definition:

Amino acid polymers of ≤50 amino acids are called

"polypeptides, peptides, oligopeptides, etc."

Amino acids polymer of >50 amino acids are called "proteins."

- **Peptide bonds have *partial* double bond character due to resonance that limits rotation about this bond:**



Peptide bond resonance structures

Levels of Protein Structure

- **Primary (1°) Protein Structure –**

  linear sequence of amino acids. •

Secondary (2°) Protein Structure –

localized regional structures

- **Teritary (3°) Protein Structure**
  - overal shape of proteins
- **Quaternary (4°) Protein Structure**
  - interactions between proteins

Lipids

- **LIPID describes a chemically varied group of fatty substances and are highly concentrated energy stores.**
- **They are water-insoluble bio-molecules but soluble in organic solvents such as ether, benzene.**

Chloroform, etc.

- Lipids serve as fuel molecules, signal molecules, and components of membranes, hormones and intracellular messengers.

- They are esters of long chain fatty acids and alcohols.

Functions Of Lipids

- Lipids are the constituents of cell membrane and regulate membrane permeability.
- They protect internal organs, serve as insulating materials and give shape and smoothness to the body.
- They serve as a source of fat soluble vitamins.
- Essential fatty acids are useful for transport of cholesterol, formation of lipoproteins, etc.

- **Phospholipids in mitochondria are responsible for transport of electron transport chain components.**
- **Accumulation of fat in liver is prevented by phospholipids.**
- **Phospholipids help in removal of cholesterol from the body by participating in reverse cholesterol transport.**
- **Cholesterol is a constituent of membrane structure and it synthesizes bile acids, hormones and vitamin D. It is the principal sterol of higher animals, abundant in nerve tissues and gallstones.**

Classification Of Lipids

Based on their Biological functions, Lipids can be classified into:

1. Storage Lipids—The principal stored form of

energy

2. Structural Lipids– The major structural elements of Biological Membranes

3. Lipids are signals, cofactors and pigments

Classification Of Lipids

1. SIMPLE LIPIDS: These lipids are the esters of fatty acids with alcohols. They are of three types: Waxes, sterol esters and Triacylglycerol.

2. COMPOUND/COMPLEX LIPIDS: These lipids are esters of fatty acids with alcohols and additional groups such as phosphate, nitrogenous base, etc. They are again divided into 3 types: Phospholipids, Glycero phosphlipids, Sphingophospholipids.

3. DERIVED LIPIDS: These lipids are obtained on hydrolysis of simple and complex lipids. These lipids contain glycerol and other alcohols. This class of lipids include steroid hormones, ketone bodies, hydrocarbons, fatty acids, fatty alcohols, mono and diacylglycerides.

4. MISCELLANEOUS LIPIDS: These include compounds, which contain characteristics of lipids. They include squalene, terenes hdrocarbons carotenoids etc.

Classification Scheme

Lipids

Simple

1. Wax esters 2. Sterol esters

Complex Derived

3. Diglycerides

Phospholipids

4. monoglycerides

Glycolipids 1.Cerebrosides

2.Gangliosides

1. Fatty acids
2. Sterols
3. Triacylglycerol

Sphingolipids

1.Phosphatidylcholine (PC)
2.Phosphatidylethanolamine (PE)
3.Phosphatidylinositol (PI)

1.Ceramides 2.Sphingomyelin

Glycerophospholipids

Storage Lipids

Storage Lipids include fats and oils, and wax.

- **Fats and oils are composed of 3 fatty acids each in ester linkage with a single glycerol (Triacylglycerols)**

- **Waxes are esters of long-chain(C14-C36) saturated and unsaturated fatty acids with long chain (C16-C30) alcohols**

Triacylglycerol's (TAG)

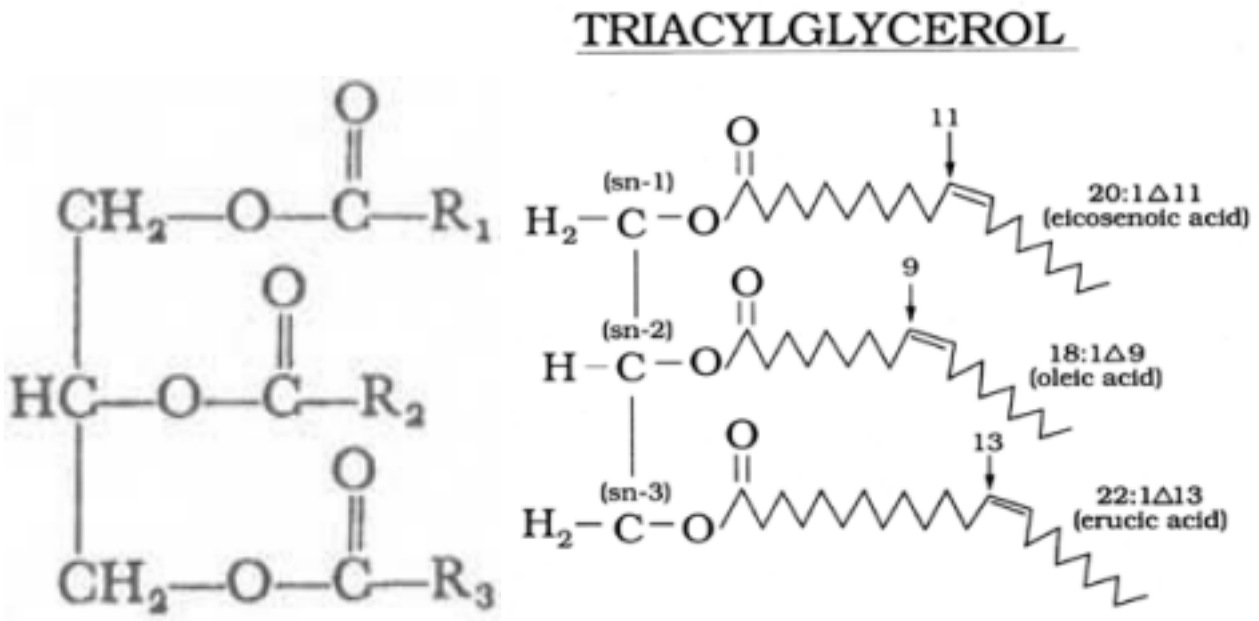
- Triacylglycerol(Triglyceride) is an ester of glycerol with three fatty acids.

- It is also called neutral fat.

- They are stored in adipocytes in animals and endosperm and cotyledon cells in plants.

- A mammal contains 5% to 25% or more of its body weight as lipids,90%TAG

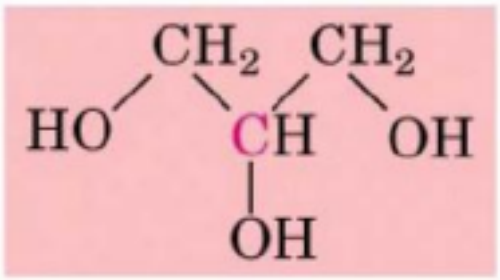
Structure of Triacylglycerol



An example of TAG

The TAG that contains same kind of fatty acids in all the three positions are called as simple TAG, otherwise, Mixed TAG

Fats and Oils (TAGs)



Glycerol

Most occurring TAGs are mixed, which contain two or more different fatty acids. TAGs are non polar, hydrophobic molecules, essentially insoluble in water

Fatty Acids

- **Fatty acids are composed only of carbon, hydrogen and oxygen in the proportion of 76%, 12.6% and 11.3%**

respectively.

- Fatty Acids are carboxylic acids with hydrocarbon chains ranging from 4-36.
- Fatty acids are of 2 types: Saturated and Unsaturated.
- Saturated Fatty Acids have no double bonds and thus the hydrocarbon chain is completely unbranched

Unsaturated fatty acids contain one or more double bonds, usually in the cis-conformation.

- Polyunsaturated fatty acids have 2-6 double bonds.

Saturated Fatty Acids

Completely Unbranched and saturated with no double bonds

Nomenclature of Fatty Acids

18 16 14 12 10 8 6 4

15 13 11 9 7 5 3

17

$^{1}COOH\ ^{2}$

Number of Double Bonds

Carbon Chain Position of Double Bonds Length

18:3 (, 12, 15)

The most commonly occurring fatty acids have even number of carbon atoms in an un-branched chain of12-24 carbons

Systematic names are based on IUPAC nomenclature:

CH3-CH2-CH2-CH2-CH2-CH2-CH2-CH2-CH2-CH2-CH2-COO

H 12 11 10 9 8 7 6 5 4 3 2 1

or

CH3 (CH2)10 –COOH Dodecanoic acid (Lauric)

- 14:0 tetradecanoic acid
- 16:0 Hexadecanoic acid
- 20:0 Eicosanoic acid
- 22:0 Docosanoic acid
- 24:0 Tetracosanoic acid

- No double bonds for eg in 18:0, Octadecanoic acid
- If one double bond then acid Octadecenoic acid
- If two double bonds then Octadecadienoic acid
- If three double bonds Octadecatrienoic acid.

General Patterns of Double Bonds

- The most common positions for double bonds are $\Delta 9$, $\Delta 12$, and $\Delta 15$.

- The double bonds of polyunsaturated fatty acids

are separated by methyl group:

-CH=CH-CH2-CH=CH-

🗣 In almost all the naturally occurring unsaturated fatty acids, the double bonds are in Cis- configuration

Some Naturally Occurring Fatty Acids

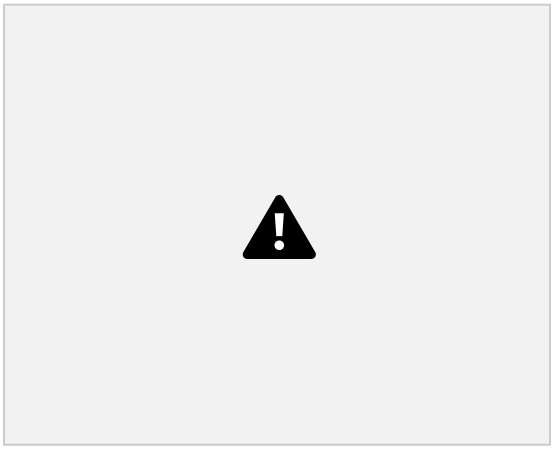
Physical Properties of Fatty Acids

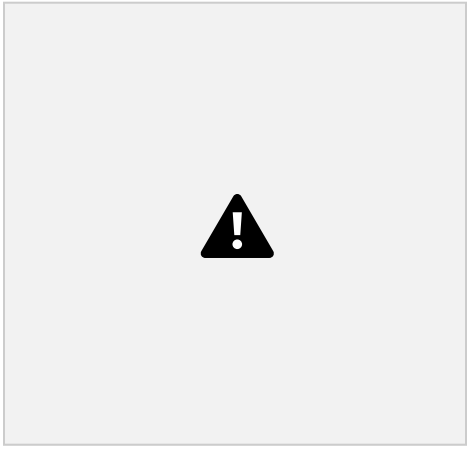
🗣 The physical properties of fatty acids are largely determined by the length and degree of unsaturation of the hydrocarbon chain. The longer the chain and the fewer the double bonds, the lower is the solubility in water, and higher is the melting point. Addition of double bonds decreases the melting point whereas, increasing the chain length increases the melting point. For example; 4:0 MP -7.9 C, 12:0 MP 44.2 C, 16:0 MP 62.7 C, 18:1 MP 10.5 C, 18:2 MP -5.0 C, 18:3 MP -11 C.

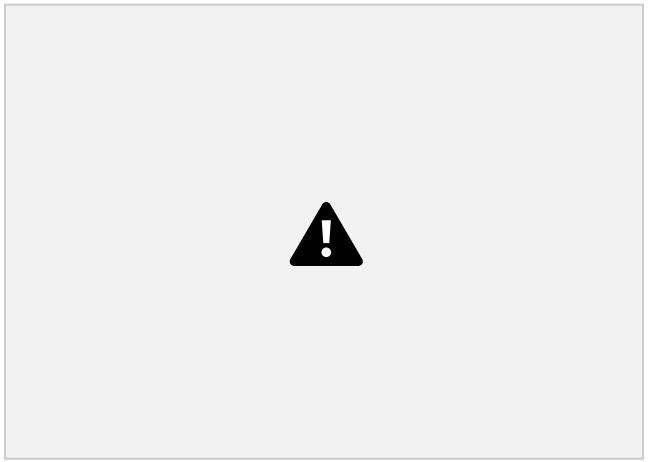
- **Trivial names of fatty acids refer to the natural sources of derivation: eg**

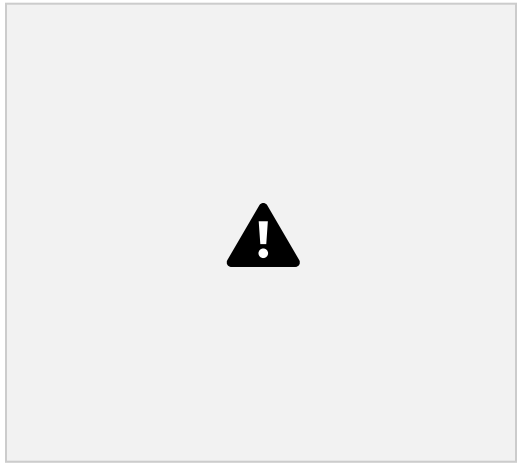
- **Lauric (12:0) isolated from seed fat of Lauraceae**
- **Myristic (14:0) –seed fat Myristaceae**
- **Palmitic (16:0) –seed fat of palmae**
- **Oleic (18:1) –seed fat of olive oil.**

The Packing of Fatty Acids









isomerism

- A double bond in Fatty acid chain permits two types of geometrical isomers, cis and trans.

- Cis isomers have a curved configuration. •

Trans isomers have a linear configuration.

- Due to curve configuration cis unsaturated fatty acids have a lower melting point as compared to

there trans counterpart.

- **Most of the natural unsaturated fatty acids have cis double bonds.**

Positional Isomers

Saturated

Linear structure

M.P.(69.6 C)

Trans, similar to

linear structure
M.P. (42.0 C)

CH3

Positional Isomers

Saturated

Linear

structure

M.P.(69.6 C)

COOH

Cis one curved structure

M.P. (10.5

C)COOH

CH3 CH3

Positional Isomers Saturated Linear structure

M.P.(69.6 C)

structure
M.P. (-5.0

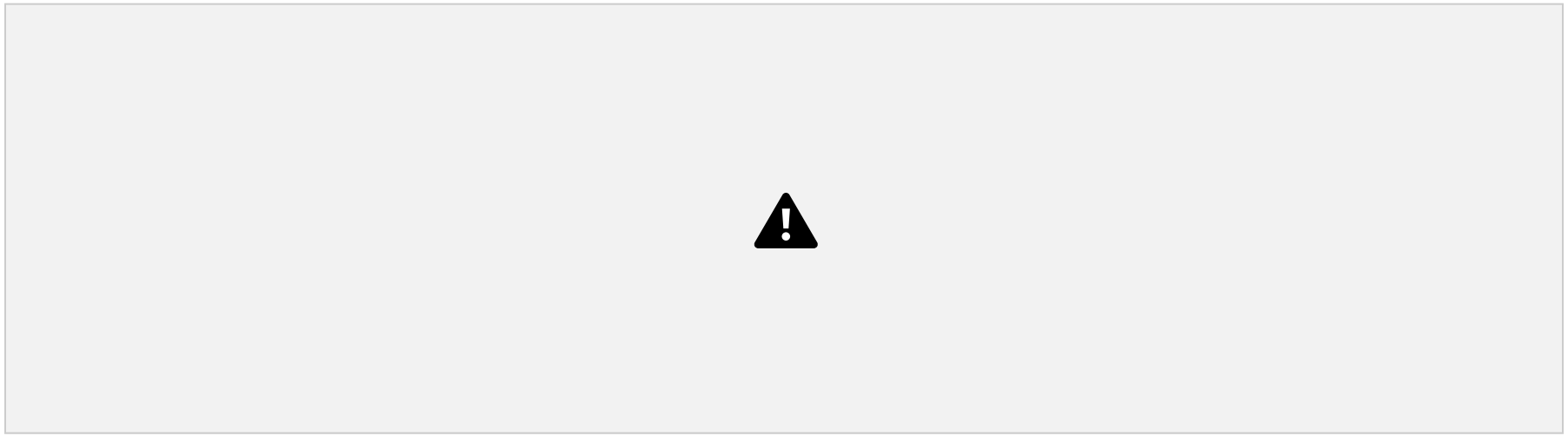
C)COOH

COOH
Cis Two curved

CH3 CH3

Wax

- **Waxes are esters of long chain (C14-C36) saturated and unsaturated fatty acids with long chain (C16-C30) alcohols.**



Functions of Wax

1. Chief storage fuels for some of the

microorganisms. 2. Protect skin and hair.

3. Prevents excess water evaporation in

plants. 4. Protects against parasites

5. Application in industries, pharmaceuticals, and cosmetics

Madenet Alelm University College
Department of Medical Physics
2nd Year Medical Chemistry 2021– 2022

Enzymes Structure, Classification and Mechanism of Action

Dr. Hamza Yaseen Isa
Lecture M 9 I 2

Objectives:

- Concept for enzymes.
- Mechanism of enzyme action.
- Factors affect rate of enzyme action.

- **Enzyme specificity.**
- **Enzyme kinetics (Km & Vmax).**
- **Enzyme inhibition.**
- **Regulation of enzyme activity.**
- **Clinical uses of enzymes in diagnosis and prognosis of different diseases.**
- **Classes of enzymes.**
- **Coenzymes.**

Importance

- Enzymes play an important role in Metabolism, Diagnosis, and Therapeutics.
- All biochemical reactions are enzyme catalyzed in the living organism.

- Level of enzyme in blood are of diagnostic importance e.g. it is a good indicator in disease such as myocardial infarction.
- Enzyme can be used therapeutically such as digestive enzymes.

Define enzymes

(Enzymes as Biological Catalysts)

- **Enzymes** are proteins that increase the rate of reaction by lowering the energy of activation

- They catalyze nearly all the chemical reactions taking place in the cells of the body.

- Not altered or consumed during reaction.

Reusable

What is the difference between an enzyme and a protein?

Protein enzymes are classified into **2 types: 1- Simple Protein enzymes:** They are formed of protein only.

2- Complex (conjugated) Protein : They are formed of protein part and non protein part.

- **All enzymes are proteins except some**

RNAs • not all proteins are enzymes

ACTIVE SITES

- **Enzyme molecules contain a special pocket or cleft called the active sites. The area on the enzyme where the substrate or substrates attach to is called the active site.**
- **Enzymes are usually very large proteins and the active site is just a small region of the enzyme molecule.**
-

Examples

- **dehydration synthesis (synthesis)**

enzyme

±

H_2O

- **hydrolysis (digestion)**

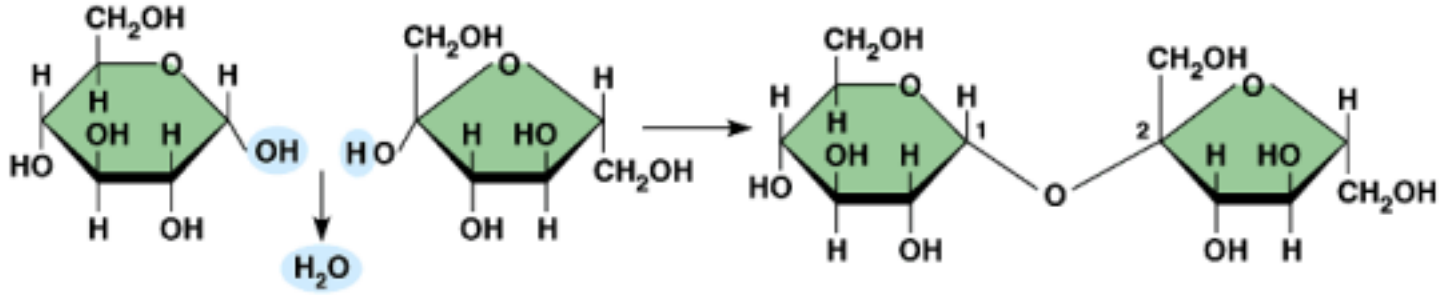
+

enzyme

H_2O

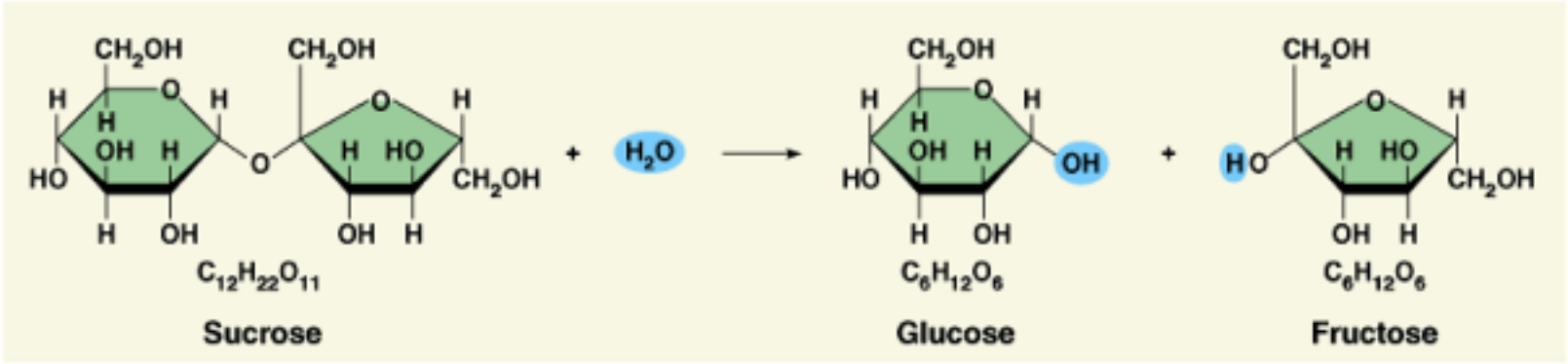
Examples

- **dehydration synthesis (synthesis)**



enzyme

- **hydrolysis (digestion)**



enzyme

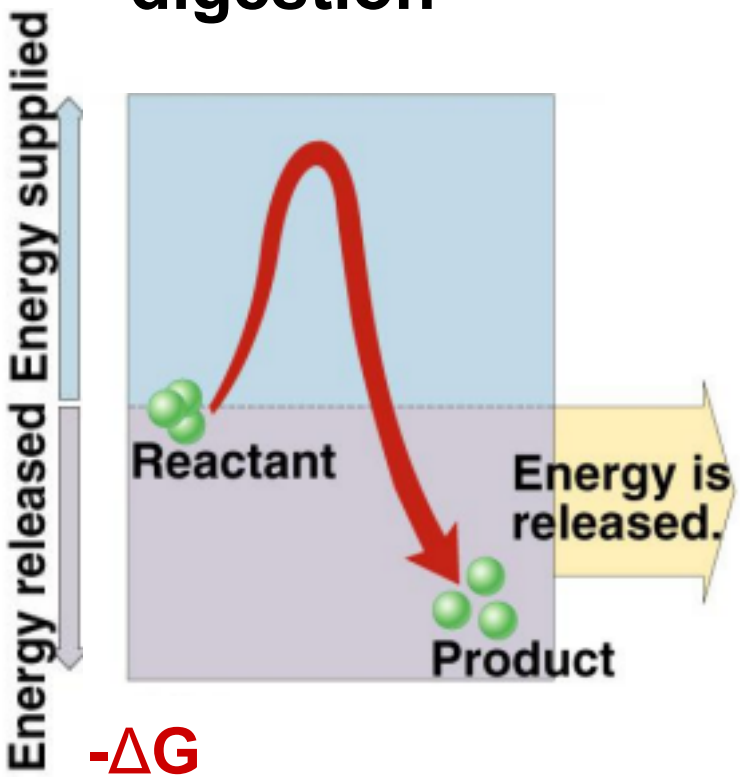
Chemical reactions & energy

- Some chemical reactions release energy
  - **Exergonic (catabolism)**
  - digesting polymers
  - hydrolysis = catabolism
- Some chemical reactions require input of energy
  - **Endergonic(anabolism)**
  - building polymers
  - dehydration synthesis = anabolism

Endergonic vs. exergonic reactions **exergonic endergonic**

- energy released
- digestion

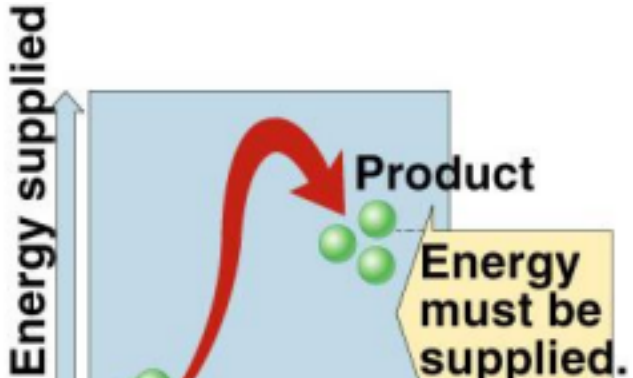
invested -
synthesis



+ΔG

-ΔG

- energy



ΔG = change in free energy = ability to do work

Energy & life

- Organisms require energy to live
  - where does that energy come from?
    - **coupling exergonic reactions (releasing energy) with endergonic reactions (needing energy)**

+ + energy

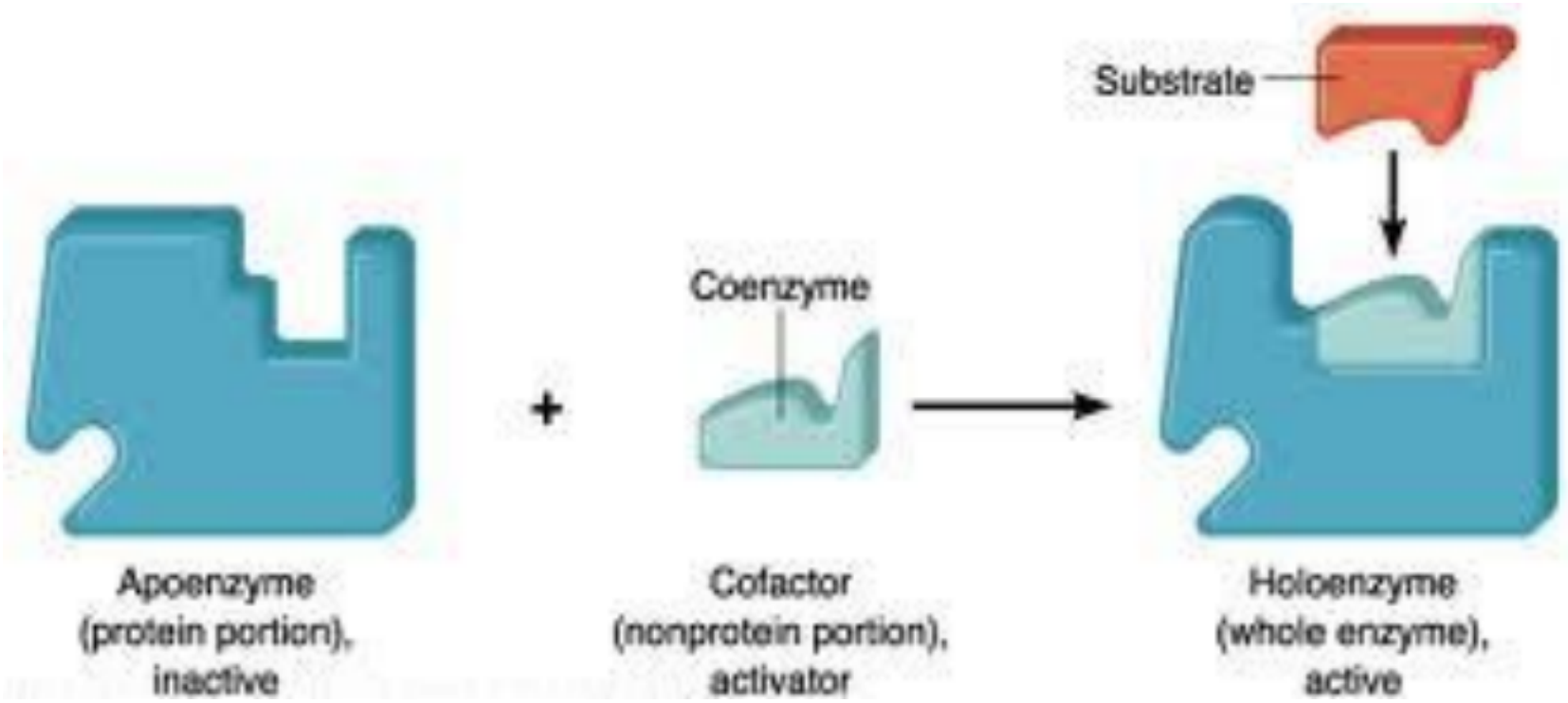
digestion

synthesis

+ + energy

APOENZYME and HOLOENZYME

- The enzyme without its non protein moiety is termed as Apo enzyme and it is inactive.
- Holoenzyme is an active enzyme with its non protein moiety component.



Important Terms to Understand Biochemical Nature And Activity of Enzymes

- **Cofactor:**
  - –A cofactor is a non-protein chemical compound that is bound (either tightly or

loosely) to an enzyme and is required for catalysis.

– **Types of Cofactors:**
  - Coenzymes.
  - Prosthetic groups.

Types of Cofactors

- **Coenzyme:**

The non-protein component, loosely bound to apoenzyme by non-covalent bond. • Examples : vitamins or compound derived from vitamins ,ex : Vit B derivatives ; NAD and FAD.

- **Prosthetic group**

  The non-protein component, tightly bound to the apoenzyme by covalent bonds is called a Prosthetic group.

Enzyme Specificity

- Enzymes have varying degrees of **specificity** for substrates
- Enzymes may recognize and catalyze:
  - a single substrate
  - a group of similar substrates
  - a particular type of bond

Activation energy or Energy of Activation: All chemical reactions require some amount of energy to get them started.

OR

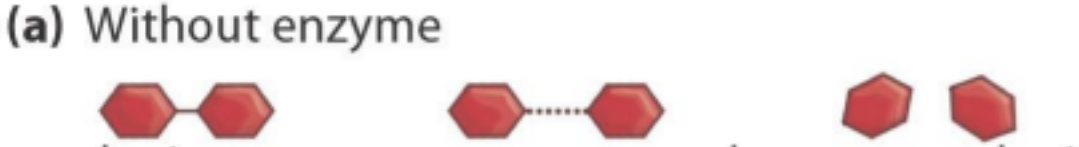
- It is First push to start reaction.

This energy is called activation energy.

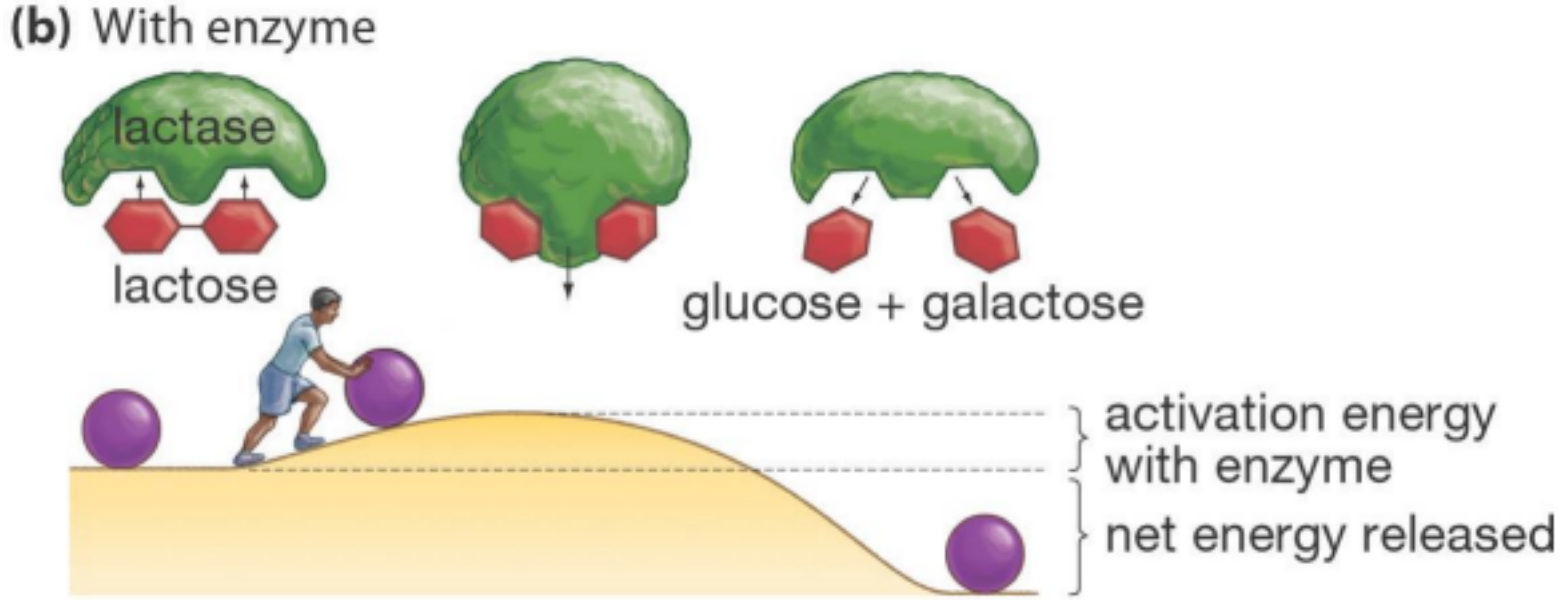
Mechanism of Action of Enzymes

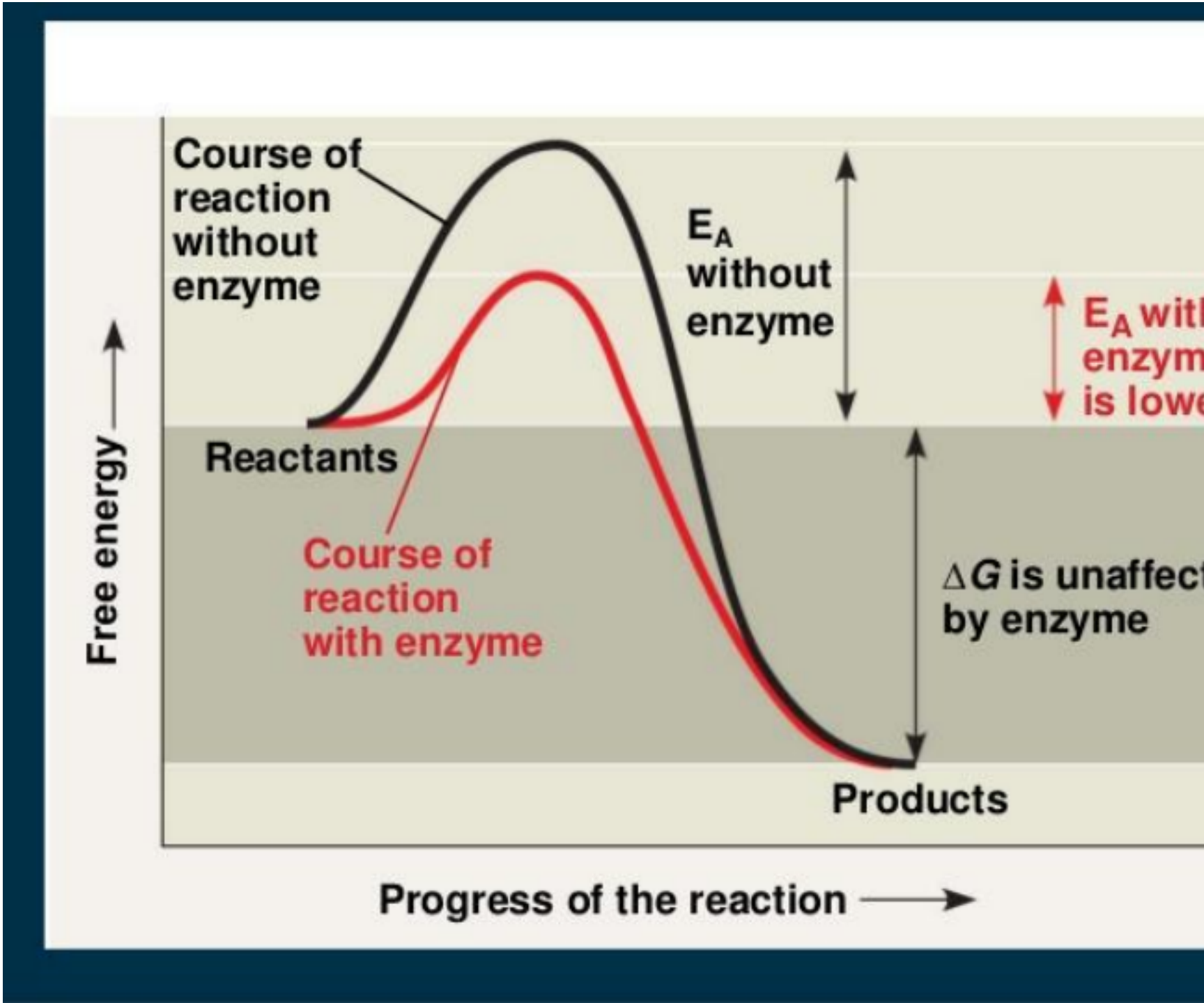
- Enzymes increase reaction rates by decreasing the Activation energy:
- Enzyme-Substrate Interactions:
  - Formation of Enzyme substrate complex by:
  - Lock-and-Key Model
  - Induced Fit Model

Enzymes



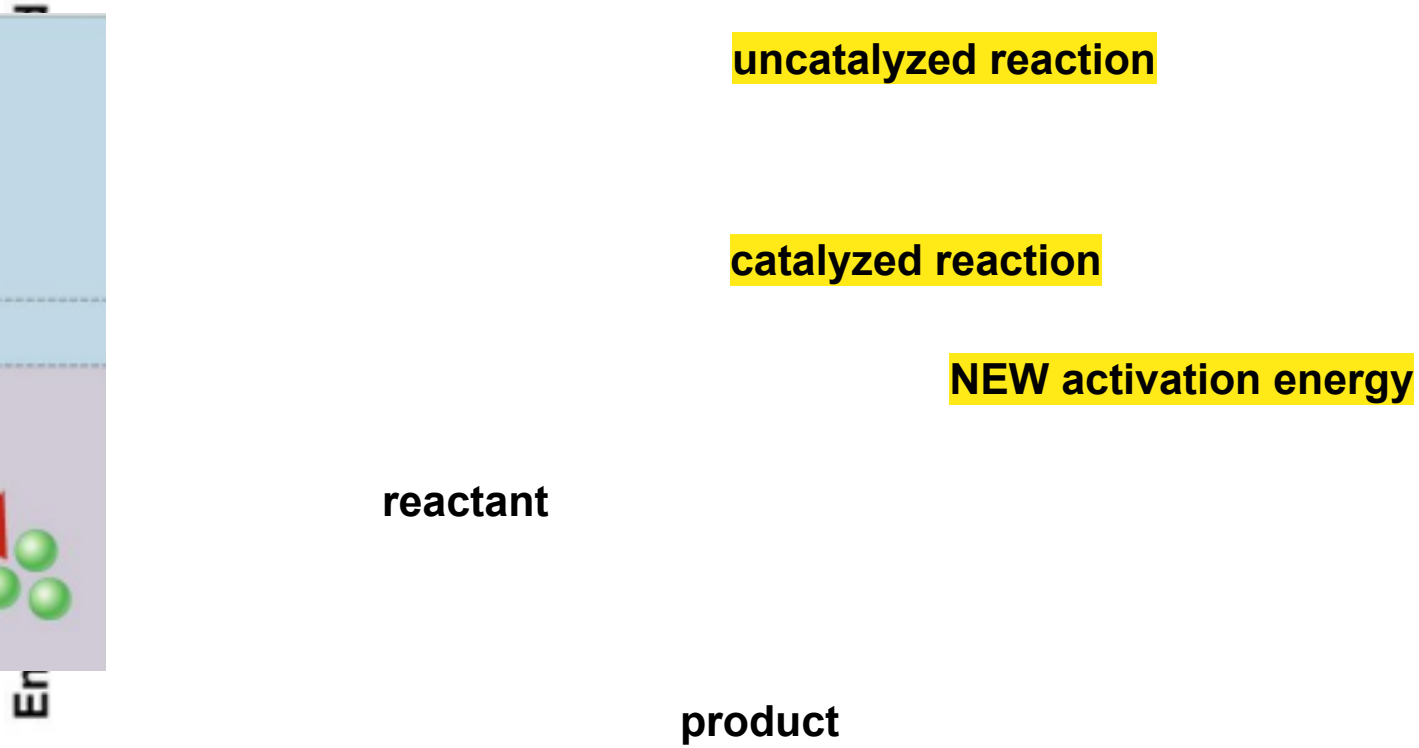
Lower a Reaction's Activation Energy




Course of reaction without enzyme
E_A without enzyme
E_A with enzym is lowe
Reactants
Course of reaction with enzyme
ΔG is unaffec by enzyme
Products
Free energy
Progress of the reaction

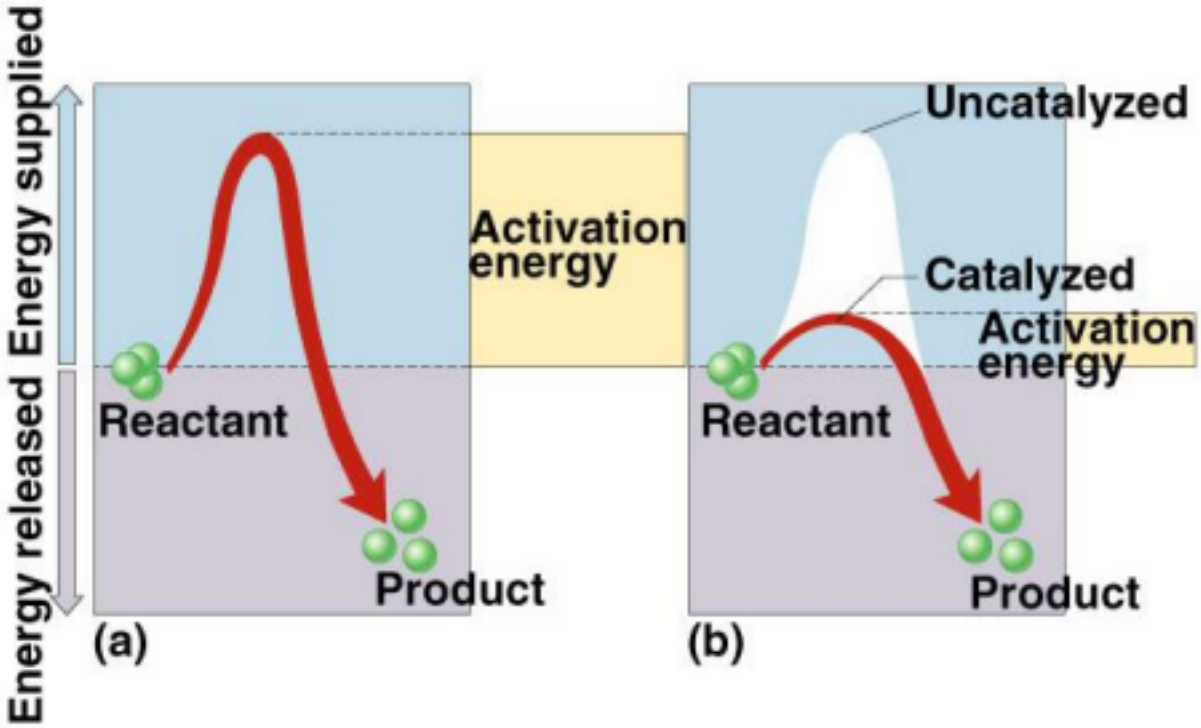
Reducing Activation energy

- Catalysts
  - reducing the amount of energy to start a reaction



Catalysts

- So what's a cell got to do to reduce activation energy?
  - get help! … chemical help… **ENZYMES**

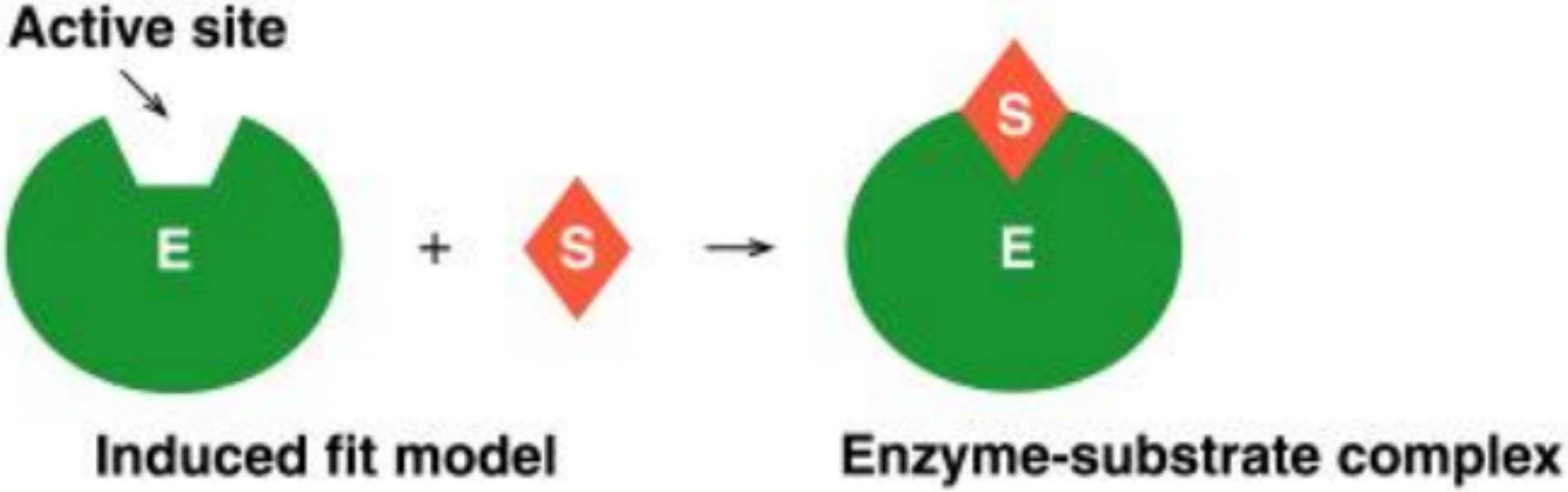


ΔG

Induced Fit Model

- In the **induced-fit model** of enzyme action:
  - the active site is flexible, not rigid
  - the shapes of the enzyme, active site, and substrate adjust to maximumize the fit, which improves catalysis

- there is a greater range of substrate specificity • This model is more consistent with a wider range of



enzymes

Enzyme-substrate complex

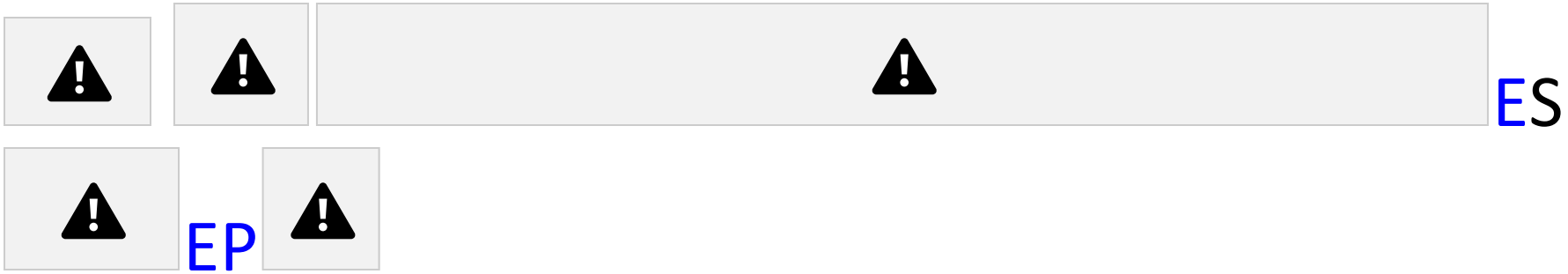
- Step 1:
- Enzyme and substrate combine to form complex

- E + S ES • Enzyme Substrate Complex

+

Enzyme-product complex

- Step 2: Within the active site of the ES complex, the reaction occurs to convert substrate to product (P)
  An enzyme-product complex is formed.



ES transition EP state

Product

- The enzyme and product separate
- EP E + P **The product is made**

Enzyme is


EP

ready
for
another substrate.

What

Affects Enzyme Activity ?

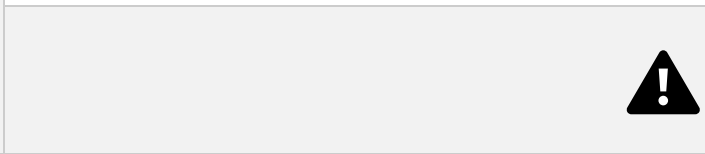

Three factors:

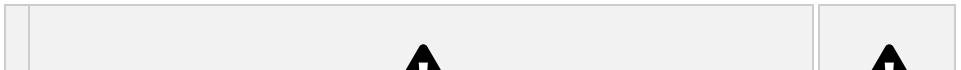
1. Environmental Conditions

2. Cofactors and Coenzymes

3. Enzyme Inhibitors

[1. Environmental Conditions]





1. Extreme Temperature are the most dangerous

- high temps may denature (unfold) the enzyme.

2. pH (most like 6 - 8 pH near neutral)

3. substrate concentration .

stomach
pepsin

pH

intestines
trypsin

7

pH

11 12 13 14

0 1 2 3 4 5 6 8 9 10

2.

Cofactors and Coenzymes

- Inorganic 

substances (zinc, iron) and vitamins

(respectively) are sometimes needed for proper enzymatic activity.

Example:

Iron must be present in the quaternary structure - hemoglobin in order for it to pick up oxygen.

Naming Enzymes

- **The name of an enzyme in many cases end in *–ase***
- **For example, *sucrase* catalyzes the hydrolysis of sucrose**

- **The name describes the function of the enzyme For example, *oxidases* catalyze oxidation reactions**

- **Sometimes common names are used, particularly for the digestion enzymes such as *pepsin* and *trypsin***

- **Some names describe both the substrate and the function • For example, *alcohol dehydrogenase* oxides ethanol**

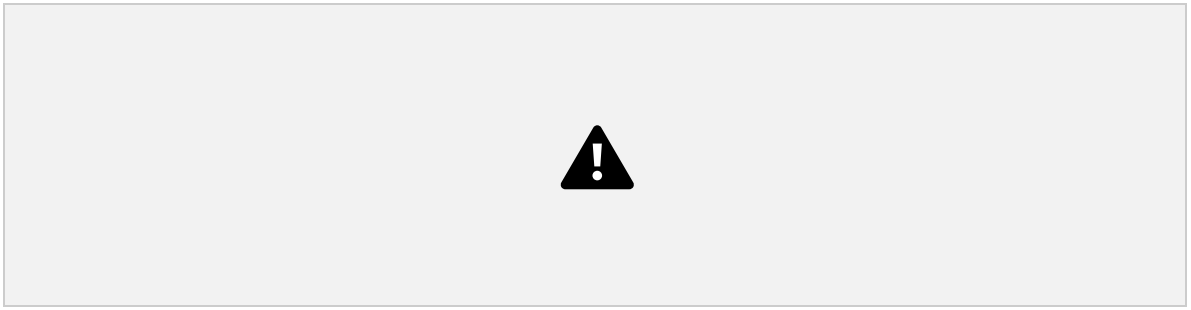
Enzymes Are Classified into six functional Classes (EC number Classification) by the International Union of Biochemists (I.U.B.). on the Basis of the Types of Reactions That They Catalyze

- **EC 1. Oxidoreductases**
- **EC 2. Transferases**
- **EC 3. Hydrolases**

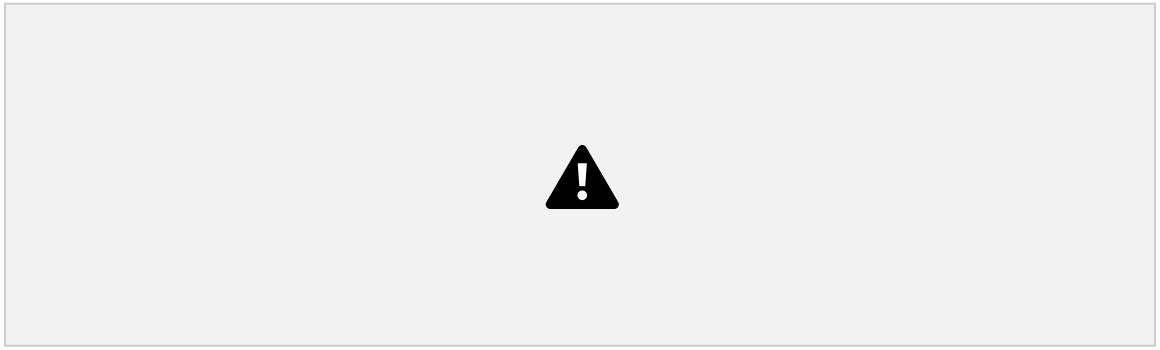
- **EC 4. Lyases**
- **EC 5. Isomerases**
- **EC 6. Ligases**

Enzyme Classes

1. Oxidoreductase

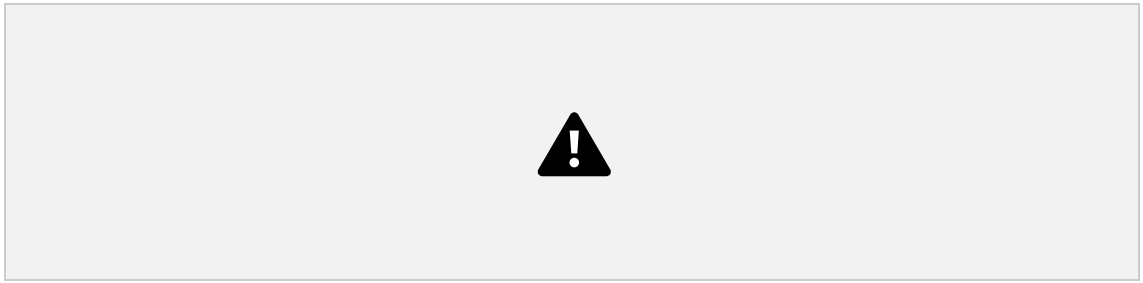


2. Transferase

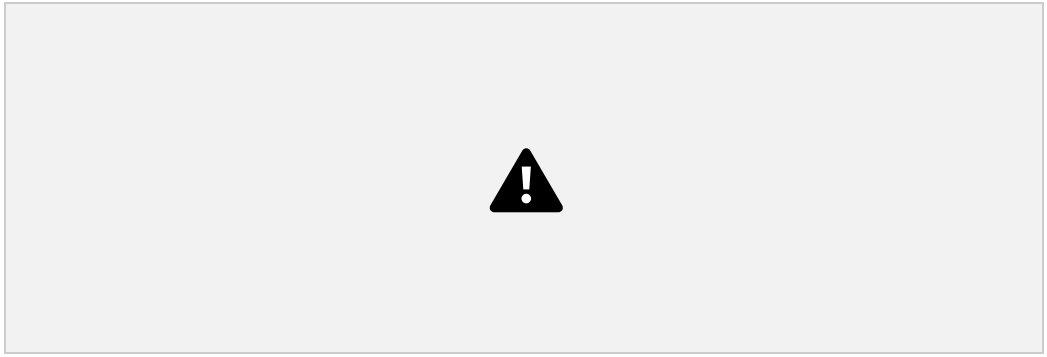


Enzyme Classes

3. Hydrolase

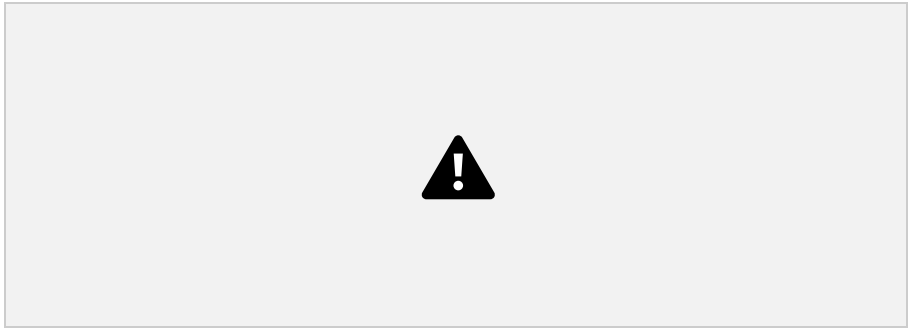


4. Lyase



Enzyme Classes

5. Isomerase



6. Ligase

Chemical Kinetics

- Rate: measure product
  formed per second
- Rate slows as reactant
  disappears
- Measure initial rate

- Do a second experiment
  with more starting material,
  and the initial rate is faster

Madenat A lelm University College
Department of Medical Physics
2nd Year Medical Chemistry 2021 – 2022

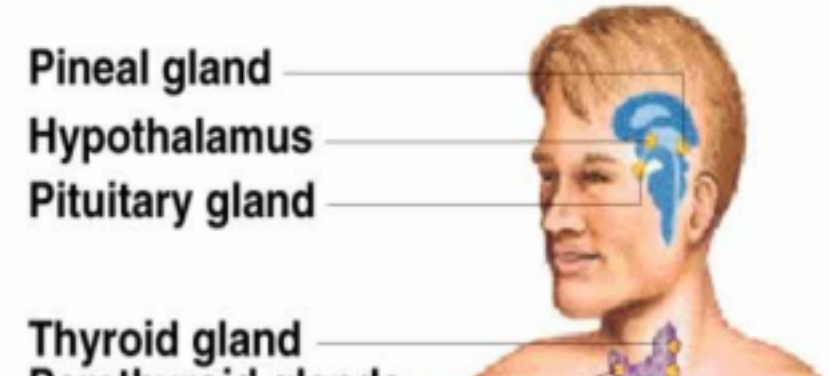
Hormones

General Characteristics and Classifications

Dr. Hamza Yaseen Isa
Lecture M 10 I 2

What is the

What is the ?



endocrine system

endocrine system?

The endocrine system is made up of glands and the hormones they secrete. Although the endocrine glands are the primary hormone producers, the brain, heart, lungs, liver, skin, thymus, gastrointestinal mucosa, and placenta also produce and release hormones.

Hormones – organic biologically active compounds of different chemical nature that are produced by the endocrine glands, enter directly into blood and accomplish humoral regulation of the metabolism of compounds and functions on the organism level.

Hormonoids (tissue hormones) – compounds that are produced not in glands but in different tissues and regulate metabolic processes on the local level, but some of them (serotonin, acetylcholine) enters blood and regulate processes on the organism level.

1. **Paracrine**- hormones that have a biological effect nearby.
2. **Autocrine**- hormones that have a local effect

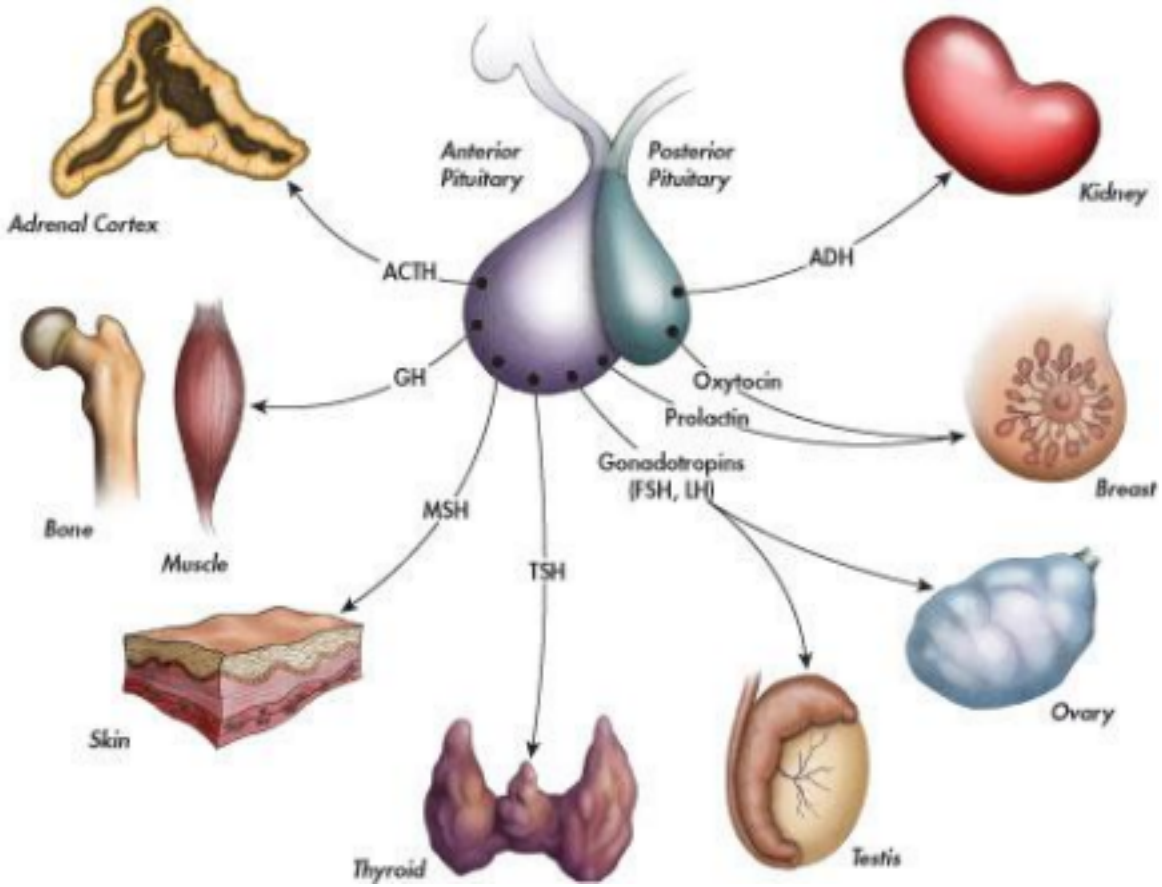
Hormones…

Hormones…

Hormones regulate growth,

Hyposecretion or hypersecretion of any hormone can be harmful to the body. Controlling the production of hormones can treat many hormonal disorders in the body.

development, mood, tissue function, metabolism, and sexual function.



Endocrine glands: 1. Hypothalamus

2. Pituitary
3. Epiphysis
4. Thymus
5. Thyroid gland

6. Parathyroid glands 7. Langergans' islands of pancreas
8. Epinephrine glands
9. Sex glands

1. nervous impulse:

2. concentration of certain compound in blood passing through the endocrine gland

Factors affecting Specific stimulus for hormones secretion are:

Classification of hormones according to chemical nature

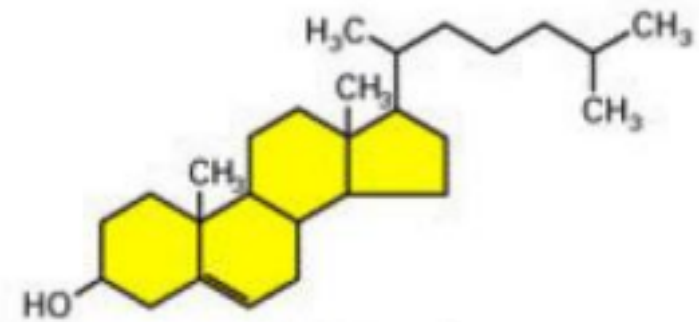
1. **Proteins:** hormones of anterior pituitary (except ACTH), insulin, parathyroid hormone.

2. **Peptides:** ACTH, calcitonin, glucagon, vasopressin, oxytocin, hormones of hypothalamus (releasing factors and statins).

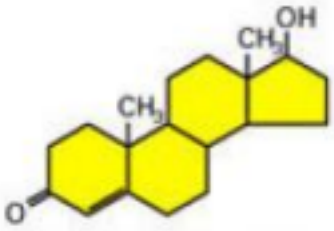
3. Derivatives of amino acids: catecholamins (epinephrine and norepinephrine), thyroxin, triiodthyronin, hormones of epiphysis.

4. Steroid (derivatives of cholesterol): hormones of the cortex of epinephrine glands, sex hormones. 5. Derivatives of polyunsaturated fatty (arachidonic) acids: prostaglandins.

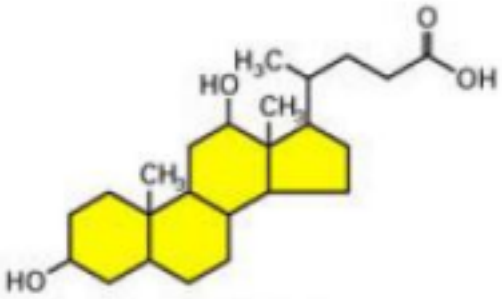
Cholesterol is a precursor of steroid hormones, bile acids (which help in digestion of dietary fats) and vitamin D.



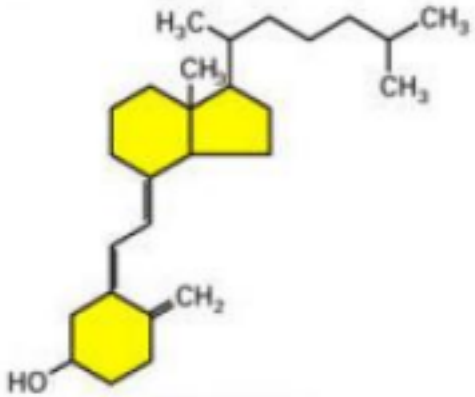
Cholesterol
(animal)



Steroid hormone
(testosterone)



Bile acid
(deoxycholic acid)



Vitamin D_3

Fate of hormones in organisms:

They are secreted directly into the blood

1. Peptide and protein hormones are secreted by exocytosis

2. Steroid (lipophilic) hormones continuously penetrate the membrane (they are not

accumulated in cells, their concentration in blood is determined by the speed of synthesis)

Transport of hormones in blood:

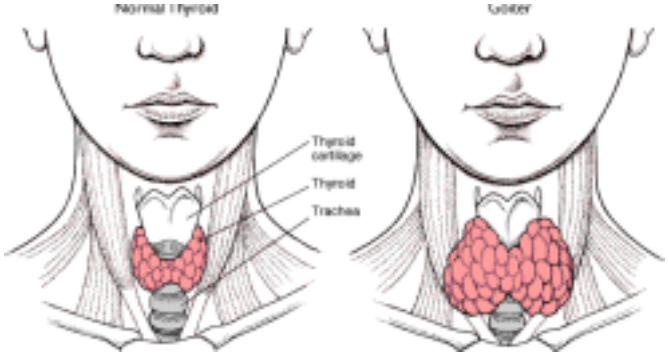
1. Protein and peptide hormone nature – in free state

2. Steroid hormones and hormones of thyroid gland – bound with alpha-globulins or albumins

3. Catechol amines – in free state or bound with albumins, sulphates or glucuronic acid.

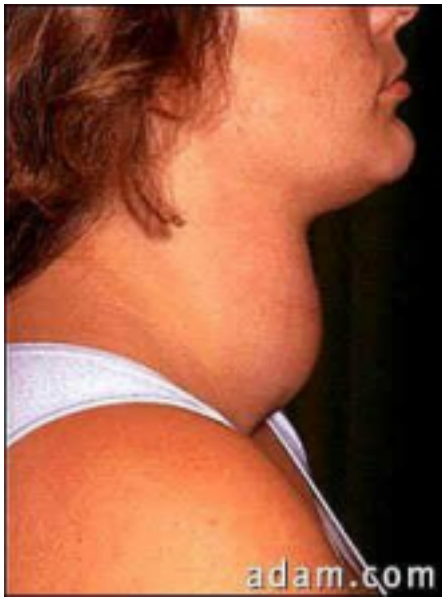
They reach the target organs

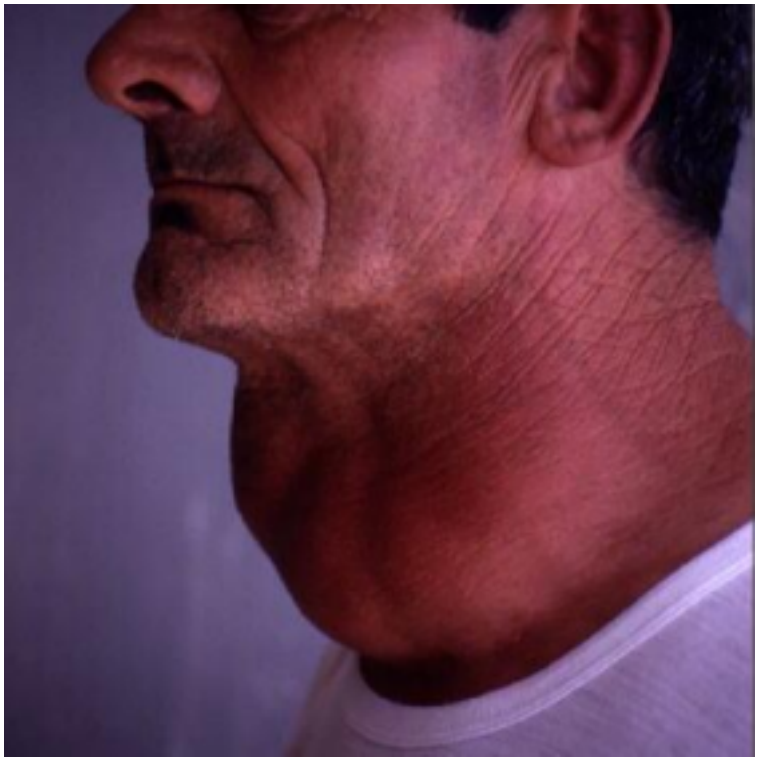
Cells have specific receptors to certain hormones



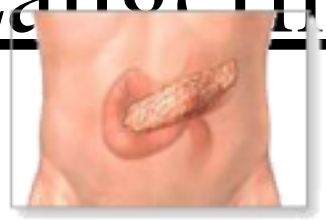
Thyroid

- **Iodine** deficiency in your diet results in **goiter** (enlargement of thyroid gland)





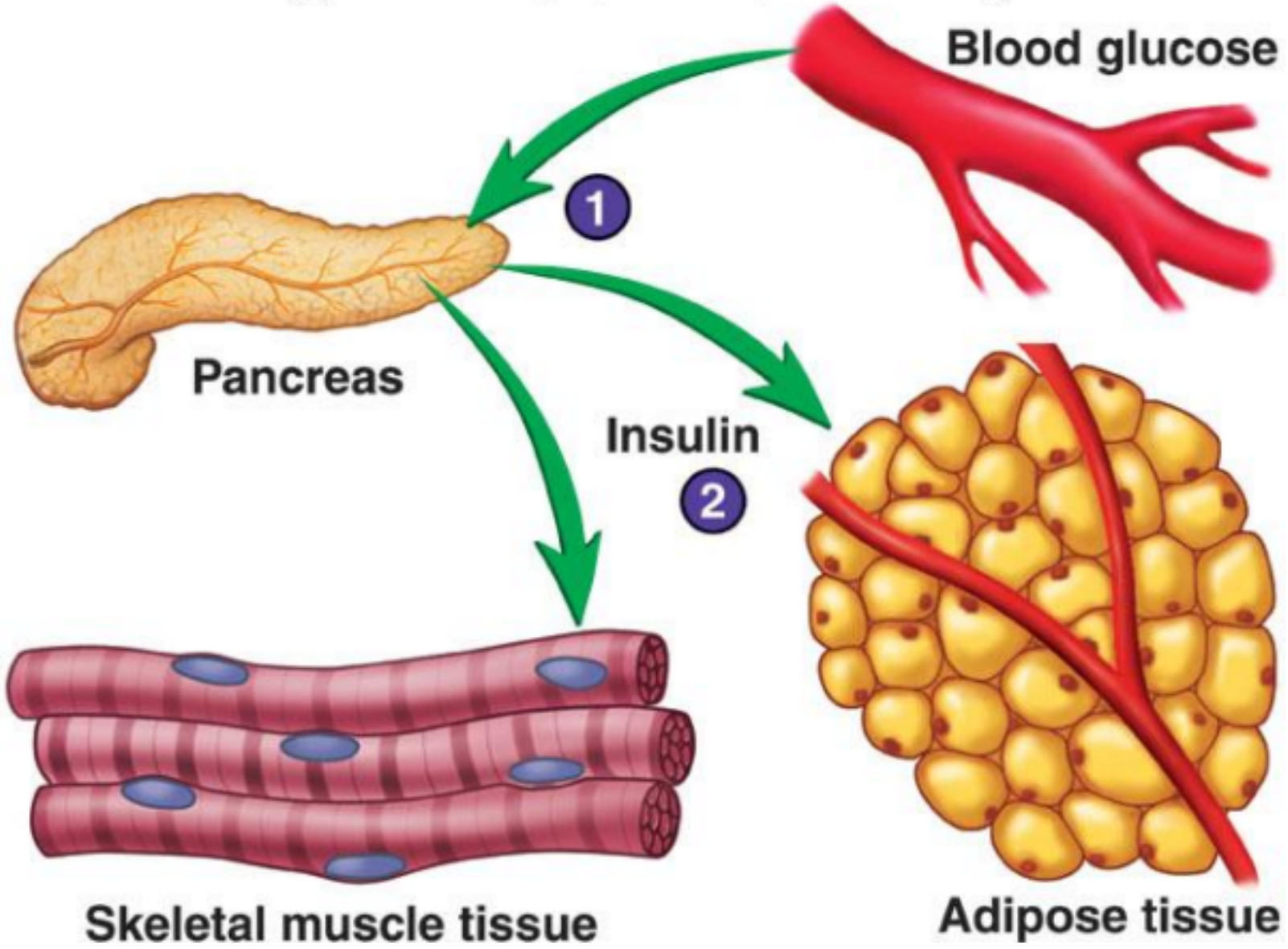
Islet of Langerhans



- **Located on the pancreas**
- **Hormones secreted are insulin and glucagon**

- **Insulin stimulates glucose uptake by cells**

- **Glucagon promotes conversion of glycogen (animal-based carbohydrate) to glucose**



Control of Secretion Rates

- **Hormones control the rates of many activities in the body.**
- **The rate at which each hormone is secreted is controlled by a negative feedback mechanism.**
- **Three major patterns of regulation:**
  1. **Non-hormone substance (e.g. insulin)**
  2. **Stimulation by the nervous system (e.g. epinephrine) 3. Hormone from another endocrine tissue (e.g. TRH, TSH)**
- **Biosynthesis of Hormones**
- **Biosynthetic mechanisms are many. Some protein hormones are synthesized as:**
- **1. precursors, which are converted to active form by**

removal of certain peptide sequences.

- E.g. Insulin is synthesized as pre-proinsulin (m.wt11500).Removal of some amino acids, peptides produce insulin (m.wt 5734).
- Thyroxine, a single amino acid hormone. It is synthesized as a glycoprotein precursor called thyroglobulin, which has 115 amino acids.
- 2. Pro-hormones: Some hormones are synthesized as biologically inactive or less active molecules called pro-hormones.
- Usually they are polypeptides/ proteins.
- E g. Pre-proinsulin→ Proinsulin.
- Storage
- Hormones are stored in secretory granules within the

cytoplasm of endocrine cells. eg. Thyroid hormones are stored in follicles filled with colloid particles.

- Catechol amines of Adrenal medulla are stored in secretory granules of cytoplasm.
- **Release:**

- When the target cells require free hormones, they are released immediately.
- The deficit in the bound form is replaced by the secretion of the endocrine gland. Feed back inhibition/stimulation controls hormone release
- Protein, polypeptide hormones are released by exocytosis or pinocytosis. It involves fusion of granules and cellular membrane, followed by secretion into blood stream.
- Stimulus excites the endocrine cell.
- The specific enzymes in the storage vesicle activate the hormone before release.

- **Disruption of the process by certain drugs interferes with exocytosis.**
- **The secretory process is linked to the release of neurotransmitters.**

Interaction of Hormones with Their Target Tissues.

- **Hormones only interact with cells that have binding sites that are specific for the particular hormone.**

Classes of Hormone Receptors.

- **Hormones can be placed into one of two major**

categories.

1. **Hormones that cannot pass through the plasma membrane.**
2. **Hormones that can pass through the plasma membrane.**

- **As a result, hormone receptors need to be located in different locations.**

Membrane-Bound Hormone Receptors.

- **Some receptors are located in the membrane of the target tissue.**
- **After a hormone binds to the receptor, the receptor initiates events that lead to a response.**

– Some receptors alter membrane permeability. – Some receptors activate G proteins.

Receptors of hormones

Two groups:

-placed on the surface of membrane – peptide and protein hormones, prostaglandins;

-placed inside the cells (cytoplasm, nucleus) – steroid and thyroid hormones

Inactivation of hormones

After biochemical effect hormones are released and metabolized

Hormones are inactivated mainly in liver Inactive metabolites are excreted mainly with urine

Half-time life

-from several min to 20 min – for the majority of hormones

-till 1 h – for steroid hormones

-till 1 week – for thyroid hormones

THE FINAL EFFECTS OF HORMONES ACTION

***1. Change the permeability of cell membrane*, accelerate the penetration of substrates, enzymes, coenzymes into the cell and out of cell.**

***2. Acting on the allosteric centers affect the activity of enzymes* (Hormones penetrating membranes). *3. Affect the activity of enzymes through the messengers (cAMP)*.**

(Hormones that can not penetrate the membrane).

4. Act on the genetic apparatus **of the cell (nucleus, DNA) and promote the synthesis of enzymes (Steroid and thyroid hormones).**