HISTORY OF THE PAST

IMPORTANT PEOPLE OF THE PAST

- Robert HOOKE – a polymath
  - made one of the first microscopes
- Anton Van LEEUWENHOEK – made the first useful microscope in 19th century
  - made lens held in metal clip
    - ↳ molten glass
- Lady Mary WORTLEY MONTAGUE – introduced the small pox vaccination
- Francisco REDI – Italian physician
  - disproved the theory of spontaneous generation
- John NEEDHAM – Irish priest
  - tested abiogenesis; experimented boiled broth and stated that air can bring microorganisms to life
- Lazaro SPALLANZANI – Italian priest
  - disproved the theory of spontaneous generation
- Louis PASTEUR – a chemist
  - performed a crucial experiment that proved that new life didn't just spontaneously arise from substances
- Ilya METCHNIKOFF – renowned bacteriologist
  - first to realize that animals have a defense system against infections (immune system)
- Paul EHRLICH – synthesized the first successful (but very toxic) drug against a disease – syphilis, it was an arsenic derivative called salvarsan
- Hans Christian GRAM – invented Gram stain to identify bacteria
- Gerhardt DOMAGK – developed the first useful drug against variety of bacterial infection, the first sulfra drug – prontosil
- Sir Alexander FLEMING – discovered the first relatively safe and effective antibiotics – isolated from microorganisms
  - discovered penicillin
- Selman WAKSMAN – discovered streptomycin and other antibiotics
- Robert KOCH – Father of Medical Microbiology
  - initiated the use of agar as a stable material for the formation of gel that separated the pure colonies of bacteria and fungi could be grown
- John TYNDALL – demonstrated that dust carries microorganisms
  - provided evidence for the existence of exceptionally heat resistant forms of bacteria

PROPONENTS OF CELL THEORY

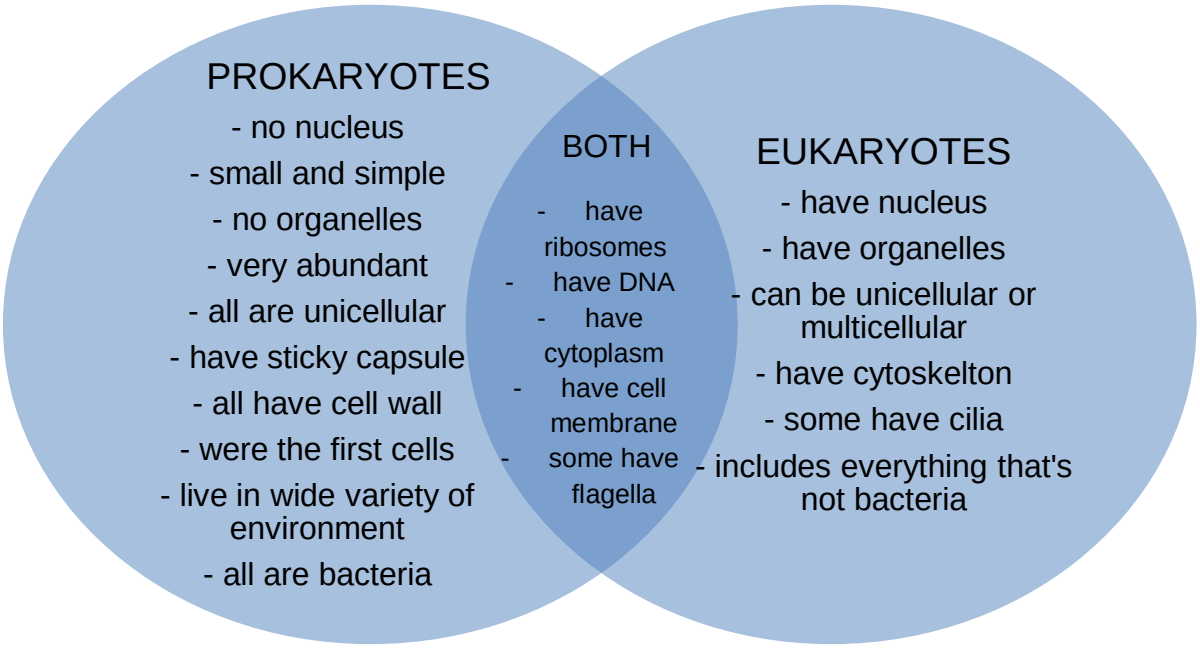
- Robert HOOKE – used a microscope to examine a thin slice of cork
  ↳ oak tree
  - Hooke is responsible for naming cells
  - Hooke called them cells because they looked like the small rooms that monks lived in called cells
- Anton Van LEEEWENHOEK – first to view organism
  - used a simple, handheld microscope to view pong water and scrapings from his teeth
  - animalcules → microorganisms
- Matthias SCHLEIDEN – a German botanist who concluded that all plants were made of cells
- Theodore SCHWANN – a German zoologist who concluded that all animals were made of cells
- Rudolph VIRCHOW – a German medical doctor who observed cells dividing (under a microscope)
  - reasoned that all cells come from other pre-existing cells by cell division

CYTOLOGY – study of cells

TYPES OF CELL

CELL THEORY

1. All living things are made up of cell.
2. Cells are the basic unit of structure and function in an organism.
3. Cells come from the reproduction of existing cells (cell division).



*PRO*KARYOTIC → nucleus
↓
no

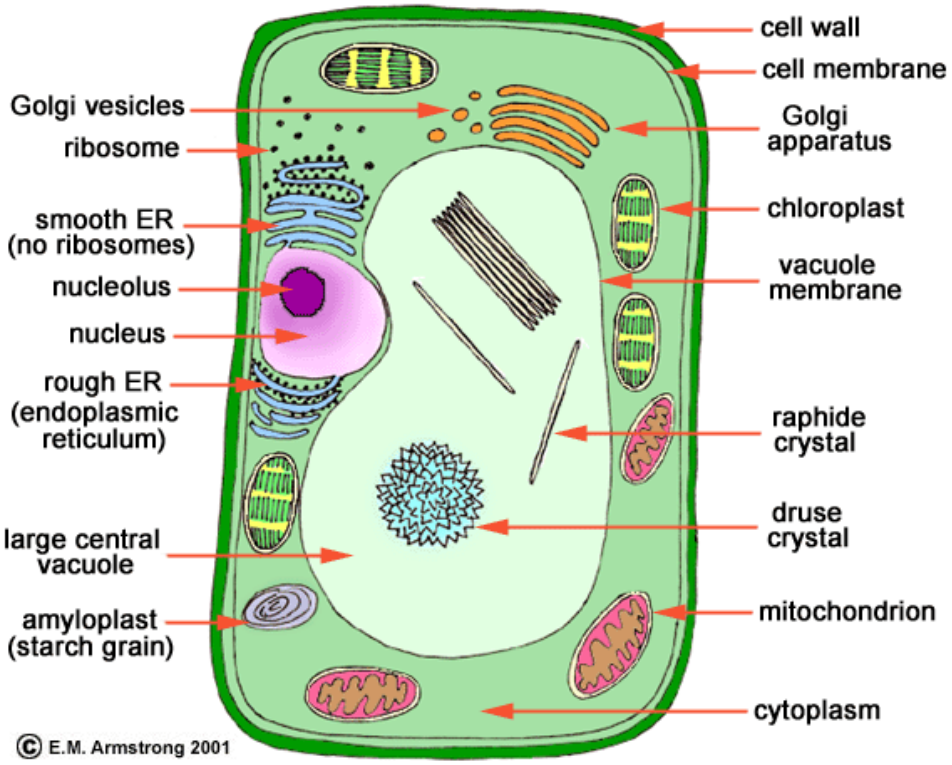
- wide variety of environment → moist, bodies of water

*EU*KARYOTIC → nucleus
↓
true

- cytoskeleton → inside the cytoplasm
- cilia → hair-like projection

BOTH

- ribosomes → protein synthesis
- DNA → genetic material
- flagella → tail


cell wall
cell membrane
Golgi vesicles
Golgi apparatus
ribosome
chloroplast
smooth ER (no ribosomes)
vacuole membrane
nucleolus
nucleus
rough ER (endoplasmic reticulum)
raphide crystal
druse crystal
large central vacuole
mitochondrion
amyloplast (starch grain)
cytoplasm
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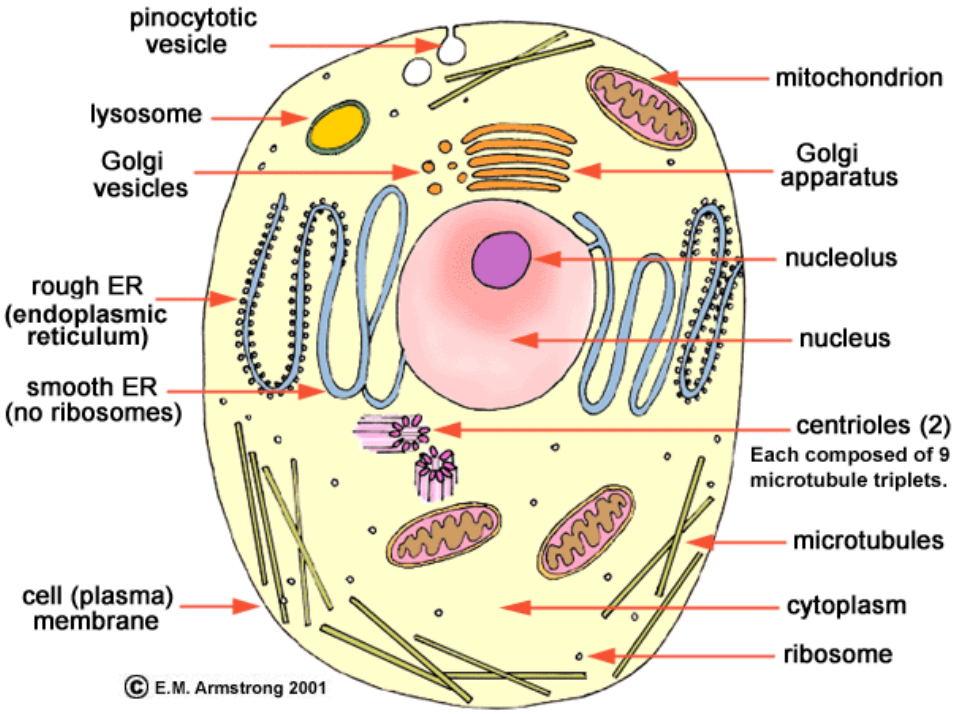
pinocytotic vesicle
mitochondrion
lysosome
Golgi vesicles
Golgi apparatus
nucleolus
rough ER (endoplasmic reticulum)
nucleus
smooth ER (no ribosomes)
centrioles (2)
Each composed of 9 microtubule triplets.
microtubules
cell (plasma) membrane
cytoplasm
ribosome
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THE ORGANELLES OF THE CELL

- ORGANELLES – very small; microscopic
    - performs various functions for a cell
- CELL MEMBRANE – composed of double layer of phospholipids and proteins
    - surrounds outside of the cell; controls what enters and leaves the cell
- PHOSPHOLIPIDS – *head*: glycerol and phosphate ; hydrophilic (attracts water)
    - *tail*: fatty acids ; hydrophobic (repel water)
    - make up a bilayer where tails point inward towards each other
- PROTEIN – help move large molecule or aid in cell recognition
    - *peripheral protein*: attached on the surface
    - *integral protein*: embedded completely through the membrane
- CELL WALL (plant cell) – outside the cell membrane
    - supports and protects cell
- CYTOSOL – fluid present in cell membrane
- CYTOPLASM – cell component present inside the cell membrane; region
- NUCLEUS – controls cell's activities
    - contains the DNA chromosomes
- CYTOSKELETON – helps cell maintain shape
    - *microfilaments*: threadlike, made of actin
    - *microtubules*: tubelike, made of tubulin
- CENTRIOLES – paired structure near the nucleus
    - made up of bundle of microtubules
    - appear during cell division forming mitotic spindle; helps to pull chromosome pairs apart to opposite ends of the cell
- MITOCHONDRION – powerhouse
    - generate cellular energy
    - site of cellular respiration
    - folded inner membrane → cristae – increases surface area for more chemical reaction
- ENDOPLASMIC RETICULUM

SMOOTH ENDOPLASMIC RETICULUM	ROUGH ENDOPLASMIC RETICULUM
does not bear ribosomes over the surface of its membrane	possess ribosomes attached to its membrane
main function: synthesis of lipids	main function: synthesis of proteins
formed of vesicles and tubules	formed of cisternae and few tubules
usually found in periphery	found deep inside the cytoplasm
may develop from RER	may develop from nuclear envelope

- RIBOSOME – proteins and rRNA
    - protein factories
    - join amino acids to make protein through protein synthesis

- VACUOLE – fluid filled sacs for storage
- CHLOROPLASTS – surrounded by <u>double membrane</u>
  → outer: smooth – inner: modified into sacs called thylakoids
  - ✓ Grana → thylakoids in stacks; interconnected
  - ✓ Stroma → gel-like material surrounding thylakoids
- CILIA and FLAGELLA – function in moving cells, moving fluids or in small particles across the cell surface
  - ✓ CILIA – shorter and more numerous
  - ✓ FLAGELLA – longer and fewer (1-3)

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

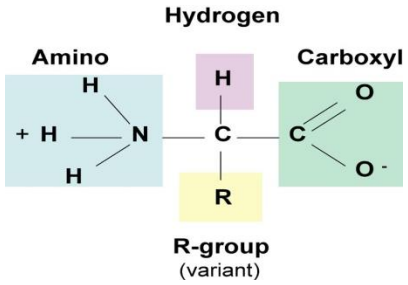
➢ Types

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

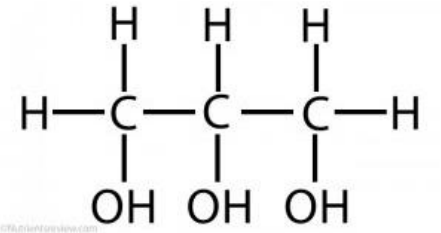
- CHARACTERISTICS
  - ✓ compose of carbon, hydrogen and oxygen
  - ✓ hydrophobic in nature
  - ✓ includes fats, oils, phospholipids and steroids
  - ✓ building blocks: fatty acids, glycerol

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

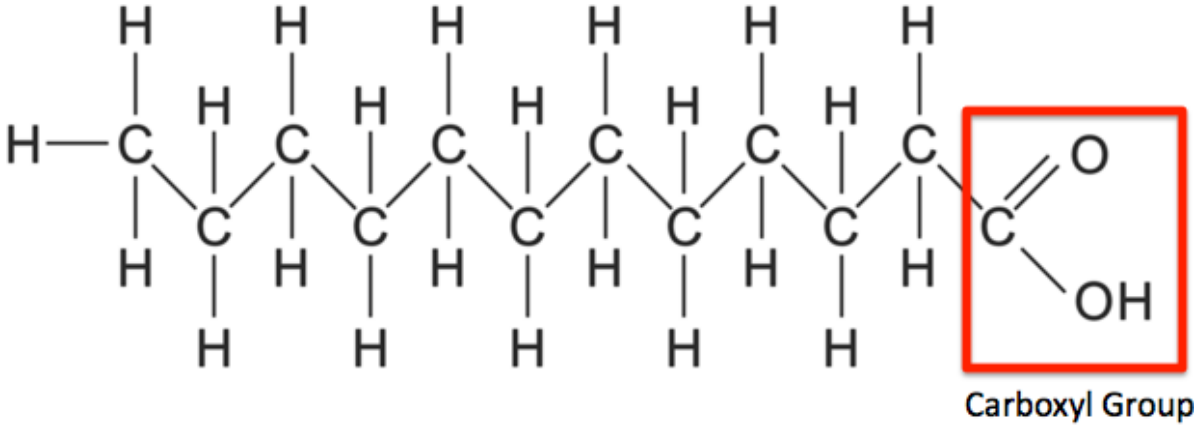
FATS – large molecules assembled from smaller molecules by dehydration process
- constructed from fatty acids and glycerol

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

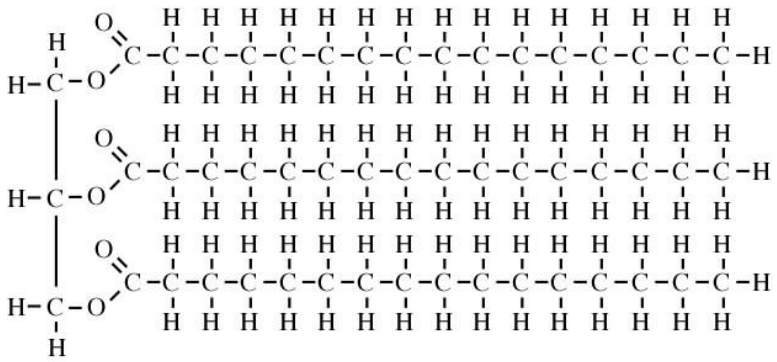
GLYCEROL – an alcohol; each of its 3 carbon bears a hydroxyl group



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



FATS – neutral fats / triglycerides / triacylglycerol

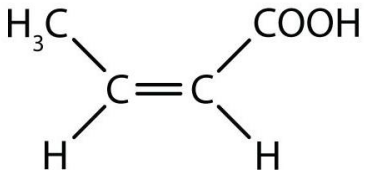


SATURATED FATTY ACIDS

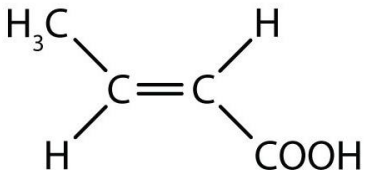
- No double bonds in their long hydrocarbon chain
- Stearic acid: $CH_3(CH_2)_{16}COOH$
- At room temperature, the molecules of a saturated fat are packed closely together, forming a solid
- Animal fat

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



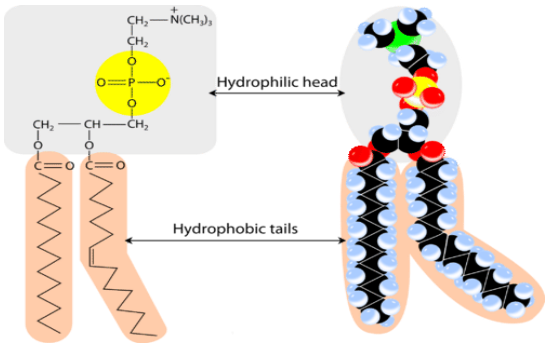
trans

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