BIOMOLECULES

INTRODUCTION

*BIO*MOLECULES – chemicals or molecules present in living organisms
↓ life
↳ Combination of two or more molecules

>> Proteins, Lipids, Carbohydrates, Nucleic Acid

- Carbon – most versatile and most predominant element of life
  - 18% in living organisms

- COMPOSITION
  - INORGANIC – minerals, gases, water
  - ORGANIC – carbohydrates, lipids, amino acids, proteins, enzymes, nucleotides, nucleic acid, vitamins

- SIZE
  - MICROMOLECULES – small sized, low mol weight (18-800 Daltons)
    - found in acid soluble pool
  - MACROMOLECULES – large sized, high mol weight (↑100 Daltons)
    - found in acid insoluble pool

- MAJOR COMPLEX BIOMOLECULES

BIOMOLECULES	BUILDING BLOCK	MAJOR FUNCTION
protein	amino acid	basic structure and function
DNA	deoxyribonucleotide	hereditary information
RNA	ribonucleotide	protein synthesis
polysaccharide	monosaccharide	storage form of energy
lipids	fatty acids and glycerol	storage form of energy to meet long-term demands

CARBOHYDRATES – most abundant organic molecule in nature

- derived from French term *hydrate de carbone*
- hydrate of carbon / $C_n(H_2O)_n$

➢ FUNCTIONS

- most abundant source of energy
- precursors for many organic compounds
- present as glycoproteins and glycolipids in cell membrane and functions such as cell growth and fertilizations
- present as structural components like cellulose in plants, exoskeleton of some insects and cell wall of microorganisms
- storage form of energy (glycogen) to meet the energy demands of body

MONOSACCHARIDES – basic unit of carbohydrates

- can't be hydrolyzed into smaller units

a. based on number of C-atoms
b. based on type of functional group

OLIGOSACCHARIDES – can be further hydrolyzed

a. disaccharides
b. trisaccharides
c. tetrasaccharides

POLYSACCHARIDES – non crystalline, nonsoluble in water and tasteless

CLASS	CHEMICAL FORMULA	EXAMPLE	SOURCE
monosachharide	$C_6H_{12}O_6$	glucose fructose galactose	fruit honey digested milk
disaccharide	$C_{12}H_{22}O_{11}$	maltose sucrose lactose	barley table sugar milk
polysaccharide	$(C_6H_{12}O_5)_n$	starch cellulose pectin glycogen	bread pasta whole cereal fruits

MONOSACCHARIDES

✓ simple sugars, possess a free ketone or aldehyde group
✓ examples: glucose, fructose, galactose, glycerose, ribose, ribulose

➢ Based on number of C-atoms

a. TRIOSES – $C_3H_6O_3$
   - gyceraldehyde, dihydroxyacetone
b. TETROSES – $C_4H_8O_4$
   - erythrose, theose
c. PENTOSES – $C_5H_{10}O_5$

- ribulose, xylose, arabinose

d. HEXOSES – $C_6H_{12}O_6$
   - glucose, fructose, galactose, mannose

e. HEPTOSES – $C_7H_{14}O_7$
   - sedoheptulose, glucoheptose

➢ Based on the Functional Group

a. ALDOSES – functional group is aldehyde – CHO
   - glyceroldehyde, glucose

b. KETOSES – functional group is keton (C=O)
   - dihydroxyacetone, fructose

OLIGOSACCHARIDES

✓ oligo -> few ; sugars that break down into 2-10 molecules of monosaccharides when hydrolyzed
✓ examples: sucrose, maltose, lactose, raffinose, stachyose

➢ DISCCHARIDES – consist of 2 monosaccharide units held together by a glycosidic bond
   - crystalline, water soluble, sweet in taste

a. MALTOSE – malt sugar
   - glucose + glucose

b. LACTOSE – milk sugar ; found naturally in milk
   - glucose + galactose

- souring of milk: conversion of lactose to lactic acid

c. SUCROSE – cane sugar ; sugar found in sugar cane and sugar beet
   - most abundant among naturally occurring sugars
   - important source of dietary carbohydrates
   - glucose + fructose

POLYSACCHARIDES

✓ poly -> many
✓ composed of molecules that yield more than 10 monosaccharides on hydrolysis
✓ classified depending on type of molecules hydrolyzed
- include homopolysaccharide (with several polysaccharide of one type) and heteropolysaccharide (with different types of monosaccharides)
✓ also called as glycans
✓ not sweet
✓ ideal as storage and structural component

a. HOMOGLYCANS – made up of only 1 type of monosaccharide monomer
   - starch, glycogen, cellulose

b. HETEROGLYCANS – made up of condensation of 2 or more types of monosaccharide
   - hyaluronic acid, agar, chitin, peptidoglycans

- Storage Polysaccharide
  a. STARCH – carbohydrate reserve for plants, most important dietary source for animals
     - cereals, roots, tubers, vegetables
     - homopolymer made up of glucose units called glucan
     - starch = amylose + amylopectin
  b. GLYCOGEN – carbohydrate reserve in animals ; animal starch
     - also found in plants that don't have chlorophyll (yeast, fungi)
     - repeating unit: glucose
  c. INULIN – polymer of fructose (fructosan)
     - Found in Dahlia, bulbs, garlic, onion
     - Easy soluble in water
     - Not really metabolized in human body ; readily filtered through the kidney

- Structural Polysaccharide
  a. CELLULOSE – occurs exclusively in plants ; most abundant organic substance in plant kingdom
     - predominant constituent of plant cell wall
     - totally absent in animals
  b. CHITIN – second most abundant organic substance
     - complex carbohydrate of heteropolysaccharide
     - found in exoskeleton of some invertebrates ; provides both strength and elasticity
     - becomes hard when infused with calcium carbonate

PROTEINS – made up of polypeptide

- peptid bond – chains of amino acids
- from Greek word *proteios* which means first or primary
- most structurally sophisticated molecule known

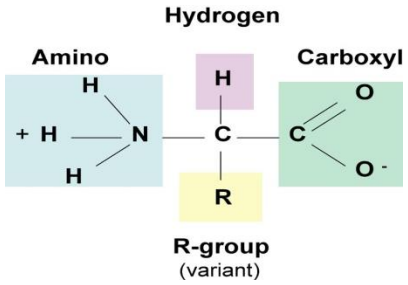
➢ Types

a. ENZYMATIC – selective acceleration for chemical reactions
b. STORAGE – storage of amino acids
c. DEFENSIVE – protection against diseases
d. TRANSPORT – transport of substances
e. HORMONAL – coordination of an organism's activities
f. CONTRACTILE and MOTOR – movement
g. RECEPTOR – response of cell to chemical stimuli
h. STRUCTURAL – support

- Pikachurin – retinal protein named after Pikachu
- Sonic Hedgehog – protein named after Sonic Hedgehog
- Ranasmurfin – blue protein named after Smurf

AMINO ACID (protein monomer) – grouped according to properties of sidechains

- joined by dehydration process



➢ 20 AMINO ACIDS

a. NONPOLAR SIDE CHAINS ; HYDROPHILIC

glycine	alanine	valine	leucine	isoleucine
methionine	phenylalanine	trytophan	proline	

b. POLAR SIDE CHAINS ; HYDROPHILIC

serine	threonine	cysteine
tyrosine	aspargine	glutamine

c. ELECTRICALLY CHARGED SIDE CHAINS ; HYDROPHILIC

ACIDIC (negatively charged)	BASIC (positively charged)
aspartic acid	lysine
glutamic acid	arginine
	histidine

ESSENTIAL	NONESSENTIAL	CONDITIONALLY ESSENTIAL
histidine	alanine	arginine
isoleucine	arpargic	cysteine
leucine	aspartic acid	glutamine
lysine	glutamic acid	glycine
methionine	serine	proline
phenylalanine		tyrosine
threonine		
trytophan		

POLYPEPTIDE (amino acid polymer) – amino acid groups reacts with carboxyl group and water is lost

- Protein – biologically active polypeptide with 50 or more amino acids

VISUALIZING PROTEIN

a. space-filling – all atoms
b. ribbon – backbone
c. wireframe – backbone with side chains

FOUR LEVELS OF STRUCTURE

1. PRIMARY (1º) Structure – order/sequence of amino acids
    - slight change in sequence can affect protein's structure and function
2. SECONDARY (2º) Structure – local folding
    - Interactions between adjacent amino acids
3. TERTIARY (3º) Structure – whole molecule folding
    - Interactions between distant amino acids
4. QUATERNARY (4º) Structure – more than 1 polypeptide chain bonded together

- Denaturation – unfolding of protein
    - Process in which protein loses native shape due to disruption of weak chemical bonds and interactions, becoming biologically inactive

LIPIDS

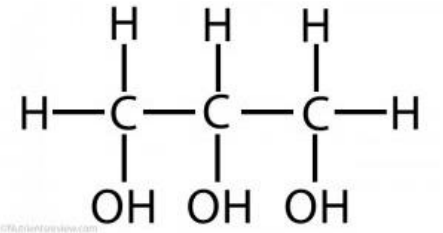
- CHARACTERISTICS
  - ✓ compose of carbon, hydrogen and oxygen
  - ✓ hydrophobic in nature
  - ✓ includes fats, oils, phospholipids and steroids
  - ✓ building blocks: fatty acids, glycerol

- FUNCTIONS
  - ✓ energy storage
  - ✓ structural component
  - ✓ signaling molecule

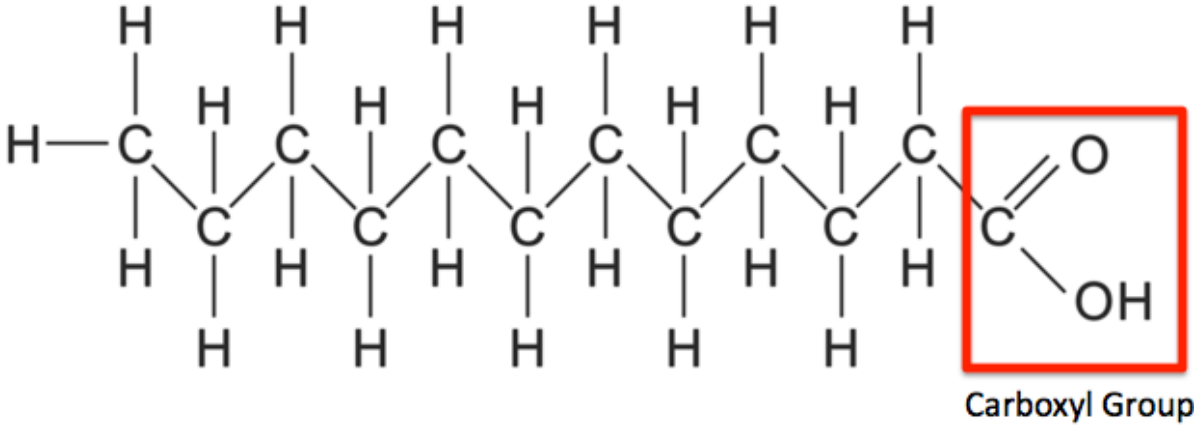
FATS – large molecules assembled from smaller molecules by dehydration process
- constructed from fatty acids and glycerol

- dehydration – loss of water molecule
- hydrolysis – addition of water molecule

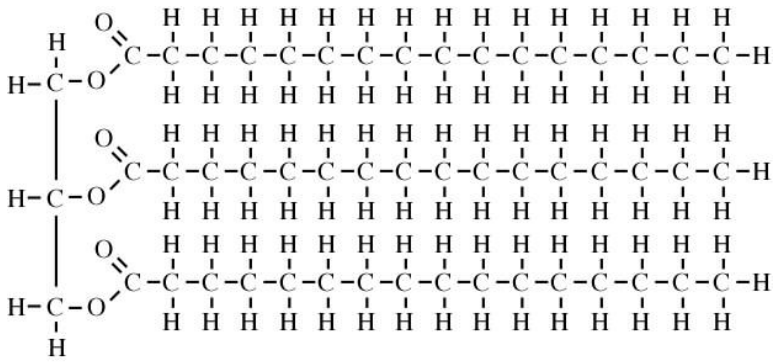
GLYCEROL – an alcohol; each of its 3 carbon bears a hydroxyl group



FATTY ACID STRUCTURE – carboxyl group (COOH) forms the acid
- R group is a hydrocarbon chain



FATS – neutral fats / triglycerides / triacylglycerol

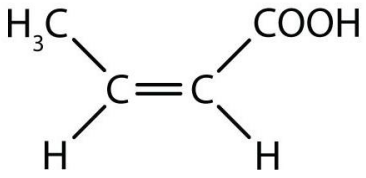


SATURATED FATTY ACIDS

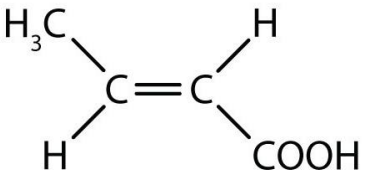
- No double bonds in their long hydrocarbon chain
- Stearic acid: $CH_3(CH_2)_{16}COOH$
- At room temperature, the molecules of a saturated fat are packed closely together, forming a solid
- Animal fat

UNSATURATED FATTY ACIDS

- Have 1 or more double bonds (generally *cis*) in their long hydrocarbon chain
- Oleic acid: $CH_3(CH_2)_7CH = CH(CH_2)_7COOH$
- At room temperature, the molecules of an unsaturated fat cannot pack together closely enough to solidify because of the kinks in some of their fatty acid hydrocarbon chains
- Plant and fish oil



cis



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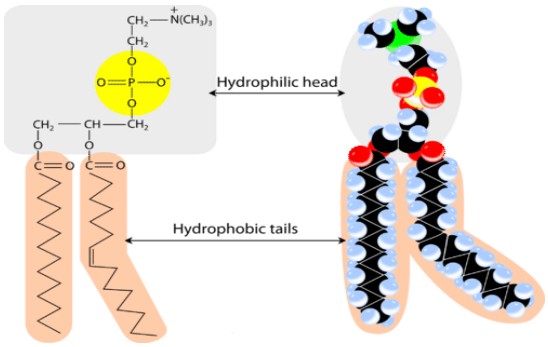
Fats as ENERGY STORAGE

- A gram of fat stores more than twice as much energy as a gram of a polysaccharide
- Plants are relatively immobile, they can function with bulky energy storage
    - Vegetable oils are generally obtained from seeds where more compact storage is an asset to the plant
- Animals must carry their energy stores with them so there is an advantage to having a more compact reservoir of fuel → fat
- Humans and other mammals stock their long-term food reserves in adipose
- Adipose tissue cushions vital organs (like kidneys) and a layer of fat beneath the skin insulates the body

PHOSPOLIPIDS

- Fats as structural component



STEROIDS

- Fats as signaling molecule
- Characterized by a carbon skeleton consisting of four fused rings
- Different steroids are distinguished by the particular chemical groups attached to its ensemble of rings

CLASS OF STEROID	NUMBER OF C ATOMS	EXAMPLE
CORTICOSTEROIDS		
Mineralocorticoids	21	aldosterone
Glucocorticoids	21	cortisol
Androgens	19	DHEA
GONADAL STEROIDS		
Progesterons	21	progesterone
Androgens	19	testosterone
Estrogens	18	estradiol

- ➢ CHOLESTEROL – type of steroid
  - Crucial molecule in animals
- Steroids are common component of animal cell membranes and is also the precursor from which other steroids are synthesized
- In vertebrates, cholesterol is synthesized in the liver and is also obtained from the diet
- Functions – known as sterol or modified steroid
  - Helps build and maintain membranes
  - Composes over 30% of all animal cell membranes
  - Four interconnected carbon rings
  - Synthesizes steroid hormones at adrenal cortex